

Remedial Action Plan Update for the Sheboygan River Area of Concern



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**Wisconsin Department of Natural Resources
Office of Great Waters**

Remedial Action Plan Update for the Sheboygan River Area of Concern

This Remedial Action Plan (RAP) includes updates from May 2020 through December 2021.

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Cover Photo: Roy Sebald Sheboygan River Natural Area. Photo taken by GEI.

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The Great Lakes Water Quality Agreement is a non-regulatory agreement between the U.S. and Canada, and criteria developed under its auspices are non-regulatory. The actions identified in this document as needed to meet Beneficial Use Impairment (BUI) delisting targets are not subject to enforcement or regulatory actions. The actions identified in this RAP Update do not constitute a list of preapproved projects, nor is it a list of projects simply related to BUIs or generally to improve the environment. Actions identified in this document are directly related to removing a BUI and are needed to delist the Area of Concern (AOC).

More information on the Great Lakes AOC Program and Wisconsin-based AOCs can be retrieved from the following websites:

- [Great Lakes Areas of Concern | US EPA](#)
- [Area of Concern \(AOC\) Restoration - Wisconsin DNR](#)

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Purpose Statement

This Remedial Action Plan (RAP), which updates the 2018-2019 RAP, documents and communicates progress made in the Sheboygan River AOC in 2020 and 2021 and shares the path forward with partners and stakeholders. The RAP includes a summary of BUI status and tracks progress on specific actions that are important for reaching BUI removal targets. These “actions” may include on-the-ground restoration projects, monitoring and assessment projects, and stakeholder engagement processes. As the primary agency with the responsibility to develop and implement the RAP, the Wisconsin Department of Natural Resources (DNR) Office of Great Waters (OGW) is committed to making progress in remediating and restoring Wisconsin’s Areas of Concern. To be lasting and effective, the RAP must be a program of continuous improvement, evaluating its course as new information and technology become available. Subsequent RAP updates will be produced as needed to incorporate new information.

Remedial Action Plans are required by Annex 1 of the Great Lakes Water Quality Protocol of 2012 (which replaced the 1987 Protocol amending the Revised Great Lakes Water Quality Agreement of 1978). The 2012 Protocol indicates that Remedial Action Plans must include the following elements:

1. Identification of BUIs and causes;
2. Criteria for the restoration of beneficial uses that consider local conditions and are established in consultation with the local community;
3. Remedial measures to be taken, including identification of entities responsible for implementing these measures;
4. A summary of the implementation of remedial measures taken and the status of the beneficial use; and
5. A description of surveillance and monitoring processes to track the effectiveness of remedial measures and confirm restoration of beneficial uses.

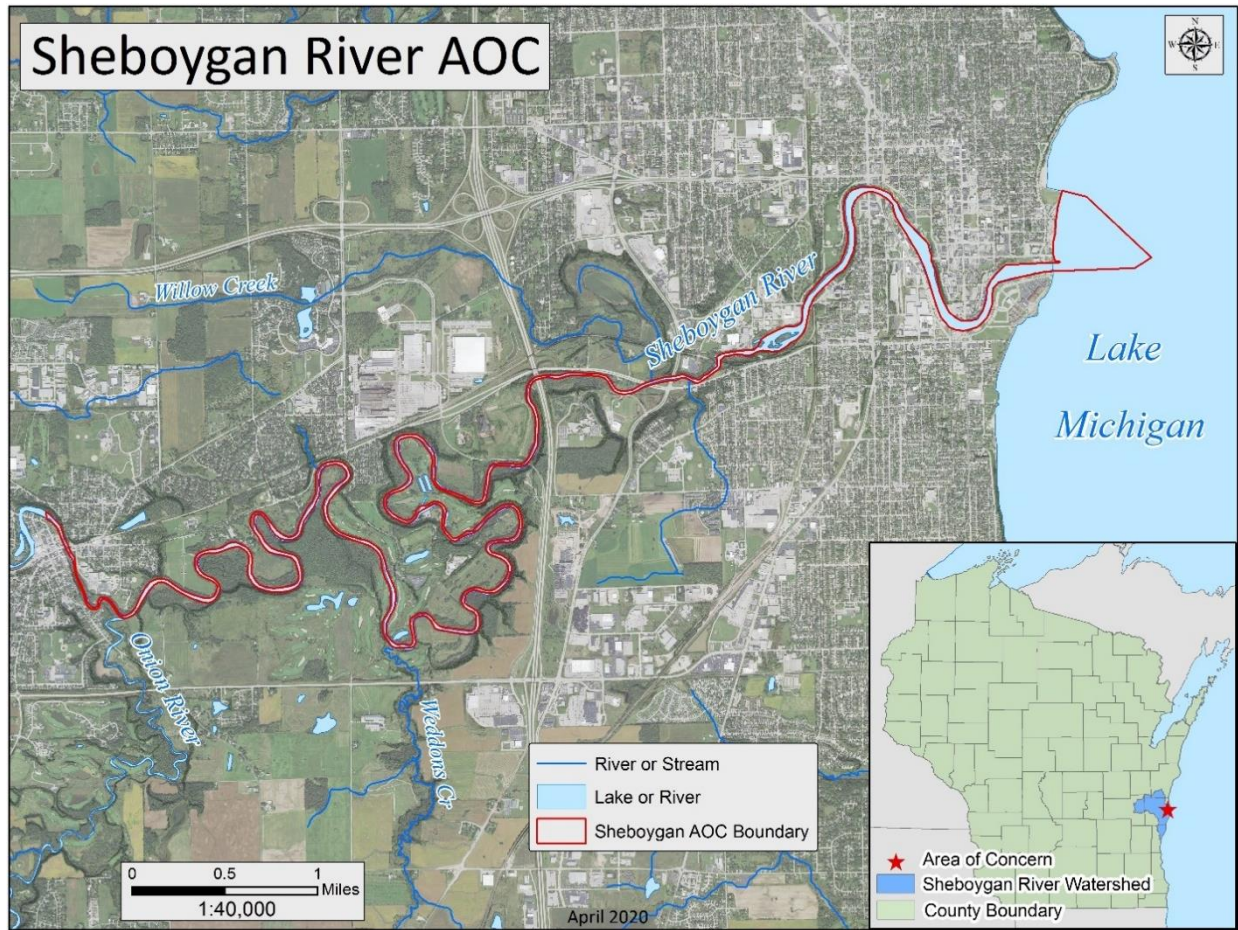


Figure 1. The boundaries of the Sheboygan River AOC. For additional information about the history of the AOC and a narrative description of the AOC boundary, please refer to previous RAP documents which are available online: <https://dnr.wisconsin.gov/topic/GreatLakes/Sheboygan.html> ; RAP documents are stored in the "AOC Plans" tab. Links to the previous RAPs are also available at the end of this document.

Progress Summary

Projects to remediate contaminated sediments and restore habitat for fish and wildlife in the Sheboygan River AOC were completed in 2013. Following that work, the Restrictions on Dredging Activities and Eutrophication or Undesirable Algae Beneficial Use Impairments (BUIs) were removed in 2015. In 2020 the Degradation of Benthos BUI was removed, followed by Degradation of Phytoplankton and Zooplankton Populations in 2021.

Since remediation and restoration were completed, wildlife and aquatic habitats have been monitored for signs of recovery. DNR plans to present results to, and gather feedback from, technical experts and the public on two more proposed BUI removals: Loss of Fish and Wildlife Habitat, and Degradation of Fish and Wildlife Populations. Removal of these two BUIs, projected for 2021, is paused pending further information on the identification of additional sediment and floodplain soil contamination in the most recent Superfund 5-year review (USEPA, 2020). The United States Environmental Protection Agency (USEPA) issues a 5-year review for all superfund sites when hazardous substances remain on site above levels that permit unlimited use and unrestricted exposure, as is the case for the Sheboygan Harbor and River Superfund Site. The superfund site is routinely monitored by the responsible party (RP) for contaminant levels in sediments, fish, and earthworms to ensure these populations are recovering. In addition, the RP routinely monitors groundwater to ensure that polychlorinated-biphenyl (PCB)-contaminated groundwater is not moving towards the river, as well as physical parameters, including bathymetry to assess sediment thickness and scouring. The USEPA uses the results from this routine monitoring, in addition to site visits and environmental assessments, to determine if the implementation and remedial actions are, and will continue to be, protective of human health and the environment through the 5-year review process.

During the most recent 5-year review, additional areas of contaminated sediment within the river and soil contamination within the floodplains were discovered. In the upper river portion of the AOC, surface sediments within deposit 26, an area downstream of the Riverbend Dam, were analyzed for PCB content, and results indicated concentrations that exceed the Toxic Substances Control Act (TSCA) threshold of 50 parts per million (ppm) PCBs. The RPs will be conducting sediment sampling in 2022 in accordance with the long-term monitoring plan for the site, which includes surface grab samples at deposit 26.

In 2016, the USEPA directed the RP to conduct an environmental assessment of the Tecumseh property, which was used as a dewatering facility for dredging activities of the Sheboygan River, after several breaks in dewatering geotextile tubes occurred. During this environmental assessment, significant PCB and polycyclic aromatic hydrocarbon (PAH) contamination was found that was consistent with impacts from past manufacturing operations at the plant. Additional investigations in 2018 found extensive soil contamination around the foundation of the former plant building. In the fall of 2021, the RPs conducted additional sampling at the site and Rochester Park to the east of the facility to inform a plan to remediate the soils. Preliminary results from this sampling indicated high PCB concentrations within the foundation of the former plant building, and along the eastern edge of the park. The park was used

as a landfill until 1972. The City of Sheboygan Falls closed off areas of the park where elevated levels of PCBs were detected. The City has collected additional surface soil samples within the park to better delineate extent of PCB contamination and to evaluate what additional actions need to be taken to protect public health. The source of the PCBs within the park is currently under evaluation.

The removal of the Loss of Fish and Wildlife Habitat BUI requires that the waters within the Sheboygan River AOC are not listed as impaired due to aquatic toxicity in the most recent Clean Water Act 303(d) and 305(b) Wisconsin Water Quality Report (DNR 2020a). As of the 2022 listing, there is no aquatic toxicity impairment in the AOC. However, Rochester Park is also adjacent to one of the fishery habitat enhancement projects, where woody structures were anchored into the banks of the river near the park. The woody structures may need to be removed and replaced depending on future remediation activities. As a result, the DNR has decided to wait to pursue the removal of the Loss of Fish and Wildlife Habitat BUI until there is more certainty about additional remedial actions both in the floodplains and river.

The Degradation of Fish and Wildlife Populations BUI removal requires that remedial actions, including Superfund actions, for contaminated sediments and floodplains have been implemented. Due to the Superfund site developments, DNR has paused the removal process for the Loss of Fish and Wildlife Habitat and Degradation of Fish and Wildlife Populations BUIs.

The three remaining BUIs require additional monitoring for system recovery following the completed management actions. This update describes progress for the BUIs from May 2020 to December 2021. The following is a list of assessment and reporting actions undertaken by DNR and/or partners that represent progress toward removing BUIs and eventually delisting the AOC. Details about projects in the AOC are included in Appendix B.

Fish tumors or other deformities

- The 2017 assessment of white suckers (*Catostomus commersonii*) showed that the incidence of liver tumors was higher than the 5% target (Blazer *et al.* 2019). This may have been due to the limited time between remediation and sampling. DNR and US Geological Survey (USGS) collected 200 white suckers in spring 2021 when a smaller proportion of the population was exposed to pre-remediation conditions. Histopathology and age-class analysis of the 2021 samples are in progress.

Restrictions on fish and wildlife consumption

- DNR began reassessing waterfowl consumption advisories over a three-year period beginning in 2018. Ducks sampled for three years from 2018 - 2020 showed substantially decreased PCB levels compared with 2011-2012. However, roughly 30% of those samples continued to remain higher than the “do not eat” PCB concentration advisory (Appendix D).

