FINAL

Desktop Supplemental Remedial Investigation Badger Army Ammunition Plant Gruber's Grove Bay, WI

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirements
Army	United States Department of the Army
AUF	area use factor
BAAP	Badger Army Ammunition Plant
BIA	Bureau of Indian Affairs
BSD	Bluffview Sanitary District
bss	below sediment surface
BTV	background threshold value
bw	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	Centimeters
COC	chemical of concern
COPC	chemical of potential concern
CPAH	carcinogenic polyaromatic hydrocarbon
CSM	conceptual site model
CY	cubic yards
DBG	Deterrent Burning Ground
DGI	Data Gap Investigation
DI	daily intake
DNT	2,4-dinitrotoluene
EPC	exposure point concentration
EPT	Ephemeroptera, Plecoptera and Trichoptera
EQuIS™	Environmental Quality Information System™
ERA	ecological risk assessment
FS	Feasibility Study
ft	Feet
FUDS	Formerly Used Defense Sites
GGB	Gruber's Grove Bay
GOF	goodness of fit
HHRA	human health risk assessment

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HI	hazard index
HoChunk	Ho-Chunk Nation
HQ	hazard quotient
IPaC	Information, Planning, and Conservation System
IRIS	USEPA's Integrated Risk Information System
IRM	interim remedial measure
LANL	Los Alamos National Laboratory
LOAEL	Lowest observed adverse effects level
MEC	median effect concentration
mg/kg	milligrams per kilogram
MIRM	modified interim remedial measure
MPBC	Most Probable Background Contamination
msl	mean sea level
ng/L	nanograms per liter
NOAEL	No observed adverse effects level
NPS	National Park Services
NTE	not-to-exceed
PBG	Propellant Burning Ground
PCB	polychlorinated biphenyl
PEC	probable effect concentration
ProUCL	EPA Statistical Software ProUCL 5.2 for Environmental Applications version 2022
PWS	performance work statement
RAL	Remedial Action Level
RfD	reference dose
RI	Remedial Investigation
RSL	regional screening level
SOW	scope of work
SPSDA	Settling Ponds and Disposal Area
SQG	sediment quality guideline
SUF	seasonal use factor

SVOC	semi-volatile organic compound
SWAC	surface weighted average concentration
TCE	Trichloroethylene
TDD	total daily dose
TEC	threshold effect concentration
TL	trophic level
TMF	trophic magnification factor
TRV	toxicity reference values
µg/kg	micrograms per kilogram
USACE	United Stated Army Corps of Engineers
USCS	Unified Soil Classification System
USDA	United States of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	upper tolerance limit
VOC	volatile organic compound
WDNR	Wisconsin Department of Natural Resources
WDOT	Wisconsin Department of Transportation
WL&P	Wisconsin Light & Power

Executive Summary

This executive summary provides an overview of the Desktop Supplemental Remedial Investigation (RI) for mercury contamination above the most probable background concentration (MPBC) in Gruber's Grove Bay (GGB) sediment from the Badger Army Ammunition Plant (BAAP) in Baraboo, Wisconsin. The overall scope of this Desktop Supplemental Remedial Investigation was to (1) determine data quality and usability, (2) characterize the site to the extent possible with pre-existing data, (3) evaluate the nature and extent of current contamination, (4) evaluate the remedial objective identified in the 2000, (5) develop and refine a conceptual site model, and (6) define risk to human health and the environment posed by site contaminants.

The RI initially focused on post-remedial sampling events from 2009, 2016, 2018, and 2019, subsequent to the dredging of approximately 88,333 cubic yards (CY) of sediment between 2003 and 2006 and approximately 60,000 CY in 2006. AECOM identified discrepancies between the sediment investigations during the 2009 event and the 2016 and 2018 events. In addition, data collected by US Geological Survey (USGS) in 2019 was collected under a sampling program utilizing different sampling horizons from those in the 2016/2018 data collection. Consequently, it was determined that 2016/2018 results would be used to further evaluate the extent of contamination, data gaps, and the risk assessment described in this report.

Existing sample datasets do not allow for accurate estimation of changes in sediment concentration over time. The sampling priority for the 2016 sampling event was predominantly surface sediments, while the sampling priority of the 2018 sampling event was predominately subsurface sediments; resampling at selected locations to evaluate change over time was not a goal of previous sampling events.

Historical samples collected during the 2016 and 2018 sampling events were screened against the MPBC of 0.36 milligrams per kilogram (mg/kg), a background threshold value (BTV) of 0.49 mg/kg, and Wisconsin Department of Natural Resources (WDNR) 2003 midpoint effect concentration (MEC) sediment quality guideline (SQG) of 0.64 mg/kg. The BTV of 0.49 mg/kg was estimated using USGS collected sediment samples from multiple locations upstream of GGB. The samples were taken from the top five (5) centimeters of recently deposited surficial sediments in Wiegands Bay and Lake Wisconsin. The USGS background data from 2019 resulted in a BTV of 0.49 mg/kg for mercury, slightly higher than the MPBC of 0.36 mg/kg that has been used as the cleanup level for mercury-contaminated sediment in GGB. AECOM reviewed the BTV calculations using the USEPA statistical software package ProUCL, and the background data were found to be normally distributed without any outliers.

Data for total mercury concentrations collected in 2016 and 2018 were interpolated to create maps for surface (0 – 0.5 feet [ft]) and subsurface (> 0.5 ft) sediment horizons (**Figures 2-3 and 2-4**). Sixty-two (62) surface samples were used to evaluate the distribution of total mercury in surface sediments and forty (40) sample locations were used to evaluate distribution in the subsurface horizon. In general, mercury is concentrated within the surficial sediment layer across GGB and decreases with depth. The vertical extent of elevated mercury concentrations has not been fully delineated. Sediment impacts within the majority of GGB have been horizontally delineated; however, impacts at the northeast and south shores of the bay, and near the mouth of the bay have not been horizontally delineated. Recommendations were made for further vertical and horizontal delineation at specific locations such as shorelines and the mouth of the bay.

A conceptual site model (CSM) was originally developed in 2000 and included information on known contaminant sources and impacted media, potential other sources, transport pathways, exposure pathways, and receptors. Current potential human health receptors include residents, recreational users, and anglers. Potential ecological receptors include benthic invertebrates, fish, birds and mammals. The land use surrounding the bay is expected to remain unchanged for the foreseeable future. Potential future receptors are anticipated to remain the same as current receptors. Mercury is the primary chemical of potential concern (COPC) and cleanup of mercury is anticipated to address cleanup of other co-occurring COPCs below applicable action criteria based on the prior site investigations. For human consumers of small panfish, the cumulative hazard indices (HIs) are below 1, indicating potential adverse health effects are not expected. The cumulative HIs for an adult and child exceeded 1 due to consumption of larger sportfish. In summary, ingestion of larger sportfish from GGB has the potential to result in adverse noncarcinogenic health effects under the conservative assumptions used in this human health risk assessment (HHRA). Existing datasets did not allow for development of a sediment stability component of the CSM.

An ecological risk assessment (ERA) was conducted using sediment and fish tissue collected within GGB after remedial dredging efforts conducted in 2006. The relevant ecological assessment endpoints were developed based on the CSM. Two types of exposures were evaluated in this ERA: direct exposures through contact with sediment (benthic macroinvertebrates) and indirect exposure via bioaccumulation of mercury into fish tissue and ingestion of contaminated prey/forage. Ecological receptors evaluated in the ERA included benthic invertebrates, fish, and piscivorous mammals. Benthic invertebrate hazard quotients (HQs) based on the probable effect concentration (PEC) ranged from 1.6 in the subsurface sediment data set (> 0.5 ft) to 1.9 in the surface data set (0 - 0.5 ft). According to WDNR (2003), these exceedances of the PEC suggest that toxicity to benthic-dwelling organisms is probable. For the fish community assessment endpoint, risks to small fish represented by panfish tissues were not identified. For higher trophic level fish, the no observed adverse effect level (NOAEL) HQ was slightly above 1; however, based on the uncertainties associated with the estimated higher tropic level fish concentration and the similarity of GGB and upstream fish tissue concentrations, mercury in sediment is unlikely a risk to higher trophic level fish that obtain a portion of their diet within GGB. The potential for adverse effects of mercury on piscivorous mammals foraging within GGB is unlikely. NOAEL and lowest observed adverse effect level (LOAEL) HQs based on ingestion of panfish and incidental ingestion of sediment by mink were all less than 1 and inclusion of higher trophic level fish in the diet is not expected to pose a risk to mink or other piscivorous mammals like the river otter.

The recommendations of this Desktop RI include progression of GGB to data gap investigation (DGI) and feasibility study (FS) phases beginning in 2024 toward identification of a recommended remedial action alternative. The focus of the DGI report will be bench-scale treatability testing and additional sediment investigation results near the shorelines and the mouth of GGB where historical sediment samples exceeded the MPBC and the BTV. Additional comparative analysis of existing data from the 2000 dataset through the 2016/2018 dataset is recommended to assist in better understanding of the effects of past removal actions and determining the efficacy of future removal actions. Bench-scale treatability testing is recommended to evaluate feasibility and measure efficacy of in situ and ex situ sediment dewatering and solidification/stabilization alternatives for sediment management for future remediation. Based on results of the DGI, the feasibility study (FS) will develop and compare the effectiveness, implementability and cost of remedial alternatives, and identify a recommended remedial alternative in the FS report.

1.0 Introduction

This document presents the Desktop Supplemental Remedial Investigation (RI) for the Badger Army Ammunition Plant (BAAP) located adjacent to Gruber's Grove Bay (GGB), WI under Contract Number W9128F22D0006.

1.1 AUTHORITY

AECOM Technical Services, Inc. (AECOM) has been contracted by the United States Army Corps of Engineers (USACE) Omaha District under Contract Number W9128F22D0006, Delivery Order W9128F22F0266 to complete a Desktop RI. AECOM has prepared this technical memorandum in accordance with Task 2 – Desktop Supplemental RI guidelines provided in the United States Department of the Army (Army) Performance Work Statement (PWS) dated 22 August 2022 (USACE, 2022). As detailed in Volume 1 of the AECOM Technical Proposal, as part of this Desktop RI AECOM compiled, analyzed and modeled available GGB historical sediment data through time, performed screening-level human health and ecological risk assessments based on these updated historical data sets and recalculated background threshold values (BTVs) for mercury and subsequently provided recommendations for a data gap investigation (DGI), treatability tests and a revised alternatives analysis for potential future sediment remediation.

1.2 PURPOSE AND SCOPE

The purpose of this supplemental RI is to re-evaluate the potential for risk with current criteria and assessment tools and, if necessary, review the use of previous remedial alternatives and/or identify and select cost-effective and efficient remedial alternative(s) to reduce the potential for human health and ecological risk(s) following appropriate Wisconsin Department of Natural Resources (WDNR) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance. AECOM compiled and evaluated GGB historical data to:

- Determine data quality and usability;
- Characterize the site to the extent possible with pre-existing data with the goal of supporting subsequent risk-based decisions;
- Evaluate the nature and extent of current contamination;
- Evaluate the remedial objective identified in the 2000 Decision Document and the data collected before and after previously completed sediment remediations to assess and document remedy effectiveness;
- Develop and refine a conceptual site model;
- Define risk to human health and the environment posed by the site contaminants;
- Review previously implemented remedial actions; and
- Evaluate the need for a DGI, treatability tests and a revised remedial alternatives analysis.

If the risk is still unacceptable based upon the reanalysis, AECOM will reassess, develop, and screen remedial alternatives in a subsequent feasibility study (FS). The identification of

Applicable or Relevant and Appropriate requirements (ARARs) for remedial alternatives will be provided as part of the FS.

1.3 REPORT ORGANIZATION

This report is organized into the sections described below.

Section	Description
Section 1 – Introduction	Provides the project objectives, scope of work, and presents facility background and status of the site. Provides information on previous site investigations.
Section 2 – Distribution of Contamination	Discusses pre-existing data, data usability, nature and extent of contamination and data gaps.
Section 3 – Conceptual Site Model	Describes the previously identified and potential contaminant sources, transport and exposure pathways, and receptors.
Section 4 –Human Health and Ecological Risk Assessments	Presents the human health risk and ecological risk assessments for the site.
Section 5 – Previous Remedial Actions	Reviews the previous remedial actions and identifies opportunities for alternatives.
Section 6 – Recommendations	Provides recommendations for the DGI and FS.
Section 7 – References	Provides references cited in this report.

1.4 PROJECT SITE AND FACILITY BACKGROUND

The BAAP is located in south central Wisconsin within the Sumpter and Merrimac Township in Sauk County. BAAP is located on the Sauk Prairie and is bordered by the Wisconsin River to the east and the Baraboo Mountain Range to the west. The Plant was constructed in 1942 to manufacture smokeless gunpowder and solid rocket propellants as munitions components for World War II by the Army. To manufacture munitions components, the plant produced nitric acid, sulfuric acid, oleum, nitrocellulose, and nitroglycerin. Production periods occurred during World War II (1942 to 1945), Korean War (1951 to 1958), and Vietnam Conflict (1966 to 1975). The plant was maintained on stand-by status during interim periods between production. A portion of the site was transferred after World War II under the Formerly Used Defense Sites (FUDS) program (SPS, 2019).

The methods used for waste during operational periods were incineration and landfill disposal. These disposal methods impacted soil and groundwater in the BAAP. BAAP was maintained on stand-by-status until it was determined to be military excess in 1997. While in operation, hazardous substances were disposed of primarily in two locations onsite: the Propellant Burning Ground (PBG) location and Deterrent Burning Ground (DBG). Upon Plant closure and after the transfer of property to the FUDS program, 7,275 acres remained as the BAAP property. This acreage was transferred and divided among the United States Department of Agriculture (USDA), Wisconsin Department of Transportation (WDOT), United States Department of Health Services on behalf of the Bluffview Sanitary District (BSD), Bureau of Indian Affairs (BIA) on behalf of the Ho-

Chunk Nation and the National Park Services (NPS) on behalf of the Wisconsin Department of Natural Resources (WDNR). The property that comprised BAAP is being used as agricultural and grazing land (USDA), Highway 78 (WDOT), recreational land (NPS/WDNR), agricultural and industrial land (Ho Chunk), and a wastewater treatment plant (BSD). The Army still maintains ownership of two cemeteries on the former BAAP (SPS, 2019). The location of BAAP and historical features are shown on **Figure 1-1**.

Within and immediately adjacent to the project area, predominant land use has been divided into rural residential, agricultural, recreational, and industrial uses. BAAP formerly represented the industrial segment of land use; however, the southern portion of the facility is presently agricultural in nature, serving as a dairy forage research station operation by the U.S. Department of Agriculture and the University of Wisconsin. Cropland, principally alfalfa, corn and soybean cultivation, and pastures are present, with scattered forested stands. Timber harvesting is conducted as part of research on the facility, but there are no significant tree farming operations within the project vicinity.

1.4.1 Gruber's Grove Bay

GGB (**Figure 1-1**) is located on the northwestern shore of the Wisconsin River (Lake Wisconsin). GGB was formed following the construction of the Prairie Du Sac Dam in 1915. The bay is located immediately south of BAAP and approximately 6,000 feet (ft) upstream of the dam. GGB lies within a northwest-trending valley. The constructed embankment of the former State Highway 78 forms the northwest end of the bay. The southeast end of the bay opens into the Wisconsin River. Permanent and vacation residences occupy portions of the shoreline. Undeveloped portions of the shoreline are typically wooded. GGB occupies approximately 27 acres of water surface area. GGB is approximately 250 ft wide at the former State Highway 78 crossing and 530 ft wide at the confluence with the Wisconsin River. At its widest point, GGB is approximately 800 ft wide. The distance from the former State Highway 78 to the Wisconsin River is approximately 2,250 ft. The valley defining GGB slopes steeply to the water's edge on the south side of the bay. Slopes as steep as 20% are found along the south shore. Slopes are gentler on the north shore of GGB. The water level of GGB is controlled by the Wisconsin Power and Light (WP&L) Dam and is approximately 774 ft below mean sea level (msl). The bay is relatively shallow; the deepest portion of the bay is approximately 22 ft. The GGB and bathymetric contours from the 2012 survey are shown in **Figure 1-2**.

1.4.2 Wastewater Treatment Plant

BAAP discharged treated process and sanitary wastewater to GGB during active munitions manufacturing periods from 1942 to 1975. The facility was closed and decommissioned in 1977. Process water from the BAAP was treated to remove color, odor and suspended solids. Prior to 1970, treatment consisted of alum flocculation with powdered activated carbon addition, sedimentation, rapid sand filtration and chlorination. In the 1970s, the use of powdered activated carbon was discontinued and was replaced by the use of granular activated carbon on the surface of the sand filters. Also, in the 1970s, the sand filter backwash and sedimentation basin sludge was rerouted from the industrial waste sewer to a small lake on the plant site. Thus, the discharge of large quantities of spent powdered activated carbon and alum sludge to the industrial waste sewer (and eventually GGB) was eliminated. Industrial wastewater included process water and cooling water discharged into the industrial waste sewer. Additionally, domestic wastewater was discharged to the industrial waste stream downstream from the industrial wastewater treatment facility. These discharges contributed some 105 tons of suspended solids per month in approximately 26 million gallons (Ayers, 1973).

The combined wastewater stream flowed by an open channel for approximately 12,000 ft into the Settling Ponds and Disposal Area (SPSDA) before its outfall into GGB. The SPSDA consisted of Final Creek, four separate Settling Ponds, and five separate spoils disposal sites. Final Creek flows into the Settling Ponds, which in turn flowed into GGB via culverts buried beneath the former Highway 78 roadbed (see **Figure 1-1** for reference). The Settling Ponds were first used in 1941. Final Creek and Settling Ponds received effluent consisting of treated sewage, neutralized industrial wastewater, and surface runoff from the Nitroglycerine, Rocket Paste, and Magazine areas during periods of operation at BAAP. The 87-acres of Settling Ponds served as aeration and settling basins for the treated effluent. Final Creek and the Settling Ponds were unlined (Shaw, 2004). The outfall was a 24-inch diameter culvert beneath State Highway 78 at the north end of the bay (SPS, 2019). Process wastewater has not been discharged to GGB since 1977, when manufacturing operations were terminated. Additional existing records regarding the current status of culverts to GGB will be summarized in the DGI.

Sanitary and process wastewater discharged from BAAP operations into GGB contained solid materials consisting primarily of powdered activated carbon, aluminum (alum) oxide floc and nitrocellulose. Quantities of these solids deposited in GGB resulted in a blanket of variable thickness on the bottom of GGB. Sand and silt from surface runoff unrelated to the Army incorporated with the wastewater residuals in the sediments of GGB. These additional sand and silt deposits originated from private lands surrounding GGB and during the construction of Highway 78 (USACE, 2022).

According to the *Environmental Impact Statement and Report on Technical Evaluation Study for Dredging Gruber's Grove Bay* (Ayers, 1973) and the Department of the Army correspondence with the BAAP plant manager (1978), all four shallow ponds were planned to be dredged and abandoned in 1978 (Ayers, 1973). Dredging activities did not occur in the 1970s (ABB-ES, 1993). The Spoils Disposal Area consists of five unlined spoil sites adjacent to Settling Ponds 3 and 4. Each site was reportedly placed in a shallow depression or man-made pit. Spoils Disposal Areas 1 through 4 were used for collecting and dewatering sludge and dredge spoil removed from the Settling Ponds. Spoil Disposal Areas 3 and 4 contain hydraulically removed dredge spoils covered with sludge that were removed from the Settling Ponds in the early 1970's (ABB-ES, 1994). Spoils Disposal Area 5 was originally designed to receive dredge material from GGB but was never used. Instead, it was partially filled with dredged material from the Settling Ponds (Kearny, A.T., 1987; Ayres, 1984). Additional Settling Ponds investigation reports regarding mercury will be summarized in the DGI.

1.4.3 Propellant Burning Grounds and Modified Interim Remedial Measures (MIRM) Groundwater Pump and Treat System, SVE system, and BEST system

The PBG Waste Pits area was used as a disposal area from 1942 through 1975. It is located on the southwestern portion of the BAAP and spans approximately 6 acres. The entire PBG area is approximately 80 acres. Within the PBG are three former disposal pits that contain subsurface soils with concentrations of 2,4-dinitrotoluene (DNT) and volatile organic compounds (VOCs) above remediation goals. The location consists of three former pits (WP-1, WP-2, and WP-3), a large open area used for burning propellant-contaminated materials, and the 1949 Pit Area next to the PBG. The chemicals of concern (COCs) in the PBG area are 2,4-DNT, 2-6-DNT, carcinogenic polyaromatic hydrocarbons (CPAH), benzene, trichloroethylene (TCE), arsenic, chromium, lead, selenium, and zinc (Shaw, 2006). Based on the historical review, there has been no mercury or methyl-mercury mass input from these groundwater plumes at GGB.

An Interim Remedial Measures (IRM) groundwater extraction system was installed in 1995 along the southern boundary to the Wisconsin River to prevent off-site migration of groundwater. The system includes six high-capacity wells placed on the east-west axis at the BAAP southern boundary. Additional groundwater modeling was completed to increase the amount of contaminant concentrations extracted thus shortening the remedial timeframe. Modifications to the system were completed in 2004 and 2005 to include four high-capacity wells along the north-south axis, revising the system name to the Modified Interim Remedial Measures (MIRM) system. The system also terminated three of the original six east-west wells. The groundwater extraction system was shut down in 2012 (US Army, 2020).

1.5 GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS

Approximately 80% of Sauk Country was not covered by the last glaciation from the Laurentide Ice Sheet between 35,000 and 11,000 years ago (Attig, J.W, et al., 2011). According to the *Final Remediation Action Competition Report* by Shaw Environmental (2007), the dominant geologic features of the area lie north of BAAP, the Precambrian Baraboo Quartzite bluffs and Devils Lake State Park (Shaw, 2008). Prior to the last continental glacier, the Wisconsin River flowed through these bluffs, creating an 800-to-900-foot gorge at the present location of Devils Lake (6 miles north of BAAP).

The surface of the BAAP area is composed of glacial outwash with some ground end moraines in the area. These features are underlain by Paleozoic rocks, primarily Cambrian sandstones and Ordovician limestones. Soils within the lagoon and dewatering area of the project are mainly comprised of silt loams and loams with variable amounts of erosion. Major soil types in the project area include the McHenry, St. Charles, Richwood, and Ringwood silt loam units, as well as the Fox loam and Wyocema sandy loam (Shaw, 2008).

Extensive groundwater investigations have been completed at the BAAP site by the USGS and previous consultants for the USACE. Three aquifer zones were identified in the vicinity of the BAAP with similar groundwater flow directions. The first unconsolidated aquifer lies within the glacial till and outwash sand and gravel deposits (SPS, 2018). The next aquifer is in the Eau Claire Formation within the Cambrian sandstones and Ordovician limestones and is hydraulically connected with the overlying aquifer. This intermediate aquifer is partially confined by a shale unit on the eastern side of the BAAP property and north of GGB (Shaw, 2005). The third aquifer is in the crystalline Precambrian bedrock which underlies the entire state.

The Lake Wisconsin Reservoir and the Wisconsin River have the greatest impact on groundwater flow direction within the area. The Lake Wisconsin Reservoir, located to the east and southeast of

BAAP, is formed by the WP&L Dam, which results in a constant lake elevation of approximately 774 ft msl. Below the dam, water elevation drops abruptly to 736 ft msl as the lake reverts to the flowing Wisconsin River. The rapid change in water elevations at the dam results in a dramatic hydraulic drop in groundwater elevations around the dam (Shaw, 2004).

The general direction of groundwater flow within the study area is from north to south but is influenced by the Lake Wisconsin Reservoir and the Wisconsin River. Comparison of groundwater and reservoir level elevations indicates water from Lake Wisconsin Reservoir recharges groundwater north of the dam and groundwater discharge to the Wisconsin River south of the dam. Groundwater flows from the northwest side of the BAAP property southward toward the WP&L Dam. Groundwater on the eastern side of the BAAP property flows parallel to the Wisconsin River to the south-southwest in the vicinity of the north shore of GGB. Historical monitoring well groundwater elevations on the north shoreline of GGB (associated with monitoring the Central Plume) within the unconsolidated aquifer presents a 10 ft lower elevation than the surface water of GGB (Shaw, 2005). Thus, it has been inferred from this geological representation that surface water within GGB likely recharges the underlying sand and gravel aquifer. Groundwater from upgradient areas north of GGB appears to flow west/southwest without discharging into GGB.

1.6 CURRENT AND POTENTIAL FUTURE USE

GGB is currently used for recreational purposes. AECOM is currently unaware of any future use plans for the bay and surrounding area. It is assumed the future use of this area will continue to be recreational. Adjacent land use is rural residential, agricultural, recreational and industrial.

1.7 HISTORICAL INVESTIGATIONS AND REMEDIAL ACTIONS

A series of investigatory and remedial operations have been conducted since 1970 by various parties for GGB. A comprehensive list of site assessment activities and remedial operation reports are compiled in **Appendix A**. Site assessment and investigation documents relevant to this desktop RI are summarized below from most to least recent.

1.7.1 2022 Assessment of Mercury in Sediments and Waters of Grubers Grove Bay, Wisconsin

The purpose of this site assessment performed by the USGS in 2019 was to measure and evaluate results for total mercury and methylmercury concentrations within GGB and surrounding areas and use stable isotopes to fingerprint mercury from the BAAP site, GGB, and upstream sites (Routhier, et al., 2022). The study was further designed to assess the contributions of mercury from BAAP to sediments within GGB to better inform the next phase of remediation at the site. Samples were taken at five designated areas: one within BAAP grounds and four within Lake Wisconsin, including GGB, GGB Margin, Weigands Bay and open-lake locations upstream. Sediments and soils at multiple depths were collected and analyzed for total mercury and methylmercury concentrations.

The 2022 report indicates isotope analysis of mercury contamination in GGB has come from either land-based or riverine sources. The land-based source, based on isotope ratios and an observed decreasing gradient of concentrations from the innermost to the outermost part of the bay, and low concentrations by shoreline and terrestrial area margins surrounding the bay, indicating historical versus current sources. Average mercury within GGB was estimated to be more than 50% from BAAP sources (USGS, 2022). A higher proportion of mercury in deeper sediments of GGB were identified to be from BAAP sources, thus further supporting the conclusion of historical versus ongoing sources.

1.7.2 2019 Gruber's Grove Bay, Sediment Sampling Report

This report documents the 2018 sediment sampling activities conducted on behalf of the Army in GGB (SPS, 2019). SPS collected 79 sediment samples from 40 sample locations that were analyzed for mercury in two vertical intervals from the southeastern locations. Sediment samples were collected from soft sediment to 2.9 ft below the sediment surface. The sediment consisted of an upper layer of watery gelatinous "mud" sediment underlain by a thicker layer of firmer fine-grained sediment, down to the underlying native clay bottom. Previous boring logs described this non-native material as a watery, very fine-grained sediment, non-cohesive, and black with a high organic content and mild to moderate hydrogen sulfide gas odor (SPS, 2019).

Analytical results estimated that approximately 17.27 acres of GGB contained mercury-impacted sediment at concentrations exceeding the mercury Most Probable Background Contamination (MPBC) of 0.36 milligrams per kilogram (mg/kg) (SPS, 2019). The WDNR has referred to the MPBC also as the Remedial Action Level (RAL) in the site-specific decision documents. The MPBC was established by the WDNR in 2000 (WDNR, 2000). Overall mercury concentrations ranged from non-detect to 12.4 mg/kg and from 0.37 to 4.0 mg/kg within the top 0.5 ft in GGB. Forty-three (43) samples (at 27 locations) were measured to have concentrations exceeding the mercury MPBC. Thirty-one (31) of the 40 samples collected from the bottom interval of the cores had mercury concentrations below the MPBC. Volumetric and sediment thickness modeling was completed based on the location and concentrations of both the 2016 and 2018 sediment sampling results. Model results indicated 2 ft of mercury-impacted sediment toward the northwest (Highway 78) increasing to greater than 3 ft in the southeast portion of GGB, closer to the Wisconsin River. A few pockets of thicker sediment, 4 to 6 ft, were identified in the center and towards the Wisconsin River. The modeling effort was utilized to estimate an impacted sediment volume of 54,120 CY.

1.7.3 2016 Gruber's Grove Bay, Sediment Sampling Report - Final

This sediment investigation was conducted to further delineate horizontal and vertical mercury concentrations, quantify the residual soft sediment in GGB and evaluate the viability of alternative closure alternatives (SPS, 2016). SPS collected 69 sediment samples from 60 sample locations for percent solids and total mercury within GGB. Sediment thickness measurements were collected from 39 locations. Sediment samples were only collected from the soft sediment within the top 0.5 ft of material. The sediment consisted of an upper thin layer (within the top 1.5 ft) of watery gelatinous "mud" sediment underlain by a thicker layer of firmer fine-grained sediment, down to the underlying native clay bottom. Sediment thickness measurements were collected from 95 locations in GGB to estimate the thickness and volume of the soft sediment.

Analytical results were compared to three screening criteria - the MPBC, a not-to-exceed (NTE) concentration, and a Surface Weighted Average Concentration (SWAC) estimate (SPS, 2016). The report estimated approximately 15.84 surface acres of GGB contained mercury-impacted sediments at concentrations exceeding the MPBC and approximately 9.81 acres contained mercury-impacted sediments at concentrations exceeding an NTE concentration of 1.5 mg/kg. Mercury concentrations ranged from 0.022 to 6.3 mg/kg in the top 0.5 ft of material. Forty-seven (47) samples (at 47 locations) were measured to have concentrations exceeding the mercury MPBC. A SWAC was used to estimate an average mercury concentration per acre for GGB sampling limits. The calculated SWAC was 1.112 mg/kg for GGB sampling limits, exceeding the WDNR's target MPBC of 0.36 mg/kg. Based on these results, further evaluation was recommended to determine if additional action was needed to close the site and remove GGB from Section 303(d) list of impaired waters.

1.7.4 2009 Gruber's Grove Bay, Sediment Sampling Report, Badger Army Ammunition Plant

SPS collected sediment thickness measurements from 60 locations within the footprint of the 2006 dredged area of GGB and collected 164 samples from 59 locations for total mercury analysis (SPS, 2009). Total sediment thickness within the 2006 dredge area varied from 0 to 6.9 ft. Analytical results indicated that approximately 6,600 CY of mercury-impacted sediment at concentrations exceeding the MPBC remained within the 2006 dredged area of GGB. Mercury concentrations ranged from non-detect (< 0.009) to 4.5 mg/kg. Twenty-eight (28) samples (at 23 locations) were measured to have concentrations exceeding the mercury MPBC. The SWAC results for the 2006 dredged area were 0.715 mg/kg per acre and 0.499 mg/kg per acre for the entire GGB.

Based on AECOM's review in Section 2.1 of this report, the sediment sampling methodology and analytical methodology employed in 2009 sediment investigation differed significantly from the 2016 and 2018 sampling events.

1.7.5 2007 Final Remedial Action Completion Report, Gruber's Grove Bay Dredging Project, Badger Army Ammunition Plant, Baraboo, Wisconsin

The objective of this remedial action was to remove and dispose of remaining sediment in GGB containing mercury concentrations greater than the MPBC (Shaw, 2008). To achieve this objective, the following activities were performed:

- Removed affected sediment by hydraulic dredging;
- Confirmed sediment removal by sampling and analyses;
- Flocculated the dredged material with a cationic polymer;
- Dewatered dredged sediment with geotextile filter technology within a lined disposal facility;
- Disposed of filtrate by spray irrigation;
- Closed in-place dewatered sediment within the lined disposal facility and covered with a vegetated soil cap; and

- Constructed two engineered wetlands to mitigate residuals in long-term drainage from disposed sediment.

GGB sediments, from approximately 17 acres (approximately 60,000 cubic yards [CY]), with total mercury concentrations above the MPBC were dredged from GGB in 2006 (Shaw, 2008). Pre- and post-dredging bathymetric surveys and confirmation sampling were conducted to determine depth to the bottom of the dredge prism and confirm removal volumes of sediment, respectively. WDNR completed confirmation sampling of sediment in GGB in 2007. WDNR collected nine sediment samples for mercury analysis. Two of the samples were below the MPBC; the remaining seven sediment samples had mercury concentrations greater than the MPBC.

1.7.6 2005 Draft Addendum, Residual Sediment Investigation Report, Gruber's Grove Bay, Badger Army Ammunition Plant, Baraboo, Wisconsin

Shaw collected sediment and surface water samples in 2005 from GGB and Lake Wisconsin (Shaw, 2005). Sediment sample depths were vertically delineated from 0 to 0.5 ft and 0.5 to 1 ft below the sediment surface. Surface water samples were collected from six locations within GGB to determine whether COCs in sediments are potentially impacting GGB surface water and exceed water quality criteria. Three background water samples were collected from Wiegands Bay, the shoreline of Lake Wisconsin, and Moon Valley Bay located upriver of GGB and analyzed for dissolved lead (SW 846 Method 7421).

Results indicate that average concentrations of metals in GGB and Lake Wisconsin were below WDNR ambient water quality criteria (Shaw, 2005). Metal concentrations within GGB were not statistically greater than Lake Wisconsin, an indication that GGB sediment may not be impacting water concentrations.