- Geese were not tested in 2020 due to the low levels of PCBs encountered in samples between 2018 and 2019; levels are not expected to increase based on goose feeding patterns.
- Consumption restrictions remain in place for waterfowl and fish. Fish sampling and analysis did not occur in 2020 due to COVID-19 restrictions. Due to DNR staff capacity, the lower river and harbor were sampled in 2021 but the upper river was not. Preliminary results from 2021 sampling will likely be available in late 2022 or early 2023. Upper river is anticipated to be sampled in 2023.

Bird or animal deformities or reproductive problems

- In 2018 USGS published a synthesis of their 2014-2017 studies on reproductive effects of PCB exposure on tree swallows (*Tachycineta bicolor*). Results indicate that exposure to sediment contaminants is not adversely affecting tree swallow reproduction in the AOC (Custer *et al.*, 2018).
- DNR has had limited success collecting American mink (*Neovison vison*) despite multiple years of trapping effort, a variety of project designs, and enlisting the aid of a local trapper. At this time, DNR will not continue mink sampling efforts for the purposes of this BUI assessment.
- Because of limited success collecting mink and based on advice from the United States Fish and Wildlife Service (USFWS), DNR will assess fish and fish-eating birds in addition to the tree swallow nestlings collected from 2011-2014 as part of this BUI Assessment.

Remedial Action Plan Update for the Sheboygan River Area of Concern
2020-2021

Table 1. Current Status of Beneficial Use Impairments in the Sheboygan River AOC. Information regarding specific projects addressing each BUI is found in Appendix C.

Beneficial Use Impairment	Beneficial Use Remains Impaired	Summary Status
Fish tumors or other deformities	Yes	Two hundred mature white suckers were collected in spring 2021 and samples are being analyzed for age class and liver tumor incidence.
Bird or animal deformities or reproductive problems	Yes	DNR attempted to trap additional mink within the AOC with the help of a local trapping expert in 2020 but was unsuccessful. As a result of limited success collecting mink and based on advice from the USFWS, DNR will assess fish and fish-eating birds in addition to the tree swallow nestlings collected by USGS from 2011-2014 as part of this BUI Assessment. DNR plans to collect data on fish and fish-eating birds starting in either 2023 or 2024, depending on the need for additional remedial actions through the Superfund program.
Restrictions on fish and wildlife consumption	Yes	DNR began a three-year reassessment of waterfowl consumption advisories in 2018. Ducks sampled in 2018 through 2020 show substantially decreased PCB levels compared with samples collected in 2011-2012, but levels were still high enough that consumption advisories remain in effect. PCB levels in geese were comparable to pre-restoration levels and a consumption advisory remains in effect. Fish sampling and analysis did not occur in 2020 due to COVID-19 restrictions. Due to DNR staff capacity, fish were sampled only in the lower river and harbor in 2021. Preliminary results of the 2021 sampling will likely be available in 2022 or early 2023. Sampling in the upper river is anticipated in 2023.
Restrictions on dredging activities	No	BUI was removed in August 2015.
Degradation of phytoplankton and zooplankton populations	No	BUI was removed in September 2021.
Degradation of benthos	No	BUI was removed in December 2020.
Loss of fish and wildlife habitat	Yes	The six tier-one habitat restoration projects outlined in the Fish and Wildlife Plan are complete, and maintenance and monitoring of those projects continued through 2016. A habitat assessment of the restoration projects in 2019 indicated that restoration goals are being achieved. As of the 2022 impaired waters listing, the AOC is not on the 303(d) list for aquatic toxicity. However, DNR has decided to wait to pursue the removal of the Loss of Fish and Wildlife Habitat BUI until there is more certainty about additional remedial actions both in the floodplains and river, and the effect on habitat restoration projects in the area.
Degradation of fish and wildlife populations	Yes	Verification monitoring studies of macroinvertebrates, birds, bats, herptiles and mussels were completed by 2018. Results indicate that populations are stable or recovering, compared to 2011-2012. Due to the Superfund site developments, DNR has paused the removal process for the Loss of Fish and Wildlife Habitat and Degradation of Fish and Wildlife Populations BUIs.
Eutrophication or undesirable algae	No	BUI was removed in November 2015.

Beneficial Use Impairment Updates

For each BUI section, the following symbols indicate the status of the management actions listed:

- *Not Started*
- *Underway*
- ✓ *Complete*



Fish Tumors and Other Deformities

Target	Status
All known sources of polycyclic aromatic hydrocarbons (PAHs) and chlorinated compounds within the AOC and tributary watershed have been controlled through issuance of the appropriate regulatory control document or eliminated.	Reassess
The superfund PCB cleanup and Manufactured Gas Plant cleanup have been implemented.	Reassess
There have been no reports of external Deformities, Lesions, and Tumors (DLTs) or internal organ/system impacts that have been verified by qualified DNR personnel to have been caused by chemical contaminants for a period of five years.	In Progress
A fish health survey of resident benthic fish species such as white suckers finds incidences of tumors or other deformities at an incidence rate of less than 5 percent.	In Progress
OR, in cases where any tumors have been reported a comparison study of resident benthic fish (e.g., brown bullhead or white suckers) of comparable age and at maturity (3 years), or of fish species which have historically been associated with this BUI, in the AOC and a non-impacted control site indicates that there is no statistically significant difference (with a 95% confidence interval) in the incidence of liver tumors or deformities.	In Progress

Status

In 2012 DNR and the University of Wisconsin collected a baseline sample of 193 mature white suckers (between 3 and 28 years old) during the spring spawning run, primarily in the vicinity of Kiwanis Park in the lower Sheboygan River. Examination by personnel at USGS and West Virginia University (WVU) found that 8.3% of the fish had neoplastic liver tumors, exceeding the criteria of less than 5% specified in the BUI removal targets as well as the 3.5% incidence at a non-AOC reference site at the Kewaunee River (Blazer and Mazik 2012; Blazer *et al.* 2016).

In 2012-2013, over 300,000 cubic yards of PCB- and PAH-contaminated sediments were dredged from the lower Sheboygan River (DNR 2015a). Sampling in spring 2017 found that the incidence of liver tumors was not statistically different than in 2012 (Blazer *et al.* 2016). All but one year-class of fish collected during this study were born before and during sediment cleanup. It was hypothesized that their tumors resulted from exposure to contaminated sediments prior to the completion of dredging in 2013, or to contaminants suspended in the water by the dredging operations (Blazer *et al.* 2019).

In spring 2021, USGS and WVU collected 200 mature white suckers from the lower river. A higher proportion of fish from this sampling event should have recruited after cleanup was completed. As of November 2021, age class analysis and histopathology were in progress.

Management Actions

- ✓ *All sources of contaminants have been identified and controlled or eliminated within the Sheboygan River AOC.**

*Additional contamination within the AOC was reported in the most recent 5-year Superfund review. The USEPA Superfund program will review the need for subsequent remediation actions for sediment contamination following additional sample collection that is anticipated to take place in 2022.

Additional Actions

- ✓ *A 2017 sample of mature white suckers found that the rate of neoplastic tumors was not statistically different than in 2012.*
- ➡ *White suckers were sampled again in spring 2021 and histopathology is in progress.*

Bird or Animal Deformities or Reproductive Problems

Target	Status
Superfund and Resource Conservation and Recovery Act (RCRA) sediment and floodplain remedial actions have been implemented.	Reassess
Studies conducted in the AOC indicate that the beneficial use should not be considered impaired; or	In progress
If studies conducted in the AOC determine that this use is impaired, then two approaches can be considered for removal:	
<p>Approach 1 – Observational Data and Direct Measurements of Birds and Other Wildlife</p> <p>Evaluate observational data of bird and other animal deformities for a minimum of two successive monitoring cycles, in the indicator species identified in the initial studies as exhibiting deformities or reproductive problems. If deformity or reproductive problem rates are not statistically different from those at minimally impacted reference sites (at a 95% confidence interval), or no reproductive or deformity problems are identified during the two successive monitoring cycles, then the BUI can be removed. If the rates are statistically different from the reference site, it may indicate a source from either within or outside the AOC. Therefore, if the rates are statistically different or the data are insufficient for analysis, then</p> <p>Evaluate tissue contaminant levels in egg, young and/or adult wildlife. If contaminant levels are lower than the Lowest Observable Effect Level (LOEL) for that species for a particular contaminant and are not statistically different from those at minimally impacted reference sites (at a 95% confidence interval), the BUI can be removed.</p>	In progress
Where data from direct observation of wildlife and wildlife tissue data are not available, the following approach should be used:	
<p>Approach 2 – Fish Tissue Contaminant Levels as an Indicator of Deformities or Reproductive Problems</p> <p>If fish tissue concentrations of contaminants of concern identified in the AOC are at or lower than the LOEL known to cause reproductive or developmental problems in fish eating birds and mammals, the BUI can be removed, or</p> <p>If fish tissue concentrations of contaminants of concern identified in the AOC are not statistically different from those found in Lake Michigan (at 95% confidence interval), then the BUI can be removed. Fish of a size and species considered prey for the wildlife species under consideration must be used for the tissue data.</p>	Not Complete

Status

Following the completion of remedial action at the Superfund site in 2013, UGSG and DNR monitored contaminant levels and effects in tree swallow eggs and nestlings and in American mink, respectively, as described in Approach 1 of the target. Tree swallows feed on flying insects, including those with a benthic life stage in which they are potentially exposed to sediment contaminants; in addition, they are

common summer residents that readily use nest boxes so egg samples are easily taken. Mink are fish-eating mammals that are sensitive to bioaccumulative chemicals (mink reproduction is known to be particularly sensitive to PCB exposures) and may be considered a “sentinel” species to indicate toxins in the aquatic food chain (Basu *et al.* 2007; Blankenship *et al.* 2008). Local trappers reported that, despite abundant habitat, few mink were trapped in the Sheboygan AOC, suggesting that contaminants or some other cause may have been affecting survival and reproduction. DNR has had limited success trapping mink despite multiple years of effort, a variety of project designs, and enlisting the aid of a local trapper. At this time, DNR will not continue mink sampling efforts for the purposes of this BUI assessment.

Based on advice from the USFWS, the DNR will incorporate fish and fish-eating birds into this BUI assessment. DNR is still determining which fish-eating birds will be targeted within the AOC based on availability and ease of collection. Herring gulls (*Larus argentatus*) will likely be targeted as they are abundant within the AOC, and there are data available for comparison from multiple sites across the Great Lakes (de Solla *et al.* 2016). Fish are collected routinely to assess the fish consumption advisory by the DNR, and these data can be used in addition to the regular fish collection through the Superfund long-term monitoring plan to inform the status of fish contaminant levels and deformities. The assessment of fish and fish-eating birds will begin in 2023 or 2024, depending on the need for additional sediment remediation action through the Superfund Program.

Tree swallow studies

From 2011-2014, USGS researchers measured contaminant concentrations in tree swallow eggs (Custer *et al.* 2016) and nestlings (Custer *et al.* 2017) at four sites in the Sheboygan River AOC. They compared tissue concentrations of contaminants to background levels at non-AOC sites, and to the levels that have been established to cause reproductive effects in tree swallows. They also compared the reproductive success, measured by the daily probability of egg failure or the number of eggs that failed to hatch at the AOC and non-AOC sites.

The average levels of PCBs in the tree swallow eggs were higher at the AOC sites (1.53-4.55 parts per million, [ppm]) than at non-AOC sites (0.32 ppm); however, reproductive effects do not occur until concentrations reach 20 ppm. Concentrations of dioxins/furans, pesticides, mercury, and other legacy contaminants were at background levels in eggs and nestlings at all the sites (Custer *et al.* 2018). These results are inconclusive, and in consultation with the USFWS, DNR is now considering other bird species which are more sensitive to PCBs, such as piscivorous birds (e.g., gulls or herons), which might better serve as indicators of reproductive effects (Bush *et al.* 2020).