1.7.7 2003 Draft Corrective Measures Implementation Report, Gruber's Grove Bay Dredging Project, Baraboo, Wisconsin

This report describes activities related to dredging and disposal of sediment from GGB performed intermittently from 2000 to 2003 (Shaw, 2003). To achieve this objective, the following primary activities were performed:

- The sediment disposal and dewatering area, consisting of a geotextile tube laydown area and a primary catchment basin, on BAAP was constructed;
- Large debris (woody vegetation, appliances, scrap metal, etc.) in GGB was removed by mechanical means prior to dredging;
- A horizontal-auger hydraulic dredge was mobilized to GGB and sediment was removed;
- Sediment was pumped via a floating pipeline and overland pipeline to the sediment disposal and dewatering area;
- Interstitial/carriage water was sampled for water quality and disposed via spray irrigation to select agricultural and frosted areas on BAAP;
- The sediment disposal and dewatering area was covered with a soil cover and wetlands were constructed downgradient of the disposal area; and

- GGB was restored by re-establishing aquatic and plant life within the bay.

Before dredging began a pre-determined contour representative of sediments expected to contain concentrations of mercury greater than the MPBC was generated (Shaw, 2003). A 10-inch horizontal-auger (MudCat MC-2000) hydraulic dredge was used to remove 88,333 CY of sediment from GGB.

1.7.8 2000 Draft Sediment Investigation Report, Gruber's Grove Bay, Badger Army Ammunition Plant, Baraboo, Wisconsin

The primary objective of this Sediment Investigation Report was to determine the quality as well as the vertical and lateral extent of contaminated sediment within GGB (Stone & Webster, 2000a). Sediment sampling occurred in February 2000 at 31 sediment sample locations totaling 138 samples. Sediment sample depths ranged from 0 to 11 ft below the sediment surface. Four sediment samples were collected from Weigand's Bay for comparison.

VOCs, SVOCs, PCBs and nitroglycerine were detected at concentrations at or near detection or reporting limits. Polycyclic aromatic hydrocarbons (PAHs) were not detected in sediment from any sediment sample. Of the 138 sediment samples, copper, lead, and mercury were detected in 68 sediment samples. Copper concentrations ranged from 1.8 to 277 mg/kg, lead concentrations ranged from 2.9 to 1,200 mg/kg and mercury concentrations ranged from non-detect to 12 mg/kg. The highest concentrations of metals were detected in the shallow sediments in the northwestern half of the bay. Methyl mercury was detected in all six samples analyzed and ranged from 0.084 micrograms per kilogram (µg/kg) to 149 µg/kg. Ammonia was detected in all 14 samples analyzed with concentration ranging from 24 to 741 mg/kg.

Following this sediment investigation, Stone & Webster developed the Expanded Problem Formulation Plan (Stone & Webster, 2000b). This report indicated that the removal of mercury contamination will result in the removal of other contaminants; therefore, the use of 'co-occurrence' SQGs (i.e., the threshold effect concentration [TEC] and probable effect concentration [PEC]) is assumed to be appropriate for the GGB evaluation due to the potential for other co-located contaminants to also be present within the Bay.

2.0 Data Management

In support of this Desktop RI and to better analyze the data, AECOM utilized the EarthSoft software Environmental Quality Information System™ (EQuIS™) to implement a data information management system with the historical data available. The original data loaded into the database was associated with the data provider (analytical laboratory or previous consultant) that generated the data. Since validation values were present in the database, AECOM did not perform an additional validation for laboratory quality control. AECOM's designated data team leader was responsible for EQuIS™ maintenance and completeness of the database structure. Fields such as sample identifications (IDs), location IDs, sample depths, and lithology were reviewed for completeness and accuracy against the historical reports. The data was used to generate visual tools such as tables, figures and models.

As part of this Desktop RI, historical samples collected during the 2016 and 2018 sampling events were screened against the MPBC of 0.36 mg/kg, BTV of 0.49 mg/kg, and WDNR (2003) MEC SQG of 0.64 mg/kg and are presented in **Table 2-1**. Split sample and SWAC results were not included in this assessment. Samples prior to the 2006 and 2001 dredge events have not been screened, as the locations have been determined to be removed or have been previously determined to not pose a risk to the ecosystem.

As discussed above, a total of 60 sample locations were collected by SPS and analyzed during the 2009 sampling event for mercury using USEPA Method 7471A. Of those samples, 27 locations exceeded the MPBC. The sample locations were closely correlated to areas of thicker sediment throughout the bay; however, data disparities were found within the sampling collection process and are discussed in the data usability section below. AECOM did not rescreen these samples.

During the 2016 sampling event, a total of 63 surface sample locations were analyzed for mercury using USEPA Method 7471B (**Table 2-1**). Of those samples, 46 locations exceeded the MPBC. During the 2018 sampling event, a total of 63 primarily subsurface sampling locations were analyzed for mercury using USEPA Method 7473. Of those samples, 27 locations exceeded the MPBC. Sediment sample locations from 2016 and 2018 are presented on **Figure 2-1**.

It should be noted that similar sample IDs between the 2009, 2016, and 2018 sampling events were used; however, the sample locations between 2009 and 2016/2018 do not match spatially. In 2009, GGB-01 began in a 130-ft grid pattern starting from the GGB/Wisconsin River margin towards the BAAP. The 2016 and 2018 sample location labels began at GGB-01 at the nearest point to BAAP in GGB out towards the GGB/Wisconsin River margin.

Eleven sediment samples from GGB, nine settling pond sediment samples, and five sediment samples near the GGB confluence with the Wisconsin River were collected during the 2019 sampling event. Of those samples, 15 locations exceeded the MPBC. Sediment sample locations from 2019 are presented on **Figure 2-2**. Samples from the Wiegands Bay and UR sites were not included in this screening.

Other COCs were collected prior to 2001 and 2006 dredge events. Sediment samples collected from GGB in 2000, 2003 and 2004 were also analyzed for VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), metals, nitrocellulose, nitroglycerine, methyl mercury, Total Organic Carbon (TOC) and ammonia. Based on reports prior to the 2001 and 2006 dredge events, locations of the samples which had an exceedance of at least one additional COC in the surface sediment fall within the previous dredge boundaries and/or were co-located with mercury. No further vertical or horizontal delineation has been evaluated in this RI for these other COCs. In a letter from WDNR in 2005, a decision was made to focus on mercury due to the risk it poses on the benthic environment in GGB (WDNR, 2005).

2.1 DATA USABILITY

The following describes the data usability assessment that was performed to verify the quality of the data from the previous GGB investigations and to evaluate its acceptability for use in site decisions. Data collected prior to the 2006 and 2001 dredging events were not included in the risk assessment as they were assumed to be removed by the remedial efforts or have been previously determined to not pose a risk to the ecosystem.

AECOM identified two discrepancies between the sediment sampling during the 2009 event and the 2016 and 2018 events. Standard sediment collection practices utilizing the AMS Multi-Stage sludge sampler device were taken during the core sampling, which included retrieval of the entire sediment horizon, rather than discrete depth intervals, based on the sediment thickness measurements to refusal/clay "plug" as described in the 2009 Gruber's Grove Bay Sediment Sampling Report (SPS, 2007). According to the report, SPS submitted the top six inches of each core for analysis. The submitted sediment samples were generally described as having a high moisture content; however, some samples extended through the soft "gelatinous" sediment that are of interest. Samples were homogenized and sent for analysis under USEPA Method 7471A included the underlying thicker fine-grained sediment, resulting in an inconsistency of the type of material sent for analysis. Six split samples collected by WDNR at the time of the 2009 event included only the gelatinous portion of the sediment, which provided the basis for comparability between results. This disparity was noted by the difference in analytical results between SPS and WDNR in Table 3 of the 2009 report (SPS, 2009).

Furthermore, 2009 analytical results were compared to 2016/2018 results and variability was observed among samples near proximity to one another. In addition, the area of mercury background exceedances for the 2009 dataset was far less than the area for the 2016/2018 dataset. Thus, homogenization of gelatinous and non-gelatinous material across the full sediment horizon appears to have masked the maximum concentration at each sampling location (SPS, 2009).

The differences between the 2016 and 2018 datasets were also significant regarding assessing the changes in total mercury concentration with time and overall sediment stability. The sampling priority for the 2016 sampling event was predominantly 63 surface sediments, while the sampling priority of the 2018 sampling event was predominately 63 subsurface sediments. Thus, these existing sample datasets did not allow for accurate estimation of changes in sediment concentration over time.

The discrepancies in variability, maximum concentration, and spatial resolution were the main reasons for excluding the 2009 dataset for generation of the most representative geospatial description of GGB for this report. The 2009 samples were not used in the risk assessment described in the following sections.

2.2 UPDATED BACKGROUND DATA

As part of a 2019 investigation of mercury concentrations in GGB and the surrounding areas, USGS collected sediment samples from multiple locations upstream from GGB (Routhier, et al., 2022). A subset of 27 samples collected from the top five centimeters (0 – 0.16 ft horizon) in locations within Wiegands Bay and Lake Wisconsin were used to derive an updated background concentration. These samples represent recently deposited surficial sediments in upstream background locations and were used to derive a BTV for mercury for comparisons against GGB sediment concentrations. Samples from GGB were not included in the BTV calculation.

The MPBC of 0.36 mg/kg currently being used as the sediment RAL for GGB is based on background data collected upstream from GGB in Weigands Bay and Moon Valley Bay (WDNR, 2000). A mercury BTV of 0.49 mg/kg was calculated based on the updated background data collected by USGS in 2019 and provided in **Table 2-3**. Supporting documentation for the BTV calculations is provided in **Appendix B**.

The USEPA statistical software package ProUCL (2022) was used to calculate the BTV (**Table 2-4**). General summary statistics for the background data are summarized in the top portion of the table. Normal goodness of fit (GOF) test results are also provided. The background data were concluded to be normally distributed. Rosner's outlier test indicated that no outliers were present.

A 95% upper tolerance limit (UTL) with 95% coverage was used to estimate the revised BTV, as recommended by ProUCL. This value provides coverage for 95% of background concentrations, or 95% of a population that is consistent with background, with 95% confidence.

2.3 CONTAMINANT DISTRIBUTION

Data for total mercury concentrations collected in 2016 and 2018 were interpolated to create maps for surface (0 – 0.5 ft) and subsurface (> 0.5 ft) sediment horizons (**Figures 2-3 and 2-4**). Mercury concentrations were estimated independently by horizon using ordinary kriging (Goovaerts, 1997) and represent only the data in each horizon. This approach allows only one sample per location. One surface sample collected in 2018 was removed from the data used for kriging since data from 2016 were available and results were consistent. At locations with multiple subsurface depths, the deeper sample was retained to better characterize vertical extent in the interpolated subsurface horizon. Consequently, data from 62 surface locations and 40 subsurface locations were included in the analysis. Results are color coded in one of four categories: <= 0.49 (BTV), > BTV and <= 0.64 (the midpoint effect concentration, MEC), > MEC and <= 1.1 (PEC), and > PEC. The TEC is less than the BTV and therefore was not incorporated. TEC, MEC, and PEC are discussed further in Section 4.2.2 of this report.

Figures 2-5 and 2-6 illustrate uncertainty as the standard deviations (SDs) of the estimated mapped concentrations. Areas of lowest uncertainty occur in the vicinity of sample locations. Highest uncertainty occurs in areas where sample density is lowest or samples were not collected. Because fewer samples were collected from the subsurface sediment horizon than the surface horizon, uncertainty is higher. Areas with high uncertainty and low estimated concentrations may also indicate data gaps due to lack of data in areas of GGB. Data gaps will be discussed in detail in the following section.

Surface Sediment

62 surface samples were used to evaluate the distribution of total mercury in surface sediments. **Figure 2-3** illustrates the distribution of mercury concentrations in surface sediments; sample locations are shown as black dots. As shown on **Figure 2-3**, mercury concentrations in surface sediments along the eastern portion of the northern shoreline are below the BTV of 0.49 mg/kg. This portion of GGB is shown in dark blue. Small portions of the southern shoreline are also below the BTV. In these locations, the lateral extent of mercury contamination has been defined as the line between the dark and light blue areas, where mercury concentrations are greater than the BTV. The lateral extent of contamination in the remaining areas is not defined analytically, but physically by the shoreline. Much of the central portion and western portion of the Bay exceeds the BTV. The maximum observed concentration was 6.3 mg/kg at location GGB-22. The most highly impacted surface sediments (shaded red or pink) tend to be in the inner section of GGB, portions of the southern shoreline, and portions of the northern shoreline in the western portion of the Bay. **Figure 2-5** illustrates the uncertainty in interpolated concentrations shown in **Figure 2-3**. Uncertainty is lowest in the vicinity of sampling locations. Areas of highest uncertainty occur in some locations along the shoreline as well as locations where sampling did not extend to the east and west at the mouth of the bay.

Subsurface Sediment

The distribution of mercury in the subsurface sediment horizon (> 0.5 ft) is illustrated on **Figure 2-4**. The estimated concentrations shown on this map are based on samples collected from depths of 0.5 - 1.0 ft and > 1.0 ft. At most locations, samples were not collected from both depths. Evaluation of the vertical extent of contamination relies on concentrations from one or the other depth. In cases where data are available at both depths, the sample result from the deeper sample was incorporated in mapping subsurface concentrations shown on **Figure 2-4**.

Based on the 40 sample locations shown in the subsurface horizon, mercury concentrations are generally lower in the subsurface sediments than in surface sediments, indicating a decreasing concentration with depth. Elevated estimated mercury concentrations in the subsurface horizon occur in localized areas, with many areas below the BTV based on the 2019 USGS data. Highly impacted areas in the middle horizon generally correspond with highly impacted areas in the surface horizon, with the exception of an area of elevated subsurface concentrations at sampling location GGB-52. Based on the interpolated mercury concentrations in subsurface sediments, the lateral extent is defined analytically in many locations, with the exception of the area surrounding GGB-06, GGB-28, and GGB-52. Furthermore, the lateral extent of contamination is not defined at the mouth of the Bay (sample locations and GGB-96 and -97). **Figure 2-6** identifies large areas of higher uncertainty along the shorelines as well as at the mouth of the Bay to the east and west, where sampling was not conducted.

Mapped values and standard deviations of these estimates were obtained using R Statistical Software (2022) and the gstat (Pebesma E, 2004; Gräler B *et al*, 2016), sp (Pebesma E and Bivand R, 2005; Bivand *et al*, 2013), and spdep (Pebesma E and Bivand R, 2023) packages.

2.4 DATA GAPS

In general, mercury is concentrated within the surficial sediment layer across GGB and decreases with depth. The vertical extent of elevated mercury concentrations has not been fully delineated. **Table 2-2** summarizes locations at which mercury concentrations exceed the MPBC and the updated BTV. The 2018 sampling event attempted to vertically delineate the 2016 samples that exceeded the MPBC in the upper 0.5 ft of sediment (SPS, 2019). Those sample locations have been noted in **Table 2-2**. **Figure 2-7** illustrates mercury concentrations in 2016 and 2018 samples in surface and subsurface samples to allow for evaluation of the proximity of locations and depths at which mercury concentrations exceed the updated BTV. Additional vertical delineation is recommended at locations where vertical delineation is incomplete.

Sediment impacts within the majority of GGB have been horizontally delineated; however, impacts at the northeast and south shores of the bay, and near the mouth of the bay have not been horizontally delineated as discussed below. The following locations have not been horizontally delineated:

Location ID	Sample Event	Descriptive Location in GGB
GGB-02	2016	Northern tip of GGB nearest BAAP
GGB-10	2016/2018	Northwest shoreline of GGB
GGB-41	2009	Northeast shoreline of GGB
GGB-43/54/55	2016/2016	South shoreline of GGB
GGB-89	2016/2018	Near confluence with Wisconsin River/mouth of the bay

Horizontal sediment delineation in these locations is recommended to provide more detailed evidence to delineate areas where additional removal may be warranted versus areas where removal will not be necessary.

Based on the 2021 Assessment by the USGS, GGB mercury-impacted sediment is from the BAAP and from suspended sediment deposition in the Wisconsin River near the margin (Routhier, et al, 2022). Analytical results from the 2018 and 2019 samples collected near the Wisconsin River are above the MPBC, suggesting that delineation towards the confluence is recommended to assess the extent of mercury impact to determine the future remedial boundary.

3.0 Impacted Media and Transport Pathways

A conceptual site model (CSM) generally includes information on known contaminant sources and impacted media, potential other sources, transport pathways, exposure pathways, and receptors. A CSM for the bay was previously included in the Expanded Problem Formulation Plan (Stone & Webster, 2000b). The following description of the CSM has been updated, as necessary, as additional information has been reviewed. A depiction of the CSM for GGB is presented in **Figure 3-1**.

Previous reporting (Shaw, 2005) indicated that surface water concentrations of metals were below WDNR ambient water quality criteria. The Expanded Problem Formulation Plan (Stone & Webster, 2000b) indicated that ingestion of surface water would be at an intake level less than the intake level of sediment and that ingestion via the surface water pathway could be excluded for mercury. Surface water exposures for both human and ecological receptors are expected to be insignificant relative to sediment exposures. The CSM provided by Stone & Webster (2000b) indicated that the only complete exposure pathway of significance was the food chain pathway and that the potential receptors for this pathway included aquatic species and members of the public that consume fish from the Bay.

3.1 CURRENT RECEPTORS

The area immediately surrounding GGB is primarily residential with several homes and docks along the shoreline. Land use in the area surrounding the bay includes rural residential, agricultural, recreational, and industrial uses. Current potential receptors are discussed below.

Potential human health receptors and exposure pathways include the following:

- Anglers - Anglers may consume fish caught in the bay that have accumulated sediment-associated contaminants. Although there is a fish consumption advisory in place within the Wisconsin River, including the bay, fish ingestion may be a potentially complete pathway.
- Residential and Recreational Use – Recreational boat traffic is unrestricted in this area and local residents have docks and boats in the bay. Direct contact (incidental ingestion and dermal contact) with sediment and surface water for residents and recreational users are potentially complete exposure pathways. It should be noted that exposures from direct with surface water are typically insignificant and that WDNR and the Wisconsin Division of Health previously indicated that dermal contact and ingestion of sediment did not pose unacceptable risks to human receptors (Stone & Webster, 2000b).

Potential ecological receptors and exposure pathways include the following:

- Benthic invertebrates – Exposures may occur via direct contact with sediment. The presence of benthic organisms within the gelatinous sediment layer versus firm sediment base layer has not been confirmed by studies to date.
- Fish – Exposures may occur via direct contact with or ingestion of sediment or ingestion of prey that contain contaminants in tissues via bioaccumulative processes.

- Birds and mammals – Exposures may occur via incidental ingestion of sediment or ingestion of forage or prey that contain contaminants in tissues via bioaccumulative processes. Given the lack of mudflats and areas of shallow water, foraging along the shoreline by birds (e.g., herons or sandpiper) and mammals (e.g., raccoon) is likely to be limited; however, mink or river otter may forage within the bay.

3.2 POTENTIAL FUTURE RECEPTORS

The land use surrounding the bay is expected to remain unchanged for the foreseeable future. Potential future receptors are anticipated to remain the same as current receptors.

4.0 Risk Assessment

4.1 HUMAN HEALTH RISK ASSESSMENT

This section provides the approach used and results of a human health risk assessment (HHRA) conducted using data for sediment and fish tissue collected within GGB after remedial dredging efforts conducted in 2006.

The objectives of the HHRA are to:

- Provide a risk-based interpretation of the environmental data collected in GGB;
- Determine whether the Site poses a risk to human health under current and foreseeable uses; and
- Facilitate efficient regulatory decision-making regarding the need for, and scope of any additional remediation.

4.1.1 Potential Human Receptors

Potential human receptors identified in the CSM (Section 3.2) are residents, recreational users, and anglers. Exposures to GGB sediments for residents and recreational users are potentially complete, but likely insignificant due to the infrequent nature of exposure to submerged sediments. However, occasional exposure to sediments by recreational users is evaluated in this HHRA for completeness. The remaining human receptor identified in the CSM is the angler. Although there is a fish consumption advisory in place for the Wisconsin River upstream of the Prairie du Sac Dam, including GGB, due to the presence of mercury and PCBs, fish ingestion may be a potentially complete pathway. As indicated in Section 3.0, surface water exposures for human receptors are expected to be insignificant relative to sediment exposures; therefore, surface water exposures have not been quantitatively evaluated.

4.1.2 Chemicals of Potential Concern

Mercury is the only chemical of potential concem (COPC) based on the prior Site investigations, as summarized in Section 1. Mercury is also known to be bioaccumulative and may be taken up into the tissues of aquatic receptors, including fish.

4.1.3 Exposure Assessment

Estimates of COPC intake are required for quantitative risk characterization. The basic equation used to calculate the human intake of COPCs (in terms of dose) for the ingestion pathway (USEPA, 1989) is presented below:

$$DI = C \times \frac{IR \times EF \times ED}{BW \times AT}$$

Where:

DI = Daily intake (mg of chemical per kg of body weight per day [mg/kg-bw/day])

C	=	Concentration of COPC (e.g., mg/kg in fish tissue)
IR	=	Intake rate; the amount of impacted medium contacted over the exposure period (e.g., kg/day for fish)
EF	=	Exposure frequency; describes how often exposure occurs (days/year)
ED	=	Exposure duration; describes how long exposure occurs (years)
BW	=	Body weight; the average body weight over the exposure period (kg)
AT	=	Averaging time; period over which exposure is averaged (days)

The equation can be rearranged to solve for the risk-based concentration of a contaminant ("C" in above equation) corresponding to a specific risk level and including a contaminant-specific toxicity factor (see Section 4.1.4). The "back-calculation" of an allowable concentration of a contaminant in sediment or fish tissue is consistent with the methodology used in the USEPA's online Regional Screening Level (RSL) Calculator (https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search). The general form of the equation used to calculate the RSLs for mercury is shown below.

$$RSL = \frac{Target\ HQ \times RfD\ x\ BW\ x\ AT}{IR\ x\ EF\ x\ ED}$$

Where:

RSL	=	Regional Screening Level
HQ	=	Hazard quotient (Target of 1)
RfD	=	Reference dose (See Section 4.1.4)
IR	=	Intake rate; the amount of impacted medium contacted over the exposure period (e.g., kg/day for fish)
EF	=	Exposure frequency; describes how often exposure occurs (days/year)
ED	=	Exposure duration; describes how long exposure occurs (years)
BW	=	Body weight; the average body weight over the exposure period (kg)
AT	=	Averaging time; period over which exposure is averaged (days)

The USEPA's RSL Calculator was used to derive risk-based concentrations for mercury in fish tissue that are protective of the fish ingestion pathway and sediment RSLs that are protective of direct contact exposure. The sediment RSLs were derived to be protective of a recreator who may incidentally ingest and dermally contact sediment while recreating in or along the shores of the bay (e.g., wading, swimming, boating, fishing). RSLs were calculated for both an adult and young child (0-6 years).

Input parameters used to derive the RSL for fish ingestion were based on the default values provided in the RSL Calculator as shown in **Appendix C**, except for fish ingestion rate, for which the RSL Calculator no longer provides a default. For fish ingestion rate, in the absence of a site-specific rate, the RSL Calculator's historical default of 54 grams per day for adults was used [1]. It should be noted the historical default of 54 grams per day for adults is more than twice the adult fish ingestion rate of 20 grams per day used by WDNR to derive the state's human health water quality criteria. The 20 grams per day rate represents the average per capita daily consumption of sport-caught fish by Wisconsin anglers (WDNR, 2016). The fish ingestion rate for the young child was assumed to be one third of the adult rate, or 18 grams per day, based on the ratios of mean child-to-adult rates for fish consumption (USEPA, 2011).

The input parameters used to derive the sediment RSL were based on default values, except for exposure frequency, exposure time, and sediment dermal adherence factor, for which conservative site-specific values were used. The sediment exposure frequency was set to 150 days/year, exposure time was set to 2 hours per day, and dermal adherence was set to 0.2 milligrams per centimeter (mg/cm^2) for children and 0.3 mg/cm^2 for adults. The exposure frequency of 150 days/year is very conservative and assumes sediment exposure occurs 5 days/week for 30 weeks of the year (limited/negligible exposure to sediment is assumed to occur during cold weather). The adherence factor for children is based on the 50th percentile surface area weighted soil adherence data for children playing in wet soil and the adherence factor for adults is based on the 50th percentile value for reed gatherers (hands, lower legs, forearms, and feet) (USEPA, 2004).

The RSLs were derived based on a hazard quotient (HQ) of 1, as mercury is the only COPC. RSL calculator outputs are presented in **Appendix C**.

4.1.3.1 Concentration Terms

For the HHRA, the USEPA guidance "Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002) and the accompanying ProUCL 5.2 software (USEPA, 2022) were used to estimate concentration terms necessary in the quantification of COPC intakes. Exposure point concentrations (EPCs) are the chemical concentrations to which a receptor is likely to be exposed. As a conservative measure, the 95% upper confidence limit of the arithmetic mean (95% UCL) is typically adopted as the EPC in HHRAs.

<u>Sediment</u>

The overall sediment data set used to calculate UCLs included data collected from within the bay on behalf of the Army in 2016 and 2018. The 2009 data not used in the calculation are discussed in Section 2.2. The concentration of mercury in sediment was based on UCLs calculated for two sediment data sets:

– Surface sediment (0 - 0.5 ft): Data collected from within the top 0.5 ft of the sediment surface were included in the surface sediment EPC (n=63).

1 The USEPA RSL "Frequent Questions" notes that the previous default fish intake rate of 54 grams per day, which was taken from USEPA's Standard Default Exposure Factors has been removed and the user may specify a site-specific rate. https://www.epa.gov/risk/regional-screening-levels-frequent-questions#FQ21

- Subsurface sediment (>0.5 ft): Data collected from greater than 0.5 ft below the sediment surface were included in the subsurface sediment EPC (n=63). The deepest sample was collected from the 2.8 to 2.9 ft horizon.
- While surface sediment is expected to be the principal exposure horizon for direct contact and uptake into organisms, the subsurface sediment horizon (>0.5 ft) has also been evaluated to assess relative differences in potential risks with depth and to assess potential future risks (e.g., what is the potential for risk if the top 0.5 ft is removed).

Table 4-1 shows summary statistics for sediment mercury data evaluated in the risk assessments including the number of samples, the frequency of detection, minimum and maximum detected concentrations, statistical approach, and EPC selected. ProUCL outputs are provided in **Appendix D**.

<u>Fish Tissue</u>

The EPC for mercury in fish tissue was estimated using empirical data. Mercury in panfish from GGB were measured by WDNR in 2012. These data provide an empirical estimate of mercury concentrations in small fish. A review of Figure 2 from the WDNR report of the panfish data (presented as **Figure 4-1** of this report) indicates the maximum concentration of mercury measured in whole body pumpkinseed and bluegill was approximately 0.044 mg/kg wet weight (WDNR 2013). While some anglers may consume panfish, larger sportfish which may accumulate higher levels of mercury may also be targeted. Therefore, in addition to evaluating the risk posed by consuming whole panfish, a mercury EPC in higher trophic level fish was estimated using a trophic magnification factor (TMF). Based on a review of the literature, TMFs for methylmercury (the form of mercury assumed to be present in fish tissue) vary depending on physicochemical characteristics of the water body, as well as fish diet, and ranged between 4 and 8.3 for freshwater environments (Lavoie et al., 2013, Finley et al., 2015, Jardine et al., 2013, USEPA, 1997a). A conservative TMF of 8.3 was used for this analysis (Lavoie et al., 2013).

The TMF was applied to the panfish concentration to estimate mercury concentrations in an upper trophic level (TL) fish such as pike or walleye. The resulting EPC is expected to be conservative as large sportfish are likely to be transient and spend limited time feeding in GGB.

4.1.4 Toxicity Assessment

The toxicity assessment provides a framework for characterizing the relationship between the magnitude of exposure to a chemical and the nature and likelihood of adverse health effects that may result from such exposure. In a HHRA, chemical toxicity is typically divided into two categories: carcinogenic and non-carcinogenic effects. Potential health effects are evaluated separately for these two categories, because their toxicity criteria are based on different mechanistic assumptions and associated risks are expressed differently.

Mercury is considered to only have non-carcinogenic (noncancer) effects, with impacts to the neurological system the toxicity endpoint of concern. Noncancer health effects are evaluated using a reference dose (RfD) expressed in units of milligrams of chemical per kilogram body weight per day (mg/kg-bw/day). The RfDs for the relevant forms of mercury were obtained from USEPA's RSL Calculator (last updated November 2022; https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). For evaluating exposure to mercury from fish consumption, the RfD for methylmercury of 1E-04 mg/kg-day was used, as all mercury in the fish tissue is conservatively assumed to be the more toxic methylated form. For evaluating exposure to mercury from direct contact with sediment, the RfD of 3E-04 mg/kg-day for the inorganic form (mercuric chloride) was used; mercury is rarely present in methylated form in sediment. As indicated previously, the surface water exposure pathway is expected to be insignificant and surface water exposure pathways were not evaluated.

4.1.5 Risk Characterization

In the risk characterization step of the HHRA, toxicity and exposure assessments are integrated into quantitative expressions of non-carcinogenic hazard. For this HHRA, a ratio approach was used that relates the matrix-specific EPC to the receptor-specific RSL to estimate a noncancer HQ for each exposure pathway. A cumulative hazard index (HI) that sums the pathway-specific HQs was calculated using the following equation:

$$Cumulative\ HI = \frac{C_{fish-meHg}}{RSL_{fish-meHg}} + \frac{C_{sed-Hg}}{RSL_{sed-Hg}}$$

Where:

$C_{fish\text{-}meHg}$ = Concentration of methylmercury in fish tissue (mg/kg)

$RSL_{fish\text{-}meHg}$ = RSL for methylmercury in fish tissue (mg/kg)

$C_{sed\text{-}Hg}$ = Concentration of inorganic mercury in sediment (mg/kg)

$RSL_{sed\text{-}Hg}$ = RSL for inorganic mercury in sediment (mg/kg)

This analysis assumes the same recreational receptor (i.e., angler) is exposed to mercury from both fish ingestion and direct contact with sediment. Separate HQs and HIs were generated for the adult and young child age groups. Derivation of the pathway-specific HQ are presented in **Tables 4-2 and 4-3** for fish ingestion and sediment direct contact, respectively. The calculation of the cumulative HI for each sediment depth interval of interest is presented in **Table 4-4**. Separate HI estimates are provided for consumption of small panfish and larger sportfish, as summarized below. The HIs for fish ingestion are independent of sediment depth; the same HI is therefore used for each depth interval. The cumulative HIs greater than the acceptable benchmark of 1 are shown in bold and orange shading.

	Estimated Noncancer Hazard for the Recreational Receptor Fish Ingestion and Direct Contact with Sediment					
	Child			Adult		
	Fish Ingestion HQ	Sediment Direct Contact HQ	Cumulative HI	Fish Ingestion HQ	Sediment Direct Contact HQ	Cumulative HI
Surface Sediment (0 – 0.5 ft)						
Mercury (small panfish)	0.5	0.04	0.5	0.3	0.004	0.3

	Estimated Noncancer Hazard for the Recreational Receptor Fish Ingestion and Direct Contact with Sediment					
	Child			Adult		
	Fish Ingestion HQ	Sediment Direct Contact HQ	Cumulative HI	Fish Ingestion HQ	Sediment Direct Contact HQ	Cumulative HI
Mercury (larger sportfish)	4.2	0.04	**4.2**	2.4	0.004	**2.4**
Subsurface Sediment (>0.5 ft)						
Mercury (small panfish)	0.5	0.03	0.5	0.3	0.003	0.3
Mercury (larger sportfish)	4.2	0.03	**4.2**	2.4	0.003	**2.4**

Notes: HQ = hazard quotient; HI = hazard index. Cumulative HIs greater than the acceptable benchmark of 1 are shown in bold and orange shading.

For consumers of small panfish, the cumulative HIs are below 1, indicating potential adverse health effects are not expected. The cumulative HIs exceed 1 for consumers of larger sportfish, indicating a potential hazard due to assumed higher levels of mercury in gamefish. As previously indicated, this analysis is expected to be conservative as larger sportfish such as pike or walleye are likely to be transient in GGB. The contribution of the sediment direct contact pathway to the cumulative HI is minor and the HQ is well below 1 for both depth horizons.

4.1.6 Uncertainty Analysis

Within the multiple steps of the risk assessment process, assumptions must be made which introduce some degree of uncertainty into the HHRA. Much of the potential uncertainty is discussed in qualitative terms because there is generally not enough information for most uncertainties to assign numerical values. Uncertainties in the following sections are discussed with respect to:

- Data Collection and Evaluation,
- Exposure Assessment,
- Toxicity Assessment, and
- Risk Characterization.

4.1.6.1 Data Collection and Evaluation Uncertainty

Analytical data used in the HHRA are subject to uncertainty associated with sampling and analysis and subsequent evaluation. Uncertainties include:

- Data were collected from locations assumed to be representative of areas where chemicals may contribute to potential exposures. However, uncertainty may be introduced through biases in sampling rather than from a truly random sampling approach. Incorporating biased sampling locations into exposure estimates is likely to result in an overestimate of potential risks because the data are not randomly collected.

This subsequently contributes to bias in statistical estimates of exposure, which assume random sample collection.

- Random variability of samples and lack of homogeneity of the media may result in either an over- or under-estimate of actual exposure concentrations.
- Samples were analyzed using USEPA methodologies. However, sample analysis is subject to uncertainties associated with precision and accuracy, and detection of chemicals at low concentrations. Differences between how accurately measured concentrations reflect actual concentrations could lead to an over- or underestimate of exposures and potential risks.

4.1.6.2 Exposure Assessment Uncertainty

The 95% UCL of the mean was calculated and used as the exposure point concentration for sediment. The maximum concentration was used for fish tissue, which is a conservative approach. The maximum fish tissue concentration was selected due to limitations in the fish tissue data set (e.g., fish tissue collected during a single sampling event rather than over multiple years).

For calculating UCLs for mercury in sediment, the statistical approach applied is dependent on the frequency of detection, number of data values and distribution of the data within the dataset. The accuracy of these numbers in reflecting exposure depends on how well the data represents the site. In general, the more samples collected from an area, the lower the associated uncertainty when calculating an EPC. Both sediment UCLs were based on data sets with 63 samples, which is well above the minimum of 8 to 10 samples recommended by ProUCL guidance. The use of the 95% UCL of the mean (or the maximum) results in a high level of confidence that risks are not under-estimated, but at the same time, may tend to over-estimate actual exposures and associated risks.

The HHRA assumed a sediment direct contact exposure frequency of 150 days per year. On each day, the recreational receptor is assumed to incidentally ingest and dermally contact GGB sediment. The default exposure assumptions used to quantify direct contact with sediment are conservative and not likely to underestimate the potential for sediment exposure while recreating in GGB.

The potential for exposure to mercury from contacting GGB surface water was not evaluated quantitatively in this HHRA, as surface water exposures have been shown to be negligible and not pose unacceptable risks. The Expanded Problem Formulation Plan (Stone & Webster, 2000b) indicated that ingestion of surface water would be at an intake level less than the intake level of sediment and that ingestion via the surface water pathway could be excluded for mercury. USGS (2022) reported surface water total mercury results for four samples collected within the Bay in 2019. Mercury concentrations were below the WDNR human threshold criterion of 1.5 nanograms per liter (ng/L) (Wisconsin Administrative Code, 2023), confirming that surface water is not a medium of concern for human health.

The HHRA assumed that the adult angler consumes 54 grams of fish (historical default assumption in USEPA's RSL Calculator for the fish ingestion pathway) daily for 26 years. This is extremely conservative and equivalent to 87 half-pound fish meals per year exclusively from GGB. It is unlikely, particularly given the size of the bay and the existing fish consumption advisory, that the entirety of an angler's diet would be obtained exclusively from GGB, or that the bay provides adequate habitat for the larger sportfish considered in this analysis. These conservative assumptions will result in overestimates of Site risks.

4.1.6.3 Toxicity Assessment Uncertainty

In general, the available scientific information is insufficient to provide a thorough understanding of all the potential toxic properties of chemicals to which humans may be exposed. Consequently, varying degrees of uncertainty surround the assessment of adverse health effects in the exposed populations. To account for uncertainty, USEPA typically relies on a conservative approach in determining toxicity values.

Both RfDs used in this HHRA are from USEPA's Integrated Risk Information System (IRIS) which is considered the agency's top source of toxicity values (USEPA, 2003). Values on IRIS have undergone peer review and represent the agency's consensus on the chemical's toxicity. The toxicity value used for methylmercury (the organic form assumed to be present in fish tissue) is based on human studies and was derived using a combined uncertainty factor of 10. The methylmercury RfD has undergone extensive peer review, and USEPA assigns a high degree of confidence to this RfD (https://iris.epa.gov/static/pdfs/0073_summary.pdf). The toxicity value used for mercuric chloride (inorganic mercury is the form assumed to be present in sediment) is based on a study in rats and was derived using a combined uncertainty factor of 1,000. The mercuric chloride RfD has also undergone peer review and USEPA assigns a high degree of confidence to this RfD (https://iris.epa.gov/static/pdfs/0692_summary.pdf).

4.1.6.4 Risk Characterization Uncertainty

The conservative assumptions made in each step of the risk assessment process to account for uncertainty can be magnified in the final risk characterization. The final quantitative estimates of risk may be one or several orders of magnitude different from the actual potential risk associated with a given exposure. Because of the conservative approaches used in each step, the overall results of this risk assessment are most likely to over-estimate the potential risks posed by mercury at the Site.

4.1.7 Human Health Risk Assessment Conclusions

Human receptors evaluated in the HHRA were recreational receptors (i.e., anglers) that may consume fish and contact sediment in the bay. The only COPC was mercury, which has been associated with adverse neurological effects when exposure to the organic form (methylmercury) exceeds the safe threshold dose. The cumulative HI exceeded 1 due to consumption of larger sportfish, which is assumed to be attributable to bioaccumulation of methylmercury in the tissue of larger sportfish. The cumulative HI associated with consumption of panfish did not exceed 1. The HQs for direct contact with sediment (incidental ingestion and dermal contact) were below 1 for both sediment depth intervals evaluated. In summary, ingestion of larger sportfish from GGB has the potential to result in adverse noncarcinogenic health effects under the conservative assumptions used in this HHRA.

4.2 ECOLOGICAL RISK ASSESSMENT

This section provides the approach used and results of an ecological risk assessment (ERA) conducted using sediment and fish tissue collected within GGB after remedial dredging efforts conducted in 2006.

The relevant ecological assessment endpoints were developed based on the CSM presented in Section 3. Ecological receptors likely to be present with GGB include free-swimming aquatic invertebrates, fish, benthic invertebrates, and wildlife that may forage on these lower trophic level receptors. Receptors may be directly exposed to mercury in sediment or may be exposed via ingestion of sediment, water, or food items that have bioaccumulated mercury into their tissues.

4.2.1 Potential Ecological Receptors and Exposure Pathways

Ecological receptors are the components of ecosystems (i.e., species or sensitive habitats) that are or may be adversely affected by a chemical, physical, or biological stressor. Receptors can be any part of an ecological system, including species, populations, communities, and the ecosystem itself. This ERA is focused on the pathways for which the potential for chemical exposures is the highest and most likely to occur and for which there are adequate data pertaining to the receptors, exposure pathways, and toxicity for completion of risk analyses.

Exposure pathways for several groups of ecological receptors were identified as potentially relevant. Each exposure pathway includes a potential source of a chemical, an environmental medium (e.g., sediment), and a potential exposure route to an ecological receptor. Incomplete routes of exposure were not evaluated. This approach is used to focus the risk evaluation on exposure pathways that are considered potentially complete and for which there are adequate data pertaining to the receptors, exposure, and toxicity for completion of the risk analysis.

A previous evaluation of surface water conducted prior to the dredging of the sediment (Shaw, 2005) indicated that surface water concentrations of mercury were below WDNR ambient water quality criteria and mercury concentrations in sediment did not appear to be impacting water concentrations. Surface water sampling (representing suspended particulate matter in the water column) conducted by USGS in 2019 included four samples from within GGB with mercury concentrations ranging from 1.0 to 1.4 ng/L (USGS, 2022). Mercury concentrations were below the WDNR chronic aquatic life criterion of 440 ng/L, but two samples from GGB had mercury levels slightly above the wildlife criterion of 1.3 ng/L (Wisconsin Administrative Code, 2023). The wildlife criterion represents a no effect level of protection based on five piscivorous species (i.e., bald eagle, kingfisher, herring gull, mink, and otter) consuming a diet of trophic level 3 and 4 fish from a waterbody. A population of trophic level 3 and 4 fish is not expected to be supported given the size of GGB and the bay is not expected to provide a valuable foraging area for the piscivorous receptors considered in the derivation of the criterion. Therefore, the wildlife criterion of 1.3 ng/L may be overly conservative for use within GGB. Mercury concentrations in GGB water were lower than concentrations reported in three upstream locations that were all above the wildlife criterion (ranging from 1.6 to 2.5 ng/L) indicating that regional sources of mercury occur within the Wisconsin River system. Based on the presence of mercury concentrations below the aquatic life criterion prior to and after dredging, the conservative nature of the wildlife criterion, and the low magnitude of the two 2019 wildlife criterion exceedances, surface water concentrations are not considered further in this ERA. As discussed below, wildlife exposures mercury via ingestion of sediment and prey were considered.

Exposure pathways for several groups of ecological receptors were identified as potentially relevant.

- Benthic invertebrates exposed to surface sediment within GGB;
- Fish exposed to surface water and sediment within GGB; and
- Wildlife exposed through incidental ingestion of sediment, and/or by ingestion of prey items impacted by sediment within GGB.

Fish species observed within GGB include panfish like bluegill and pumpkinseed (WDNR, 2013), bottom-dwelling fish like bullhead and carp (Ayers, 1973), and sportfish like largemouth bass and walleye (Stone & Webster, 2000b).

In general, birds and mammals may consume invertebrates and fish from aquatic ecosystems. However, the lack of mudflats and shallow water habitat at GGB is likely to limit the use of the area by wildlife that forage from the shoreline. Therefore, exposure pathways for receptors such as raccoon or shorebirds are expected to be insignificant, and these pathways are not considered further.

Swimming mammals such as mink or river otter may be present within the Wisconsin River and may forage within the bay and these receptors may be exposed to mercury through incidental ingestion of sediment and ingestion of prey items that bioaccumulate mercury from the sediment of GGB.

A query of the online US Fish and Wildlife Service (USFWS) Information, Planning, and Conservation System (IPaC) (USFWS, 2023) identified the following federally endangered, threatened, proposed, and/or candidate species in the vicinity of GGB:

- Mammal: Northern long-eared bat, *Myotis septentrionalis* (threatened); tricolored bat, *Myotis subflavus* (proposed endangered)
- Bird: Whooping crane, *Grus americana* (experimental population)
- Clam: Higgins eye, *Lampsilis higginsii* (endangered); sheepnose mussel, *Plethobasus cyphyus* (endangered)
- Insects: Monarch butterfly, *Danaus plexippus* (candidate); rusty patched bumble bee, *Bombus affinis* (endangered)
- Plants: Northern wild monkshood, *Aconitum noveboracense* (threatened); prairie bush-clover, *Lespedeza leptostachya* (threatened)

Of these species, the two species of clam are most likely to be found in aquatic habitats such as those present near GGB. Both of the clam species are also state-listed endangered species with observations within Sauk County. Both species may be found in large rivers and tend to prefer stable sand or sand and gravel substrates (WDNR, 2023). These conditions are not likely to be present within GGB so it is unlikely that these species are present.

4.2.2 Assessment and Measurement Endpoints

An assessment endpoint is the explicit expression of an environmental value that is to be protected (USEPA, 1992, 1997b, 1998). They usually describe potential adverse effects to long-term persistence, abundance, or reproduction of populations of key species or key habitats. Two elements are needed to define an assessment endpoint: 1) the valued ecological entity (e.g., a local population of a species, a functional group of species), and 2) the property or attribute of that entity which is potentially at risk and important to protect. A measurement endpoint is a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. Measurement endpoints represent the lines-of-evidence used to evaluate the assessment.

These assessment endpoints and associated measurement endpoints for GGB are described below:

- **Viability and Function of the Benthic Macroinvertebrate Community** - Invertebrate communities can comprise a large portion of the base of the food chain for aquatic ecosystems. Impacts to sediment invertebrate communities may have direct effects (e.g., loss or reduction of forage) and indirect effects (transfer of bioaccumulative compounds) on higher trophic-level organisms. Sediment invertebrates process organic material and are important in nutrient and energy transfer as well as to the overall ecosystem function. The measurement endpoint for the benthic macroinvertebrate community is the comparison of sediment exposure concentrations with toxicity reference values (TRVs), specifically, the threshold effect concentration (TEC), median effect concentration (MEC) and probable effect concentration (PEC) identified by WDNR (2003).
- **Viability and Function of the Fish Community** - Fish communities play a key role in ecosystem functions such as energy flow, nutrient cycling, and organic matter accumulation, and are an important food resource for higher trophic level species. The measurement endpoint for the fish community is the comparison of fish tissue concentrations against tissue residue TRVs for mercury in fish tissue.
- **Survival, Growth, and Reproduction of Mammalian Wildlife Community** – Adverse effects on the wildlife community may occur due to consumption of prey items containing mercury. As indicated above, exposure pathways for shorebirds and mammals foraging from the shoreline are expected to be insignificant, so this assessment endpoint is focused on mammals (e.g., mink or river otter) that may forage on prey items from the bay. These wildlife predators regulate prey density, species abundance, and diversity, and impacts to predator populations could also cause detrimental population changes and/or shifts in community assemblages for prey item communities. The measurement endpoint for mammalian wildlife is a food web model that estimates a total daily dose (TDD) of mercury and compares that dose against a dose-based TRV.

4.2.3 Contaminant Identification

As indicated for the HHRA, mercury is the only chemical of potential concern based on the prior Site investigations summarized in Section 1. Mercury is also known to be bioaccumulative and may be taken up into the tissues of aquatic receptors, including fish and benthic invertebrates that may represent a prey based for birds and mammals.

4.2.4 Exposure Assessment

Two types of exposures are evaluated in this ERA:

- Direct exposures through contact with sediment (benthic macroinvertebrates); and,
- Indirect exposure via bioaccumulation of mercury into fish tissue and ingestion of contaminated prey/forage (for evaluation of wildlife).

Direct exposures are evaluated by comparing sediment concentrations with direct exposure TRVs, which are also expressed as media concentrations (i.e., the TEC, MEC, and PEC).

The fish community is evaluated for adverse effects associated with mercury detected in fish tissue. Tissue residue TRVs represent fish tissue concentrations associated with an adverse effect on the fish community. Fish within the bay may be exposed to mercury through ingestion of food items such as algae, macrophytes, invertebrates, and smaller fish. It is expected that mercury exposure via ingestion is more significant for fish than exposures via direct contact with surface water or sediment.

For higher trophic-level receptors (e.g., mammals feeding in the bay), food web models were used to estimate a TDD of mercury that the mammal would be exposed to due to incidental ingestion of sediment and ingestion of prey items (e.g., fish). An exclusive diet (e.g., receptor diet represented by 100% of one item) was used to evaluate potential doses from the dominant prey item.

Wildlife exposure assumptions for the food web model (e.g., body weights, relative consumption of food items, etc.) were obtained from the USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993). Allometric equations (Nagy, 2001) were used to estimate food ingestion rates.

The mink (*Mustela vison*) was selected as the representative mammalian receptor for the food web model. The model evaluates the mink as a piscivorous mammal consuming a diet of 100% fish.

The river otter (*Lutra canadensis*) is likely to consume more fish than the mink which is typically expected to consume small mammals and other terrestrial prey in addition to fish. However, the mink has a smaller body weight than the otter so the evaluation of the mink in the food web model is expected to also be protective of the river otter (receptors with higher body weights are generally exposed to lower contaminant doses).

It is assumed that mercury in prey items such as fish is present primarily as methylmercury. As described in Section 4.1.3, panfish (whole body pumpkinseed and bluegill) were collected from within GGB in 2012 by WDNR. These empirical data were used in the food chain model and in the fish community evaluation (e.g., tissue residue TRV comparisons).

Consistent with the HHRA, a TMF of 8.3 was also applied to the panfish mercury concentration to estimate mercury levels in higher trophic level fish that were evaluated in the fish community evaluation. Given the size of the mink (body weight of just over a kilogram), panfish like bluegill and pumpkinseed are expected to be a reasonable size for consumption and larger sportfish like walleye are not expected to be a significant prey item.

4.2.4.1 Exposure Point Concentrations

EPCs are the chemical concentrations of COPECs to which an ecological receptor is exposed when contact is made with a specific environmental medium. For this evaluation, sediment EPCs are expressed as the upper 95% confidence limit of the mean (95% UCL). The 95% UCLs were defined for the following sediment depth intervals (as previously noted in the HHRA):

- Surface sediment (0 – 0.5 ft)
- Subsurface sediment (>0.5 ft)
- Summary statistics and EPCs are presented in **Table 4-1**. ProUCL outputs are provided in **Appendix D**.

Surface sediment (0 – 0.5 ft) is expected to represent the current exposure horizon for benthic invertebrates. Fish within the bay may feed upon benthic invertebrates present within this horizon and may in turn be consumed by wildlife like mink or river otter. The subsurface sediment horizon (>0.5 ft) has also been evaluated to assess relative differences in potential risks with depth and to assess potential future risks (e.g., what is the potential for risk if the top 0.5 ft is removed).

The measurement endpoint for the fish community assessment endpoint is based on fish tissue concentrations and fish tissue concentrations are also used in the food web model. Mercury concentrations in whole-body fish (pumpkinseed and bluegill) were measured by WDNR in GGB in 2013. These samples represent fish collected within that bay that piscivorous wildlife may consume and they are representative of small fish present in the bay after the dredging efforts. The raw dataset was not available for the panfish data to estimate a UCL or other reasonable maximum exposure, so the maximum fish concentration for the GGB samples (0.044 mg/kg wet weight as identified in Figure 2 of WDNR [2013]) was selected as the fish tissue EPC.

The fish community evaluation also considered mercury concentrations in higher trophic level fish by applying a TMF of 8.3 to the panfish mercury concentration (consistent with the HHRA). This resulted in an estimated mercury tissue concentration of 0.37 mg/kg wet weight. Higher trophic level fish such as walleye are present within the Wisconsin River and may forage within the bay; however, these higher trophic level fish are expected to obtain a significant portion of their diet outside the bay so modeling concentrations from panfish that are more likely to stay within the bay may overestimate concentrations in higher trophic level fish.

4.2.4.2 Ingestion Exposures

The principal exposure pathway for wildlife to be exposed to mercury in the environment is through ingestion. Ingestion exposures are based on an estimate of the dose, which is subsequently related to anticipated responses. Ingestion rates for food items and incidental sediment ingestion were obtained from literature sources (i.e., USEPA, 1993; Nagy, 2001).

The TDD calculation considers the following factors: concentrations of the contaminant in the food items that the species would consume, estimated amounts of sediment that it would be incidentally ingested, the relative amount of different food items in its diet, body weight, species-specific area use factors (AUFs), seasonal use factors (SUFs), and food ingestion rates.

The AUF is a ratio based on the size of the available habitat within the exposure area divided by an organisms' home range size. The larger the animal's home range, the smaller the AUF (less likely to forage solely in one exposure area). The food web model conservatively assumes that the receptors obtain all of their dietary input from GGB (AUF =1).

A SUF is defined as the fraction of the year a receptor spends within the exposure area. Since the target species were selected to be protective of entire guilds and to protect resident species as well as transient species, a default SUF of 1 was applied for all wildlife receptors regardless of potential target receptor seasonal presence. This SUF assumes the receptors are present all year and that foraging is not restricted by ice cover or migration during the winter months (forage within the study area for their entire lifespan).

The following generalized equation was used to evaluate the TDD from each source (i.e., food item, drinking water, incidental ingestion):

$$TDD = \frac{\sum(\text{Tissue or Media Concentration} \times \text{Ingestion Rate} \times AUF \times SUF)}{\text{Body Weight}}$$

This generalized equation was modified for each representative species and sediment depth horizon.

4.2.5 Toxicity Assessment

4.2.5.1 Benthic Invertebrate Community – Toxicity Reference Values

TRVs selected for evaluation of the benthic invertebrate community are the consensus-based sediment quality guidelines (WDNR, 2003). The TEC was selected as a lower bound TRV and the PEC was selected as an upper bound TRV. The MEC is the midpoint between the TEC and PEC. The TEC as defined by MacDonald et al. (MacDonald et al., 2000) as the concentration below which adverse effects are unlikely to occur. The PEC is the concentration above which adverse effects are expected to frequently occur. **Table 4-5** provides the benthic invertebrate community TRVs.

4.2.5.2 Fish Tissue Residue TRVs

Effects levels for mercury in fish tissue were obtained from Dillon et al. (2010). The endpoints considered in determining the effects levels included fish mortality, failure to spawn, failure to hatch, and lethal developmental abnormalities. The range of observed concentrations in bottom-dwelling and predatory species (~0.1–0.2 mg/kg wet weight) in this study were reportedly considered average US background residues for mercury in fish. In the juvenile/adult fish model, the modelled percent injury at 0.3 mg/kg wet weight was estimated at 8.2%. The percent injury at 1 mg/kg wet weight was estimated at 24.0%. This range was selected for mercury TRVs:

- No observed adverse effects level (NOAEL) TRV = 0.3 mg/kg wet weight
- Lowest observed adverse effects level (LOAEL) TRV = 1.0 mg/kg wet weight

Table 4-6 provides the fish tissue residue TRVs.

4.2.5.3 Wildlife Dose-based TRVs

Los Alamos National Laboratory (LANL) has identified avian and mammalian dose-based TRVs for use in calculated ecological screening levels (N3B, 2022). These TRVs can be defined as the daily dose of a constituent that is considered protective of wildlife populations or individuals. The dose is expressed in milligram per kilogram body weight per day (mg/kg-bw/day) and can be based on either a NOAEL or a LOAEL.

Inorganic mercury usually dominates in most mercury-contaminated sediment, the methylated form of mercury biomagnifies through the food web (Conder, et al., 2015), and methylmercury typically dominates on tissues. Wildlife may ingest both inorganic mercury (via sediment) and methylmercury (via tissue); therefore, dose-based TRVs were identified for both forms of mercury and separate TDDs were calculated.

The mink food web model presented in **Table 4-7** includes the following mammalian dose-based TRVs:

- Inorganic mercury NOAEL TRV = 1.41 mg/ kg-bw/day
- Inorganic mercury LOAEL TRV = 14.1 mg/ kg-bw/day
- Methylmercury NOAEL TRV = 0.032 mg/ kg-bw/day
- Methylmercury LOAEL TRV = 0.16 mg/ kg-bw/day

4.2.6 Ecological Risk Characterization

The risk characterization has two principal components: risk estimation and risk description (USEPA, 1997b). These two components are bridged by an uncertainty analysis. Risk estimation uses the data analysis to calculate a range of potential risks for each COPEC. The risk description provides an interpretation and discussion based on the risk estimates and uncertainty analysis. The risk estimates and uncertainties are evaluated in interpreting the degree of confidence in the risk estimates. This discussion is intended to assist risk managers in judging the likelihood and ecological significance of the estimated risks.

4.2.6.1 Risk Estimation

The primary line of evidence for estimating risk consists of comparison of the exposure concentration with a TRV. This ratio is referred to as the HQ. The HQ for each community or representative receptor is calculated by dividing the EPC (or the TDD) by the TRV.

A range of HQs is developed to portray a range of potential ecological risks. The HQ at the lower end of the range is calculated with the lower-bound TRV (TEC or NOAEL) and the HQ at the upper end with the upper-bound TRV (LOAEL TRV). For benthic invertebrates an HQ based on the MEC (midpoint) is also calculated.

Exposure pathways with HQs greater than 1 were subjected to a more intensive investigation of the data (e.g., magnitude of screening level exceedances, confidence in the screening levels, etc.) in the risk description phase to build a weight of evidence upon which to base conclusions regarding the potential for ecological risk.

Surface sediment (0 – 0.5 ft) is expected to represent the current exposure horizon for benthic invertebrates. Fish within the bay may feed upon benthic invertebrates present within this horizon and may in turn be consumed by wildlife like mink or river otter. Subsurface sediment (>0.5 ft) has also been evaluated to assess relative differences in potential risks with depth and to assess potential future risks (e.g., what is the potential for risk if the top 0.5 ft is removed). However, sediment below the bioactive zone (typically the top 0.5 ft of sediment) and down to the maximum sampling depth of 2.9 ft are not likely to be accessible to ecological receptors.

4.2.6.1.1 Viability and Function of the Benthic Macroinvertebrate Community

Potential risks to benthic invertebrates from direct exposure to mercury in sediment were evaluated using comparisons to SQG identified by WDNR (2003). Benthic invertebrate HQs for mercury are presented in **Table 4-5** and summarized below. HQs greater than the acceptable benchmark of 1 are shown in bold and orange shading.

Sediment EPCs from the two sediment horizons were compared to the TEC, MEC, and PEC. HQs ranged from 1.6 based on the PEC in subsurface sediment to 11 based on the TEC in surface sediment.

The occurrence of a benthic invertebrate community within the gelatinous sediment layer has not been confirmed. Infaunal benthic invertebrates typically burrow into consolidated bottom sediment and detritus layers while epibenthic species would be found on the sediment surface as discussed in Section 4.2.6.3.1.

Sediment Horizon	**TEC HQ**	**MEC HQ**	**PEC HQ**
Surface (0 - 0.5 ft)	**11**	**3.2**	**1.9**
Subsurface (>0.5 ft)	**10**	**2.8**	**1.6**

4.2.6.1.2 Viability and Function of the Fish Community

Potential risks to the fish community in the bay from exposure to mercury in sediment and the diet were evaluated using comparisons to fish tissue residue TRVs identified by Dillon et al. (2010). HQs calculated for mercury in fish tissue are presented in **Table 4-6** and summarized below. HQs were calculated for measured panfish concentrations from GGB and for estimated concentrations of mercury in higher trophic level fish (estimated from panfish using a TMF of 8.3 consistent with HHRA).

Fish Species	**NOAEL HQ**	**LOAEL HQ**
Bluegill & Pumpkinseed (small panfish)	0.15	0.044
Higher trophic level fish	**1.2**	0.37

4.2.6.1.3 Survival, Growth, and Reproduction of Mammalian Wildlife Community

A food web model was used to assess the potential for risks to the mink primarily due to consumption of fish exposed to mercury in the bay. The food web model estimated a TDD of methylmercury from fish ingestion and a TDD of inorganic mercury from incidental sediment ingestion (e.g., ingested during grooming or feeding).

HQs calculated for mink exposed to mercury are presented in **Table 4-7** and summarized below. Two types of HQs were calculated for the mink using the NOAEL and LOAEL TRVs to estimate the potential for adverse effects due to mercury. By calculating two HQs, one equal to the TDD divided by the NOAEL TRV and one equal to the TDD divided by the LOAEL TRV, a risk manager can more definitively assess risk to the typical individual and to the overall population.

Sediment Horizon	Ingestion Exposure	NOAEL HQ	LOAEL HQ
Surface (0 - 0.5 ft)	Fish Tissue	0.26	0.052
	Sediment	0.0020	0.00020
Subsurface (>0.5 ft)	Fish Tissue	0.26	0.052
	Sediment	0.0018	0.00018

As indicated above, HQs based on fish tissue ingestion are orders of magnitude higher than the HQs due to incidental sediment ingestion. This is due to the greater sensitivity (lower TRVs) of mammals to methylmercury rather than inorganic mercury and a higher TDD for tissue over incidental sediment ingestion.

4.2.6.2 Uncertainty Analysis

As discussed in the HHRA, assumptions must be made within the multiple steps of the risk assessment process which introduce some degree of uncertainty into the ERA. Much of the potential uncertainty is discussed in qualitative terms because there is generally not enough information for most uncertainties to assign numerical values. Many of the uncertainties previously discussed for the HHRA are also common within the ERA. Uncertainties more specific to the ERA are discussed below.

4.2.6.2.1 Exposure Assessment Uncertainty

The exposure assessment is based on assumptions concerning the types of receptors likely to be present, patterns of behavior leading to exposure, and the estimate of exposure concentrations. Uncertainties include:

- Selection of receptors requires an understanding of the complex interactions in an ecosystem, including abiotic processes and interactions between organisms. Uncertainties are associated with the representativeness of the selected receptors as sensitive species and as key organisms in the functioning of the ecosystem. Birds were not considered as potential receptors in the ERA due to the lack of mudflats and shallow water for foraging. This could lead to an underestimate of potential risks to avian receptors, if in fact, there were present and foraging primarily in GGB.
- Generalized and conservative assumptions are made about the behavior of the receptor in the environment in terms of diet, activity, mobility and seasonality. There were no

adjustments made to account for either mobility, foraging area or seasonality within the ERA. In the food web model, mink were assumed to forage exclusively within GGB (all dietary items from the bay all year long). The conservativeness of the assumptions is more likely to over-estimate than under-estimate risks. For mink, the size of the bay (27 acres) is likely smaller than the foraging range[2]. The approach applied in this evaluation assumes that the foraging range is limited to GGB, which likely overestimates potential risks.

- In the evaluation of the fish community, a TMF of 8.3 was used to estimate mercury concentrations of higher trophic level fish from the available panfish data. There are uncertainties associated with the use of a TMF to estimate fish tissue concentrations (relative to evaluating empirical data) and whether concentrations in the bay are over- or under-estimated. It is unlikely that higher trophic level fish forage exclusively within the bay so modeling concentrations from panfish that are more likely to stay within the bay may overestimate concentrations in higher trophic level fish. Stone & Webster (2000b) noted average mercury tissue concentrations of 0.39 mg/kg for largemouth bass collected from GGB in 1987 and 1993 and 0.28 mg/kg for walleye collected from GGB in 1998. These levels are similar to the 0.37 mg/kg estimated for higher trophic level fish using the TMF. However, it would be expected that mercury concentrations in fish collected from the bay would be lower now, than they were prior to dredging.

4.2.6.2.2 Toxicity Assessment Uncertainty

Generally, the available scientific information is insufficient to provide a thorough understanding of all the potential toxic properties of mercury. TRVs from the published literature were used to characterize risks. Uncertainties include:

- Differences in sensitivities to mercury between surrogate and receptor species;
- Differences between laboratory endpoints and receptor-specific endpoints;
- Differences between the duration of laboratory studies and the likely duration of exposure to receptors in the wild; and

The use, validity, and understanding of laboratory-based TRVs lie in their experimental definitions. Experimentally, these values are determined statistically. Derivation of TRVs by definition is biased by the experimental design. It is possible that a 20% or 30% reduction in reproduction or growth could occur but be statistically defined as a no-effect level. Conversely, it is possible for a 1% or 5% reduction to be statistically less than a control and result in an effect level. Statistical significance does not automatically relate to biological significance.

4.2.6.2.3 Risk Estimation Uncertainty

Risks in the ERA were characterized largely by calculating an HQ. HQs are not probabilistic measures of potential risk, and do not linearly represent hazard potentials. However, they can be used to estimate the potential level at which the measured or predicted exposure relates to known

2 USEPA (1993) indicated home ranges of 19 to 50 acres for mink in Montana riverine habitats and 988 to 4695 acres for river otter in Missouri march and stream habitats.

effects. The greater the departure from unity, the greater the indication that either a potential level of concern is present (HQ much greater than one) or there is little potential for concern (HQ much less than one). Uncertainty in the HQ is also compounded by the uncertainties associated with data, exposure and toxicity assessment uncertainties as discussed previously. The HQs contribute to a "line-of-evidence" for interpreting the potential for ecological impact. In the context of the ERA, HQs represent the first tier of an iterative ecological risk approach and can be used for assessing if a potential level of concern exists, whether additional evaluation is necessary or if remedial actions are warranted.

4.2.6.3 Risk Description

4.2.6.3.1 Viability and Function of the Benthic Macroinvertebrate Community

Benthic invertebrate HQs based on the PEC exceed 1 in both of the sediment data sets evaluated. HQs based on the PEC were 1.6 in the subsurface sediment data set (> 0.5 ft) and 1.9 in the surface sediment data set (0 - 0.5 ft). According to WDNR (2003), these exceedances of the PEC suggest that toxicity to benthic-dwelling organisms is probable.

However, more recent literature suggests that the mercury PEC and other mercury SQGs derived based on paired chemistry and benthic invertebrate effects data obtained from field-collected studies (referred to as 'co-occurrence' SQGs) may over-estimate the potential for effects, in part because multiple stressors co-occur in the sediments used to derive the SQGs. Conder, et al. (2015) reviewed more than 40 'co-occurrence' SQGs for mercury and assembled mercury data and benthic effects data for seven laboratory studies with mercury-spiked sediment and 23 studies at mercury contaminated sites to characterize mercury-specific effects thresholds. The review indicated that the median 'co-occurrence' SQG associated with a lack of effects was 0.16 mg/kg (similar to the TEC of 0.18 mg/kg) and the median SQG associated with a potential for effects was 0.88 mg/kg (slightly lower than the PEC of 1.1 mg/kg). These SQGs were orders of magnitude below the median no-observed effect concentrations reported for mercury-spiked studies (3.3 mg/kg) and mercury site investigations (22 mg/kg). Spiked sediment laboratory studies are often conducted with bioavailable forms of chemicals, so these types of toxicity studies typically result in lower no-observed effect concentrations than studies conducted with field sediments containing more weathered and less bioavailable forms of chemicals.

Both of the GGB sediment EPCs are below the median no-observed effect concentrations reported by Conder, et al. (2015) for mercury-spiked studies and mercury site investigations suggesting that GGB sediment may not pose a risk to the benthic invertebrate community.

While mercury has been the focus of on-going study in GGB, other metals and chemical stressors also exist within the gelatinous materials. The Expanded Problem Formulation Plan (Stone & Webster, 2000b) indicated that removal of mercury contamination will result in the removal of other contaminants; therefore, the use of 'co-occurrence' SQGs (i.e., the TEC and PEC) is assumed to be appropriate for the GGB evaluation due to the potential for other co-located contaminants to also be present within the Bay.

Sediment toxicity testing conducted with GGB sediments in 2005 indicated that sediments were less toxic than expected based on comparisons to the PEC (all tested samples were at least three times higher than the PEC). Although PEC comparisons suggested considerable toxicity, the results of 10-day toxicity tests with the midge (*Chironomus tentans*) showed limited toxicity in most samples. In particular, a sediment sample with a mercury concentration 15 times the PEC only resulted in a reduced survival rate of 55%. Elevated levels of acid volatile sulfides and total organic carbon were suggested as potential reasons for the improved survival of the test organisms (Shaw, 2005). The toxicity testing (which included other co-located contaminants) identified less toxicity than would be suggested by the mercury PEC exceedances. These toxicity testing samples were collected and tested prior to the 2006 dredging effort and mercury concentrations have decreased since 2005 (maximum mercury concentration in the top 1 ft was 16.7 mg/kg in 2005 compared to a maximum of 12.4 mg/kg in the data set used to derive EPCs in the top 1 ft). Thus, toxicity to the benthic invertebrate community within the Bay has also likely decreased over time.

The majority of the sediment samples that have been collected for characterizing mercury concentrations have been characterized as gelatinous material. Due to the gelatinous nature of this material, it may be physically challenging for burrowing benthic invertebrate communities to be established. Studies have shown that high levels of fine-grained sediment, such as those expected within the gelatinous material, can be associated with lower species diversity and lower numbers of taxa representing Ephemeroptera, Plecoptera and Trichoptera (EPT) orders, which provide the most productive and available food for fish. Although other species like Chironomidae, Oligochaeta and Sphaeridae are able to burrow into fine sediment (Harrison, et al., 2007), it is not clear that the material within GGB is suitable for burrowing. Epibenthic organisms may be present on the surface of sediments within GGB. The gelatinous nature of the sediment may also be physically challenging for these species as there is not a solid substrate to attach to or move along.