American mink studies

Live trapping efforts in 2014-2016 in areas where mink tracks were observed were unsuccessful. In 2017, DNR revised the mink sampling strategy (Selle and Fischer 2018). In 2018, DNR set body-grip traps in areas of likely habitat where tracking surveys and camera traps indicated the presence of mink. That season two mink were trapped in the AOC and a roadkill specimen was collected in the control area along the Sheboygan River upstream of the AOC. Analysis by the Wisconsin State Lab of Hygiene (WSLH)

determined that the two mink from the AOC had significantly higher total PCB hepatic tissue concentrations (0.956 ppm and 1.464 ppm) than the individual from the control area (0.031 ppm).

Trapping efforts continued unsuccessfully in 2019. However, DNR was able to procure two specimens from a local trapper in the control area, and two roadkill specimens from 2013 (AOC) and 2015 (control area) that were still viable for tissue analysis. These samples were analyzed in 2018-2019. Preliminary indications from these data are that PCB concentrations in mink livers are higher within the AOC than in the control area. The average tissue concentration in the AOC, 1.60 ppm, is below the 2-ppm toxic threshold used to indicate potential adverse impacts but is high enough that potential effects cannot be ruled out (Strom 2019). To increase the odds of obtaining at least 10 specimens, DNR engaged a local trapper and obtained a scientific collector's permit to trap mink out of season in 2020. DNR was unable to collect any mink specimen through this effort, so different indicator species, including fish-eating birds, will be targeted to assess this BUI.

Results of mink surveys and contaminant monitoring are summarized in Appendix C.

Management Actions

- ✓ *All sources of contaminants have been identified and controlled or eliminated within the Sheboygan River AOC. **

*Additional contamination within the AOC was reported in the most recent 5-year Superfund review. The USEPA Superfund program will review the need for subsequent remediation actions for sediment contamination following additional sample collection that is anticipated to take place in 2022.

Additional Actions

- ✓ *USGS published results from tree swallow studies in three technical journal articles in 2016, 2017, and 2018.*
- ✓ *The Quality Assurance Project Plan (QAPP) for mink sampling was updated for 2018 with a revised strategy.*
- ✓ *DNR collected four mink in 2018-2019 and obtained hepatic tissue PCB concentrations.*
- ✓ *DNR consulted with USFWS regarding additional species that may be suitable for this BUI assessment. The BUI assessment will now focus on fish, fish-eating birds, and the tree swallow collection from 2011-2014.*
- 🔄 *Fish and fish-eating bird data collection will begin in 2023 or 2024, depending on the need for additional sediment remediation action through the Superfund Program.*

Restrictions on Fish and Wildlife Consumption

Target	Status
Fish Consumption	
The Superfund PCB cleanup and Manufactured Gas Plant cleanup have been implemented.	Reassess
All other known sources of bioaccumulative contaminants of concern (PCBs, mercury, pesticides, and PAHS) have been identified and controlled or eliminated.	Reassess
Waters within the Sheboygan River AOC are no longer listed as impaired due to PCB fish consumption advisories in the most recent Impaired Waters (303(d)) list.	Not Complete
Wildlife Consumption	
The floodplain cleanup action that is part of the Superfund Cleanup is implemented.	Reassess
All other known sources of bioaccumulative contaminants of concern (PCBs, mercury, pesticides, and PAHs) have been identified and controlled or eliminated.	Reassess
Waters within the Sheboygan River AOC are no longer listed as impaired due to wildlife consumption advisories listed in the annual Wisconsin Migratory Bird Regulations.	Not Complete

Status

Currently, the Sheboygan River is listed as a 303(d) impaired water based on PCB contamination in fish tissue (DNR 2020b). The lower 14 miles are under a “do not eat” restriction for all fish species except brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), chinook salmon (*Oncorhynchus tshawytscha*), and coho salmon (*Oncorhynchus kisutch*), which may be consumed once per week or once per month, depending on fish size and the age and sex of the consumer (i.e., children and women of childbearing age should consume less; DNR 2020b). The third portion of the target for the fish consumption BUI is currently not met. Fish sampling and analysis did not occur in 2020 due to COVID-19 restrictions. Due to DNR staff capacity, the lower river and harbor were sampled in 2021 but the upper river was not. Preliminary results of the 2021 sampling will likely be available in late 2022 or early 2023. Sampling in the upper river is anticipated in 2023.

In 2011 and 2012, prior to completion of sediment remediation projects, DNR and the U. S. Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) collected waterfowl including dabbling ducks, diving ducks, and Canada geese (*Branta canadensis*) from the AOC. These three categories comprise different feeding niches and thus possible avenues of PCB exposure: Top of water column dabblers, lower water column or sediment foragers, and upland grazers. PCB concentrations in muscle tissue of diving and dabbling ducks were consistently above the “do not eat” threshold of >2.0 ppm, while those in geese were below 1 ppm (DNR 2020c).

After a five-year post-remediation recovery time, DNR re-sampled waterfowl from 2018-2020. PCB levels decreased within all three categories compared to 2011-2012 (Figure 2, Appendix D). Levels in geese were much lower than in ducks, and the 2018-2019 results resembled those of 2011-2012: the highest PCB level fell under the advisory of no more than one meal/month, and 20% of geese had levels indicating unlimited consumption allowed. After evaluating these results with a fish and wildlife toxicologist and considering their upland feeding patterns, geese were removed from the list of waterfowl species to be sampled in 2020 (DNR 2020c).

Mean PCB Levels in diving ducks were slightly higher than in dabbling ducks in 2018-2020, Figure 2. Although the overall mean concentration in diving ducks for the three years is below 2.0 ppm, the 75th percentile in each year exceeds that threshold, indicating that a “do not eat” advisory is still appropriate. For dabbling ducks, the overall mean of the three years is 1.2 ppm, well within the 6 meals per year advisory range (1.0 – 2.0 ppm). The pooled median and 75th percentile values are also within this advisory range, indicating that advisories could be revised for dabbling ducks in the Sheboygan River AOC (Appendix D; DNR, 2021).

Lesser scaup (*Aythya affinis*) from the Sheboygan Harbor portion of the AOC remained under a “do not eat” restriction in 2021 (DNR 2021). The third portion of the target for the wildlife consumption BUI is currently not met. Waterfowl sampling is recommended to continue in three to five years.

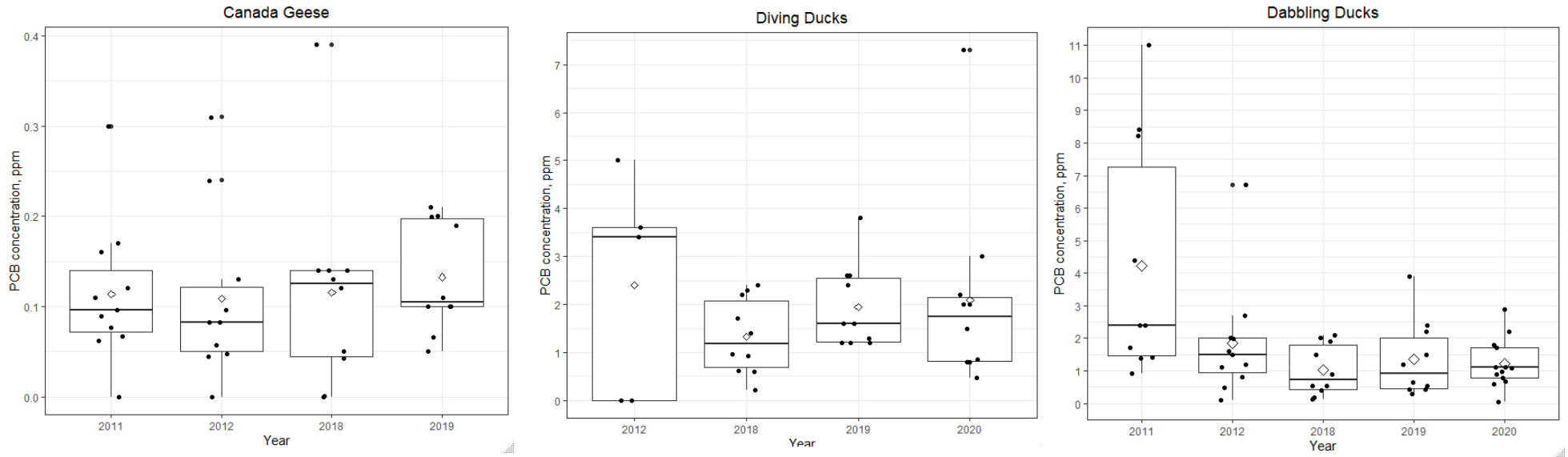


Figure 2. Waterfowl tissue PCB concentration quartile box plots. Dots represent data points, diamonds represent mean values, lines represent median values.

Management Actions

- ✓ *All sources of contaminants have been identified and controlled or eliminated within the Sheboygan River AOC. **

*Additional contamination within the AOC was reported in the most recent 5-year Superfund review. The USEPA Superfund program will review the need for subsequent remediation actions for sediment contamination following additional sample collection that is anticipated to take place in 2022.

Additional Actions

- ✓ *PCB monitoring in waterfowl (dabbling and diving ducks) occurred from 2018-2020.*
- ➡ *Fish collection and tissue contaminant monitoring were not conducted in 2020-2021 due to COVID-19 restrictions and DNR staff capacity.*
- ➡ *The BUI status will be evaluated in 2025.*

Degradation of Phytoplankton and Zooplankton Populations

Target	Status
Sources causing nutrient enrichment to the Outer Harbor and near shore waters are identified and controlled if nutrients are the main contributor to plankton population degradation; OR Sources of ambient water toxicity in the Outer Harbor and near shore waters are identified and controlled if toxicity is the main contributor to plankton population degradation.	Complete
Phytoplankton or zooplankton bioassays confirm no toxicity in ambient waters and the community structure is diverse and contains species indicative of clean water.	Complete
The phytoplankton and zooplankton communities within the site being evaluated are statistically similar to those of a reference site with similar habitat and minimal sediment contamination.	Complete

Status

A final removal package was sent to USEPA on September 9, 2021 and with the concurrence of USEPA, the BUI was formally removed later that month. The final BUI removal document can be found on DNR's Sheboygan River AOC web page under the ["Impairments" tab](#).

Management Actions

- ✓ *No further actions are necessary for this BUI.*

Degradation of Benthos

Target	Status
Known contaminant sources contributing to sediment contamination and degraded benthos have been identified and control measures implemented.	Complete
All remediation actions for contaminated sediments are completed and monitored according to the approved plan with consideration to using consensus-based sediment quality guidelines and equilibrium partitioning sediment benchmarks.	Complete
The benthic community within the site being evaluated is statistically similar to that of a reference site with similar habitat and minimal sediment contamination.	Complete

Status

A final removal package was sent to USEPA on December 8, 2020 and with the concurrence of USEPA, the BUI was formally removed later that month. The final BUI removal document can be found on DNR's Sheboygan River AOC web page under the ["Impairments" tab](#).

Management Actions

- ✓ *No further actions are necessary for this BUI.*

Restrictions on Dredging Activities

Target	Status
All remediation actions for contaminated sediments are completed and monitored according to the approved remediation plans.	Complete
<p>A dredging alternatives plan is developed that includes an evaluation of the following:</p> <ul style="list-style-type: none"> • Restrictions that must remain in place to protect human health and the environment. • Restrictions that must remain in place due to Superfund or RCRA requirements that are based upon state and federal law. • Priority areas for navigational use. • Priority areas where dredging is needed for other purposes (i.e., utilities) • Costs associated with removing dredging restrictions in priority areas. • Funding available to address removing dredging restrictions in priority areas. 	Complete

Status

A final removal package was sent to USEPA in July 2015 and with the concurrence of USEPA, the BUI was formally removed in August 2015. The final BUI removal document can be found on DNR's Sheboygan River AOC web page under the ["Impairments" tab](#). A summary of sediment removal projects can be found in Table 4 of the 2014 RAP Update.

Management Actions

- ✓ *No further actions are necessary for this BUI.*

Loss of Fish and Wildlife Habitat

Target	Status
<p>A local fish and wildlife habitat management and restoration/rehabilitation plan has been developed for the entire AOC that accomplishes the following:</p> <ul style="list-style-type: none"> ✓ <i>Defines the causes of all habitat impairments within the AOC.</i> ✓ <i>Establishes site-specific habitat and population targets for fish and wildlife species within the AOC.</i> ✓ <i>Identifies primary and secondary habitat restoration goals, management activities, and projects that would adequately restore or rehabilitate fish and wildlife habitat within the Sheboygan River AOC.</i> 	Complete
All primary habitat restoration goals, management activities, and projects identified in the fish and wildlife management and restoration plan are implemented and modified as needed to ensure continual improvement.	Complete
Waters within the Sheboygan River AOC are not listed as impaired due to aquatic toxicity in the most recent Clean Water Act 303(d) and 305(b) Wisconsin Water Quality Report to Congress (submitted to USEPA every two years).	Complete

Status

The first two targets were met by the completion of the Fish and Wildlife Restoration Plan for the Sheboygan River AOC, and the completion in 2012 of the habitat restorations and management actions. Six habitat restoration projects and one preservation project were completed to address the eight Tier 1 project conservation goals identified by the Plan (DNR 2016; USFWS 2017; GEI 2019).

Conservation goals:

1. Migratory bird stopover habitat
2. Shorebird stopover and breeding habitat
3. Resident breeding bird habitat
4. Warmwater fisheries community habitat
5. Herptile habitat
6. Riparian emergent wetlands
7. Riparian forested floodplains
8. Coldwater fisheries community habitat

Habitat Projects (Figure 3):

1. Kiwanis Park Shoreline Restoration (Goals 1-5)
2. Taylor Drive and Indiana Avenue Riparian Area and Wetland Restoration (Goals 1-6)
3. Wildwood Island Area Restoration (Goals 1-6)

4. Shoreline Stabilization in Problem Areas (Goals 1-5)
5. In-Stream Habitat Improvements (Rochester Park and Kohler Site) (Goal 4)
6. Targeted Invasive Species Control (Goals 1-8)
7. Preservation of Schuchardt Property (Goals 1-8)

From 2014-2018, habitat and population assessments were conducted at the six project sites and other areas throughout the AOC. A comprehensive study by GEI Consultants concluded that all site-specific Tier One Restoration project goals were attained (GEI 2019). Details of the habitat projects, post-restoration assessments, and habitat improvements are found in 2018-2019 Sheboygan Remedial Action Plan Update.

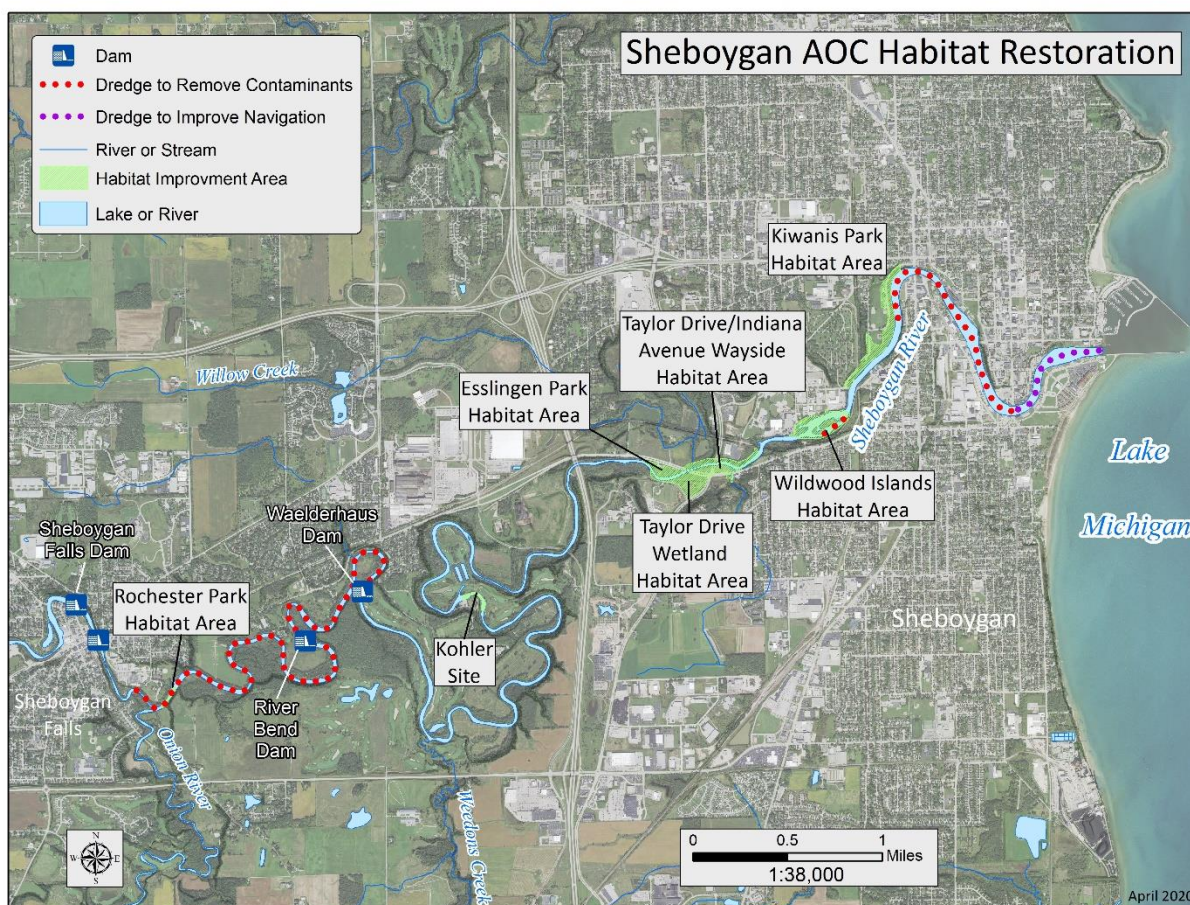


Figure 3. Locations of the shoreline habitat and in-stream restoration projects to address Fish and Wildlife BUIs in the Sheboygan River AOC.

Management Actions

- ✓ Seven habitat projects and their maintenance and monitoring periods have been completed.

Additional Actions

- ✓ *GEI Consultants conducted a detailed habitat assessment and published their report in 2019.*
- ✓ *Aquatic toxicity is not contributing to the 303(d) impaired waters listing of the Sheboygan River.*
- ➡ *The removal of the Loss of Fish and Wildlife Habitat BUI has been paused pending further information from the Superfund 5-year review, any further remediation actions that may be necessary, and the effects on the in-stream habitat restoration projects in the area.*

Degradation of Fish and Wildlife Populations

Target	Status
Approved remedial actions (Superfund and RCRA) for contaminated sediment and floodplains have been fully implemented; and	Reassess
<p>A local fish and wildlife management and restoration plan has been developed for the entire AOC that:</p> <ul style="list-style-type: none"> • Defines the causes of all population impairments within the AOC. • Establishes site specific local population targets for native indicator fish and wildlife species within the AOC. • Identifies all fish and wildlife population restoration programs/activities within the AOC and establishes a mechanism to assure coordination among all these programs/activities including identification of lead and coordinative agencies. • Establishes a time table, funding mechanism, and lead agency responsibility for all fish and wildlife population restoration activities needed with the AOC. 	Complete
The programs necessary to accomplish the recommendations of the fish and wildlife management and restoration plan are implemented.	Complete
Populations of native indicator fish/wildlife species are statistically similar to populations in reference sites with similar habitat, but little to no contamination.	Complete

Status

The second and third portions of the target are met by the Fish and Wildlife Restoration Plan and the restoration actions described in the Loss of Fish and Wildlife Habitat section. To address the last portion of the target, DNR and partners conducted pre- and post-restoration wildlife assessments in 2011-2012 and in 2014-2018, respectively, to determine the wildlife response to habitat improvements. The results, described in the 2018-2019 RAP Update (DNR 2020), are summarized below:

- Fish community surveys conducted in 2014-2016 from at nine sites in the Sheboygan River showed that overall, populations were relatively healthy and resembled those at sites with comparable habitat but no contamination.
- Breeding bird surveys in 2016 at the habitat restoration sites and other areas in the AOC found higher abundance and species richness compared to pre-restoration surveys. The breeding bird numbers will likely increase as the restoration plantings mature; migrating birds, which use early-successional vegetation for stopover habitat, will benefit from the softened forest-prairie transitions.

- Acoustic surveys for bats along the Sheboygan River in 2016 detected an increased number of species and bat passes per detector-hour compared to surveys in 2010-2011. A decline in detections of little brown bat may be due to white-nose syndrome affecting the population of a hibernaculum within 50 miles of the AOC.
- The 2020 mink trapping season was unsuccessful. The low number of mink samples collected make it an unsuitable indicator for population assessments.
- Herptile community surveys in 2018 found comparable species numbers to 2011, and all species except snapping turtle (*Chelydra serpentina*) were detected at more sites in 2018.
- The non-wadeable site at the mouth of the Sheboygan River had “Poor” macroinvertebrate Index of Biotic Integrity (IBI) ratings and Hilsenhoff’s Biotic Index (HBI) scores both pre- and post- restoration, due to lack of habitat and dominance of fine sediment substrate. At all other sites in the Sheboygan River the mean macroinvertebrate IBI scores after restoration were sufficiently high that the macroinvertebrate community is not considered impaired.
- Mussel surveys at 14 sites in the Sheboygan River in 2011 and at seven sites in 2016 found the mussel community to be moderately diverse with varying abundance depending on the site. The restoration sites at Taylor Drive and Esslingen Park had good populations of most of the observed species, and the abundance increased post-restoration. Populations may rebound over time as fish move these species to new areas of restored habitat in the river.

Management Actions

- ✓ *All sources of contaminants have been identified and controlled or eliminated within the Sheboygan River AOC. **

*Additional contamination within the AOC was reported in the most recent 5-year Superfund review. The USEPA Superfund program will review the need for subsequent remediation actions for sediment contamination following additional sample collection that is anticipated to take place in 2022.

Additional Actions

- ✓ *Pre- and post-restoration assessments of the major taxa indicate that species metrics are stable or improving.*
- ↻ *The removal of the Degradation of Fish and Wildlife Populations BUI has been paused pending further information from the Superfund 5-year review.*

Eutrophication or Undesirable Algae

Target	Status
In-river total phosphorus concentrations meet Wisconsin AOC target criteria with a 95% level of confidence; and	Complete
There are no violations of the minimum dissolved oxygen concentrations established in NR 102 within the AOC due to excessive sediment deposition or algae growth; and	Complete
The Wisconsin AOC target criteria will be considered to have been met when the sample population does not exceed nutrient targets or evidence indicates the lack of biological impairment (as determined by fish and macroinvertebrate Indicators of Biological Integrity, or IBIs).	Complete

Status

A final removal package was sent to USEPA in September 2015 and with the concurrence of USEPA, the BUI was officially removed in November 2015. The final BUI removal document can be found on DNR's Sheboygan River AOC web page under the ["Impairments" tab](#).