It is possible that a benthic community is not currently present due to the unsuitability of the substrate, and therefore not exposed to the mercury contained in the gelatinous material with GGB. Ayers (1973) identified the flocculent consistency of the bay sediments as a stressor likely impacting the benthic community and the aquatic plant community. While Ayers (1973) noted a variety of benthic invertebrates colonized artificial substrate plates, few species were found within the sediments themselves. This potential lack of a benthic invertebrate community may reduce the potential for mercury to move up into the food web since there would be limited connections between mercury in sediment and invertebrates that may be consumed by some fish species and life stages. Sediment ingestion by fish is expected to occur within the gelatinous material.

A lack of benthic invertebrate community due to the presence of the gelatinous sediment and unstable substrate represents an impairment based on physical conditions within GGB. The substrate limitations (e.g., gelatinous nature of the sediment) may not limit the growth of plants or reduce foraging opportunities for herbivorous fish and some invertebrates may be present within the gelatinous material. Therefore, mercury may move into the food web via sediment ingestion, herbivorous pathways, or predation on epibenthic species, if present.

4.2.6.3.2 Viability and Function of the Fish Community

Mercury was evaluated with respect to the fish community by comparing fish tissue concentrations of mercury to fish tissue residue TRVs. NOAEL and LOAEL HQs based on measured panfish mercury concentrations were all less than 1 indicating that adverse impacts on small fish residing within the bay are not expected.

The NOAEL HQ, but not the LOAEL HQ, for higher trophic level fish slightly exceeded 1 (HQ = 1.2). As stated previously, higher trophic level sportfish are likely to be transient within GGB so would not feed exclusively on forage fish from the bay.

The maximum mercury concentration in upstream fish collected by WDNR in 2012 was approximately 0.038 mg/kg wet weight (WDNR, 2013) which would result in an estimated higher trophic level fish concentration of 0.32 mg/kg wet weight and a NOAEL HQ of 1.1 for the upstream fish community. This shows that risks to fish within GGB are in the same range as risks to fish in upstream areas.

Based on the lack of LOAEL HQs above 1, the uncertainties associated with the estimated concentration, and the similarity of GGB and upstream fish tissue concentrations, mercury in sediments is unlikely to result in potential risks to higher trophic level fish that obtain a portion of their diet within GGB.

4.2.6.3.3 Survival, Growth, and Reproduction of Mammalian Wildlife Community

Mercury was also evaluated for potential impacts on piscivorous mammals represented by the mink. NOAEL and LOAEL HQs based on ingestion of panfish and incidental ingestion of sediment were all less than 1 indicating that adverse impacts on mink foraging exclusively within the bay are not expected.

It is noted that this evaluation is based on ingestion of 100% panfish. The mink HQs remain below 1 if the diet contains less than 35% higher trophic level fish. As stated previously, higher trophic level fish are likely to spend limited time within the bay and mink are not as likely to consume large walleye or other sportfish so this evaluation is likely to be overly conservative. In addition, risks to a larger mammal like a river otter would be lower due to the increased body weight of the otter (average of 8 kg; USEPA, 1993). These evaluations show that adverse effects on piscivorous mammals foraging within the bay are unlikely.

4.2.7 Ecological Risk Assessment Conclusions

Ecological receptors evaluated in the ERA included benthic invertebrates, fish, and piscivorous mammals. Benthic invertebrate HQs based on the PEC ranged from 1.6 in the subsurface sediment data set (> 0.5 ft) to 1.9 in the surface data set (0 – 0.5 ft). According to WDNR (2003), these exceedances of the PEC suggest that toxicity to benthic-dwelling organisms is probable.

However, more recent literature suggests that the mercury PEC may over-estimate the potential for adverse effects on the benthic invertebrate community. A review of laboratory studies with mercury-spiked sediment and studies at mercury contaminated sites by Conder, et al. (2015) found that median no-observed effect concentrations reported for mercury-spiked studies (3.3 mg/kg) and mercury site investigations (22 mg/kg) were much higher than the PEC (1.1 mg/kg).

The EPCs from both the surface and subsurface sediment horizons (2.1 and 1.8 mg/kg, respectively) are below the median no-observed effect concentrations reported by Conder, et al. (2015) for both the mercury-spiked studies and mercury site investigations suggesting that the GGB sediment may not pose a risk to the benthic invertebrate community. This finding is supported by sediment toxicity testing conducted with GGB sediments in 2005 that indicated sediments were less toxic than expected based on comparisons to the PEC.

There is also uncertainty associated with whether a benthic invertebrate community is present within the mercury contaminated gelatinous sediments. If this material does not provide suitable habitat for a benthic invertebrate community, then there is reduced potential for mercury to cause toxicity to benthic organisms or for mercury to move up into the food web. Mercury may bioaccumulate into fish species and higher trophic levels species via sediment ingestion, herbivorous pathways, or fish predation on epibenthic species, if present.

For the fish community assessment endpoint, risks to small fish represented by panfish tissues were not identified. For higher trophic level fish, the NOAEL HQ was slightly above 1 suggesting the potential for adverse effects; however, based on the lack of LOAEL HQs above 1, the uncertainties associated with the estimated higher tropic level fish concentration, and the similarity of GGB and upstream fish tissue concentrations, mercury in sediments is unlikely to potential risks to higher trophic level fish that obtain a portion of their diet within GGB. The endpoints considered in determining the effects levels for fish were related to mortality or lethality-equivalent endpoints (e.g., fish mortality, failure to spawn); it is possible that other sub-lethal endpoints (e.g., inhibition of growth or behavioral changes) could be more sensitive than the selected endpoints and that risks to fish due to sub-lethal effects is under-estimated.

The potential for adverse effects of mercury on piscivorous mammals foraging within GGB is unlikely. NOAEL and LOAEL HQs based on ingestion of panfish and incidental ingestion of sediment by the mink were all less than 1 and inclusion of higher trophic level fish in the diet is not expected to pose a risk to mink or other piscivorous mammals like the river otter.

5.0 Previous Remedial Actions

Remediation activities associated with the 2000-2003 GGB Dredging Project are detailed in the *Draft Corrective Measures Implementation Report Gruber's Grove Bay Dredging Project, Revision 1* (Shaw, 2003). A hydraulic dredge (Mudcat MC-2000) was used to dredge 88,333 in situ CY within 16.5 surface acres containing total mercury concentrations of greater than 0.36 mg/kg. Significant debris was removed by mechanical excavators prior to dredging. However, debris blocked the cutterhead and booster pump impeller continuously during dredging. Sediments were dredged from GGB to geotextile tubes (111 tubes in three layers) for dewatering with the assistance of a cationic flocculant. Filtrate water was analyzed for water quality and disposed of through spray irrigation on a designated rangeland/forest on BAAP property as necessary. Once dewatered, the sediment management area and dewatered tubes were capped in place with a soil cover and wetlands constructed downgradient to treat filtrate downstream of the containment area.

Remediation activities associated with the 2006-2007 GGB Dredging Project are detailed in the *Remedial Action Completion Report Gruber's Grove Bay Dredging Project, Revision 1* (Shaw, 2007). A hydraulic dredge (Ellicott Dragon 370) was used to dredge 60,250 in situ CY from 17 acres containing total mercury concentrations of greater than 0.36 mg/kg. Sediments were dredged from GGB to geotextile tubes (21 tubes in three layers) for dewatering with the assistance of a cationic flocculant. Filtrate water was analyzed for water quality and disposed of through spray irrigation on a designated rangeland/forest on BAAP property as necessary. Once dewatered, the sediment management area and dewatered tubes were capped in place with a soil cover and wetlands constructed downgradient to treat filtrate downstream of the containment area. Although confirmation sampling was conducted during dredging and additional polishing passes were executed during construction, post-dredge sampling conducted the following year (2008) measured seven exceedances of the MPBC (0.36 mg/kg) from the ten samples collected and analyzed. Recreational activities within GGB were highlighted as a potential cause of sediment resuspension and increased mercury concentrations in surficial sediment.

Hydraulic dredging and geotextile tube dewatering activities described above were conventional methods used for excavating, capturing, dewatering, consolidating and monitoring contaminated dredge material. In AECOM's review of means and methods described in the Completion Reports there are no obvious contradictions to conventional sediment management practices that would explain the presence of mercury in surficial sediments above the MPBC value post-dredging, However, it appears that recontamination of surficial sediment of the targeted dredge area did occur relatively quickly after both remedial actions. This recontamination may be a function of several factors that may need to be investigated further including but not limited to:

1) Identification of additional potential sources of Hg from a landside source(s), upriver, in deep areas of the Bay sediment or wetlands;
2) Confirm nature and extent delineation of Hg-contaminated sediment and speciation per identified data gaps from the preliminary model;
3) Hydrologic and hydraulic (H&H) modeling and sediment transport modeling of particulate-associated Hg distribution; and
4) Geotechnical characterization and treatability tests of representative sediment samples to perform site-specific alternatives analysis and subsequently develop strategies to mitigate

"fall back" and "spill" of high organics and moisture content sediment during dredging, capping and/or other alternatives.

In addition to the previous hydraulic dredging and geotextile tube dewatering approach, additional alternatives to be considered as stand-alone strategies or in combination with other conventional strategies include amended engineered caps (e.g., powdered or granulated activated carbon, Sedimite, AquaGate, organoclay, zero-valent iron, apatite, zeolite and bauxite), MercLok™, dredging with high solids (Toyo) hydraulic pumps and/or use of shrouds over the suction-end of a dredge pump.

6.0 Recommendations

The overall recommendation for GGB is to close the desktop supplemental RI phase or work and begin the DGI to obtain key information needs for completion of the remedial alternatives analysis, to be summarized and presented in the FS report. The specific recommendations of this RI are to:

1) As part of DGI, conduct additional sediment investigation near the shorelines and near the mouth of the bay is recommended where historical sediment samples exceeded the MPBC. Historical sample depths in these areas advanced to approximately 3-ft below sediment surface (bss), therefore proposed depths would extend from 3 to 5-ft bss per SPS 2016 sediment thickness maps (SPS, 2016). As per preliminary modeling results, additional sampling is required to refine the vertical and lateral delineation of Hg in several hotspot areas as insufficient data are available to refine the uncertainty around plume margins. The sample collection procedures and laboratory analyses should be consistent with the previous sampling events for data quality. Previous geotechnical results for percent solids, bulk density, and particle size are available from the 2009 investigation for review and comparison of trends. Additional details would be developed as part of the DGI and associated scope of work.

2) Document in the DGI report, the absence of a mercury migration pathways from Settling Ponds using existing site characterization and investigation documentation.

3) With additional sediment data from the DGI, statistical modeling and plume refinement is recommended in order to calculate impacted sediment volumes with greater certainty and define potential dredge prisms for alternatives analyses and cost estimates as part of the FS.

4) As part of the FS, additional comparative analysis of existing data from the 2000 dataset through the 2016/2018 dataset is recommended to further understand overall trends in sediment mercury concentrations through time and between remedial actions. The location of total mercury detections and change in the concentration ranges within surface and subsurface sediment layers may assist in better understanding of the effects of past removal actions and determining the efficacy of future removal actions.

5) As part of the DGI, bench-scale treatability testing is recommended to evaluate the feasibility and measure efficacy of in situ and ex situ sediment dewatering and solidification/stabilization alternatives for sediment management for future remediation. Bulk sediment and surface water would be collected from three locations in GGB representing the range of conditions that challenge sediment dewatering (e.g., PSD, TOC and high Hg concentrations). Characterization would also include geotechnical analysis (e.g., moisture content, Atterberg Limit, bulk density, TOC, and PSD) of sediment samples. Additionally, dewatered and/or stabilized sediment samples will be characterized for disposal including Unconfined Compressive Strength (UCS) (ASTM D2216) and Toxicity Characteristic Leaching Procedure (TCLP) tests (SW-846 Test Method 1311) will be performed.

The DGI work plan will be developed in early 2024. The anticipated field mobilization for DGI activities is anticipated in late 2024 or early 2025. FS activities will overlap with the DGI and are anticipated in begin in late 2024 and be completed with a draft FS report in 2025.

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TABLES

Table 2-1
Post-Dredged Sediment Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

				CHEMICAL NAME	Mercury		Mercury	
				ANALYTIC METHOD	SW7471B		SW7473	
SAMPLE LOCATION	SAMPLE ID	SAMPLE DATE	START DEPTH (ft)	END DEPTH (ft)	Result (mg/kg)	Lab Qualifiers	Result (mg/kg)	Lab Qualifiers
GGB-01	GGB-01-1-SO-20160210	2/10/2016	0	0.5	0.44			
GGB-02	02-2-18-20180611	6/11/2018	0.5	1.1	0.068			
GGB-02	GGB-02-1-SO-20160210	2/10/2016	0	0.5	2			
GGB-03	GGB-03-1-SO-20160210	2/10/2016	0	0.5	0.49			
GGB-05	05-2-18-20180611	6/11/2018	0.5	1.3	0.8	M		
GGB-05	GGB-05-1-SO-20160210	2/10/2016	0	0.5	2.4			
GGB-06	06-2-18-20180612	6/12/2018	0.5	0.8	6.1			
GGB-06	GGB-DUP-7-SO-20160210	2/10/2016	0	0.5	3			
GGB-06	GGB-06-1-SO-20160210	2/10/2016	0	0.5	2.7	M		
GGB-08	08-2-18-20180612	6/12/2018	0.5	0.9	< 0.012	U		
GGB-08	GGB-08-1-SO-20160210	2/10/2016	0	0.4	1.8			
GGB-09	GGB-09-1-SO-20160210	2/10/2016	0	0.5	3.1			
GGB-10	10-1-18-20180612	6/12/2018	0	0.5	4			
GGB-10	10-2-18-20180612	6/12/2018	0.5	1.5	0.45			
GGB-10	10-3-18-20180612	6/12/2018	1.5	1.5	0.077			
GGB-10	GGB-10-1-SO-20160209	2/9/2016	0	0.5	4.6			
GGB-11	GGB-11-1-SO-20160209	2/9/2016	0	0.5	1.6			
GGB-14	14-2-18-20180612	6/12/2018	0.5	0.8	0.11			
GGB-14	14-3-18-20180612	6/12/2018	0.9	0.9	0.087			
GGB-14	GGB-14-1-SO-20160209	2/9/2016	0	0.5	2.8			
GGB-15	15-2-18-20180612	6/12/2018	0.5	0.8	1.3			
GGB-15	GGB-15-1-SO-20160209	2/9/2016	0	0.5	3.2			
GGB-18	GGB-18-1-SO-20160205	2/5/2016	0	0.5	0.11			
GGB-20	20-2-18-20180613	6/13/2018	0.5	1.1	0.12			
GGB-20	GGB-20-1-SO-20160209	2/9/2016	0	0.5	2.4			
GGB-21	21-2-18-20180613	6/13/2018	0.5	1.5	4.3			
GGB-21	21-3-18-20180613	6/13/2018	1.5	1.5	0.01	J		
GGB-21	GGB-21-1-SO-20160209	2/9/2016	0	0.5	4.9			
GGB-22	22-1-18 (D)-20180613	6/13/2018	0	0.5	3.1	M		
GGB-22	22-1-18-20180613	6/13/2018	0	0.5	3.6			
GGB-22	22-2-18-20180613	6/13/2018	0.5	1.1	0.12			
GGB-22	GGB-22-1-SO-20160209	2/9/2016	0	0.5	6.3			
GGB-25	25-2-18-20180613	6/13/2018	0.5	1	0.16			
GGB-25	GGB-25-1-SO-20160209	2/9/2016	0	0.5	6.1			
GGB-25R	25R-2-18-20180613	6/13/2018	0.5	1	1			
GGB-26	26-2-18 (D)-20180613	6/13/2018	0.5	1	0.12			
GGB-26	26-2-18-20180613	6/13/2018	0.5	1	0.056			
GGB-26	GGB-26-1-SO-20160209	2/9/2016	0	0.5	3.1			
GGB-27	27-2-18-20180613	6/13/2018	0.5	0.5	0.25			
GGB-27	GGB-27-1-SO-20160209	2/9/2016	0	0.5	2.3			
GGB-28	28-2-18-20180613	6/13/2018	0.5	0.8	8.8			
GGB-28	GGB-28-1-SO-20160209	2/9/2016	0	0.5	1.4	M		
GGB-33	33-2-18-20180614	6/14/2018	0.5	1.5	3			
GGB-33	33-3-18-20180614	6/14/2018	1.5	2.4	2.7			
GGB-33	33-4-18-20180614	6/14/2018	2.5	2.5	0.0093	JB		
GGB-33	GGB-DUP-6-SO-20160209	2/9/2016	0	0.5	1.7			
GGB-33	GGB-33-1-SO-20160209	2/9/2016	0	0.5	2.8			
GGB-35	GGB-35-1-SO-20160205	2/5/2016	0	0.5	0.059			
GGB-36	GGB-36-1-SO-20160208	2/8/2016	0	0.5	0.21			
GGB-37	37-2-18-20180612	6/12/2018	0.5	0.6	0.18			
GGB-37	GGB-37-1-SO-20160208	2/8/2016	0	0.5	3.9			
GGB-38	38-2-18-20180612	6/12/2018	0.5	0.6	0.14			
GGB-38	GGB-38-1-SO-20160208	2/8/2016	0	0.5	1.6			
GGB-39	GGB-39-1-SO-20160208	2/8/2016	0	0.5	3.5			
GGB-40	40-2-18-20180613	6/13/2018	0.5	0.5	0.56			
GGB-40	GGB-40-1-SO-20160209	2/9/2016	0	0.5	1.7			
GGB-41	GGB-41-1-SO-20160205	2/5/2016	0	0.5	0.11			
GGB-43	GGB-43-1-SO-20160208	2/8/2016	0	0.5	1.2			
GGB-44	44-2-18-20180612	6/12/2018	0.5	0.6	0.082			

				CHEMICAL NAME	Mercury		Mercury	
				ANALYTIC METHOD	SW7471B		SW7473	
SAMPLE LOCATION	SAMPLE ID	SAMPLE DATE	START DEPTH (ft)	END DEPTH (ft)	Result (mg/kg)	Lab Qualifiers	Result (mg/kg)	Lab Qualifiers
GGB-44	GGB-DUP-5-SO-20160208	2/8/2016	0	0.5	4			
GGB-44	GGB-44-1-SO-20160208	2/8/2016	0	0.5	3			
GGB-45	45-1-18-20180612	6/12/2018	0	0.3	0.56			
GGB-45	GGB-45-1-SO-20160208	2/8/2016	0	0.5	2			
GGB-46	46-1-18-20180612	6/12/2018	0	0.5	1.8			
GGB-46	46-2-18-20180612	6/12/2018	0.5	1	0.17			
GGB-46	GGB-46-1-SO-20160205	2/5/2016	0	0.5	1.7			
GGB-47	47-2-18-20180612	6/12/2018	0.5	0.7	0.14			
GGB-47	GGB-47-1-SO-20160205	2/5/2016	0	0.5	1.6			
GGB-49	GGB-49-1-SO-20160201	2/1/2016	0	0.5	0.036			
GGB-50	GGB-50-1-SO-20160201	2/1/2016	0	0.5	0.022			
GGB-51	GGB-51-1-SO-20160201	2/1/2016	0	0.5	0.032			
GGB-52	GGB-52-1-SO-20160201	2/1/2016	0	0.5	0.037			
GGB-54	54-2-18-20180613	6/13/2018	0.5	0.7	0.1			
GGB-54	GGB-54-1-SO-20160208	2/8/2016	0	0.5	1.3			
GGB-55	55-2-18-20180615	6/15/2018	0.5	1.5	0.25			
GGB-55	55-3-18-20180615	6/15/2018	1.5	2.4	3.1			
GGB-55	55-4-18-20180615	6/15/2018	2.4	2.5	0.043	JV		
GGB-55	GGB-55-1-SO-20160205	2/5/2016	0	0.5	3.7			
GGB-56	56-2-18-20180615	6/15/2018	0.5	1.5	12			
GGB-56	56-3-18-20180615	6/15/2018	1.5	2	0.16			
GGB-56	GGB-56-1-SO-20160205	2/5/2016	0	0.5	3.2			
GGB-57	57-2-18-20180615	6/15/2018	0.5	1	0.15			
GGB-57	GGB-57-1-SO-20160205	2/5/2016	0	0.5	1.2			
GGB-58	58-1-18-20180618	6/18/2018	0	0.5	1.4			
GGB-58	58-2-18 (D)-20180618	6/18/2018	0.5	1.5	1.8			
GGB-58	58-2-18-20180618	6/18/2018	0.5	1.5	1.9	M		
GGB-58	58-3-18-20180618	6/18/2018	1.5	2.8	4.3			
GGB-58	58-4-18-20180618	6/18/2018	2.8	2.9	0.078			
GGB-58	GGB-58-1-SO-20160205	2/5/2016	0	0.5	3.4	M		
GGB-59	59-2-18-20180618	6/18/2018	0.5	1.5	1.8			
GGB-59	59-3-18-20180618	6/18/2018	1.5	1.7	0.063	JV		
GGB-59	GGB-DUP-4-SO-20160205	2/5/2016	0	0.5	3.1			
GGB-59	GGB-59-1-SO-20160205	2/5/2016	0	0.5	3.7			
GGB-60	60-2-18-20180618	6/18/2018	0.5	1.5	3.4			
GGB-60	60-3-18-20180618	6/18/2018	1.5	1.9	0.038	JV		
GGB-60	GGB-DUP-1-SO-20160201	2/1/2016	0	0.5	2.4			
GGB-60	GGB-60-1R-SO-20160210	2/10/2016	0	0.5	1.5			
GGB-60	GGB-60-1-SO-20160201	2/1/2016	0	0.5	1			
GGB-60R	GGB-DUP-8-SO-20160210	2/10/2016	0	0.5	0.88			
GGB-61	GGB-61-1-SO-20160205	2/5/2016	0	0.5	0.18			
GGB-61	GGB-62-1-SO-20160201	2/1/2016	0	0.5	0.38			
GGB-63	GGB-63-1-SO-20160201	2/1/2016	0	0.5	0.31			
GGB-64	GGB-64-1-SO-20160205	2/5/2016	0	0.5	0.27			
GGB-68	68-2-18-20180618	6/18/2018	0.5	1.5	2.5			
GGB-68	68-3-18-20180618	6/18/2018	1.5	1.9	0.11			
GGB-68	GGB-68-1-SO-20160205	2/5/2016	0	0.5	2.3			
GGB-69	69-2-18-20180618	6/18/2018	0.5	1.5	2.7			
GGB-69	69-3-18-20180618	6/18/2018	1.5	2.4	0.092			
GGB-69	GGB-69-1-SO-20160201	2/1/2016	0	0.5	1.3			
GGB-72	GGB-72-1-SO-20160204	2/4/2016	0	0.5	0.16			
GGB-72	GGB-73-1-SO-20160204	2/4/2016	0	0.5	1.4			
GGB-73	73-2-18-20180615	6/15/2018	0.5	0.8	0.051	JV		
GGB-74	74-2-18-20180618	6/18/2018	0.5	1	0.48			
GGB-74	GGB-74-1-SO-20160204	2/4/2016	0	0.5	1.7			
GGB-75	GGB-75-1-SO-20160204	2/4/2016	0	0.5	0.34			
GGB-77	77-1-18 (D)-20180615	6/15/2018	0	0.5	0.98			
GGB-77	77-1-18-20180615	6/15/2018	0	0.5	1.1	Y		
GGB-77	77-2-18-20180615	6/15/2018	0.5	1.5	0.81			

Table 2-1
Post-Dredged Sediment Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

				CHEMICAL NAME	Mercury		Mercury	
				ANALYTIC METHOD	SW7471B		SW7473	
SAMPLE LOCATION	SAMPLE ID	SAMPLE DATE	START DEPTH (ft)	END DEPTH (ft)	Result (mg/kg)	Lab Qualifiers	Result (mg/kg)	Lab Qualifiers
GGB-77	77-3-18-20180615	6/15/2018	1.5	2.2	1.1			
GGB-77	77-4-18-20180615	6/15/2018	2.2	2.3	0.11			
GGB-77	GGB-77-1-SO-20160204	2/4/2016	0	0.5	2.1			
GGB-78	78-1-18-20180614	6/14/2018	0	0.5	0.37			
GGB-78	78-2-18-20180614	6/14/2018	0.5	1.5	0.72			
GGB-78	78-3-18-20180614	6/14/2018	1.5	1.8	0.13			
GGB-78	GGB-78-1-SO-20160204	2/4/2016	0	0.5	0.52			
GGB-79	GGB-79-1-SO-20160204	2/4/2016	0	0.5	0.44			
GGB-81	81-2-18-20180614	6/14/2018	0.5	1.5	3			
GGB-81	81-3-18-20180614	6/14/2018	1.5	1.6	0.035	B		
GGB-81	GGB-DUP-3-SO-20160204	2/4/2016	0	0.5	1.2			
GGB-81	GGB-81-1-SO-20160204	2/4/2016	0	0.5	0.89			
GGB-82	82-2-18-20180614	6/14/2018	0.5	1.5	2.3			
GGB-82	82-3-18-20180614	6/14/2018	1.5	2.2	0.13			
GGB-82	GGB-DUP-2-SO-20160202	2/2/2016	0	0.5	0.51			
GGB-82	GGB-82-1-SO-20160202	2/2/2016	0	0.5	0.67			
GGB-89	89-1-18-20180614	6/14/2018	0	0.5	0.97			
GGB-89	89-2-18-20180614	6/14/2018	0.5	1.5	0.98			
GGB-89	89-3-18-20180614	6/14/2018	1.5	2.5	2.8			
GGB-89	89-4-18-20180614	6/14/2018	2.5	2.6	0.074	M		
GGB-89	GGB-89-1-SO-20160204	2/4/2016	0	0.5	0.85			
GGB-90	GGB-90-1-SO-20160202	2/2/2016	0	0.5	0.023			
GGB-96	96-1-18-20180614	6/14/2018	0	0.5	0.52			
GGB-96	96-2-18 (D)-20180614	6/14/2018	0.5	1.5	0.5			
GGB-96	96-2-18-20180614	6/14/2018	0.5	1.5	0.56			
GGB-96	96-3-18-20180614	6/14/2018	1.5	2.5	2.5			
GGB-96	96-4-18-20180614	6/14/2018	2.5	2.9	0.098			
GGB-97	97-1-18-20180614	6/14/2018	0	0.5	0.36			
GGB-97	97-2-18-20180614	6/14/2018	0.5	1.5	2.2			
GGB-97	97-3-18-20180614	6/14/2018	1.5	2.2	1.5			
GRUBERS BAY 01	GRUBERS BAY 01	5/29/2019	0.05	0.05			0.75	
GRUBERS BAY 01	GRUBERS BAY 01_SUS	5/29/2019	1	1			1.4	
GRUBERS BAY 02	GRUBERS BAY 02	5/29/2019	0.05	0.05			0.99	
GRUBERS BAY 02	GRUBERS BAY 02_SUS	5/29/2019	1.3	1.3			1.4	
GRUBERS BAY 03	GRUBERS BAY 03	5/29/2019	0.05	0.05			1.4	
GRUBERS BAY 04	GRUBERS BAY 04	5/29/2019	0.05	0.05			0.51	
GRUBERS BAY 05	GRUBERS BAY 05	5/29/2019	0.05	0.05			0.43	
GRUBERS BAY 06	GRUBERS BAY 06	5/29/2019	0.05	0.05			0.39	
GRUBERS BAY 06	GRUBERS BAY 06_SUS	5/29/2019	1.3	1.3			1.2	
GRUBERS BAY 07	GRUBERS BAY 07	5/29/2019	0.05	0.05			0.38	
GRUBERS BAY 07	GRUBERS BAY 07_SUS	5/29/2019	1.3	1.3			1	
GRUBERS BAY 08	GRUBERS BAY 08	5/29/2019	0.05	0.05			0.36	
GRUBERS BAY 09	GRUBERS BAY 09	5/29/2019	0.05	0.05			0.35	
GRUBERS BAY 10	GRUBERS BAY 10_0.05M	5/29/2019	0.05	0.05			0.34	
GRUBERS BAY 10	GRUBERS BAY 10_0.15M	5/29/2019	0.15	0.15			0.35	
GRUBERS BAY 10	GRUBERS BAY 10_0.30M	5/29/2019	0.3	0.3			0.51	
GRUBERS BAY 10	GRUBERS BAY 10_0.45M	5/29/2019	0.45	0.45			0.64	
GRUBERS BAY 11	GRUBERS BAY 11_0.05M	5/29/2019	0.05	0.05			0.34	
GRUBERS BAY 11	GRUBERS BAY 11_0.15M	5/29/2019	0.15	0.15			0.38	
GRUBERS BAY 11	GRUBERS BAY 11_0.30M	5/29/2019	0.3	0.3			0.5	
GRUBERS BAY 11	GRUBERS BAY 11_0.45M	5/29/2019	0.45	0.45			0.65	
GRUBERS BAY LAYDOWN	GRUBERS BAY LAYDOWN	5/30/2019	0.127	0.127			0.51	
GRUBERS LAYOUT POND	GRUBERS LAYOUT POND_SUS	5/30/2019	0	0			7.5	
GRUBERS MARGIN 01	GRUBERS MARGIN 01	5/29/2019	0.05	0.05			0.33	
GRUBERS MARGIN 02	GRUBERS MARGIN 02	5/29/2019	0.05	0.05			0.31	
GRUBERS MARGIN 03	GRUBERS MARGIN 03_0.05M	5/29/2019	0.05	0.05			0.32	
GRUBERS MARGIN 03	GRUBERS MARGIN 03_0.15M	5/29/2019	0.15	0.15			0.33	
GRUBERS MARGIN 03	GRUBERS MARGIN 03_0.30M	5/29/2019	0.3	0.3			0.41	
GRUBERS MARGIN 03	GRUBERS MARGIN 03_0.43M	5/29/2019	0.43	0.43			0.53	

Table 2-1
Post-Dredged Sediment Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

				CHEMICAL NAME	Mercury		Mercury	
				ANALYTIC METHOD	SW7471B		SW7473	
SAMPLE LOCATION	SAMPLE ID	SAMPLE DATE	START DEPTH (ft)	END DEPTH (ft)	Result (mg/kg)	Lab Qualifiers	Result (mg/kg)	Lab Qualifiers
GRUBERS MARGIN 04	GRUBERS MARGIN 04	5/29/2019	0.05	0.05			0.31	
GRUBERS MARGIN 05	GRUBERS MARGIN 05	5/29/2019	0.05	0.05			0.37	

Notes:
Exceeds the Most Probable Background Concentration of 0.36 mg/kg
Exceeds the AECOM calculated 95% UTL Background Value of 0.49 mg/kg
Exceeds the SQG midpoint effect concentration (MEC) of 0.64 mg/kg
Lab Qualifier (2018 samples) B = Analyte detected in the associated Method Blank.
Lab Qualifier (2018 samples) J = Estimated value.
Lab Qualifier (2018 samples) V = Raised Quantitation or Reporting Limit due to limited sample amount or dilution for matrix background interference.
Lab Qualifier (2016 & 2018 samples) M = Matrix spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
Lab Qualifier (2018 samples) U = Analyte concentration was below detection limit.
Lab Qualifier (2018 samples) Y = Replicate/Duplicate precision outside acceptance limits.

Table 2-2
Post-Dredging Vertical Delineation Sediment Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Location ID	Sample Event	Original Depth (ft)	2016 Gelatinous Thickness (ft)	Delineated Depth (ft)	Final Result (mg/kg)	Notes	Sediment Description
GGB-4	2009	0.8	--	--	**1.1**		dark gray, clay, cohesive, soft (gelatinous sediment overlying)
GGB-23	2009	0.5	--	--	**0.49**		dark gray, clay, medium stiff (2-inch gelatinous sediment overlying)
GGB-01	2016	0.5	0.3	NS	**0.44**		black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt
GGB-02	*2016*	*0.5*	*0.0*	*1.1*	*0.068*	*Delineated during 2018*	*black, silty clay, cohesive, soft*
GGB-03	2016	0.5	0.2	NS	**0.49**		black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt
GGB-05	2016	0.5	0.3	--	**2.4**		black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt
GGB-05	2018	1.3	0.3	--	**8.0**		dark gray, silty clay, cohesive, firm (gelatinous sediment overlying)
GGB-06	2016	0.5	0.4	--	**2.7**		black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt
GGB-06	2018	0.8	0.4	--	**6.1**		black, silty clay, cohesive, soft (gelatinous sediment overlying)
GGB-08	*2016*	*0.5*	*0.4*	*0.9*	*<0.012*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt*
GGB-09	2016	0.5	0.1	--	**3.1**		minimal gelatinous sediment
GGB-10	*2016*	*0.5*	*0.1*	*1.5*	*0.77*	*Delineated during 2018*	minimal gelatinous sediment
GGB-11	2016	0.5	0.2	--	**1.6**		minimal gelatinous sediment
GGB-14	*2016*	*0.5*	*0.3*	*0.9*	*0.087*	*Delineated during 2018*	minimal gelatinous sediment
GGB-15	2016	0.5	0.3	--	**3.2**		minimal gelatinous sediment
GGB-15	2018	0.8	0.2	--	**1.3**		black, silty clay, cohesive, soft (gelatinous sediment overlying)
GGB-20	*2016*	*0.5*	*0.4*	*1.1*	*0.12*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt*
GGB-21	*2016*	*0.5*	*0.6*	*1.5*	*0.01*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-22	*2016*	*0.5*	*0.1*	*1.1*	*0.12*	*Delineated during 2018*	*minimal gelatinous sediment*

Table 2-2
Post-Dredging Vertical Delineation Sediment Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Location ID	Sample Event	Original Depth (ft)	2016 Gelatinous Thickness (ft)	Delineated Depth (ft)	Final Result (mg/kg)	Notes	Sediment Description
GGB-25	*2016*	*0.5*	*0.1*	*1.0*	*0.16*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-25R	2018	1.0	0.0	--	**1.0**		black, silty clay, cohesive, firmer
GGB-26	*2016*	*0.5*	*0.2*	*1.0*	*0.056*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-27	*2016*	*0.5*	*0.3*	*0.5*	*0.25*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-28	2016	0.5	0.4	--	**1.4**		black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt
GGB-28	2018	0.8	0.4	--	**8.8**		black, silty clay, soft, moist (gelatinous sediment overlying)
GGB-33	*2016*	*0.5*	*1.5*	*2.5*	*0.0093*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-37	*2016*	*0.5*	*0.3*	*0.6*	*0.18*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-38	*2016*	*0.5*	*0.2*	*0.6*	*0.14*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-39	2016	0.5	0.3	NS	**3.5**		minimal gelatinous sediment
GGB-40	2016	0.5	0.4	--	**1.7**		black, very fine-grained gelatinous sediment, non-cohesive, wet
GGB-40	2018	0.5	0.4	--	**0.56**		dark gray, silty clay, cohesive, firmer (gelatinous sediment overlying)
GGB-43	2016	0.5	0.0	NS	**1.2**		black, sandy silt, wet
GGB-44	*2016*	*0.5*	*1*	*0.6*	*0.082*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-45	2016	0.5	0.6	--	**2**		black, very fine-grained gelatinous sediment, non-cohesive, wet
GGB-45	2018	0.3	0.6	--	**0.56**		black, silt, soft, cohesive, moist (gelatinous sediment overlying)
GGB-46	*2016*	*0.5*	*0.4*	*1.0*	*0.17*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-47	*2016*	*0.5*	*0.5*	*0.7*	*0.14*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-54	*2016*	*0.5*	*0.4*	*0.7*	*0.1*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-55	*2016*	*0.5*	*0.3*	*2.5*	*0.25*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-56	*2016*	*0.5*	*0.3*	*2.0*	*0.16*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-57	*2016*	*0.5*	*0.5*	*1.0*	*0.15*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-58	*2016*	*0.5*	*0.4*	*2.9*	*0.078*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*

Table 2-2
Post-Dredging Vertical Delineation Sediment Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Location ID	Sample Event	Original Depth (ft)	2016 Gelatinous Thickness (ft)	Delineated Depth (ft)	Final Result (mg/kg)	Notes	Sediment Description
GGB-59	*2016*	*0.5*	*0.7*	*1.7*	*0.063*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-60	*2016*	*0.5*	*1.4*	*1.9*	*0.038*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-60R	*2016*	*0.5*	*1.1*	*see GGB-60*	*0.038*	*Delineated during 2018; see GGB-60*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-62	2016	0.5	0.2	--	**0.38**		minimal gelatinous sediment
GGB-68	*2016*	*0.5*	*0.5*	*1.9*	*0.11*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-69	*2016*	*0.5*	*0.5*	*2.4*	*0.092*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-73	*2016*	*0.5*	*0.7*	*0.8*	*0.051*	*Delineated during 2018*	black, very fine-grained gelatinous sediment, non-cohesive, wet, trace brown silt
GGB-74	2016	0.5	--	--	**1.7**		minimal gelatinous sediment
GGB-74	2018	1.0	--	--	**0.48**		gray, sandy clay, firm (gelatinous sediment overlying)
GGB-77	*2016*	*0.5*	*0.2*	*2.3*	*0.11*	*Delineated during 2018*	*minimal gelatinous sediment*
GGB-78	*2016*	*0.5*	*1.0*	*1.8*	*0.13*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-79	2016	0.5	--	--	**0.44**		black, sandy silty clay, firm, moist
GGB-81	*2016*	*0.5*	*1.2*	*1.6*	*0.035*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-82	*2016*	*0.5*	*0.7*	*2.2*	*0.13*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-89	*2016*	*0.5*	*0.5*	*2.6*	*0.074*	*Delineated during 2018*	*black, very fine-grained gelatinous sediment, non-cohesive, wet*
GGB-96	*2018*	*2.9*	--	*2.9*	*0.098*	*Delineated during 2018*	*black, silty clay, firm (gelatinous sediment overlying)*
GGB-97	2018	2.2	--	--	**1.5**		black, silty clay, firm (gelatinous sediment overlying)

Table 2-3
Summary of Background Concentrations for Total Mercury
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

SAMPLE LOCATION	SAMPLE DATE	DEPTH (cm)	Mercury (mg/kg)
WIEGANDS BAY 2	5/30/2019	5	0.16
WIEGANDS BAY 4	5/30/2019	5	0.21
WIEGANDS BAY 5	5/30/2019	5	0.21
WIEGANDS BAY 6	5/30/2019	5	0.23
WIEGANDS BAY 13	5/30/2019	5	0.2
WIEGANDS BAY 3	5/30/2019	5	0.18
WIEGANDS BAY 15	5/30/2019	5	0.27
WIEGANDS BAY 9	5/30/2019	5	0.22
WIEGANDS BAY 17	5/30/2019	5	0.31
WIEGANDS BAY 14	5/30/2019	5	0.28
WIEGANDS BAY 1	5/30/2019	5	0.086
WIEGANDS BAY 16	5/30/2019	5	0.25
WIEGANDS BAY 7	5/30/2019	5	0.16
WIEGANDS BAY 11	5/30/2019	5	0.16
WIEGANDS BAY 10	5/30/2019	5	0.24
WIEGANDS BAY 8	5/30/2019	5	0.2
PINE BLUFF TRANSECT, CENTER	5/28/2019	5	0.27
PINE BLUFF TRANSECT, SOUTH	5/28/2019	5	0.37
PINE BLUFF TRANSECT, SOUTH	5/28/2019	5	0.42
PINE BLUFF TRANSECT, NORTH	5/28/2019	5	0.18
TRESTLE, SOUTH	5/28/2019	5	0.52
SUNSET	5/28/2019	5	0.35
SOD HOUSE	5/28/2019	5	0.072
TRESTLE, NORTH	5/28/2019	5	0.39
TIPPERARY BLUFFS	5/28/2019	5	0.13
TIPPERARY BLUFFS	5/28/2019	5	0.068
MOON VALLEY	5/28/2019	5	0.38

Table 2-4
Calculation of Revised Background Threshold Value Total Mercury
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Normal Background Statistics for Uncensored Full Data Sets

General Statistics			
Total Number of Observations	27	Number of Distinct Observations	21
Minimum	68	First Quartile	170
Second Largest	420	Median	220
Maximum	520	Third Quartile	295
Mean	241.3	SD	110.2
Coefficient of Variation	0.457	Skewness	0.61
Mean of logged Data	5.374	SD of logged Data	0.509

Critical Values for Background Threshold Values (BTVs)	
Tolerance Factor K (For UTL)	2.26

Normal GOF Test		
Shapiro Wilk Test Statistic	0.961	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.923	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.104	Lilliefors GOF Test
5% Lilliefors Critical Value	0.167	Data appear Normal at 5% Significance Level
Data appear Normal at 5% Significance Level		

Background Statistics Assuming Normal Distribution	
95% UTL with 95% Coverage	490.4

Table 4-1
Summary Statistics for Sediment Considered in the Risk Assessment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Sediment Dataset	Number of Samples	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Mean Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Distribution of Dataset	Selected UCL (mg/kg)	UCL Basis
Surface Sediment (0 - 0.5 ft)	63	100%	0.022	1.7	6.3	No Distribution	2.1	95% Student's-t UCL
Subsurface Sediment (>0.5 ft)	63	98%	0.0093	1.3	12.4	No Distribution	1.8	95% Student's-t UCL

Notes:
All results reported in milligrams per kilogram (mg/kg).
The distribution of datasets was determined using the Goodness-of-Fit tests (significance level 0.05) in USEPA ProUCL Version 5.2.
Upper Confidence Limit (UCL) on the arithmetic mean concentration calculated using USEPA ProUCL Version 5.2.
The UCL suggested by ProUCL is used, unless otherwise noted.

Table 4-2
Hazard Quotients for the Recreational Receptor - Ingestion of Fish Tissue
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Chemical	Panfish Tissue Concentration [1] (mg/kg-ww)	Sportfish Tissue Concentration [2] (mg/kg-ww)	Risk-Based Screening Level for Fish Tissue [3] (mg/kg)	Hazard Quotients [5]	
				Panfish	Sportfish
Young Child					
Mercury (fish tissue; methyl mercury exposure) [4]	0.044	0.37	0.087	0.5	**4.20**
Adult					
Mercury (fish tissue; methyl mercury exposure) [4]	0.044	0.37	0.15	0.3	**2.37**

Notes:

1. Maximum panfish concentration (0.044 mg/kg wet weight) collected from Grubers Grove Bay in 2012 (WDNR 2013).
2. Concentration of methylmercury in larger sportfish was estimated by applying a trophic magnification factor of 8.3 to the panfish concentration (Lavoie et al. 2013).
3. Risk-based screening level calculated using USEPA's Regional Screening Level Calculator for fish ingestion exposure. Default exposure assumptions were used including a historical default fish ingestion rate of 54 grams/day (adult) and 18 grams/day (child); it was conservatively assumed that all fish consumed comes from Grubers Grove Bay.
4. Form of mercury in fish tissue assumed to be methylmercury.
5. Hazard Quotient = Tissue Exposure Point Concentration / Risk-Based Screening Level.

Table 4-3
Hazard Quotients for the Recreational Receptor - Direct Contact with Sediment
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Chemical	Sediment Exposure Point Concentration (95% UCL) (mg/kg)	Risk-Based Screening Level for Sediment [1] (mg/kg)	Hazard Quotient [3]
Young Child			
Mercury (0-0.5 ft sediment; inorganic mercury exposure) [2]	2.1	54.7	0.038
Mercury (>0.5 ft sediment; inorganic mercury exposure) [2]	1.8	54.7	0.033
Adult			
Mercury (0-0.5 ft sediment; inorganic mercury exposure) [2]	2.1	584	0.004
Mercury (>0.5 ft sediment; inorganic mercury exposure) [2]	1.8	584	0.003

Notes:

1. Risk-based screening levels were calculated using USEPA's Regional Screening Level (RLS) Calculator for a recreational receptor with occasional direct contact exposure to sediment. Default exposure assumptions were used except for exposure frequency (150 days/year), exposure time (2 hours/day) and sediment dermal adherence (0.2 mg/cm2 for child and 0.3 mg/cm2 for adult).

2. Form of mercury in sediment is assumed to be inorganic (i.e, mercuric chloride).

3. Hazard Quotient = Sediment Exposure Point Concentration / Risk-Based Screening Level.

Table 4-4
Cumulative Hazard Indices for the Recreational Receptor
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Chemical	Young Child			Adult		
	Fish Ingestion Hazard Quotient	Sediment Direct Contact Hazard Quotient	Cumulative Hazard Index	Fish Ingestion Hazard Quotient	Sediment Direct Contact Hazard Quotient	Cumulative Hazard Index
Mercury (0-0.5 ft sediment; inorganic mercury exposure)						
Panfsh Consumption	0.5	0.038	0.54	0.3	0.004	0.29
Sportfish Consumption	4.2	0.038	**4.24**	2.4	0.004	**2.37**
Mercury (>0.5 ft sediment; inorganic mercury exposure)						
Panfsh Consumption	0.5	0.033	0.54	0.3	0.003	0.29
Sportfish Consumption	4.2	0.033	**4.23**	2.4	0.003	**2.37**

Table 4-5
Hazard Quotients for the Benthic Invertebrate Community
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Chemical	Units	TEC	MEC	PEC	Sediment Concentration (95% UCL)	TEC HQ (unitless)	MEC HQ (unitless)	PEC HQ (unitless)
Mercury	mg/kg	0.18	0.64	1.1	2.1	**11**	**3.2**	**1.9**

Subsurface Sediment (>0.5 ft)								
Chemical	Units	TEC	MEC	PEC	Sediment Concentration (95% UCL)	TEC HQ (unitless)	MEC HQ (unitless)	PEC HQ (unitless)
Mercury	mg/kg	0.18	0.64	1.1	1.8	**10**	**2.8**	**1.6**

Notes:
Shaded cells indicate an HQ greater than 1.
95% UCL - 95% upper confidence limit of the mean, a representation of the exposure point concentration
HQ - hazard quotient; calculated as the 95% UCL divided by the TEC, MEC, or PEC
MEC - midpoint effect concentration (WDNR, 2003)
PEC - probable effect concentration (WDNR, 2003)
TEC - threshold effect concentration (WDNR, 2003)

Table 4-6
Hazard Quotients for the Fish Community
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Whole Body Panfish - Mercury						
Fish Species	Units	Fish Tissue Concentration [1]	TRV_{NOAEL} [2]	TRV_{LOAEL} [2]	HQ_{NOAEL} (unitless)	HQ_{LOAEL} (unitless)
Bluegill & Pumpkinseed (small panfish)	mg/kg_{ww}	0.044	0.3	1.0	0.15	0.044
Higher trophic level fish	mg/kg_{ww}	0.37	0.3	1.0	**1.2**	0.37

Notes:
Shaded cells indicate an HQ greater than 1.
HQ - hazard quotient; calculated as the fish tissue concentration divided by the NOAEL- or LOAEL-based TRV
LOAEL - lowest-observed-adverse-effect level
NOAEL - no-observed-adverse-effect level
TRV - toxicity reference value

1. Maximum mercury concentrations for panfish collected from Grubers Grove Bay in 2012.
Value estimated from Figure 2 of Lake Wisconsin Whole Panfish Mercury 2012 (WDNR, 2013).
Concentration of methylmercury in higher trophic level fish was estimated by applying a trophic magnification factor of 8.3 to the panfish concentration (Lavoie et al., 2013).
2. TRV obtained from Dillon et al. (2010). NOAEL represents 8.2% modeled percent injury at 0.3 mg/kg wet weight tissue concentration. LOAEL represents 24.0% modeled percent injury at 1 mg/kg wet weight tissue concentration.

Table 4-7
Hazard Quotients for the Mink
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

Ingestion Exposure Scenario	Sediment Concentration (95% UCL) (mg/kg_{dw})	Fish Tissue Concentration [1] (mg/kg_{dw})	Dose (mg/kg-bw/d) from: Sediment	Dose (mg/kg-bw/d) from: Fish	Total Daily Dose (mg/kg-bw/day)	Toxicity Reference Value NOAEL (mg/kg-bw/day)	Toxicity Reference Value LOAEL (mg/kg-bw/day)	Hazard Quotients NOAEL	Hazard Quotients LOAEL
Surface Sediment (0 - 0.5 ft)									
Mercury (fish tissue; methylmercury exposure) [2]	--	0.18	--	0.0082	0.0082	0.032	0.16	0.26	0.052
Mercury (0 - 0.5 ft sediment; inorganic mercury exposure) [3]	2.1	--	0.0029	--	0.0029	1.41	14.1	0.0020	0.00020
Subsurface Sediment (>0.5 ft)									
Mercury (fish tissue; methylmercury exposure) [2]	--	0.18	--	0.0082	0.0082	0.032	0.16	0.26	0.052
Mercury (>0.5 ft sediment; inorganic mercury exposure) [3]	1.8	--	0.0025	--	0.0025	1.41	14.1	0.0018	0.00018

Exposure Parameters:

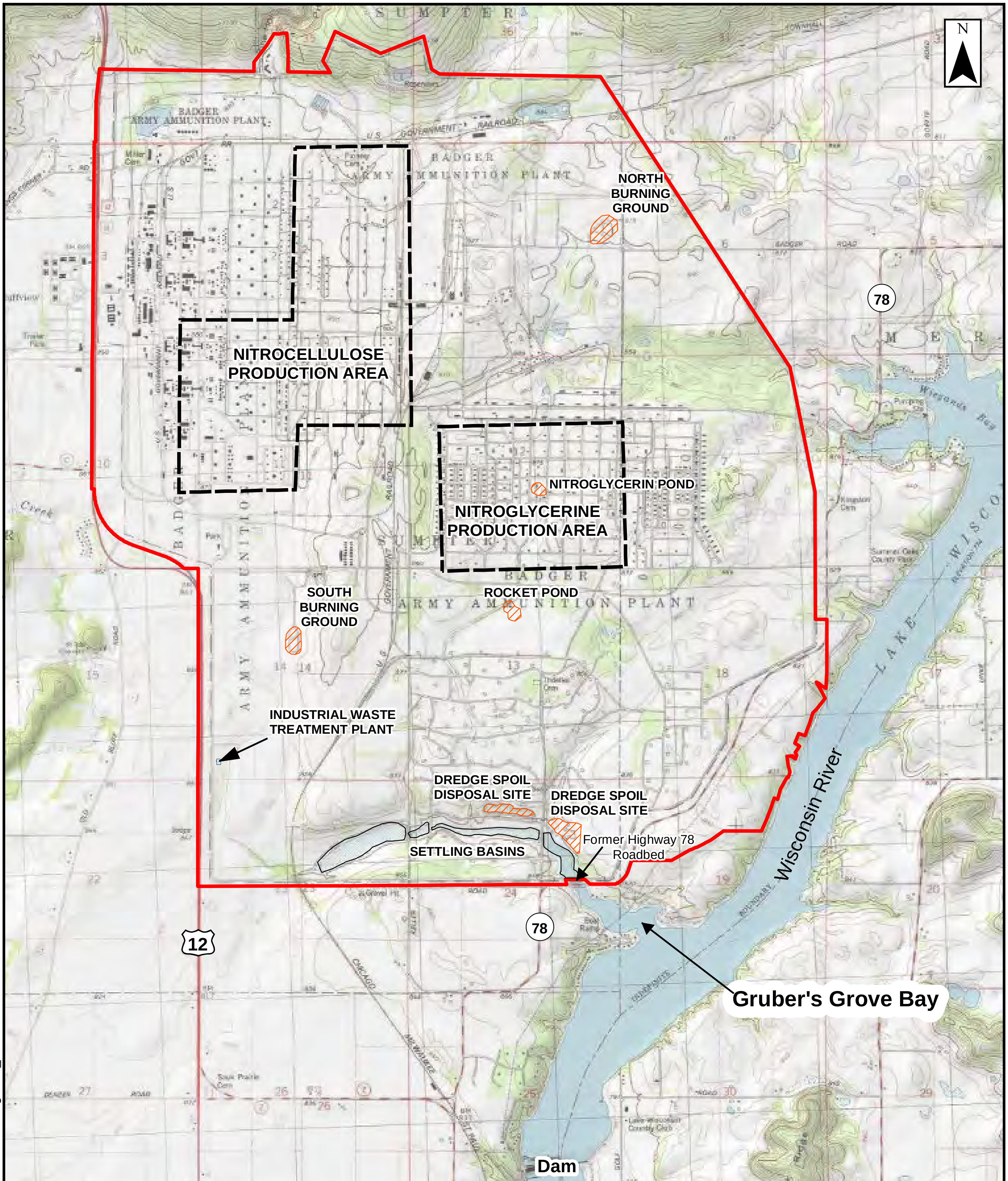
Body Weight = (BW)	1.2	kg	Dose (sediment) = (Cs * Is)(AUF)(SUF)/BW	LOAEL = Lowest Observed Adverse Effects Level
Fish Ingestion Rate = (If)	0.058	kg_{dw}/day	Dose (fish) = (Cf * If)(AUF)(SUF)/BW	NOAEL = No Observed Adverse Effects Level
Sediment Ingestion Rate = (Is)	0.0018	kg_{dw}/day	Cf = Contaminant concentration in fish	Hazard Quotient = Dose / Toxicity Reference Value
Home Range = (HR)	Assume 100% on site		Cs = Contaminant concentration in sediment	
Contaminated Area = (CA)	Assume equal to home range		Total Dose = Dose (sediment) + Dose (fish)	
Area Use Factor = (AUF)	1	unitless	AUF=CA/HR (Assume = to 1)	
Seasonal Use Factor = (SUF)	1	unitless	Assumed receptors present all year.	

Shaded cells indicate an HQ greater than 1.

Notes for Mink
Average of mean body weights for adult male and female mink (USEPA, 1993).
Food ingestion rate calculated using algorithm for carnivorous mammals developed by Nagy, 2001 [FIR (g_{dw}/day) = $0.153*BW^{0.834}$] using body weight listed above.
Sediment ingestion rate estimated to be 3% using weasel as surrogate for mink (Sample, et al. 1997).
Diet assumed to be exclusively fish.

1. Maximum panfish concentration (0.044 mg/kg wet weight) collected from Grubers Grove Bay in 2012 (WDNR 2013). Tissue data converted from wet weight to dry weight assuming 75% moisture for bony fish (USEPA, 1993). Dry weight = Wet weight / % solids.
2. Fish tissue assumed to represent methylmercury and used to calculate methylmercury dose. Methylmercury NOAEL and LOAEL values obtained from study of rats conducted by Verschuuren, et al. (1976) as cited in LANL EcoRisk Database 4.3 (N3B, 2022).
3. Sediment assumed to represent inorganic mercury and used to calculate inorganic mercury dose. Inorganic mercury NOAEL and LOAEL values obtained from study of mink conducted by Aulerich, et al. (1974) as cited in LANL EcoRisk Database 4.3 (N3B, 2022).

FIGURES



Legend

- Production Areas
- Potential Contamination Sources
- Settling Basins
- Badger Army Ammunition Plant Boundary

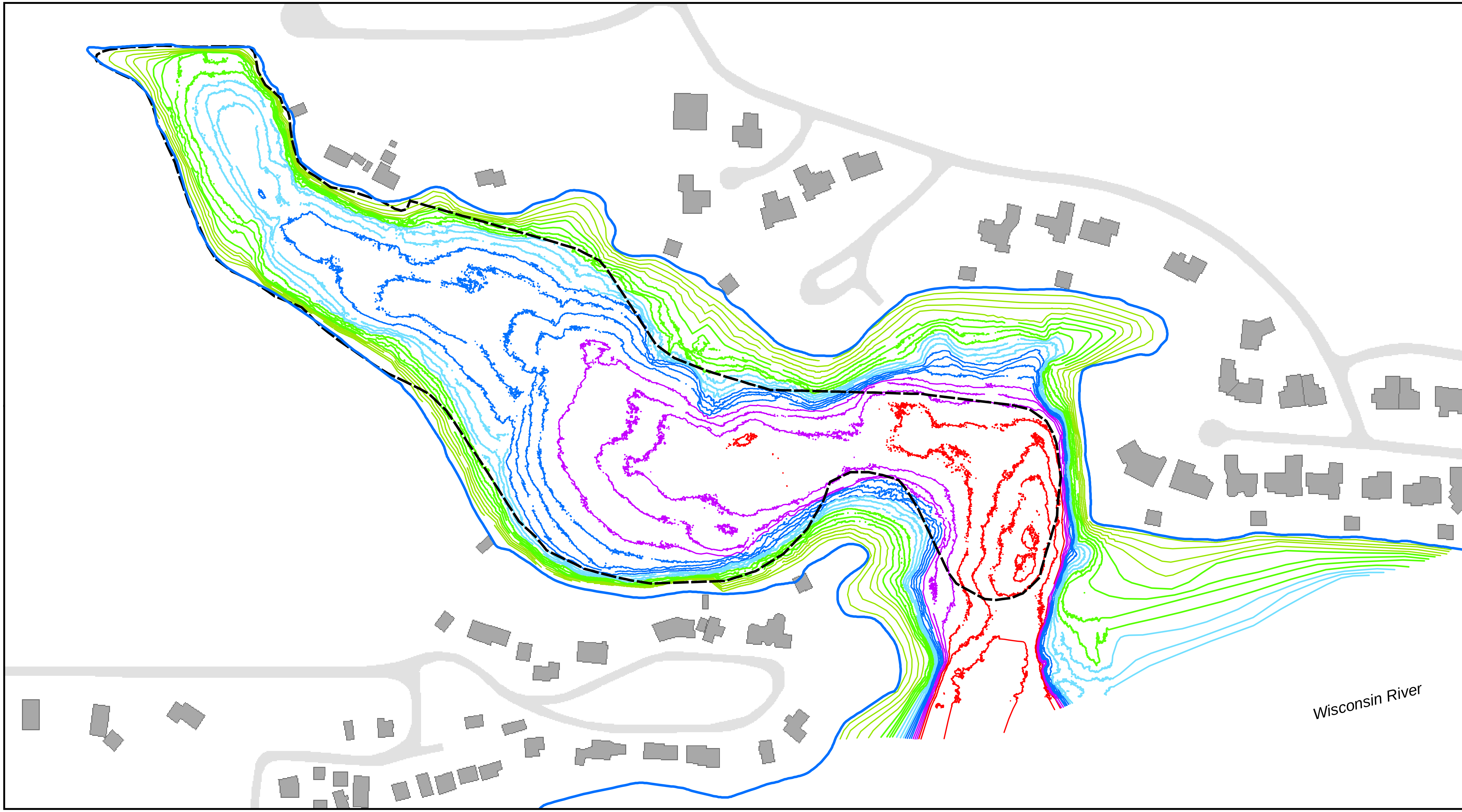
0 1,500 3,000 6,000
Feet

USGS 7.5-Minute Topographic Map
North Freedom, Baraboo, Sauk Prairie,
Sauk City Quadrangles

AECOM

Title: **Site Location Map**				
Project: Gruber's Grove Bay Sediment Sampling Report Badger Army Ammunition Plant				
Scale: As Shown	Drawn by: KPL	Date: 1/6/2023	Client: **Wisconsin DNR**	
	Chk'd by: KD	Date: 1/6/2023	Project No.: 60693459	File Name: Figure 1_Site Location.mxd	Figure: 1-1

Path: L:\DCS\GIS\Projects\Badger AAP\MXD\Figure 1_Site Location.mxd



Legend

Bathymetric Contours

Top of Sediment (Feet)

- 0.3 - 3.3
- 3.4 - 7.3
- 7.4 - 10.3
- 10.4 - 14.3
- 14.4 - 17.3
- 17.4 - 22.3

- 2006 Dredged Extent
- Building
- Roads
- Wisconsin River

Bathymetric contour survey (sediment depth) conducted by Veolia ES Special Services, Inc. on 10/10/12.
Contours were updated with 2016 & 2018 sediment depth measurements collected with manual probe.

N

0 100 200 400 Feet

AECOM

Title:	Gruber's Grove Bay Bathymetry 2012
Project:	Gruber's Grove Bay Sediment Sampling Report Badger Army Ammunition Plant
Client:	Wisconsin DNR
Scale:	As Shown
Drawn by:	KPL
Date:	1/6/2023
Chk'd by:	KD
Date:	1/6/2023
Project No.:	60693459
File Name:	Figure 2_Grubers_Grove_Bay.mxd
Figure:	1-2

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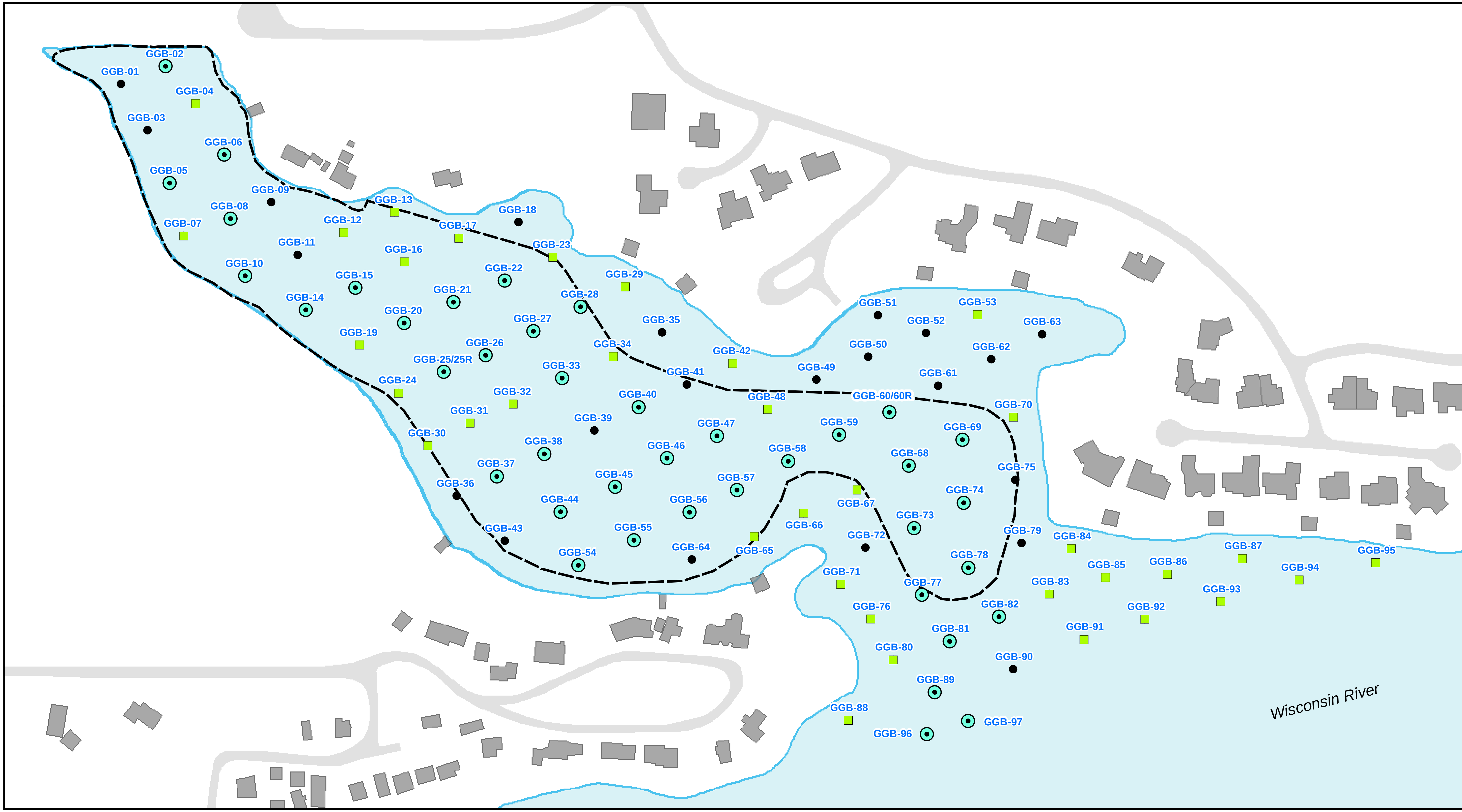

Legend

- Sample Collected - 2018
- Sample Collected - 2016
- No Sample Collected
- 2006 Dredge Extent
- Building
- Roads
- Wisconsin River

N

0 100 200 400 Feet

AECOM

Title:	**Previous Sediment Sample Locations at Gruber's Grove Bay**
Project:	Gruber's Grove Bay Sediment Sampling Report Badger Army Ammunition Plant
Client:	**Wisconsin DNR**
Scale:	As Shown
Drawn by:	KPL
Date:	1/6/2023
Chk'd by:	KD
Date:	1/6/2023
Project No.:	60693459
File Name:	Figure 3_Sampling Locations.mxd
Figure:	2-1

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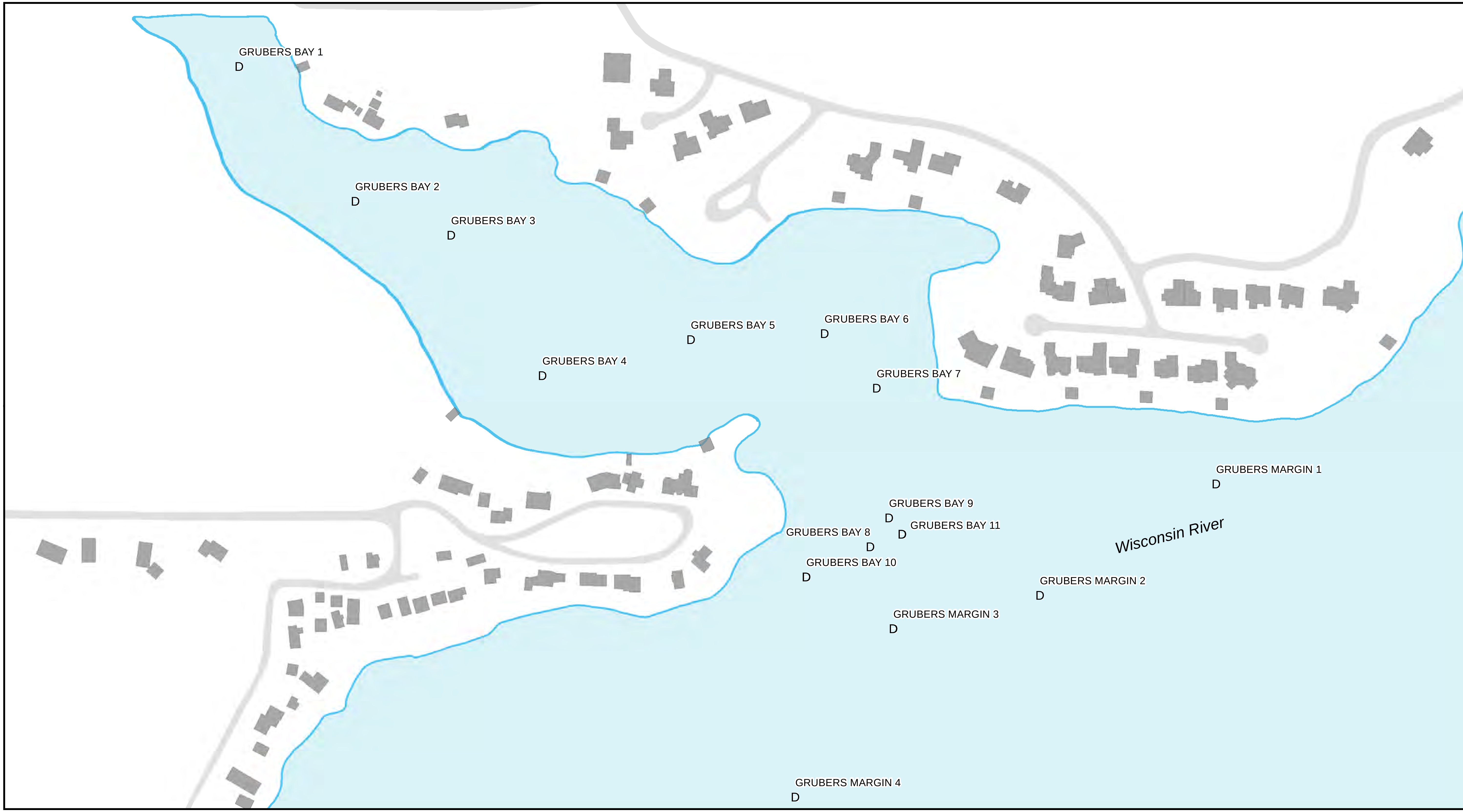