Management Actions

- ✓ *No further actions are necessary for this BUI.*

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List of Previous Remedial Action Plans, Updates, and other important historical documents:

[Degradation of Phytoplankton and Zooplankton Populations](#)

[Degradation of Benthos BUI Removal Package](#)

[Eutrophication or Undesirable Algae](#)

[Restrictions on Dredging Activities](#)

[2018-2019 Remedial Action Plan Update for the Sheboygan River Area of Concern](#)

[2017 Remedial Action Plan Update for the Sheboygan River Area of Concern](#)

[2016 Remedial Action Plan Update for the Sheboygan River Area of Concern](#)

[2015 Remedial Action Plan Update for the Sheboygan River Area of Concern](#)

[2014 Remedial Action Plan Update for the Sheboygan River Area of Concern](#)

[2012 Remedial Action Plan Update for the Sheboygan River Area of Concern](#)

[2011 Stage 2 Remedial Action Plan for the Sheboygan River Area of Concern](#)

[2008 Delisting Targets for the Sheboygan River Area of Concern: Final Report](#)

[1995 Remedial Action Plan for the Sheboygan River Area of Concern](#)

[1989 Sheboygan River Remedial Action Plan Stage 1](#)

Appendices

Appendix A – Acronyms

Appendix B – BUI Tracking Matrix

Appendix C – Sheboygan Area of Concern Verification Monitoring: Mink Survey and Contaminant Monitoring Summary Report

Appendix D – Sheboygan Waterfowl Consumption Assessment Report 2018-2020

Appendix A - List of Acronyms

AOC	Area of Concern
APHIS	Animal and Plant Health Inspection Service
BUI	Beneficial Use Impairment
HBI	Hilsenhoff's Biotic Index
IBI	Index of Biotic Integrity
LOEL	Lowest Observable Effect Level
NRDA	Natural Resources Damages Assessment
PAH	Polycyclic aromatic hydrocarbon
ppm	Parts per million
PCB	Polychlorinated biphenyl
QAPP	Quality Assurance Project Plan
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RP	Responsible Party
USDA	U. S. Department of Agriculture
USEPA	U. S. Environmental Protection Agency
USFWS	U. S. Fish and Wildlife Service
USGS	U. S. Geological Survey
WSLH	Wisconsin State Lab of Hygiene
WVU	West Virginia University

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Appendix B – BUI Tracking Matrix

Note that projects listed in the table below are the next clearly delineated action steps that have been identified by DNR in collaboration with AOC partners and stakeholders to make progress toward delisting the AOC. This list does not necessarily reflect all actions that will ultimately be needed to remove impairments and will be updated as more information is collected and as actions are completed.

Remedial Action Plan Update for the Sheboygan River Area of Concern
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Sheboygan River AOC BUI Tracking Matrix

Project Name	BUI Short List	Project Type	Project Action Type	Action Modifier	Project Status	Project Start Date	Project End Date	Project Cost	Primary Funding Source	Project Lead Organization
Assessment of Benthos and Plankton in Wisconsin's Lake Michigan Areas of Concern	BUI 6, BUI 13	Fish and Wildlife	Assessment	COMPLETED	Completed	2013	2019	\$414,300	U.S. Environmental Protection Agency [GLRI]	USGS
Benthos & Plankton BUIs Evaluation in Wisconsin's Lake Michigan Areas of Concern	BUI 6, BUI 13	Fish and Wildlife	Assessment	COMPLETED	Completed	2011	2015	\$451,500	U.S. Environmental Protection Agency [GLRI]	USGS
Camp Marina Superfund Alternative Dredging	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 14	Sediment	Remediation	COMPLETED	Completed	2011	2011	\$10,000,000	Responsible Party [Non-GLRI]	USEPA
Camp Y-Koda Citizen-based Wildlife Monitoring	BUI 3	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2015	2019	\$21,000	U.S. Environmental Protection Agency [GLRI]	
Dredging Technical Memo	BUI 7	Sediment	Remediation	COMPLETED	Completed	2012	2014	Unknown	Great Lakes Legacy Act [GLRI]	
Education and Outreach UW-Extension	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 8, BUI 13, BUI 14	Community Involvement	Education	COMPLETED	Completed	2011	2013	\$83,000	U.S. Environmental Protection Agency [GLRI]	UW-Ext
Evaluate Eutrophication BUI	BUI 8	Nonpoint	Assessment	COMPLETED	Completed	2013	2015	Unknown	Wisconsin Dept of Natural Resources [Non-GLRI]	DNR

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Project Name	BUI Short List	Project Type	Project Action Type	Action Modifier	Project Status	Project Start Date	Project End Date	Project Cost	Primary Funding Source	Project Lead Organization
Evaluation of Fish Tumors or Other Deformities	BUI 4	Fish and Wildlife	Assessment	COMPLETED	Completed	2011	2014	\$139,485	U.S. Environmental Protection Agency [GLRI]	DNR
Evaluation of Waterfowl Consumption Advisories within the AOC	BUI 1	Fish and Wildlife	Assessment	COMPLETED	Completed	2011	2013	\$66,437	U.S. Environmental Protection Agency [GLRI]	DNR
Exposure to PCBs of tree swallows nesting along the Sheboygan River, WI	BUI 3, BUI 5	Fish and Wildlife	Assessment	COMPLETED	Completed	2012	2015	\$18,920	U.S. Environmental Protection Agency [GLRI]	USGS
Fish & Wildlife Habitat Restoration and Management Plan	BUI 3, BUI 14	Fish and Wildlife	Assessment	COMPLETED	Completed	2012	2016	Unknown	Wisconsin Dept of Natural Resources [GLRI]	DNR
Fish Contaminant Monitoring and Advisory Program	BUI 1	Fish and Wildlife	Verification Monitoring	Reporting	In Progress	2015		Unknown	Wisconsin Dept of Natural Resources [Non-GLRI]	DNR
Fish Tumor Assessment	BUI 4	Fish and Wildlife	Verification Monitoring	Reporting	In Progress	2017	2019	\$74,106	U.S. Environmental Protection Agency [GLRI]	DNR
Habitat Restoration Assessment Post-Completion	BUI 14	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2018	2019	\$98,600	U.S. Environmental Protection Agency [GLRI]	DNR
In-Stream Habitat Improvements	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2012	\$144,083	U.S. Environmental Protection Agency [GLRI]	DNR

Remedial Action Plan Update for the Sheboygan River Area of Concern
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Project Name	BUI Short List	Project Type	Project Action Type	Action Modifier	Project Status	Project Start Date	Project End Date	Project Cost	Primary Funding Source	Project Lead Organization
Kiwanis Park Shoreline Restoration	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2016	\$2,115,000	U.S. Environmental Protection Agency [GLRI]	DNR
Plankton BUI post-remediation follow-up monitoring in the Sheboygan River AOC	BUI 13	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2015	2019	\$41,000	U.S. Environmental Protection Agency [GLRI]	USGS
Raising Community and CAC Awareness through the "Explore and Restore the Sheboygan River" Initiative	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 8, BUI 13, BUI 14	Community Involvement	Education	COMPLETED	Completed	2011	2014	\$51,689	U.S. Environmental Protection Agency [GLRI]	
Schuchardt Conservation Plan	BUI 3, BUI 14	Fish and Wildlife	Assessment	COMPLETED	Completed	2011	2012	\$40,000	U.S. Environmental Protection Agency [GLRI]	DNR
Schuchardt Property Invasive Species Management Planning	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2012	\$85,000	U.S. Army Corps of Engineers [GLRI]	USACE
Sheboygan AOC Pathway to Delisting Habitat BUI's – Rapid Ecological Assessment	BUI 3, BUI 14	Fish and Wildlife	Assessment	COMPLETED	Completed	2010	2012	\$202,181	U.S. Environmental Protection Agency [GLRI]	DNR
Sheboygan Harbor Navigational Improvement Dredging	BUI 7	Sediment	Navigational Dredging	COMPLETED	Completed	2012	2012	\$20,797,000	U.S. Environmental Protection Agency [GLRI]	USEPA

Remedial Action Plan Update for the Sheboygan River Area of Concern
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Project Name	BUI Short List	Project Type	Project Action Type	Action Modifier	Project Status	Project Start Date	Project End Date	Project Cost	Primary Funding Source	Project Lead Organization
Sheboygan River & Harbor Superfund Dredging-Lower River Dredging	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 14	Sediment	Remediation	COMPLETED	Completed	2011	2012	\$13,500,000	Responsible Party [Non-GLRI]	USEPA
Sheboygan River & Harbor Superfund Dredging-Upper River Dredging	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 14	Sediment	Remediation	COMPLETED	Completed	2006	2007	\$9,000,000	Responsible Party [Non-GLRI]	USEPA
Sheboygan River AOC Plankton and Other BUI Data Assessment - Consumption	BUI 1	Fish and Wildlife	Verification Monitoring	Planning	In Progress	2019	2025	\$22,500	U.S. Environmental Protection Agency [GLRI]	DNR
Sheboygan River AOC Plankton and Other BUI Data Assessment - Deformities	BUI 5	Fish and Wildlife	Verification Monitoring	Planning	In Progress	2019	2025	\$22,500	U.S. Environmental Protection Agency [GLRI]	DNR
Sheboygan River AOC Plankton and Other BUI Data Assessment - Phyto/Zooplankton	BUI 13	Fish and Wildlife	Verification Monitoring	COMPLETED	Complete	2019	2021	\$5,000	U.S. Environmental Protection Agency [GLRI]	DNR
Sheboygan River Great Lakes Legacy Act Project	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 14	Sediment	Remediation	COMPLETED	Completed	2011	2012	\$32,776,000	U.S. Environmental Protection Agency [GLRI]	USEPA
Shoreline Stabilization in Problem Areas	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2016	\$292,000	U.S. Environmental Protection Agency [GLRI]	DNR
Small Mammal Contaminant Monitoring in the Sheboygan River AOC	BUI 3, BUI 5	Fish and Wildlife	Assessment	COMPLETED	Completed	2011	2012	\$16,768	U.S. Environmental Protection Agency [GLRI]	DNR

Remedial Action Plan Update for the Sheboygan River Area of Concern
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Project Name	BUI Short List	Project Type	Project Action Type	Action Modifier	Project Status	Project Start Date	Project End Date	Project Cost	Primary Funding Source	Project Lead Organization
Supporting & Developing A Sheboygan AOC Community Advisory Committee	BUI 1, BUI 3, BUI 4, BUI 5, BUI 6, BUI 7, BUI 8, BUI 13, BUI 14	Community Involvement	Capacity	COMPLETED	Completed	2011	2012	\$28,655	U.S. Environmental Protection Agency [GLRI]	SRBP
Targeted Invasive Species Control	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2016	\$132,500	U.S. Environmental Protection Agency [GLRI]	DNR
Taylor Drive & Indiana Ave Area Wetland Restoration	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2016	\$795,000	U.S. Environmental Protection Agency [GLRI]	DNR
Verification Monitoring - Benthic & aquatic community	BUI 3, BUI 14	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2014	2018	\$27,882	U.S. Environmental Protection Agency [GLRI]	USGS
Verification Monitoring - Bird, bat, mussel, and herptiles study	BUI 3, BUI 14	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2016	2018	\$50,000	U.S. Environmental Protection Agency [GLRI]	DNR
Verification Monitoring - Fish Community Assessment	BUI 3, BUI 14	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2014	2017	\$120,000	U.S. Environmental Protection Agency [GLRI]	DNR
Verification Monitoring - Macroinvertebrates and Fish Habitat Assessment	BUI 3, BUI 14	Fish and Wildlife	Verification Monitoring	COMPLETED	Completed	2015	2017	\$27,882	U.S. Environmental Protection Agency [GLRI]	DNR
Verification Monitoring - Mink Survey and Contaminant Monitoring	BUI 3, BUI 5	Fish and Wildlife	Verification Monitoring	COMPLETED	Complete	2014	2020	\$127,500	U.S. Environmental Protection Agency [GLRI]	DNR

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Project Name	BUI Short List	Project Type	Project Action Type	Action Modifier	Project Status	Project Start Date	Project End Date	Project Cost	Primary Funding Source	Project Lead Organization
Verification Monitoring - Tree Swallows	BUI 3, BUI 5	Fish and Wildlife	Verification Monitoring	COMPLETED	Complete	2015	2017	Unknown	U.S. Environmental Protection Agency [Non-GLRI]	USGS
Verification Monitoring - Wildlife Consumption Assessment	BUI 1	Fish and Wildlife	Verification Monitoring	COMPLETED	Complete	2017	2020	\$43,500	U.S. Environmental Protection Agency [GLRI]	DNR
Wildwood Island Restoration	BUI 3, BUI 14	Fish and Wildlife	Restoration	COMPLETED	Completed	2011	2016	\$2,110,212	U.S. Environmental Protection Agency [GLRI]	DNR

BUI Number Key

BUI #	BUI Name	BUI #	BUI Name
BUI 1	Restrictions on Fish and Wildlife Consumption	BUI 8	Eutrophication or Undesirable Algae or Excessive Loading of Sediments and Nutrients
BUI 2	Tainting of Fish and Wildlife Flavor	BUI 9	Restrictions on Drinking Water Consumption or Taste and Odor Problems
BUI 3	Degraded Fish and Wildlife Populations	BUI 10	Beach Closings and Body Contact Restrictions
BUI 4	Fish Tumors and Other Deformities	BUI 11	Degradation of Aesthetics
BUI 5	Bird or Animal Deformities or Reproductive Problems	BUI 12	Added Costs to Agriculture or Industry
BUI 6	Degradation of Benthos	BUI 13	Degradation of Phytoplankton and Zooplankton Populations
BUI 7	Restrictions on Dredging Activities	BUI 14	Loss of Fish and Wildlife Habitat

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Appendix C – Sheboygan Area of Concern Verification Monitoring: Mink Survey and Contaminant Monitoring Summary Report

Sheboygan Area of Concern Verification Monitoring Mink Survey and Contaminant Monitoring Summary Report GL00E1312_sub5.b10

Background: 1993 Study and 2011 Study

In 1993, a small mammal community study discovered measurable levels of polychlorinated biphenyl (PCBs) in small mammals collected from floodplain areas along the Sheboygan River Area of Concern (AOC) (Seeley, 1993). Floodplain samples collected by Tecumseh in 1990 and 1992 for the Sheboygan River and Harbor Superfund project had already revealed high PCB levels in some floodplain areas; however, impacts on the food chain were not yet discovered. The 1993 Seeley study was significant because it was the first study showing that PCB contamination from the river had made its way into the terrestrial food chain. During the study, many small mammals were collected; however, despite abundant suitable habitat, no American mink (*Mustela vison*) samples were collected.

Due to several contaminated sediment remediation projects in the AOC from 1995 to 2013, it was anticipated that the significantly lowered levels of PCB contamination in the environment would lead to lower concentrations of PCB accumulation in the food chain. Mink have shown an extreme sensitivity to PCB contamination in laboratory settings and sit high on the food chain in riparian areas. Since suitable mink habitat was abundant in the AOC and mink consume a wide variety of prey from the floodplain while being sensitive to low levels of PCBs, they were selected as a useful bio-indicator of the ecosystem's health.

In 2011, before all sediment remediation projects were completed, a small mammal trapping survey, including mink trapping, was completed by the Wisconsin Department of Natural Resources (WDNR). The survey was set up to capture small mammals within the AOC as well as upstream of the AOC for reference samples. Collection locations included six sites in the floodplain riparian areas of the Upper and Middle River segments (as delineated by the U.S. EPA for the Superfund project) of the Sheboygan River AOC and from one reference site upstream of the contaminated area (Figure 1).

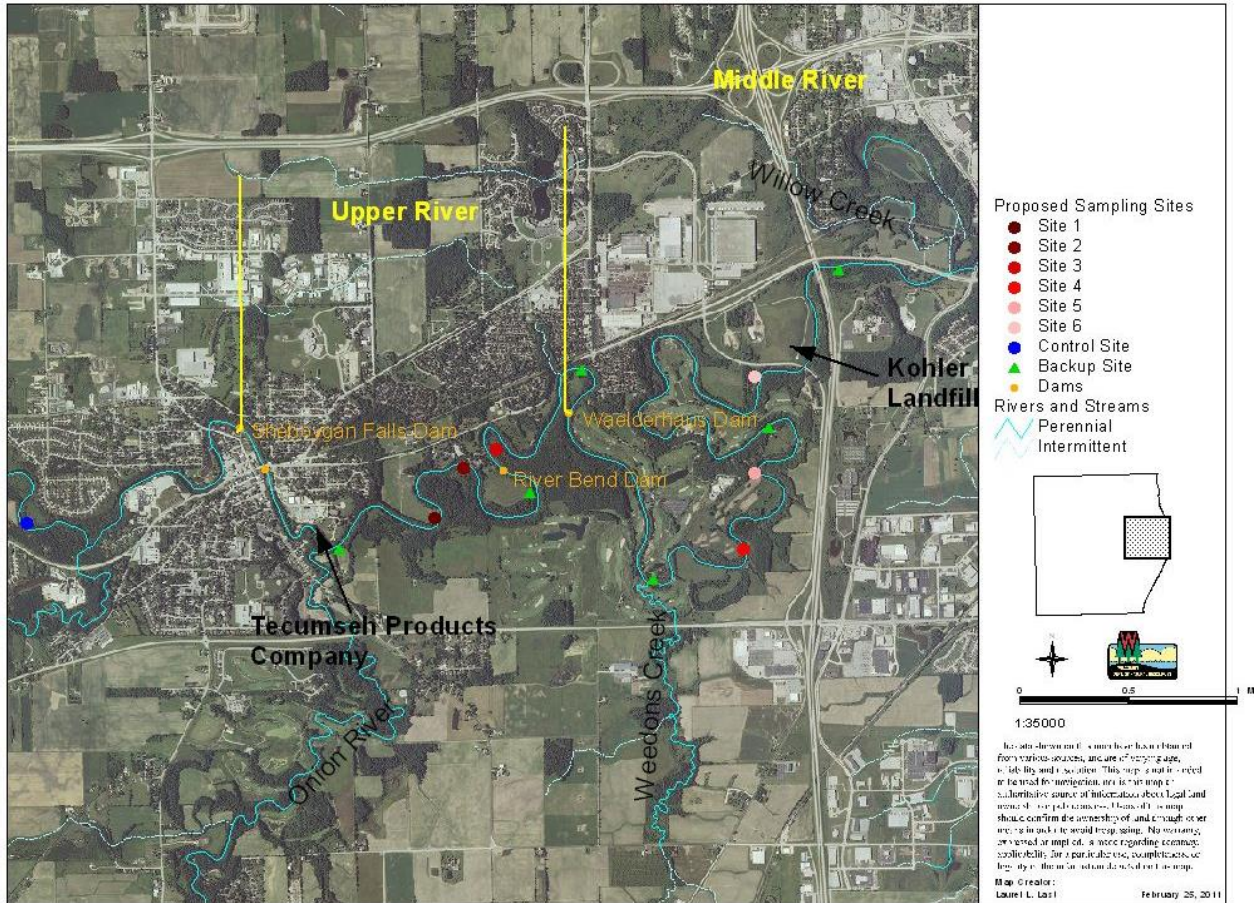


Figure 1. 2011 Sheboygan River and Harbor AOC Small Mammal Trapping Sites.

Mink collected during the small mammal trapping were sent to the Wisconsin State Lab of Hygiene (WSLH) to be analyzed for PCB concentrations. Even while working with a local trapper, only two mink were captured within the AOC. Then, a road-kill mink sample within the AOC was also submitted for analysis. Three mink were collected upstream of the AOC and served as control samples. There were a total of six mink analyzed during this study. Only capturing two mink within the AOC further suggested population limitation, and with suitable habitat for mink being plentiful in the AOC, there continued to be a question of whether population limitation was due to PCB contamination.

Though the study had a very small sample size and was not statistically significant, it did reveal liver PCB levels from mink collected within the AOC were greater than levels from mink collected outside the AOC (Table 1). However, a historic comparison was not possible due to zero mink being collected during the initial small mammal assessment conducted in 1993. Although PCB concentrations in the AOC mink livers were higher than concentrations in the control mink, they were still lower than the toxic threshold liver concentration of 2.0 ug/g. The toxic threshold liver concentration of 2.0 ug/g is the geometric mean of a group of closely related toxicity studies (Tillitt et al. 1996; Kannan et al. 2000) and is the beginning of the concentration range known to cause reproductive impairment and growth deficits (Zwiernik et al. 2011). The liver PCB concentrations from the Sheboygan mink samples did not exceed the toxic threshold, but the sample size collected was too small to make any inferences on population level

effects due to exposure to PCBs. The lack of mink collected within the AOC did further the suspicion that the population could be limited due to PBC contaminated habitat.

Table 1. Total PCB concentrations in mink collected from the Sheboygan AOC. Adapted from Table 1 in Contaminant Concentrations in Small Mammals from the Sheboygan River AOC in 2011 (Strom, 2013)

Area	Collection Date Range	Sample Size	Mean Total PCBs (ug/g)	Range
AOC	11/07/11 – 03/13/12	3	1.20	ND – 1.86
Control	11/06/11 – 12/26/11	3	0.03	0.003 – 0.066

2014 - 2016 Mink Tracking and Trapping Effort

Verification monitoring of wildlife populations within the AOC had to occur in order to confirm that contaminated sediment remediation and habitat restoration projects were benefiting wildlife as expected. This monitoring included a mink survey. From 2014 to 2016 the WDNR contracted with a local mink trapper and attempted to live-track and capture mink from the Sheboygan River AOC and from an upstream reference area.

Previous sampling efforts were met with very limited success, and since success was extremely low during the sampling effort in 2011, it was thought that utilizing float track-stations might allow the WDNR to better gauge mink activity and relative abundance. Float track-stations were placed along the Sheboygan River AOC and in an uncontaminated section of river upstream. The floating platforms could also be used for trapping mink, and it was anticipated that this method would increase the trapping efficiency.

Mink surveying and trapping efforts occurred in two stretches of the Sheboygan River (Figure 2). The stretch within the AOC was between Rochester Park in Sheboygan Falls and Kiwanis Park in the City of Sheboygan. The reference stretch upstream of the AOC was between Garton Rd. and County Hwy TT. Approximately 20 rafts in the AOC and 20 rafts at the reference site were checked a minimum of once per week for the duration of the 12-week trapping period in order to census mink from within the AOC and within the uncontaminated reference area upstream. If mink tracks were recorded on a raft, a live trap was set in order to capture the mink. If a mink was captured, blood samples were to be collected and sent to WSLH to have the plasma analyzed for PCBs.

Samples were to be analyzed primarily for PCBs, and if there was a sufficient mink sample volume, other contaminants including PBDEs, organochlorine pesticides, perfluorinated compounds, mercury, cadmium and lead were also to be analyzed. The results were anticipated to help determine whether there was a difference in mink populations that might be caused by the PCB contamination in the AOC.

Rafts were deployed from mid-July through the end of September. In 2014 and 2015, all rafts were placed for the duration of the monitoring period. In 2016, 11 rafts were set out for 11 nights before the remaining 8 rafts could be placed for the remaining 77 nights (Table 2). This delay was due to a land access issue. Throughout the three-year study duration, 29 mink tracks were observed in the reference area and 20 mink tracks were observed on rafts within the AOC. This tracking effort yielded low tracks per trap night, even in 2015 which was the year with the most abundant mink tracks (Table 2). Although mink tracks were present and traps were set, no mink were collected during the duration of the 2014-2016 study.