Legend

- D Sample Collected - 2019 (USGS)
- Building
- Roads
- Wisconsin River

0 100 200 400 Feet

AECOM

Title:	Previous Sediment Samples (2019) Locations at Gruber's Grove Bay
Project:	Gruber's Grove Bay Sediment Sampling Report Badger Army Ammunition Plant
Client:	Wisconsin DNR
Scale:	As Shown
Drawn by:	KPL
Date:	4/11/2023
Chk'd by:	KD
Date:	4/11/2023
Project No.:	60693459
File Name:	2-2_Sampling Locations (2019).mxd
Figure:	2-2

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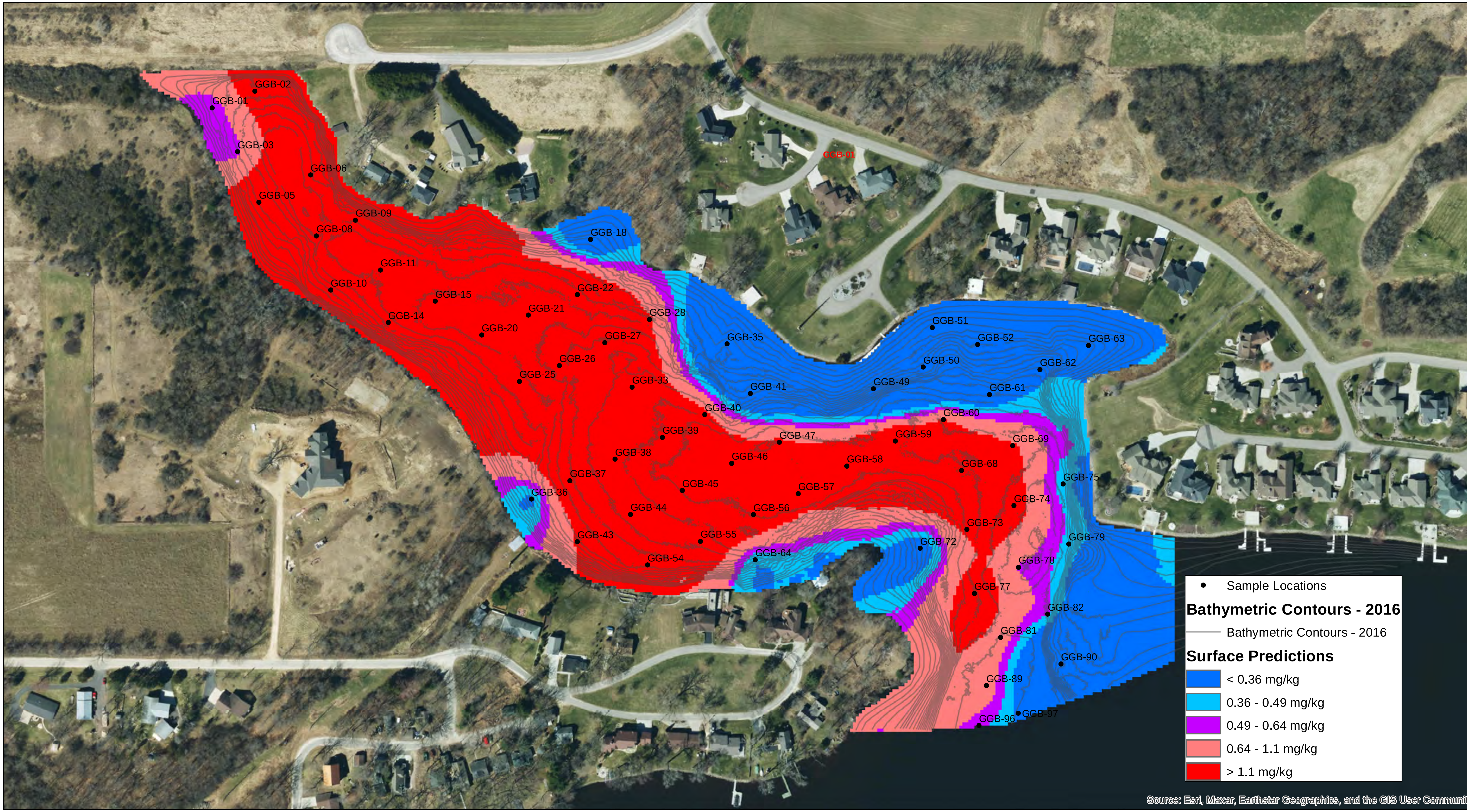


Figure 2-3

Surface Total Mercury w/ Bathymetric Contours
Gruber's Grove Bay Sediment Sampling Report
Badger Army Ammunition Plant

Bathymetric contour survey (sediment depth) conducted by Veolia ES Special Services, Inc. on 10/10/12.
Depths of GGB were obtained via multi-beam sonar survey.
Contours were updated with 2016 & 2018 sediment depth measurements collected with manual probe.

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Vertical Datum: North American Vertical Datum 88 (NAVD 88)
Units: Foot US

0 100 200 400 600 800 Feet

AECOM

N

1:2,400

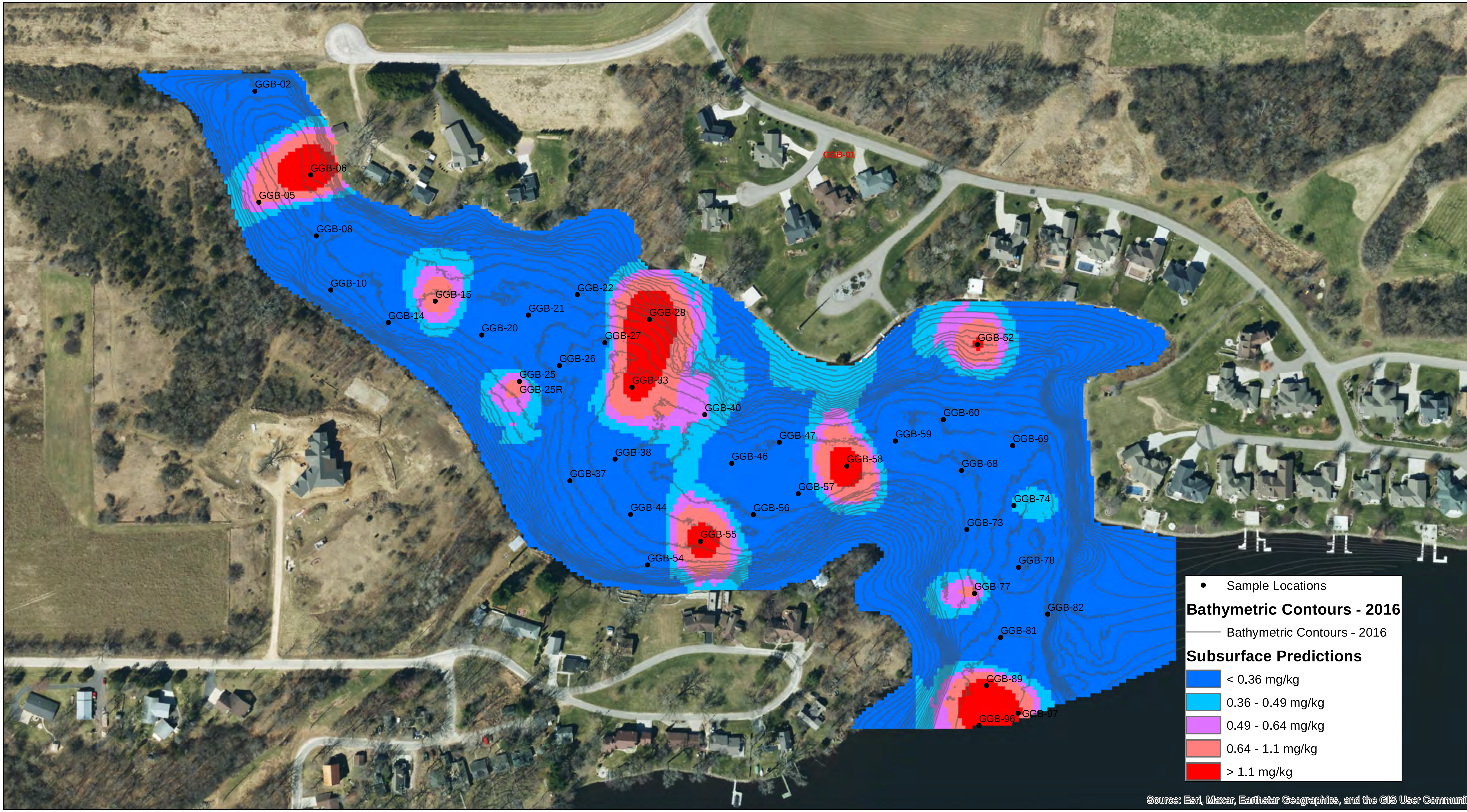


Figure 2-4

Subsurface Total Mercury w/ Bathymetric Contours
Gruber's Grove Bay Sediment Sampling Report
Badger Army Ammunition Plant

Bathymetric contour survey (sediment depth) conducted by Veolia ES Special Services, Inc. on 10/10/12.
Depths of GGB were obtained via multi-beam sonar survey.
Contours were updated with 2016 & 2018 sediment depth measurements collected with manual probe.

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Vertical Datum: North American Vertical Datum 88 (NAVD 88)
Units: Foot US

0 100 200 400 600 800 Feet

AECOM

N

1:2,400

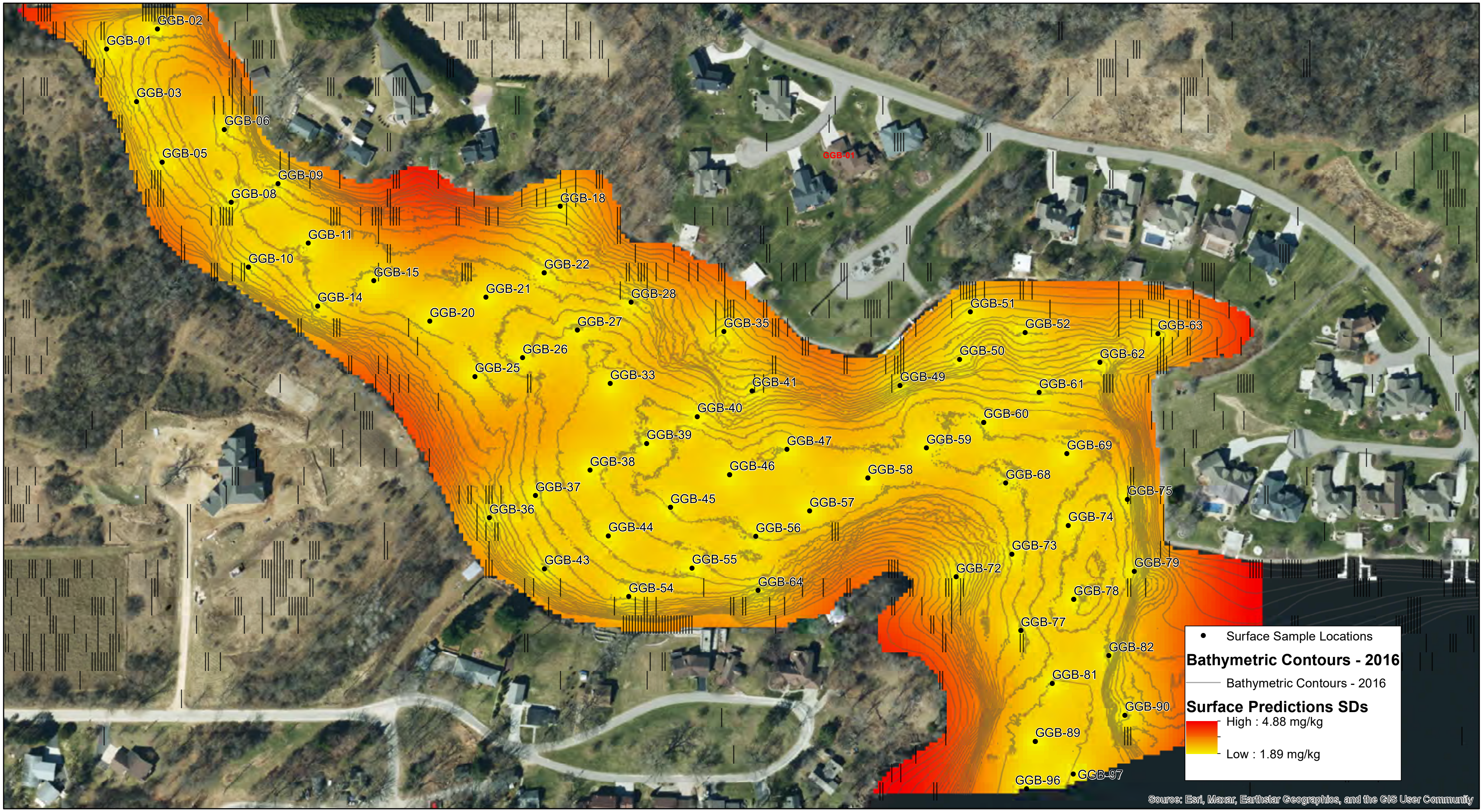


Figure 2-5

SDs of Surface Total Mercury w/ Bathymetric Contours
Gruber's Grove Bay Sediment Sampling Report
Badger Army Ammunition Plant

Bathymetric contour survey (sediment depth) conducted by Veolia ES Special Services, Inc. on 10/10/12.
Depths of GGB were obtained via multi-beam sonar survey.
Contours were updated with 2016 & 2018 sediment depth measurements collected with manual probe.

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Vertical Datum: North American Vertical Datum 88 (NAVD 88)
Units: Foot US

Feet
0 100 200 400 600 800

AECOM

1:2,000

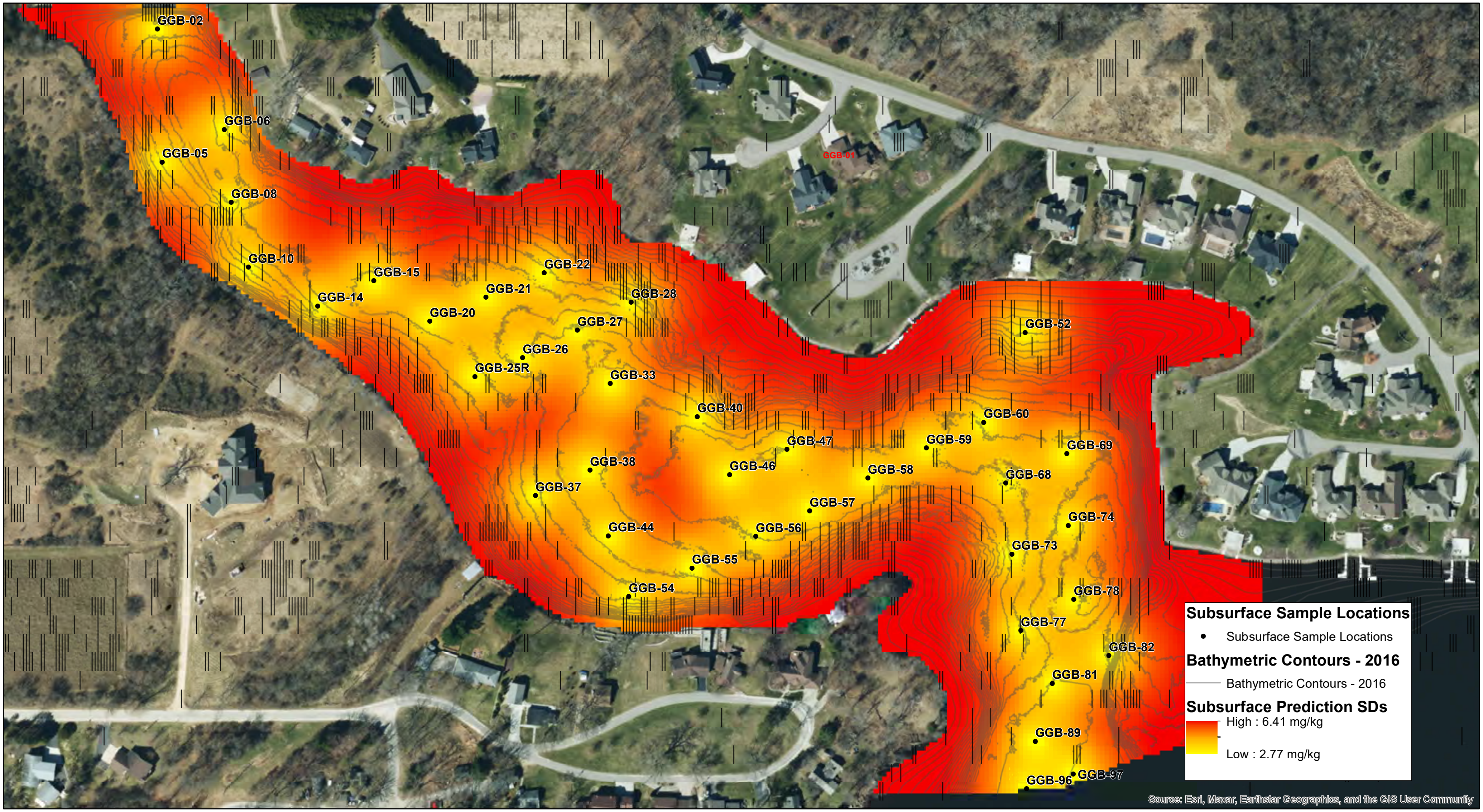


Figure 2-6

SDs of Subsurface Total Mercury w/ Bathymetric Contours
Gruber's Grove Bay Sediment Sampling Report
Badger Army Ammunition Plant

Bathymetric contour survey (sediment depth) conducted by Veolia ES Special Services, Inc. on 10/10/12.
Depths of GGB were obtained via multi-beam sonar survey.
Contours were updated with 2016 & 2018 sediment depth measurements collected with manual probe.

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Vertical Datum: North American Vertical Datum 88 (NAVD 88)
Units: Foot US

0 100 200 400 600 800 Feet

AECOM

1:2,000

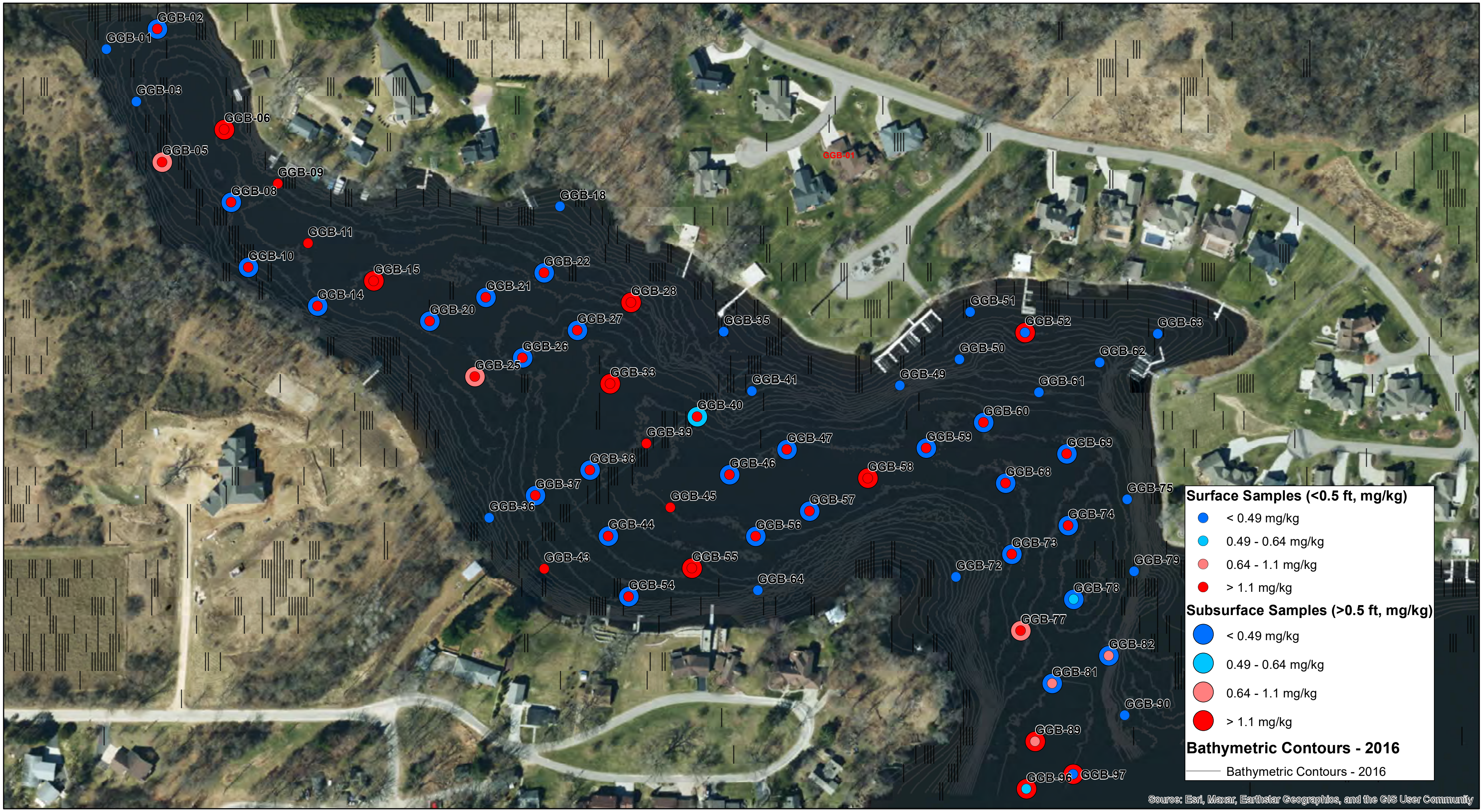


Figure 2-7

Total Mercury Sample Locations w/ Bathymetric Contours
Gruber's Grove Bay Sediment Sampling Report
Badger Army Ammunition Plant

Bathymetric contour survey (sediment depth) conducted by Veolia ES Special Services, Inc. on 10/10/12.
Depths of GGB were obtained via multi-beam sonar survey.
Contours were updated with 2016 & 2018 sediment depth measurements collected with manual probe.

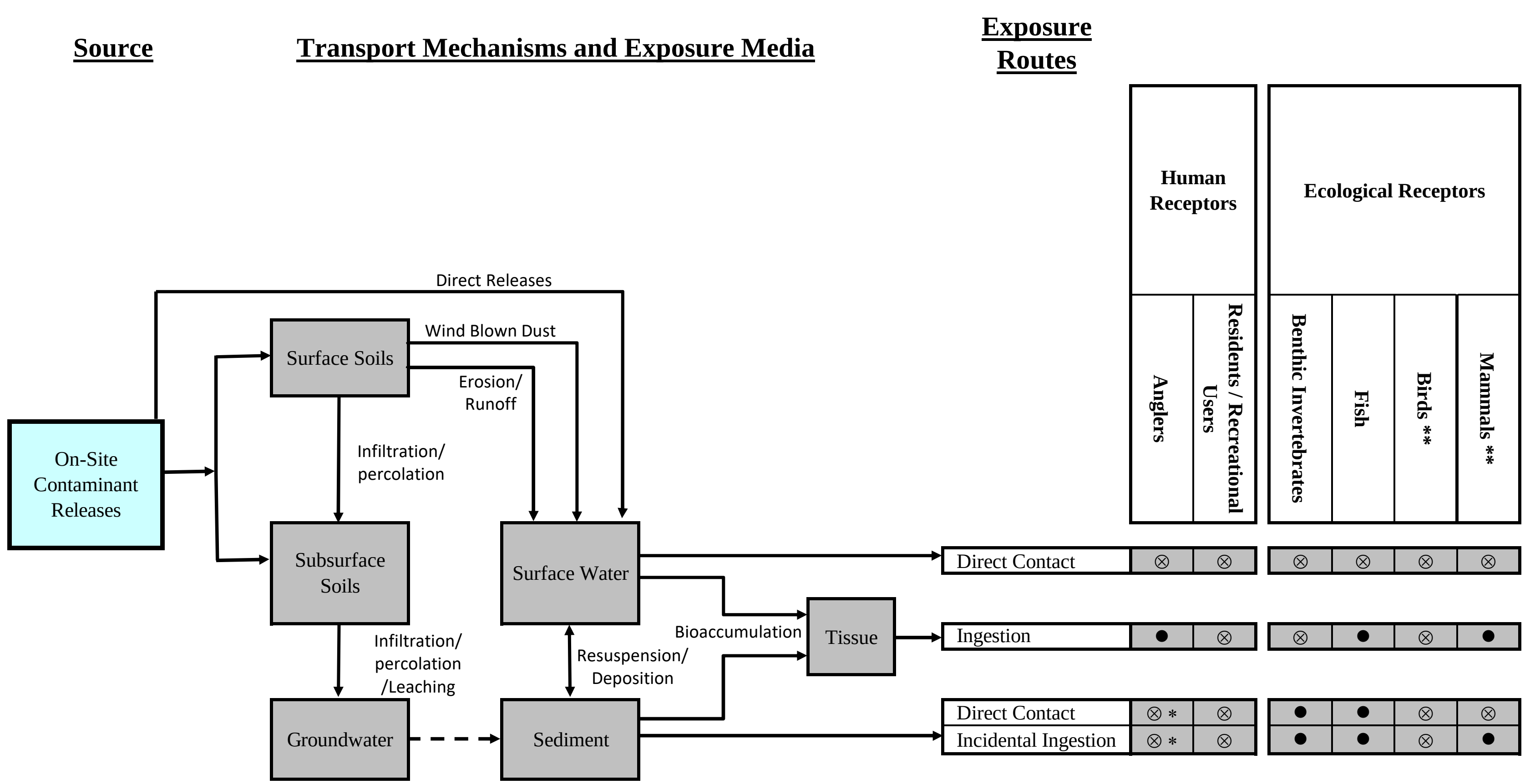
Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Vertical Datum: North American Vertical Datum 88 (NAVD 88)
Units: Foot US

0 100 200 400 600 800 Feet

AECOM

1:2,000

FIGURE 3-1: Conceptual Site Model
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

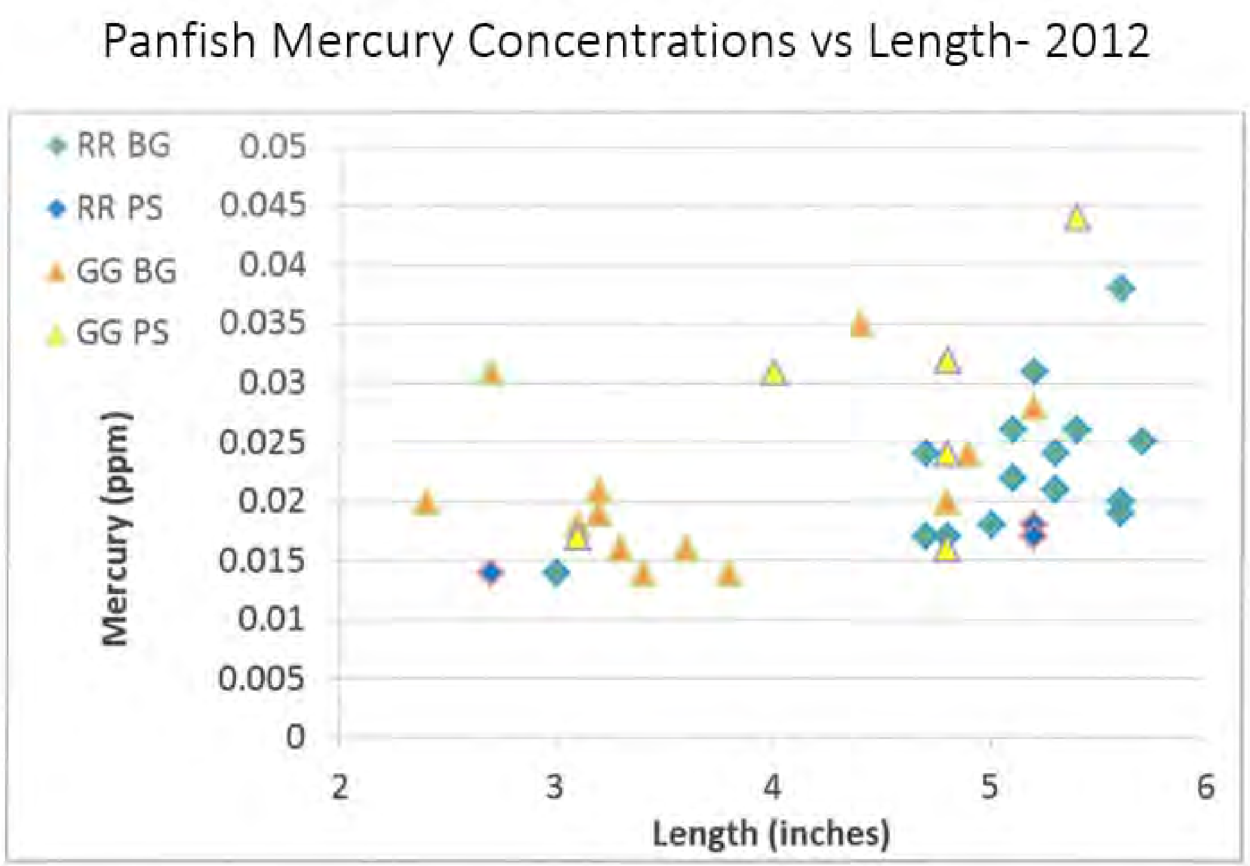


NOTEs:

——— Potentially complete pathway
– – – Incomplete, or potentially complete but insignificant pathway

● = Potentially complete exposure pathway
⊗ = Potentially complete but insignificant or not assessed
* Occasional exposure to sediments by recreational users, such as anglers, is assessed for completeness.
** Given the lack of mudflats and areas of shallow water, foraging along the shoreline by birds (e.g., herons or sandpiper) and mammals (e.g., raccoon) is likely to be limited; however, mink or river otter may forage within the bay.

Figure 4-1. Mercury Concentrations in Panfish Collected in 2012



Notes: Mercury concentrations in whole body fish collected in 2012 as shown in Figure 2 of WDNR (2013).

MRR = Merrimac RR Bridge BG = Bluegill
GG = Gruber's Grove PS = Pumpkinseed

APPENDIX A

HISTORICAL INVESTIGATION SUMMARY

Appendix A
Historical Investigation Report Summary
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

ID Number	Document Title	Date	Document Author	Samples Collected (Y/N)	Data Included	Data Format	Comments	Document Details
A	Assessment of Mercury in Sediments and Water of Grubers Grove Bay, Wisconsin, Open File Report 2022-1051	2022	United States Geological Survey	Y	Y	PDF report	None	Samples were taken from 5 designated areas: 1 location within Badger AAP grounds, and 4 locations within Lake Wisconsin (GGB, GGB margin, Weigands Bay, open-lake locations in upstream Lake Wisconsin).
B	Gruber's Grove Bay Sediment Sampling Report Badger Army Ammunition, Revision 1	Revision: March 2019 Original: August 2018	SpecPro Professional Services, LLC	Y	Y	Have EDDs and GIS Package	Revised Report, Same as Document #4.	Analytical results included in tables for 40 sampling locations and a total of 79 samples. 2018 Laboratory reports in .pdf and spreadsheet EDDs. ArcGIS Data Provided for 2018 Data. GIS Map Packages (.mpk) for the 2018 report figures. These packages contain the original figure layouts, shapefiles, & graphics. ESRI ArcMap or ArcGIS Pro can be used to open the packages. GIS Coordinate System is provided in a separate text file and in the metadata for each shapefile. Note that the 2016 and 2018 sediment sampling locations & data are provided in the data packages.
C	RFP Excel Files (3) - Data dictionary, Hg-GGB-Water, Hg-GGB-Sediments - May 2019 dataset	May, 2019	United States Geological Survey Mercury Research Laboratory	Y	Y	Excel	None	Analytical results for 12 water samples, and 65 soil/sediment
D	Gruber's Grove Bay Sediment Sampling Report	July, 2016	SpecPro Professional Services, LLC	Y	Y	N/A	None	Sediment investigation included 60 sampling locations and a total of 69 samples. Laboratory reports in .pdf (lab EDDs are not available). See Document #2 for data package details.
E	Gruber's Grove Bay Sampling Report BAAP	November, 2009	SpecPro Professional Services, LLC	Y	Y	Have EDDs	None	Sediment investigation included 164 samples from 60 locations. Geotechnical data/lab report included in PDF. 2009 Laboratory reports in .pdf and spreadsheet EDDs
F	Final Remedial Action Completion Report, Grubers Grove Bay Dredging Project. Revision 1.	Revision: 1/28/2008 Original: 11/1/2007	Shaw Environmental, Inc.	Y	N	N	None	Summary of dredging completed, permits obtained, and water filtrate/sediment floor samples. Volume 1 of report, missing tables, figures, and appendices.
G	Draft Corrective Measures Implementation Report, MIRM Extraction Well Realignment Project, Revision 1	April 10, 2006	Shaw Environmental, Inc.	N	NA	NA	Does not pertain to GGB.	Summary of MIRM installation.
H	Draft Alternative Feasibility Study, Propellant Burning Ground Waste Pits Subsurface Soil, Badger Army Ammunition Plant, Revision 1	April 6, 2006	Shaw Environmental, Inc.	N	NA	NA	Does not pertain to GGB.	Evaluation of the remedial options for PBG.
I	Draft Technical Memorandum Performance Assessment and Recommended Disposition of the Biologically Enhanced Subsurface Treatment System, Propellant Burning Ground, Badger Army Ammunition Plant	November 14, 2005	Shaw Environmental, Inc.	N	NA	NA	Does not pertain to GGB.	Evaluation of the remedial options for PBG.
J	Draft Addendum Residual Sediment Investigation Report, Gruber's Grove Bay, Badger Army Ammunition Plant, Revision 1	August 16, 2005	Shaw Environmental, Inc.	Y	Y	PDF report	None	Sampling of sediment occured prior to 2006 dredge event, no surveying data or coordinates found.
K	Draft Groundwater and Soil Investigation Report, Water's Edge Development, Badger Army Ammunition Plant. Prepared for United States Army Corps of Engineers	August 5, 2005	Shaw Environmental, Inc.	Y	Y	PDF Report Tables 4-5	None	Discussion on groundwater flow around GGB. Eight monitoring wells around shoreline installed and groundwater samples collected. One soil sample collected from each borehole location, analyzed for SVOCs and DNT, no lab reports or summary data table available for soil data.
--	2005 Badger Army Ammunition Plan Groundwater Narrative Historical Summary Report	July, 2005	SpecPro Professional Services, LLC	Y	N	N/A	Report Not Available.	Data referenced in received report titled Draft Groundwater and Soil Investigation Report, Water's Edge Development, 2005.