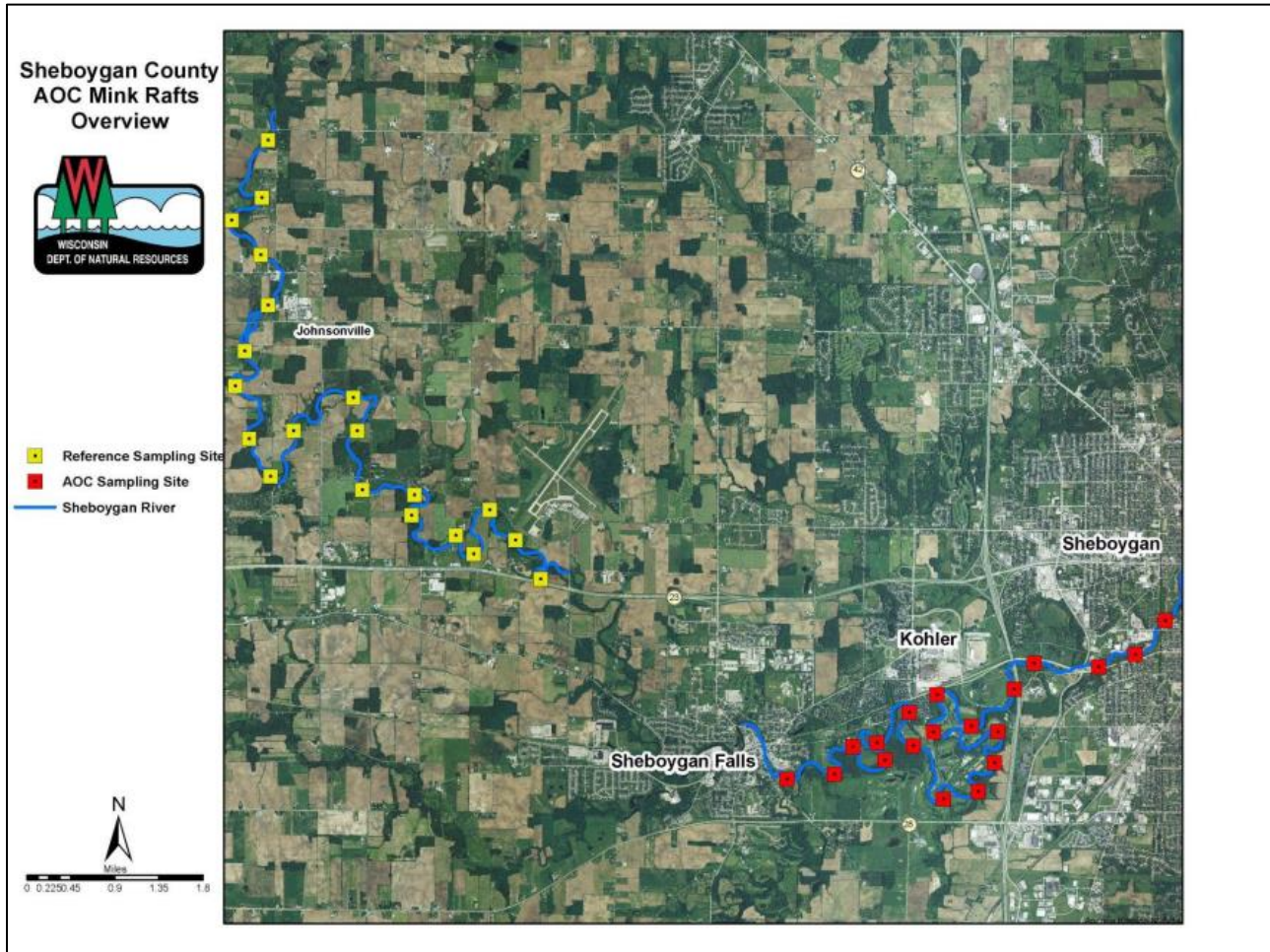


Figure 2. Mink raft sampling locations in the Sheboygan River AOC and upstream of the AOC in the Sheboygan River reference area.

Table 2 Mink tracks observed in the Sheboygan AOC and in the upstream reference area during the 2014-2016 WDNR study.

	# of Mink Tracks	# of Nights	Rafts Used	Trap Nights*	# of Trap Nights / # of Mink Tracks
2014 Control Area	4	78	20	1,560	1 Mink Every 390 Trap Nights
2014 AOC	2	73	19	1,387	1 Mink Every 693.5 Trap Nights
2015 Control Area	17	71	20	1,420	1 Mink Every 83.5 Trap Nights
2015 AOC	16	71	19	1,349	1 Mink Every 84.3 Trap Nights
2016 Control Area	8	75	20	1,500	1 Mink Every 187.5 Trap Nights
2016 AOC	2	11, then 77	11, then 19	1,584	1 Mink Every 792 Trap Nights

*Trap Nights are the number of nights multiplied by the number of rafts.

In addition to the normal survey efforts in 2015, there were two extra efforts made to increase the odds of a successful trapping season. First, local trappers were contacted and surveyed regarding their trapping experiences and observations of local mink populations. Second, on-foot searches for signs of mink (tracks and scat) were conducted along 200-meter-long segments of each surveyed river section.

Both of these additional survey actions were unfruitful and the decision was made to discontinue these additional efforts for the final year of the study.

The 2016 results were similar to those in 2014. Both years had low track per trap night ratios – 1:693.5 and 1:792 (Table 2). One possible reason for lower track numbers in years 2014 and 2016 could be higher water levels and quicker flow rates. Water levels in the Sheboygan River in 2014 and 2016 were above the historic average due to a wet summer and fall. 2015 was a year without major rain events and consistently low water levels. The low track per trap results may be due to a lack of mink, or perhaps mink might be less likely to climb on a track board when it is unstable in fast moving water.

It is known that during autumn mink tracks on a platform may be left by transient animals moving through the area, usually to find mates or disperse. Setting traps in response to tracks of transient animals would not lead to a capture if the animal responsible for the track has already left the area. This may have been the case for any tracks around the September timeframe.

In summary, this mink tracking effort yielded low track results and no captures.

2018 – 2019 Mink Tracking and Trapping Effort

In 2017, WDNR revised the Quality Assurance Project Plan (QAPP) with a new mink sampling strategy to increase the odds of capturing mink (Selle & Fischer, 2018). The new strategy included utilizing trail cameras to collect data regarding species presence and body-grip traps to capture animals. Camera traps were visited bi-weekly, and tracking surveys were also conducted to collect data on animal tracks along areas of body-grip trap placement to determine presence of animals not detected by trail cameras.

The goal of this effort was to capture 10 at minimum but closer to 20 mink total to be sent to the WSLH for contaminant analysis. As with previous surveys, traps were set within the AOC and at the upstream reference site. Trap sites were based on initial tracking surveys and camera trap detections.

The location of the surveys within the AOC were focused on the upper 10 miles of the Sheboygan River AOC from approximately Rochester Park in Sheboygan Falls downstream to Roy Sebald Sheboygan River Natural Area in the City of Sheboygan (Figure 3). The upstream reference site was between the Sheboygan Marsh Dam and Main Street in Sheboygan Falls (Figure 4). Approximately six camera traps and one to three small mammal surveys per week were used initially to determine presence of mink. If the presence of mink was determined, a body-grip trap was deployed in the area of mink detection.

Between January 22nd and March 30th, 2018, mink and small mammal populations within the Sheboygan River AOC were surveyed. Over 20 small mammal tracking surveys were completed throughout Sheboygan River Watershed (AOC and control) to determine mink presence or absence, and to determine areas to set body-grip traps. Trail cameras were set over 100 nights in the field and body-grip traps were set in three main areas with a total of 60 trap-nights. The 60 trap-nights resulted in collection of two specimens from within the AOC. There was also one road-kill mink caught in the control area. In 2018, there were a total of three specimen collected and sent to WSLH for contaminant analysis.



Figure 3. AOC sites for 2018-2019 mink tracking and trapping effort

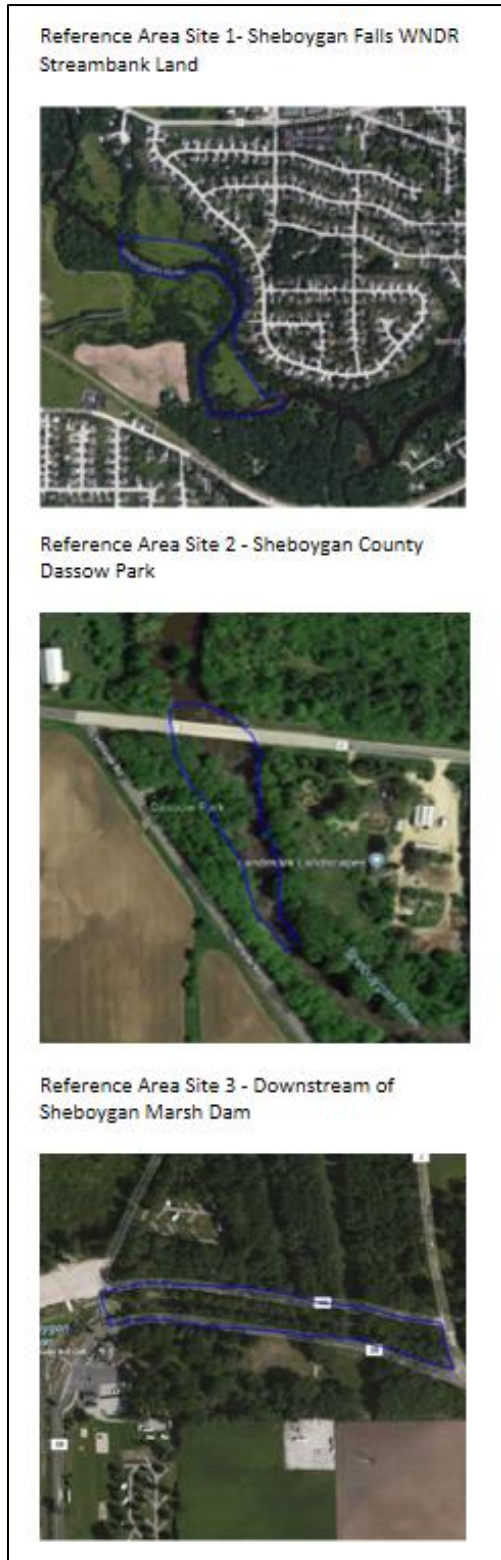


Figure 4. Reference sites for 2018-2019 mink tracking and trapping effort

Populations were also surveyed January 2nd through March 8th in 2019. Body-grip traps were set in four main areas for a total of 45 trap-nights. Three tracks were located, but no mink specimens were collected through this effort. No mink were captured with the WDNR body-grip traps; however, there were four specimens submitted to the WDNR from a local trapper, including road-kill. Of the four specimens submitted, three were from the control area and only one was from the AOC.

In 2018, both mink caught in the AOC had elevated PCB concentrations compared to those in the control area (Table 3). However, both AOC mink samples were below the 2.0 ug/g toxic threshold concentration for PCBs in mink liver. In 2019, a single mink turned into the WDNR from a local trapper had a total liver PCB concentration of 2.341 ug/g, which was above the toxic threshold. Despite one sample being above the toxic threshold, the mean PCB concentration of the three AOC samples was 1.5872 ug/g, which is below the threshold. Although the average was not above toxic levels, sample size still remains an issue and it is not possible to make a population determination on such limited data.

Table 3. Mean PBCs in mink caught in the AOC and control area during the 2018 and 2019 surveying efforts.