ID Number	Document Title	Date	Document Author	Samples Collected (Y/N)	Data Included	Data Format	Comments	Document Details
L	Field Activities Technical Memorandum - Propellant Burning Ground, Badger Army Ammunition Plant (January 2005)	June 6, 2005	Shaw Environmental, Inc.	Y	Y	PDF Report Tables 4-6	Does not pertain to GGB.	Results of soil borings from the PBG to evaluate BEST system performance.
M	Draft Southern Boundary Groundwater Phase II Investigation Report, Badger Army Ammunition Plant	January 10, 2005	Shaw Environmental, Inc.	Y	Y	PDF Report Tables 4-8	None	Summary of groundwater results around GGB from monitoring wells and residential wells. Analyzed for DDT, caffeine, and major cations/anions.
N	Draft Preliminary Groundwater Investigation Report, Southern Boundary Groundwater, Badger Army Ammunition Plant	April 26, 2004	Shaw Environmental, Inc.	Y	Y	PDF Report Tables 4 and 5	None	Groundwater sampling summary from 2000 through 2004 from wells near GGB for DNT results.
O	Draft Corrective Measures Implementation Report, Grubers Grove Bay Dredging Project, Revision 1	December 30, 2003	Shaw Environmental, Inc.	N	N/A	N/A	None	Summary of dredging completed, permits obtained, and water filtrate samples.
P	Technical Memorandum -Data Report Biologically Enhanced Subsurface Treatment System - Soil Boring and Air Sparge Well Installation - Propellant Burning Ground, Badger Army Ammunition Plant.	July 16, 2003	Shaw Environmental, Inc.	Y	Y	PDF Report Table 3	Does not pertain to GGB.	Summary of subsurface field investigations at the PBG to evaluate the BEST system performance.
--	100% Complete, Bathymetric Survey and Dredged Surface Mapping, Gruber's Grove Bay Habitat Restoration, Gruber's Grove Bay, Lake Wisconsin.	November 20, 2001	Stone & Webster, Inc.	N	N/A	N/A	Report Not Available.	Bathymetry of Gruber's Grove Bay after 2001 dredge event.
--	Field Sampling Report, Settling Ponds and Spoils Disposal Area, Badger Army Ammunition Plant.	May 21, 2001	Olin Corporation	Y	N	N/A	Report Not Available.	Data referenced in received report titled Draft Preliminary Groundwater Investigation Report, Southern Boundary Groundwater, 2004.
Q	Draft Sediment Investigation Report, Gruber's Grove Bay, Badger Army Ammunition Plant, Baraboo Wisconsin	June 21, 2000	Stone & Webster Environmental Technology & Services	Y	N	N/A	None	Summary of analytical and geotechnical sediment sampling effort. Phase I event in Feb 2000 consisted of 32 samples from 14 locations. Phase II event in Feb 2000 consisted of 107 samples from 17 locations.
R	Results of Contaminated Sediment Sampling in Gruber's Grove Bay, Lake Wisconsin	March, 1999	Wisconsin Department of Natural Resources	Y	N	N/A	None	Report provided in Appendix A of the 2000 Draft Sediment Investigation Report. Consisted of 5 sample cores along the middle of GGB.
--	Mercury Concentrations in Fish from Gruber's Grove Bay Correspondence/Memo from J. Amrhein (WDNR)	August, 1999	Wisconsin Department of Natural Resources	Y	N	N/A	Report Not Available.	Data referenced in received report titled Draft Corrective Measures Implementation Report Gruber's Grove Bay Dredging Project, 2003.
S	Sediment Sampling Narrative; unpublished report on the sediment samples at Gruber's Grove Bay, Weigands Bay, and Moon Valley Bay of Lake Wisconsin.	1999	Olin Corporation	Y	N	N/A	None	Report provided in Appendix A of the 2000 Draft Sediment Investigation Report. Consisted of 2 sample cores along the middle of GGB.
T	Final Feasibility Study Report.	August, 1994	ABB Environmental Services, Inc.	N	N/A	N/A	None	Review of nature and extent of contamination, HHRA and ERA, development of ARARs, and screening of remedial technologies presented for Settling Pond and Spoils Disposal Area. Limited information on GGB.
U	Final Remedial Investigation Report.	April, 1993	ABB Environmental Services, Inc.	N	N/A	N/A	None	Summary of HHRA, ERA, ARARs for various sites across BAAP. Limited information on GGB.
--	Grubers Grove Investigation Summary	1993	Olin Corporation	Y	N	N	Report Not Available.	Data referenced in received report titled Draft Corrective Measures Implementation Report Gruber's Grove Bay Dredging Project, 2003.
V	Water Quality Special Study No. 24-0039-78, Part I - Geohydrology, Badger Army Ammunition Plant	March 16, 1978	Owen Ayers & Associates (Olin Corporation)	Y	Y	PDF Report Table 1 and lab data last page	None	Good description of topography, soils, geology and groundwater. Seven borings completed in disposal/settling pond area north of GGB for geotechnical purposes and evaluation to use as disposal for dredged sediment. Three groundwater samples from across the BAAP site analyzed for metals.
--	Preliminary Report, Water Quality Special Study No. 24-0039-78, Part II - Biological Effects, Proposed Dredging of Gruber's Grove Bay, Badger Army Ammunition Plant	October, 1977	U.S. Army Environmental Hygiene Agency	Y	N	N/A	Report Not Available.	Data referenced in received report titled Draft Corrective Measures Implementation Report Gruber's Grove Bay Dredging Project, 2003.

Appendix A
Historical Investigation Report Summary
Gruber's Grove Bay
Badger Army Ammunition Plant
Baraboo, Wisconsin

ID Number	Document Title	Date	Document Author	Samples Collected (Y/N)	Data Included	Data Format	Comments	Document Details
W	Environmental Impact Statement, Dredging Industrial Waste from Gruber's Grove Bay at Badger AAP	July, 1973	Owen Ayers & Associates (Olin Corporation)	Y	N	N/A	None	Evaluation of dredging as a remedial action.
--	Water Quality Special Study No. 24-004-72, Part I - Industrial Wastewater Discharge, Wisconsin River, Vicinity of Badger Army Ammunition Plant	February, 1972	U.S. Army Environmental Hygiene Agency	Y	N	N/A	Report Not Available.	Data referenced in the received report 1973 Environmental Impact Statement.
--	Survey of Water Conditions at Badger Ordinance Works	1970	Mr. Arthur J. Washa with local citizens group	Y	N	N/A	Report Not Available.	Water analysis and survey of bottom organisms.

APPENDIX B

SUPPORTING DOCUMENTATION FOR DETERMINATION OF BACKGROUND THRESHOLD VALUES

Table 1 Background Mercury Concentrations in Sediment

Location	Sample Date	Latitude	Longitude	Sample Type	Depth (ft)	Total Mercury (ng/g)	Total Mercury (mg/kg)
WIEGANDS BAY 2	5/30/2019	43.35918	-89.69543	Bed Sediment	0 - 0.16	160	0.16
WIEGANDS BAY 4	5/30/2019	43.36023	-89.69197	Bed Sediment	0 - 0.16	210	0.21
WIEGANDS BAY 5	5/30/2019	43.36082	-89.69105	Bed Sediment	0 - 0.16	210	0.21
WIEGANDS BAY 6	5/30/2019	43.36038	-89.691	Bed Sediment	0 - 0.16	230	0.23
WIEGANDS BAY 13	5/30/2019	43.3595	-89.68932	Bed Sediment	0 - 0.16	200	0.2
WIEGANDS BAY 3	5/30/2019	43.35948	-89.69382	Bed Sediment	0 - 0.16	180	0.18
WIEGANDS BAY 15	5/30/2019	43.36182	-89.68733	Bed Sediment	0 - 0.16	270	0.27
WIEGANDS BAY 9	5/30/2019	43.36311	-89.69057	Bed Sediment	0 - 0.16	220	0.22
WIEGANDS BAY 17	5/30/2019	43.36126	-89.68562	Bed Sediment	0 - 0.16	310	0.31
WIEGANDS BAY 14	5/30/2019	43.36084	-89.68867	Bed Sediment	0 - 0.16	280	0.28
WIEGANDS BAY 1	5/30/2019	43.35933	-89.69704	Bed Sediment	0 - 0.16	86	0.086
WIEGANDS BAY 16	5/30/2019	43.36274	-89.68671	Bed Sediment	0 - 0.16	250	0.25
WIEGANDS BAY 7	5/30/2019	43.36347	-89.69344	Bed Sediment	0 - 0.16	160	0.16
WIEGANDS BAY 11	5/30/2019	43.36412	-89.68759	Bed Sediment	0 - 0.16	160	0.16
WIEGANDS BAY 10	5/30/2019	43.36263	-89.68916	Bed Sediment	0 - 0.16	240	0.24
WIEGANDS BAY 8	5/30/2019	43.36323	-89.69199	Bed Sediment	0 - 0.16	200	0.2
PINE BLUFF TRANSECT, CENTER	5/28/2019	43.38217	-89.57848	Bed Sediment	0 - 0.16	270	0.27
PINE BLUFF TRANSECT, SOUTH	5/28/2019	43.37572	-89.5786	Bed Sediment	0 - 0.16	370	0.37
PINE BLUFF TRANSECT, SOUTH	5/28/2019	43.37572	-89.5786	Bed Sediment	0 - 0.16	420	0.42
PINE BLUFF TRANSECT, NORTH	5/28/2019	43.38913	-89.5789	Bed Sediment	0 - 0.16	180	0.18
TRESTLE, SOUTH	5/28/2019	43.36785	-89.6122	Bed Sediment	0 - 0.16	520	0.52
SUNSET	5/28/2019	43.3636	-89.638	Bed Sediment	0 - 0.16	350	0.35
SOD HOUSE	5/28/2019	43.40497	-89.55208	Bed Sediment	0 - 0.16	72	0.072
TRESTLE, NORTH	5/28/2019	43.3719	-89.61633	Bed Sediment	0 - 0.16	390	0.39
TIPPERARY BLUFFS	5/28/2019	43.39775	-89.55885	Bed Sediment	0 - 0.16	130	0.13
TIPPERARY BLUFFS	5/28/2019	43.39775	-89.55885	Bed Sediment	0 - 0.16	68	0.068
MOON VALLEY	5/28/2019	43.36105	-89.66957	Bed Sediment	0 - 0.16	380	0.38

Notes:

ft - feet

mg/kg - milligram per kilogram

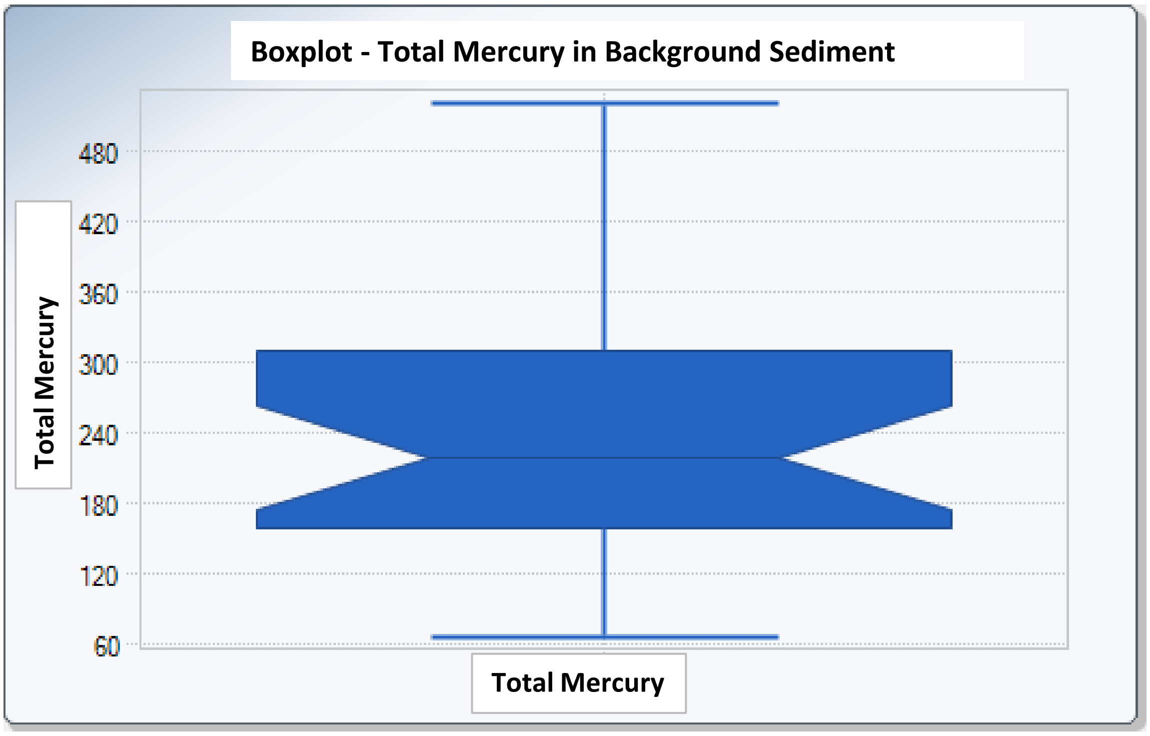
ng/g - nanogram per gram

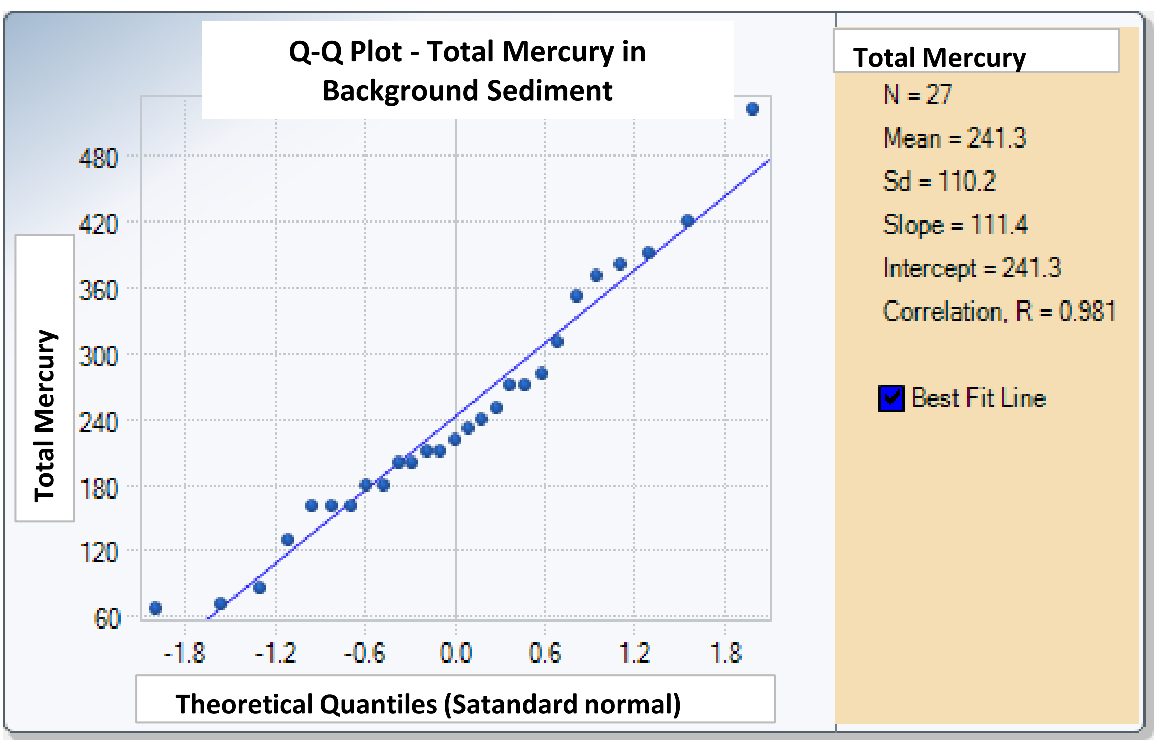
Data obtained from Table 3 of Routhier, et al. 2022.

Source reference:

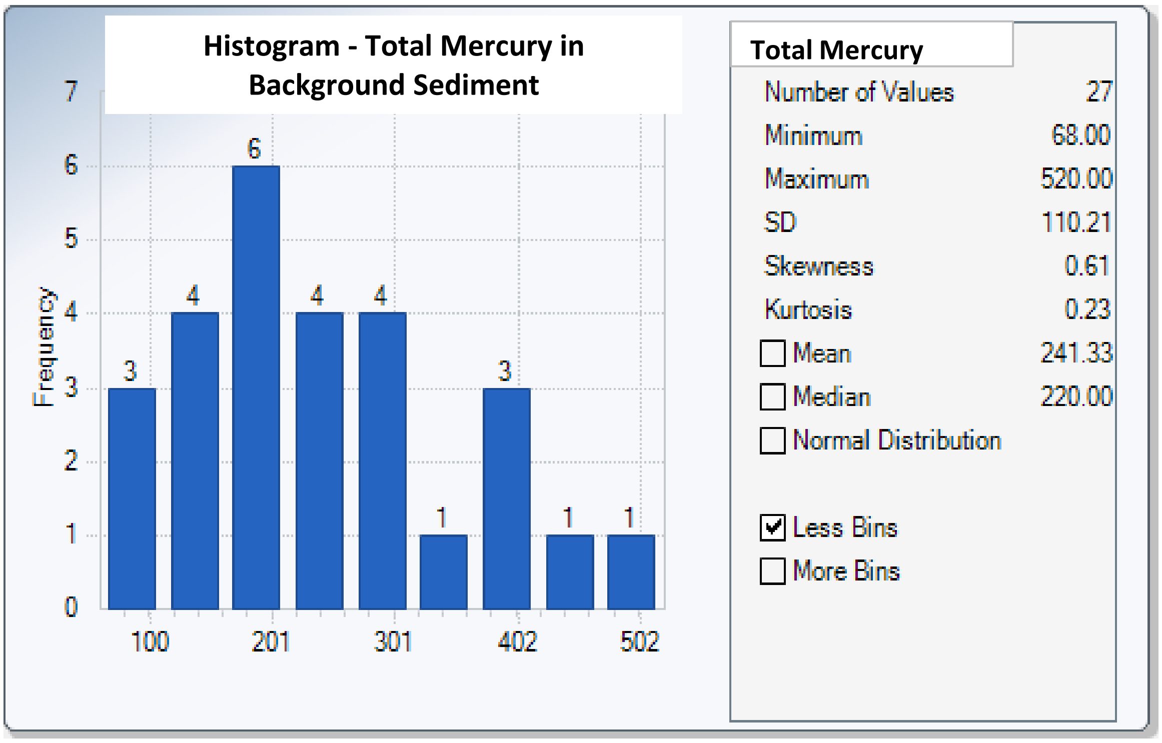
Routhier, E.J., Janssen, S.E., Tate, M.T., Ogorek, J.M., DeWild, J.F., and Krabbenhoft, D.P., 2022, Assessment of mercury in sediments and waters of Grubers Grove Bay, Wisconsin: U.S. Geological Survey Open-File Report 2022-1051, 20 p., https://doi.org/ 10.3133/ ofr20221051.

Graphs of Background Sediment Mercury Data Set





Graphs of Background Sediment Mercury Data Set



Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.13/1/2023 1:07:02 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.95

HgT_ng_g

Raw Statistics		
Number of Valid Observations	27	
Number of Distinct Observations	21	
Minimum	68	
Maximum	520	
Mean of Raw Data	241.3	
Standard Deviation of Raw Data	110.2	
Khat	4.612	
Theta hat	52.33	
Kstar	4.124	
Theta star	58.52	
Mean of Log Transformed Data	5.374	
Standard Deviation of Log Transformed Data	0.509	

Normal GOF Test Results

Correlation Coefficient R	0.981	
Shapiro Wilk Test Statistic	0.961	
Shapiro Wilk Critical (0.05) Value	0.923	
Approximate Shapiro Wilk P Value	0.404	Assume normally distributed
Lilliefors Test Statistic	0.104	
Lilliefors Critical (0.05) Value	0.167	

Data appear Normal at (0.05) Significance Level

Gamma GOF Test Results

Correlation Coefficient R	0.992
A-D Test Statistic	0.258
A-D Critical (0.05) Value	0.748
K-S Test Statistic	0.105
K-S Critical(0.05) Value	0.169

Data appear Gamma Distributed at (0.05) Significance Level

Lognormal GOF Test Results

Correlation Coefficient R	0.976
Shapiro Wilk Test Statistic	0.949
Shapiro Wilk Critical (0.05) Value	0.923
Approximate Shapiro Wilk P Value	0.214
Lilliefors Test Statistic	0.131
Lilliefors Critical (0.05) Value	0.167

Data appear Lognormal at (0.05) Significance Level

Outlier Tests for Selected Uncensored Variables

User Selected Options	
Date/Time of Computation	ProUCL 5.13/1/2023 1:19:24 PM
From File	WorkSheet.xls
Full Precision	OFF

Rosner's Outlier Test for HgT_ng_g

Mean	241.3
Standard Deviation	110.2
Number of data	27
Number of suspected outliers	1

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	241.3	108.1	520	21	2.577	2.86	3.18

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Normal Background Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.13/1/2023 1:21:10 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Coverage	95%
New or Future K Observations	1

HgT_ng_g

General Statistics			
Total Number of Observations	27	Number of Distinct Observations	21
Minimum	68	First Quartile	170
Second Largest	420	Median	220
Maximum	520	Third Quartile	295
Mean	241.3	SD	110.2
Coefficient of Variation	0.457	Skewness	0.61
Mean of logged Data	5.374	SD of logged Data	0.509

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.26	d2max (for USL)	2.698

Normal GOF Test

Shapiro Wilk Test Statistic	0.961	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.923	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.104	Lilliefors GOF Test
5% Lilliefors Critical Value	0.167	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	490.4	90% Percentile (z)	382.6
95% UPL (t)	432.8	95% Percentile (z)	422.6
95% USL	538.7	99% Percentile (z)	497.7

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

T-Test Comparing Wiegands Bay and Lake Wisconsin Mercury Data Sets

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.13/1/2023 4:25:02 PM
From File	Background_ProUCL.xls
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference (S)	0
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: HgT_ng_g(lake wisconsin)
Sample 2 Data: HgT_ng_g(wiegands bay)

Raw Statistics	Lake Wisconsin Sample 1	Wiegands Bay Sample 2
Number of Valid Observations	11	16
Number of Distinct Observations	11	12
Minimum	68	86
Maximum	520	310
Mean	286.4	210.4
Median	350	210
SD	152.5	55.06
SE of Mean	45.99	13.76

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.025)	Upper C.Val t (0.975)	P-Value
Pooled (Equal Variance)	25	1.839	-2.06	2.06	0.078
Welch-Satterthwaite (Unequal Va	11.8	1.583	-2.179	2.179	0.14

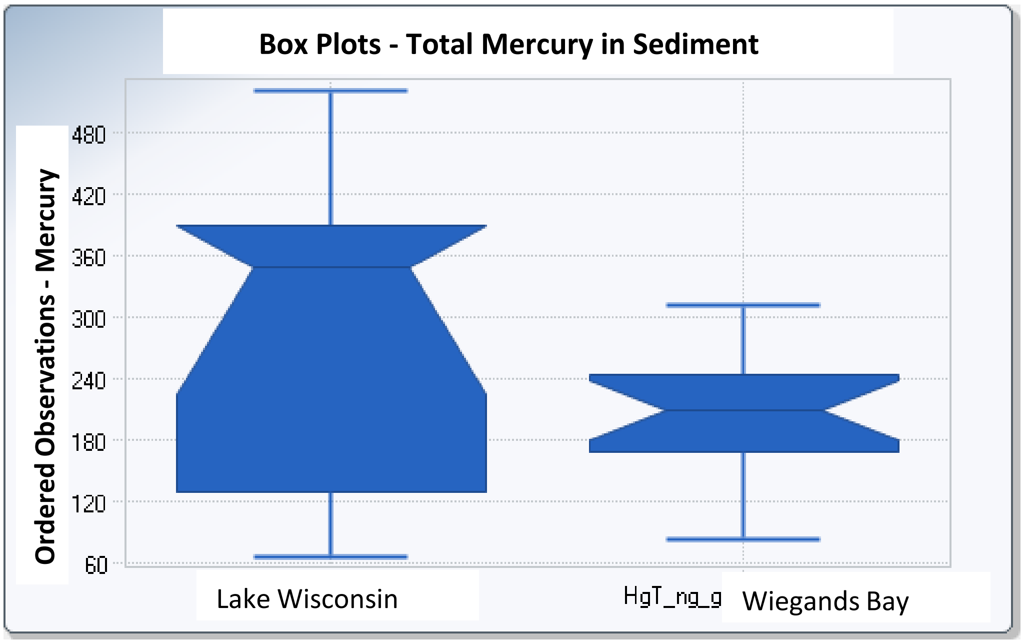
Pooled SD: 105.477
Conclusion with Alpha = 0.050
Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2
Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	23266
Variance of Sample 2	3032

Numerator DF	Denominator DF	F-Test Value	P-Value
10	15	7.675	0.001

Conclusion with Alpha = 0.05
Two variances are not equal


Box Plots - Total Mercury in Sediment
Ordered Observations - Mercury
480
420
360
300
240
180
120
60
Lake Wisconsin
HgT_ng_g
Wiegands Bay

APPENDIX C

HHRA RSL CALCULATIONS

Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI
Recreator Soil Inputs

Variable	Recreator Soil Default Value	Site-Specific Value
A (PEF Dispersion Constant)	16.2302	16.2302
A (VF Dispersion Constant)	11.911	11.911
A (VF Dispersion Constant - mass limit)	11.911	11.911
B (PEF Dispersion Constant)	18.7762	18.7762
B (VF Dispersion Constant)	18.4385	18.4385
B (VF Dispersion Constant - mass limit)	18.4385	18.4385
City (PEF Climate Zone) Selection	Default	Default
City (VF Climate Zone) Selection	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
C (VF Dispersion Constant)	209.7845	209.7845
C (VF Dispersion Constant - mass limit)	209.7845	209.7845
foc (fraction organic carbon in soil) g/g	0.006	0.006
F(x) (function dependent on U_m/U_t) unitless	0.194	0.194
n (total soil porosity) L_{pore}/L_{soil}	0.43396	0.43396
p_b (dry soil bulk density) g/cm^3	1.5	1.5
p_b (dry soil bulk density - mass limit) g/cm^3	1.5	1.5
PEF (particulate emission factor) m^3/kg	1359344438	1359344438
p_s (soil particle density) g/cm^3	2.65	2.65
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77	93.77
Q/C_{vol} (g/m^2-s per kg/m^3)	68.18	68.18
Q/C_{vol} (g/m^2-s per kg/m^3 - mass limit)	68.18	68.18
A_s (PEF acres)	0.5	0.5
A_s (VF acres)	0.5	0.5
A_s (VF mass-limit acres)	0.5	0.5
AF_{0-2} (skin adherence factor) mg/cm^2	.	0.2
AF_{2-6} (skin adherence factor) mg/cm^2	.	0.2
AF_{6-16} (skin adherence factor) mg/cm^2	.	0.3
AF_{16-30} (skin adherence factor) mg/cm^2	.	0.3
AF_{rec-a} (skin adherence factor - adult) mg/cm^2	.	0.3
AF_{rec-c} (skin adherence factor - child) mg/cm^2	.	0.2
AT_{rec} (averaging time)	365	365

Output generated 17MAR2023:08:24:38

Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI
Recreator Soil Inputs

Variable	Recreator Soil Default Value	Site-Specific Value
BW_{0-2} (body weight) kg	15	15
BW_{2-6} (body weight) kg	15	15
BW_{6-16} (body weight) kg	80	80
BW_{16-30} (body weight) kg	80	80
BW_{rec-a} (body weight - adult) kg	80	80
BW_{rec-c} (body weight - child) kg	15	15
$DFS_{rec-adj}$ (age-adjusted soil dermal factor) mg/kg	.	96336
$DFSM_{rec-adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	.	287592
ED_{rec} (exposure duration - recreator) years	26	26
ED_{0-2} (exposure duration) year	2	2
ED_{2-6} (exposure duration) year	4	4
ED_{6-16} (exposure duration) year	10	10
ED_{16-30} (exposure duration) year	10	10
ED_{rec-c} (exposure duration - child) years	6	6
EF_{rec} (exposure frequency) days/year	.	150
EF_{0-2} (exposure frequency) days/year	.	150
EF_{2-6} (exposure frequency) days/year	.	150
EF_{6-16} (exposure frequency) days/year	.	150
EF_{16-30} (exposure frequency) days/year	.	150
EF_{rec-a} (exposure frequency - adult) days/year	.	150
EF_{rec-c} (exposure frequency - child) days/year	.	150
ET_{rec} (exposure time - recreator) hours/day	.	2
ET_{0-2} (exposure time) hours/day	.	2
ET_{2-6} (exposure time) hours/day	.	2
ET_{6-16} (exposure time) hours/day	.	2
ET_{16-30} (exposure time) hours/day	.	2
ET_{rec-a} (adult exposure time) hours/day	.	2
ET_{rec-c} (child exposure time) hours/day	.	2
THQ (target hazard quotient) unitless	0.1	1
$IFS_{rec-adj}$ (age-adjusted soil ingestion factor) mg/kg	.	15750
$IFSM_{rec-adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	.	71500

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Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI

Recreator Soil Inputs

Variable	Recreator Soil Default Value	Site-Specific Value
IRS_{0-2} (soil intake rate) mg/day	200	200
IRS_{2-6} (soil intake rate) mg/day	200	200
IRS_{6-16} (soil intake rate) mg/day	100	100
IRS_{16-30} (soil intake rate) mg/day	100	100
IRS_{rec-a} (soil intake rate - adult) mg/day	100	100
IRS_{rec-c} (soil intake rate - child) mg/day	200	200
LT (lifetime - recreator) years	70	70
SA_{0-2} (skin surface area) cm^2/day	2373	2373
SA_{2-6} (skin surface area) cm^2/day	2373	2373
SA_{6-16} (skin surface area) cm^2/day	6032	6032
SA_{16-30} (skin surface area) cm^2/day	6032	6032
SA_{rec-a} (skin surface area - adult) cm^2/day	6032	6032
SA_{rec-c} (skin surface area - child) cm^2/day	2373	2373
TR (target risk) unitless	1.0E-06	1.0E-06
T_w (groundwater temperature) Celsius	25	25
$Theta_a$ (air-filled soil porosity) L_{air}/L_{soil}	0.28396	0.28396
$Theta_w$ (water-filled soil porosity) L_{water}/L_{soil}	0.15	0.15
T (exposure interval) s	819936000	819936000
T (exposure interval) yr	26	26
U_m (mean annual wind speed) m/s	4.69	4.69
U_t (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI

Recreator Risk-Based Regional Screening Levels (RSL) for Soil

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = OW; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	IUR (ug/m^3)$^{-1}$	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	GIABS
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		-		3.00E-04	I	3.00E-04	G	0.07

ABS	RBA	Soil Saturation Concentration (mg/kg)	S (mg/L)	K_{oc}\ (cm^3/g)	K_d\ (cm^3/g)	HLC (atm-m^3/mole)	Henry's Law Constant Used in Calcs (unitless)	H` and HLC Ref	Normal Boiling Point BP (K)	BP Ref	Critical Temperature T_C\ (K)	T_C\ Ref
-	1	-	6.90E+04	-	-	-	-		577.15	CRC	973	CRC

Chemical Type	D_{ia}\ (cm^2/s)	D_{iw}\ (cm^2/s)	D_A\ (cm^2/s)	Particulate Emission Factor (m^3/kg)	Volatilization Factor Unlimited Reservoir (m^3/kg)	Volatilization Factor Mass Limit (m^3/kg)	Volatilization Factor Selected (m^3/kg)	Ingestion SL TR=1E-06 (mg/kg)	Dermal SL TR=1E-06 (mg/kg)	Inhalation SL TR=1E-06 (mg/kg)
INORGANIC	-	-	-	1.36E+09	-	-	-	-	-	-

Carcinogenic SL TR=1E-06 (mg/kg)	Ingestion SL Child THQ=1 (mg/kg)	Dermal SL Child THQ=1 (mg/kg)	Inhalation SL Child THQ=1 (mg/kg)	Noncarcinogenic SL Child THI=1 (mg/kg)	Ingestion SL Adult THQ=1 (mg/kg)	Dermal SL Adult THQ=1 (mg/kg)	Inhalation SL Adult THQ=1 (mg/kg)	Noncarcinogenic SL Adult THI=1 (mg/kg)	Screening Level (mg/kg)
-	5.48E+01	-	1.19E+07	5.47E+01	5.84E+02	-	1.19E+07	5.84E+02	5.47E+01 nc

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Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI
Fish Fish Inputs (Adult)

Variable	Fish Fish Default Value	Site-Specific Value
AT (averaging time)	365	365
BW_{res-a} (body weight) kg	80	80
ED_{res} (exposure duration) yr	26	26
EF_{res-a} (exposure frequency) days/yr	350	350
THQ (target hazard quotient) unitless	0.1	1
$IRFI_{res-a}$ (fish consumption rate - adult) mg/day		54000
LT (lifetime) yr	70	70
TR (target cancer risk) unitless	1.0E-06	1.0E-06

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Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI

Fish Risk-Based Regional Screening Levels (RSL) for Fish

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = OW; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	Ingestion SL TR=1E-06 (mg/kg)	Ingestion SL THQ=1 (mg/kg)	Screening Level (mg/kg)
Methyl Mercury	22967-92-6	No	No	Inorganics	-		1.00E-04	I	-	1.54E-01	1.54E-01 nc

Output generated 17MAR2023:08:55:36

Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI

Fish Fish Inputs (Child)

Variable	Fish Fish Default Value	Site-Specific Value
AT (averaging time)	365	365
BW_{res-a} (body weight) kg	80	15
ED_{res} (exposure duration) yr	26	6
EF_{res-a} (exposure frequency) days/yr	350	350
THQ (target hazard quotient) unitless	0.1	1
$IRFI_{res-a}$ (fish consumption rate - child) mg/day		18000
LT (lifetime) yr	70	70
TR (target cancer risk) unitless	1.0E-06	1.0E-06

Site-specific: Badger Army Ammunition Plant, Gruber's Grove Bay, WI

Fish Risk-Based Regional Screening Levels (RSL) for Fish

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = OW; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	Ingestion SL TR=1E-06 (mg/kg)	Ingestion SL THQ=1 (mg/kg)	Screening Level (mg/kg)
Methyl Mercury	22967-92-6	No	No	Inorganics	-		1.00E-04	I	-	8.69E-02	8.69E-02 nc

APPENDIX D

SUPPORTING DOCUMENTATION FOR DETERMINATION OF UPPER CONFIDENCE LIMITS ON THE MEAN

Location	Sample Code	Sample Date	Depth (ft)	Sediment Horizon [1]	X Coordinate	Y Coordinate	Total Mercury (mg/kg)
GGB-01	GGB-01-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042107.10	484527.90	0.44
GGB-02	GGB-02-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042202.40	484565.90	2.0
GGB-02	02-2-18-20180611	2018-06-11 12:15	0.50 - 1.10	Subsurface	2042202.40	484565.90	0.068
GGB-03	GGB-03-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042163.50	484429.50	0.49
GGB-05	GGB-05-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042211.50	484316.50	2.4
GGB-05	05-2-18-20180611	2018-06-11 12:30	0.50 - 1.30	Subsurface	2042211.50	484316.50	0.80
GGB-06	GGB-06-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042327.90	484377.50	2.7
GGB-06	06-2-18-20180612	2018-06-12 9:50	0.50 - 0.80	Subsurface	2042327.90	484377.50	6.1
GGB-08	GGB-08-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042340.90	484240.80	1.8
GGB-08	08-2-18-20180612	2018-06-12 10:00	0.50 - 0.90	Subsurface	2042340.90	484240.80	0.012
GGB-09	GGB-09-1-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2042428.20	484275.90	3.1
GGB-10	GGB-10-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042372.80	484118.60	4.6
GGB-10	10-2-18-20180612	2018-06-12 11:08	0.50 - 1.50	Subsurface	2042372.80	484118.60	0.45
GGB-10	10-3-18-20180612	2018-06-12 11:10	1.50 - 1.60	Subsurface	2042372.80	484118.60	0.077
GGB-11	GGB-11-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042484.80	484163.80	1.6
GGB-14	GGB-14-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042502.10	484046.10	2.8
GGB-14	14-2-18-20180612	2018-06-12 11:15	0.50 - 0.80	Subsurface	2042502.10	484046.10	0.11
GGB-14	14-3-18-20180612	2018-06-12 11:20	0.90 - 1.00	Subsurface	2042502.10	484046.10	0.087
GGB-15	GGB-15-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042607.60	484093.60	3.2
GGB-15	15-2-18-20180612	2018-06-12 12:30	0.50 - 0.80	Subsurface	2042607.60	484093.60	1.3
GGB-18	GGB-18-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2042956.10	484233.10	0.11
GGB-20	GGB-20-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042711.90	484018.00	2.4
GGB-20	20-2-18-20180613	2018-06-13 12:45	0.50 - 1.10	Subsurface	2042711.90	484018.00	0.12
GGB-21	GGB-21-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042816.90	484062.70	4.9
GGB-21	21-2-18-20180613	2018-06-13 12:25	0.50 - 1.50	Subsurface	2042816.90	484062.70	4.3
GGB-21	21-3-18-20180613	2018-06-13 12:30	1.50 - 1.60	Subsurface	2042816.90	484062.70	0.010
GGB-22	GGB-22-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042926.30	484108.50	6.3
GGB-22	22-2-18-20180613	2018-06-13 10:50	0.50 - 1.10	Subsurface	2042926.30	484108.50	0.12
GGB-25	GGB-25-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042796.30	483913.90	6.1
GGB-25R	25R-2-18-20180613	2018-06-13 14:20	0.50 - 1.00	Subsurface	2042796.30	483913.90	1.00
GGB-26	GGB-26-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042885.90	483949.30	3.1
GGB-26	26-2-18-20180613	2018-06-13 15:15	0.50 - 1.00	Subsurface	2042885.90	483949.30	0.056
GGB-27	GGB-27-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2042988.10	484000.90	2.3
GGB-27	27-2-18-20180613	2018-06-13 15:25	0.50 - 0.60	Subsurface	2042988.10	484000.90	0.25
GGB-28	GGB-28-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2043088.40	484052.90	1.4
GGB-28	28-2-18-20180613	2018-06-13 11:05	0.50 - 0.80	Subsurface	2043088.40	484052.90	8.8
GGB-33	GGB-33-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2043049.50	483900.60	2.8
GGB-33	33-2-18-20180614	2018-06-14 16:10	0.50 - 1.50	Subsurface	2043049.50	483900.60	3.0
GGB-33	33-3-18-20180614	2018-06-14 16:18	1.50 - 2.40	Subsurface	2043049.50	483900.60	2.7
GGB-33	33-4-18-20180614	2018-06-14 16:25	2.50 - 2.60	Subsurface	2043049.50	483900.60	0.0093
GGB-35	GGB-35-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043262.40	483998.10	0.059
GGB-36	GGB-36-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2042823.60	483649.40	0.21
GGB-37	GGB-37-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2042909.70	483691.00	3.9
GGB-37	37-2-18-20180612	2018-06-12 17:05	0.50 - 0.60	Subsurface	2042909.70	483691.00	0.18
GGB-38	GGB-38-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2043011.40	483738.90	1.6
GGB-38	38-2-18-20180612	2018-06-12 17:18	0.50 - 0.60	Subsurface	2043011.40	483738.90	0.14
GGB-39	GGB-39-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2043117.60	483788.60	3.5
GGB-40	GGB-40-1-SO-20160209	2016-02-09 12:00	0.00 - 0.50	Surface	2043212.70	483839.00	1.7
GGB-40	40-2-18-20180613	2018-06-13 16:45	0.50 - 0.60	Subsurface	2043212.70	483839.00	0.56
GGB-41	GGB-41-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043314.90	483887.10	0.11
GGB-43	GGB-43-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2042926.60	483553.60	1.2
GGB-44	GGB-44-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2043046.10	483615.30	3.0
GGB-44	44-2-18-20180612	2018-06-12 16:10	0.50 - 0.60	Subsurface	2043046.10	483615.30	0.082
GGB-45	GGB-45-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2043162.20	483668.70	2.0
GGB-46	46-1-18-20180612	2018-06-12 14:35	0.00 - 0.50	Surface	2043273.10	483730.00	1.8
GGB-46	46-2-18-20180612	2018-06-12 14:45	0.50 - 1.00	Subsurface	2043273.10	483730.00	0.17
GGB-47	GGB-47-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043379.90	483777.40	1.6
GGB-47	47-2-18-20180612	2018-06-12 14:30	0.50 - 0.70	Subsurface	2043379.90	483777.40	0.14
GGB-49	GGB-49-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2043591.50	483897.10	0.036
GGB-50	GGB-50-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2043702.80	483946.00	0.022
GGB-51	GGB-51-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2043722.90	484034.90	0.032

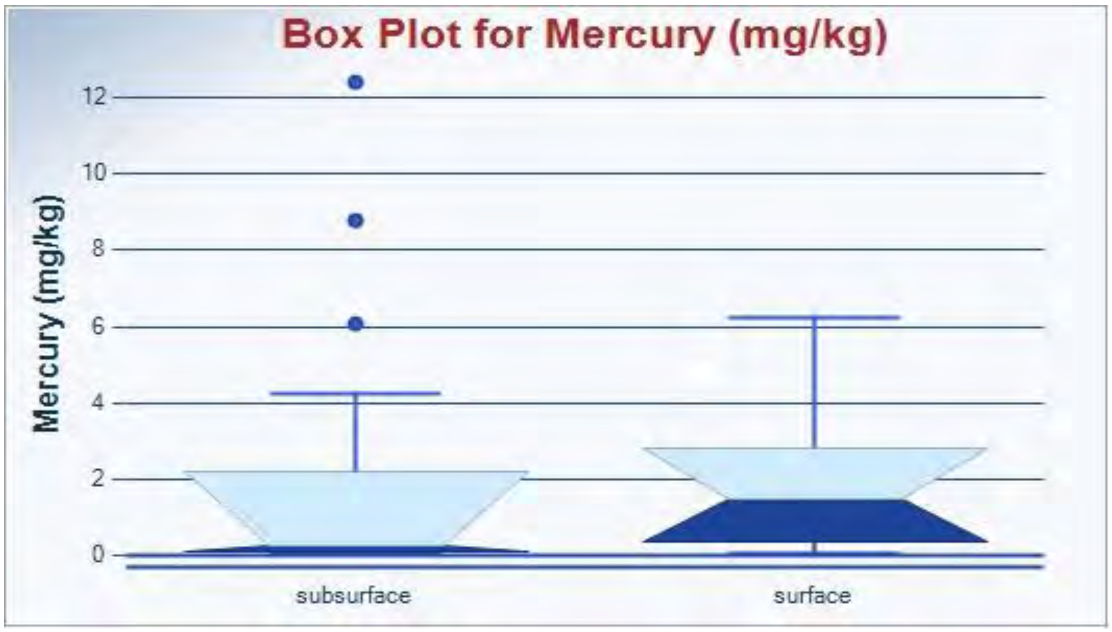
Location	Sample Code	Sample Date	Depth (ft)	Sediment Horizon [1]	X Coordinate	Y Coordinate	Total Mercury (mg/kg)
GGB-52	GGB-52-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2043825.60	483996.60	0.037
GGB-52	52-2-18-20180618	2018-06-18 12:55	0.50 - 1.00	Subsurface	2043825.60	483996.60	1.9
GGB-54	GGB-54-1-SO-20160208	2016-02-08 12:00	0.00 - 0.50	Surface	2043084.00	483501.60	1.3
GGB-54	54-2-18-20180613	2018-06-13 16:58	0.50 - 0.70	Subsurface	2043084.00	483501.60	0.10
GGB-55	GGB-55-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043202.70	483555.10	3.7
GGB-55	55-2-18-20180615	2018-06-15 13:10	0.50 - 1.50	Subsurface	2043202.70	483555.10	0.25
GGB-55	55-3-18-20180615	2018-06-15 13:13	1.50 - 2.40	Subsurface	2043202.70	483555.10	3.1
GGB-55	55-4-18-20180615	2018-06-15 13:18	2.40 - 2.50	Subsurface	2043202.70	483555.10	0.043
GGB-56	GGB-56-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043321.50	483614.70	3.2
GGB-56	56-2-18-20180615	2018-06-15 13:22	0.50 - 1.50	Subsurface	2043321.50	483614.70	12.4
GGB-56	56-3-18-20180615	2018-06-15 13:30	1.50 - 2.00	Subsurface	2043321.50	483614.70	0.16
GGB-57	GGB-57-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043422.50	483662.00	1.2
GGB-57	57-2-18-20180615	2018-06-15 14:50	0.50 - 1.00	Subsurface	2043422.50	483662.00	0.15
GGB-58	GGB-58-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043531.70	483723.60	3.4
GGB-58	58-3-18-20180618	2018-06-18 13:00	1.50 - 2.80	Subsurface	2043531.70	483723.60	4.3
GGB-58	58-4-18-20180618	2018-06-18 13:06	2.80 - 2.90	Subsurface	2043531.70	483723.60	0.078
GGB-59	GGB-59-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043640.70	483780.00	3.7
GGB-59	59-2-18-20180618	2018-06-18 13:14	0.50 - 1.50	Subsurface	2043640.70	483780.00	1.8
GGB-59	59-3-18-20180618	2018-06-18 13:20	1.50 - 1.70	Subsurface	2043640.70	483780.00	0.063
GGB-60	GGB-60-1R-SO-20160210	2016-02-10 12:00	0.00 - 0.50	Surface	2043747.90	483827.90	1.5
GGB-60	60-2-18-20180618	2018-06-18 14:36	0.50 - 1.50	Subsurface	2043747.90	483827.90	3.4
GGB-60	60-3-18-20180618	2018-06-18 14:40	1.50 - 1.90	Subsurface	2043747.90	483827.90	0.038
GGB-61	GGB-61-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043851.90	483884.30	0.18
GGB-62	GGB-62-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2043965.10	483940.50	0.38
GGB-63	GGB-63-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2044073.90	483994.30	0.31
GGB-64	GGB-64-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043325.90	483513.30	0.27
GGB-68	GGB-68-1-SO-20160205	2016-02-05 12:00	0.00 - 0.50	Surface	2043789.20	483714.20	2.3
GGB-68	68-2-18-20180618	2018-06-18 16:12	0.50 - 1.50	Subsurface	2043789.20	483714.20	2.5
GGB-68	68-3-18-20180618	2018-06-18 16:16	1.50 - 1.90	Subsurface	2043789.20	483714.20	0.11
GGB-69	GGB-69-1-SO-20160201	2016-02-01 12:00	0.00 - 0.50	Surface	2043903.90	483769.20	1.3
GGB-69	69-2-18-20180618	2018-06-18 14:55	0.50 - 1.50	Subsurface	2043903.90	483769.20	2.7
GGB-69	69-3-18-20180618	2018-06-18 15:00	1.50 - 2.40	Subsurface	2043903.90	483769.20	0.092
GGB-72	GGB-72-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2043696.30	483538.80	0.16
GGB-73	GGB-73-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2043800.70	483581.00	1.4
GGB-73	73-2-18-20180615	2018-06-15 12:12	0.50 - 0.80	Subsurface	2043800.70	483581.00	0.051
GGB-74	GGB-74-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2043906.60	483635.00	1.7
GGB-74	74-2-18-20180618	2018-06-18 16:00	0.50 - 1.00	Subsurface	2043906.60	483635.00	0.48
GGB-75	GGB-75-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2044016.80	483683.70	0.34
GGB-77	77-1-18-20180615	2018-06-15 11:04	0.00 - 0.50	Surface	2043817.40	483437.80	1.1
GGB-77	GGB-77-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2043817.40	483437.80	2.1
GGB-77	77-2-18-20180615	2018-06-15 11:08	0.50 - 1.50	Subsurface	2043817.40	483437.80	0.81
GGB-77	77-3-18-20180615	2018-06-15 11:12	1.50 - 2.20	Subsurface	2043817.40	483437.80	1.1
GGB-77	77-4-18-20180615	2018-06-15 11:16	2.20 - 2.30	Subsurface	2043817.40	483437.80	0.11
GGB-78	GGB-78-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2043916.80	483496.40	0.52
GGB-78	78-2-18-20180614	2018-06-14 15:20	0.50 - 1.50	Subsurface	2043916.80	483496.40	0.72
GGB-78	78-3-18-20180614	2018-06-14 15:23	1.50 - 1.80	Subsurface	2043916.80	483496.40	0.13
GGB-79	GGB-79-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2044029.60	483548.90	0.44
GGB-81	GGB-81-1-SO-20160204	2016-02-04 12:00	0.00 - 0.50	Surface	2043876.50	483339.10	0.89
GGB-81	81-2-18-20180614	2018-06-14 10:36	0.50 - 1.50	Subsurface	2043876.50	483339.10	3.0
GGB-81	81-3-18-20180614	2018-06-14 10:40	1.50 - 1.60	Subsurface	2043876.50	483339.10	0.035
GGB-82	GGB-82-1-SO-20160202	2016-02-02 12:00	0.00 - 0.50	Surface	2043982.10	483391.10	0.67
GGB-82	82-2-18-20180614	2018-06-14 15:00	0.50 - 1.50	Subsurface	2043982.10	483391.10	2.3
GGB-82	82-3-18-20180614	2018-06-14 15:06	1.50 - 2.20	Subsurface	2043982.10	483391.10	0.13
GGB-89	89-1-18-20180614	2018-06-14 10:15	0.00 - 0.50	Surface	2043844.40	483230.30	0.97
GGB-89	89-2-18-20180614	2018-06-14 10:20	0.50 - 1.50	Subsurface	2043844.40	483230.30	0.98
GGB-89	89-3-18-20180614	2018-06-14 10:26	1.50 - 2.50	Subsurface	2043844.40	483230.30	2.8
GGB-89	89-4-18-20180614	2018-06-14 10:30	2.50 - 2.60	Subsurface	2043844.40	483230.30	0.074
GGB-90	GGB-90-1-SO-20160202	2016-02-02 12:00	0.00 - 0.50	Surface	2044012.00	483279.10	0.023
GGB-96	96-1-18-20180614	2018-06-14 13:05	0.00 - 0.50	Surface	2043828.20	483141.10	0.52
GGB-96	96-2-18-20180614	2018-06-14 13:10	0.50 - 1.50	Subsurface	2043828.20	483141.10	0.56
GGB-96	96-3-18-20180614	2018-06-14 13:12	1.50 - 2.50	Subsurface	2043828.20	483141.10	2.5

Location	Sample Code	Sample Date	Depth (ft)	Sediment Horizon [1]	X Coordinate	Y Coordinate	Total Mercury (mg/kg)
GGB-96	96-4-18-20180614	2018-06-14 13:15	2.50 - 2.90	Subsurface	2043828.20	483141.10	0.098
GGB-97	97-1-18-20180614	2018-06-14 13:28	0.00 - 0.50	Surface	2043916.00	483169.00	0.36
GGB-97	97-2-18-20180614	2018-06-14 13:35	0.50 - 1.50	Subsurface	2043916.00	483169.00	2.2
GGB-97	97-3-18-20180614	2018-06-14 13:40	1.50 - 2.20	Subsurface	2043916.00	483169.00	1.5

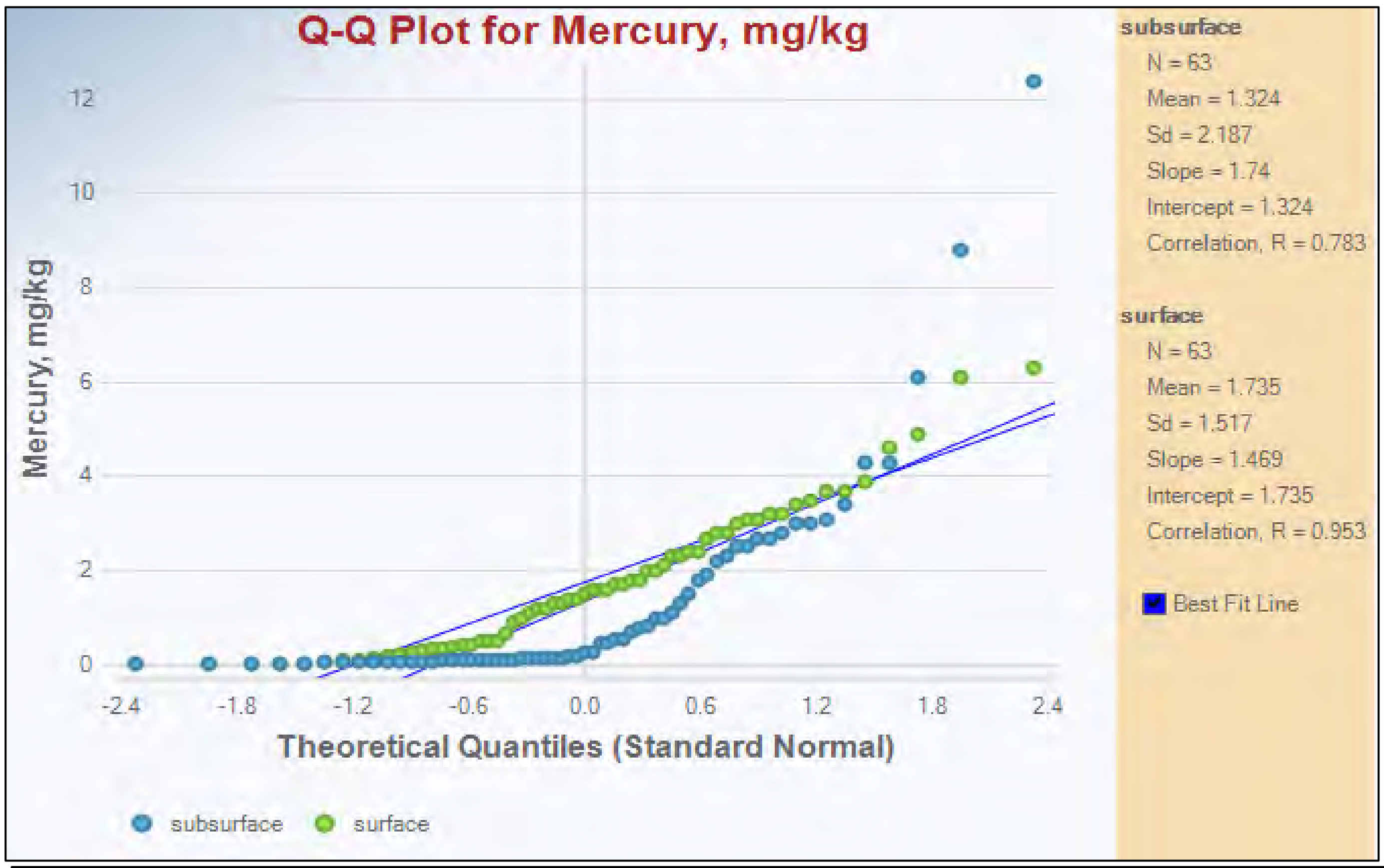
Notes:
ft - feet
mg/kg - milligram per kilogram

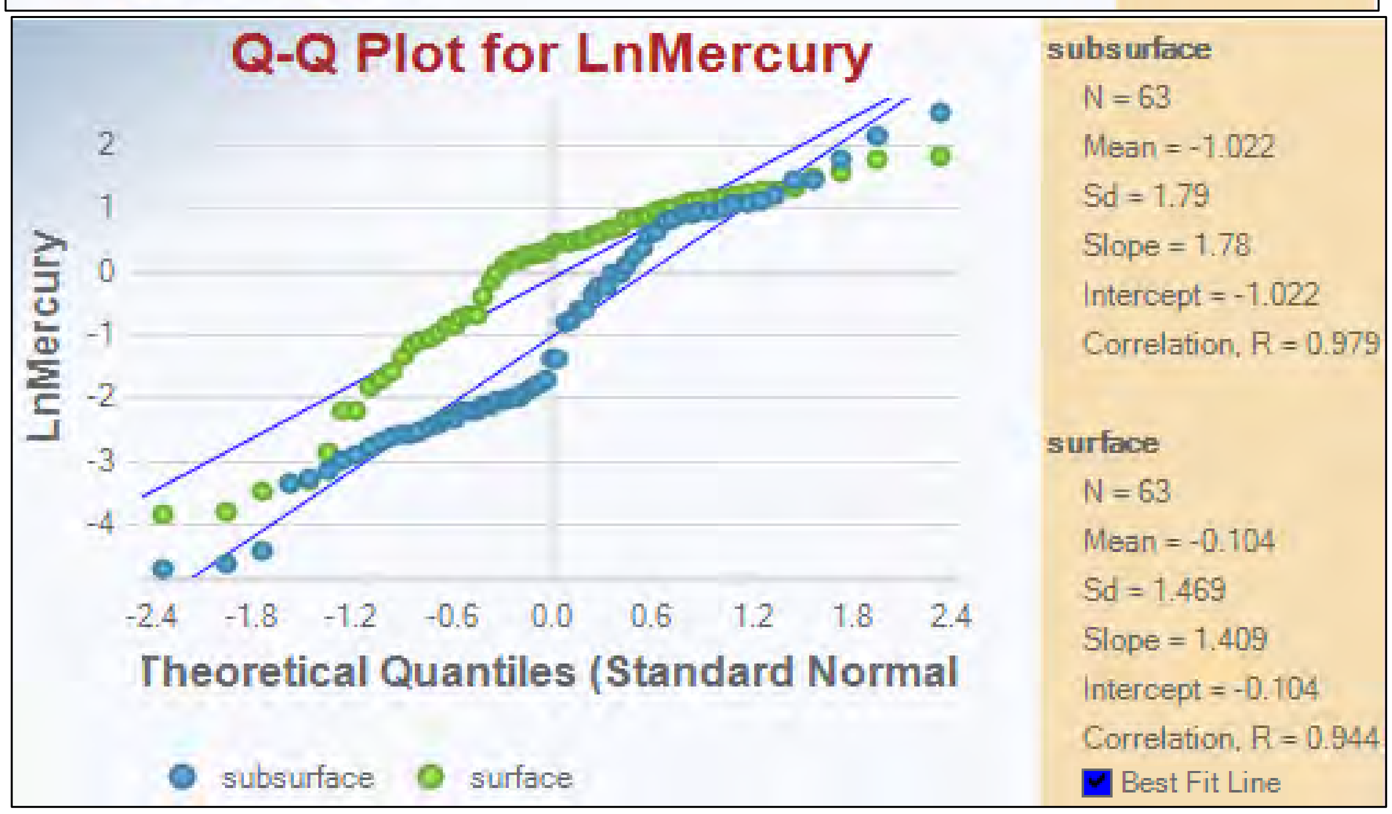
1 - Data groups for sediment horizons are listed below -
Surface - Surface Sediment (0 - 0.5 ft)
Subsurface Sediment (>0.5 ft)

Boxplots of Gruber's Grove Bay Sediment Mercury Data Set



Graphs of Gruber's Grove Bay Sediment Mercury Data Set





UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.2 4/5/2023 6:15:00 PM
From File	ProUCL5_2_characterization_data_statistics_2_horizons.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Mercury (mg/kg) (subsurface)

General Statistics

Total Number of Observations	63	Number of Distinct Observations	52
		Number of Missing Observations	0
Minimum	0.0093	Mean	1.324
Maximum	12.4	Median	0.25
SD	2.187	Std. Error of Mean	0.276
Coefficient of Variation	1.652	Skewness	3.047

Normal GOF Test

Shapiro Wilk Test Statistic	0.635	**Shapiro Wilk GOF Test**
1% Shapiro Wilk P Value	0	Data Not Normal at 1% Significance Level
Lilliefors Test Statistic	0.274	**Lilliefors GOF Test**
1% Lilliefors Critical Value	0.129	Data Not Normal at 1% Significance Level

Data Not Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1.784	95% Adjusted-CLT UCL (Chen-1995)	1.89
		95% Modified-t UCL (Johnson-1978)	1.802

Gamma GOF Test

A-D Test Statistic	2.115	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.819	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.199	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.119	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.489	k star (bias corrected MLE)	0.477
Theta hat (MLE)	2.705	Theta star (bias corrected MLE)	2.777
nu hat (MLE)	61.66	nu star (bias corrected)	60.06
MLE Mean (bias corrected)	1.324	MLE Sd (bias corrected)	1.917
		Approximate Chi Square Value (0.05)	43.24
Adjusted Level of Significance	0.0462	Adjusted Chi Square Value	42.91

Assuming Gamma Distribution

95% Approximate Gamma UCL	1.839	95% Adjusted Gamma UCL	1.853

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.941	**Shapiro Wilk Lognormal GOF Test**
10% Shapiro Wilk P Value	0.00778	Data Not Lognormal at 10% Significance Level
Lilliefors Test Statistic	0.143	**Lilliefors Lognormal GOF Test**
10% Lilliefors Critical Value	0.102	Data Not Lognormal at 10% Significance Level

Data Not Lognormal at 10% Significance Level

Lognormal Statistics

Minimum of Logged Data	-4.678	Mean of logged Data	-1.022
Maximum of Logged Data	2.518	SD of logged Data	1.79

Assuming Lognormal Distribution

95% H-UCL	3.394	90% Chebyshev (MVUE) UCL	3.319
95% Chebyshev (MVUE) UCL	4.061	97.5% Chebyshev (MVUE) UCL	5.092
99% Chebyshev (MVUE) UCL	7.117		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	1.777	95% BCA Bootstrap UCL	1.918
95% Standard Bootstrap UCL	1.764	95% Bootstrap-t UCL	1.977
95% Hall's Bootstrap UCL	2.089	95% Percentile Bootstrap UCL	1.787
90% Chebyshev(Mean, Sd) UCL	2.15	95% Chebyshev(Mean, Sd) UCL	2.525
97.5% Chebyshev(Mean, Sd) UCL	3.044	99% Chebyshev(Mean, Sd) UCL	4.065

Suggested UCL to Use

95% Student's-t UCL 1.784

The calculated UCLs are based on assumptions that the data were collected in a random and unbiased manner.
Please verify the data were collected from random locations.
If the data were collected using judgmental or other non-random methods,
then contact a statistician to correctly calculate UCLs.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Mercury (mg/kg) (surface)

General Statistics

Total Number of Observations	63	Number of Distinct Observations	46
		Number of Missing Observations	0
Minimum	0.022	Mean	1.735
Maximum	6.3	Median	1.5
SD	1.517	Std. Error of Mean	0.191
Coefficient of Variation	0.875	Skewness	1.005

Normal GOF Test

Shapiro Wilk Test Statistic	0.896	**Shapiro Wilk GOF Test**
1% Shapiro Wilk P Value	1.2313E-5	Data Not Normal at 1% Significance Level
Lilliefors Test Statistic	0.129	**Lilliefors GOF Test**
1% Lilliefors Critical Value	0.129	Data Not Normal at 1% Significance Level

Data Not Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	2.054	95% Adjusted-CLT UCL (Chen-1995)	2.075
		95% Modified-t UCL (Johnson-1978)	2.058

Gamma GOF Test

A-D Test Statistic	0.89	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.785	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.118	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.116	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.894	k star (bias corrected MLE)	0.862
Theta hat (MLE)	1.941	Theta star (bias corrected MLE)	2.013
nu hat (MLE)	112.6	nu star (bias corrected)	108.6
MLE Mean (bias corrected)	1.735	MLE Sd (bias corrected)	1.869
		Approximate Chi Square Value (0.05)	85.52
Adjusted Level of Significance	0.0462	Adjusted Chi Square Value	85.05

Assuming Gamma Distribution

95% Approximate Gamma UCL	2.202	95% Adjusted Gamma UCL	2.214

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.875	**Shapiro Wilk Lognormal GOF Test**
10% Shapiro Wilk P Value	6.5835E-7	Data Not Lognormal at 10% Significance Level
Lilliefors Test Statistic	0.18	**Lilliefors Lognormal GOF Test**
10% Lilliefors Critical Value	0.102	Data Not Lognormal at 10% Significance Level

Data Not Lognormal at 10% Significance Level

Lognormal Statistics

Minimum of Logged Data	-3.817	Mean of logged Data	-0.104
Maximum of Logged Data	1.841	SD of logged Data	1.469

Assuming Lognormal Distribution

95% H-UCL	4.184	90% Chebyshev (MVUE) UCL	4.473
95% Chebyshev (MVUE) UCL	5.337	97.5% Chebyshev (MVUE) UCL	6.537
99% Chebyshev (MVUE) UCL	8.895		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	2.049	95% BCA Bootstrap UCL	2.06
95% Standard Bootstrap UCL	2.035	95% Bootstrap-t UCL	2.063
95% Hall's Bootstrap UCL	2.061	95% Percentile Bootstrap UCL	2.052
90% Chebyshev(Mean, Sd) UCL	2.308	95% Chebyshev(Mean, Sd) UCL	2.568
97.5% Chebyshev(Mean, Sd) UCL	2.928	99% Chebyshev(Mean, Sd) UCL	3.637

Suggested UCL to Use

95% Student's-t UCL	2.054

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.