Area	Year	Sample Size	Mean Total PCBs (ug/g)	Range (ug/g)
AOC	2018	2	1.2098	0.9562 – 1.4643
Control	2018	1	0.0307	-
AOC	2019	1	2.341	-
Control	2019	3	0.0591	0.0011 – 0.1549
AOC Total	2018-19	3	1.5872	0.9562 – 2.341
Control Total	2018-19	4	0.0519	0.011 – 0.01549

2020 Mink Sampling Effort

It was decided that there would be one last effort to attempt to capture enough mink in total to make a determination about the PCB concentrations in the Sheboygan AOC mink population. At minimum, a total of 10 mink specimens would be needed for the study to be robust enough for a determination. Six mink had been collected within the AOC since the 2011 study, so the hope was that a final effort could yield collection of four more samples. Efforts to collect mink for PCB analysis were enhanced in 2020 with the hiring of a local trapping expert and permission to collect mink outside the normal trapping season with a scientific collector’s permit.

Since previous efforts to collect mink had been largely unfruitful, the best possible attempt to capture mink in 2020 was conducted by having the trapping completed by someone local, knowledgeable, and skilled at mink trapping. Although the WDNR contracted with an experienced local trapper, no mink were caught in 2020. There were no signs of mink during the trapping period. The last trapping attempt of this study yielded no mink specimens for contaminant analysis.

Summary

A pre-remediation survey in 2011 captured only two mink, suggesting population limitation (Strom, 2013; Fayram et. al., 2014). This was followed by unsuccessful live trapping efforts in 2014-2016 in areas where mink tracks were observed. In 2017, WDNR revised the sampling strategy with hopes that trapping in 2018 and 2019 would yield in more specimens collected for contaminant analysis. In 2018, two mink were caught in the Sheboygan AOC, and one road-kill mink was submitted from the upstream control area. In 2019, WDNR did not capture any mink but did receive two mink specimens from a local trapper and two roadkill specimens. Of the four samples analyzed in 2019, three were from the control area and one was from the AOC. The average PCB tissue concentration of mink within the AOC was found to be 1.6 ug/g, which is below the 2.0 ug/g toxic threshold used to indicate potential adverse impacts, but it was high enough that potential adverse effects cannot be ruled out (Strom, 2019). Sampling efforts were increased in 2020 by working with a local trapper and including trapping outside of the regular trapping season with a scientific collector's permit. No specimens were collected in 2020, and there were no signs of mink found. Due to insufficient sample size, a different indicator species will need to be chosen. WDNR will be working with U.S. Fish and Wildlife Service (USFWS) to determine alternative species suitable for beneficial use impairment (BUI) assessments.

Conclusions

There have been several attempts to quantify population dynamics and contaminant concentrations in small mammals both by academic institutions and the WDNR. These attempts have had limited success. There is a prevalence of suitable habitat in the area, which suggests that is not the limiting factor for mink populations in the AOC (Seeley, 1993). From a correspondence in 2017 between Julia Robson, a Milwaukee County Natural Areas Coordinator, and Brie Kupsky from the WDNR, there is reason to believe urbanization of Sheboygan is not the issue for low mink abundance. From surveys in Milwaukee, it is known that mink are present in the Milwaukee Estuary AOC and fairly well distributed throughout (Kupsky, 2017). It is important to note that the state of Wisconsin is one of the largest producers of mink pelts in the United States. There are several large mink farms within 15 miles of the Sheboygan AOC, including the largest individual minkery in North America. Escapees from mink farms do introduce diseases into wild populations, and with the highest density of mink farming in the country this area does have known disease issues.

It is known that mink are impacted by PCBs, but it is not known why mink are not readily found in this area. Though the mink population is not thriving in the AOC, it is also not thriving outside of the AOC. Even with suitable habitat for mink, this area has had a historic drop in population. WDNR wildlife staff and local trappers agree that the mink population in this area of Wisconsin has been struggling for a long time and that the dwindling mink population issue is broader than an AOC issue; it is a regional issue. It is inconclusive whether the limiting factor of Sheboygan area mink populations is PCBs in the environment. Regardless, given the recent large-scale remediation activities within the AOC, mink and other predators (if present) are expected to benefit both on an individual and population scale.

Due to the difficulty trapping mink and the resulting low sample sizes, it was determined that mink are not a suitable indicator species for assessing population status for the Degradation of Fish and Wildlife Populations BUI or the Bird or Animal Deformities or Reproductive Problems BUI. As such, WDNR will consult with USFWS to determine alternative species to be monitored to assess AOC BUIs.

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Appendix D – Sheboygan Waterfowl Consumption Assessment Report 2018-2020

Sheboygan Waterfowl Consumption Assessment Report 2018 – 2020

Project GL00E01312_sub5.1

Prepared by Donalea Dinsmore, Office of Great Waters

February 19, 2021

INTRODUCTION

The lower Sheboygan River and Harbor were designated a Great Lakes Area of Concern (AOC) in 1985 by the International Joint Commission (IJC) because of water quality and habitat problems associated with the historical discharge of pollutants into the AOC. Nine of the 14 Beneficial Use Impairments (BUIs) have been identified for the Sheboygan River AOC. The high levels of nutrients, solids and toxics entering the river had caused a series of problems including nuisance algal blooms, fish and waterfowl consumption advisories and contaminated sediments. The toxic pollutant discharges were also suspected of contributing to the degradation of wildlife, fish, benthos and plankton populations and the reduction in fish and wildlife habitat.

Waterfowl consumption advisories have been in place along the Sheboygan River since 1987. These advisories are the result of contamination from persistent, bioaccumulative, and toxic chemicals, primarily polychlorinated biphenyls (PCBs). Advisories currently in place for the Sheboygan River AOC include an advisory not to eat mallards from the Sheboygan River from Sheboygan Falls downstream to the river's mouth at Lake Michigan. An advisory not to eat scaup from Sheboygan Harbor is also in place.

Between 2011 and 2013, both through Superfund and the Great Lakes Legacy Act (GLLA), PCB-contaminated sediments were removed from the Sheboygan River and Harbor. Completion of GLLA remediation enabled removal of the Sheboygan River AOC "restrictions on dredging activities" BUI and expedited the recovery of fish and wildlife species affected by the PCBs.

The initial evaluation of the BUI "restrictions on fish and wildlife consumption" and waterfowl consumption advice began in 2011. DNR protocols require at least three years of data to assess consumption advice. After the 2012 sampling, the assessment was discontinued because results confirmed that PCB concentrations were consistently above "do not eat" consumption threshold. Sean Strom, the wildlife toxicologist, recommended waiting at least five years before reassessing to allow the species to recover.

This project is intended to re-evaluate the status of the waterfowl portion of the "restrictions on fish and wildlife consumption" BUI related to PCBs and provide recommendations for follow up sampling or assessments. Sean Strom (WDNR) and Dr. Henry Anderson (retired DHS) assisted with data interpretation and provided recommendations. Results from this project will be supplied to DNR's wildlife program for follow up with Department of Health (DHS) in updating consumption advice. In 2016, DNR recommended and DHS concurred with shifting advisory protocols from species-specific to feeding niche or habit assessments with waterfowl grouped into three categories: diving ducks, dabbling ducks and geese. This protocol will be followed henceforth. Although past analyses included lead and mercury, this report focuses on the PCB contaminant levels because PCBs are driving the consumption advice. Results from the previous assessment indicated that contaminant concentrations for these metals did not exceed thresholds for issuing consumption advice.

METHODS

Methods for sample collection, processing and analytical testing are detailed in the approved Quality Assurance Project Plan as amended in 2017 and are summarized below.

Waterfowl collection

USDA APHIS wildlife biologists were contracted to collect at least ten resident waterfowl of each species type (resident dabbling, diving, and geese) from locations within the Sheboygan River AOC boundaries in each of three years. Juvenile birds were avoided.

Table 1: Duck species by feeding type

Dabbling Species	Diving Species
American black duck	Barrow’s goldeneye
American green-winged teal	Bufflehead
American wigeon	Canvasback
Blue-winged teal	Common goldeneye
Cinnamon teal	Common merganser
Eurasian wigeon	Greater scaup
Gadwall	Hooded merganser
Mallard	Lesser scaup
Northern pintail	Red-breasted merganser
Northern shoveler	Redhead
Wood duck	Ring-necked duck

Migratory waterfowl start to appear in Wisconsin in September, so birds present through the summer months are considered as resident. The target collection time for dabbling ducks is August. In 2019, waterfowl were collected in June. This was corrected in the 2020 season. Scaup often overwinter on Lake Michigan and collecting them in the late winter/early spring allowed for the collection of ducks which have been in the area for 4-5 months, better reflecting local contamination. Canada geese reside within the area year around so they are resident and can be collected concurrently with the other waterfowl collections. Results were evaluated after each sampling season to determine whether sampling in subsequent years was warranted. As a result of those evaluations, sample collection for Canada geese was discontinued after the 2019 season.

DNR staff processed the carcasses, plucking the breasts and dissecting 20 – 40 grams of skin-on breast muscle. Samples were placed into a labeled plastic bag and submitted to the WI State Lab of Hygiene (WSLH) for analysis. Samples were analyzed for PCBs, lead (Pb) mercury (Hg) and percent fat.

Note: In light of growing concerns about PFAS and potential exposure pathways, in 2020 separate 40- gram subsamples of breast muscle (skin on) were placed in a PFAS-free container supplied by WSLH and archived in a freezer in DNR’s Plymouth office. As an emerging contaminant, PFAS analyses are outside the scope and budget for this project and the AOC program. Samples will be available for analysis at a later date should there be interest.

RESULTS and DISCUSSION

PCBs were pooled by species type and summary statistics calculated for each year sampled and the three years were assessed in aggregate. PCBs were detected in every sample from 2018 – 2020. These data were graphed to provide visual aid in the overall assessment.

Mean, median, and 75th percentile concentrations were compared with advisory concentrations presented in Table 2. Advisories for human consumption for PCBs are consistent with the *Protocol for a Uniform Great Lakes Fish Consumption Advisory* (GLSFATF 1993), the *Health Guide for People Who Eat Sport Fish from Wisconsin*

Waters (WDNR and WDH 1994), and *Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed* (USFDA 1994)

Table 2. Contamination levels for PCBs (ppm) for various wildlife consumption advisories in Wisconsin.

Contaminant	Minimum Detection Limit (ppm)	ADVISORY CONCENTRATION (ppm)				
		Unlimited consumption	No more than 1 meal/week	No more than 1 meal/month	No more than 6 meals/year	Do Not Eat
PCB	0.04	< 0.05	0.05-0.22	0.22-1.0	1.0-2.0	> 2.0

Diving Ducks

Diving duck PCB concentrations ranged from 0.21 – 7.3 µg/g (Table 3). The 2020 data are notable in that PCB concentration in one sample was more than double the concentration seen in previous years’ sampling; however, this result did not skew the overall assessment. Although the overall mean of the three years is below 2.0 µg/g, the 75th percentile in each year exceeds that threshold indicating that a “do not eat” advisory is still appropriate for the Sheboygan River AOC. Overall, results suggest an improvement from the 2012 sampling (Figure 1); however, the sample size was low.

Table 3: Summary Statistics for PCB concentrations (µg/g) in Diving Ducks

Diving Ducks	2012	2018	2019*	2020	Pooled 2018-2020
N	5	10	10	10	30
MIN	<0.04	0.21	1.2	0.48	0.21
Median	3.4	1.18	1.6	1.75	1.55
75 th Percentile	3.4	2.08	2.55	2.15	2.28
MAX	5	2.4	3.8	7.30	7.30
Mean	2.4	1.33	1.95	2.09	1.79
Standard Deviation	2.28	0.79	0.87	1.99	1.33
Sample Variance	5.18	0.622	0.758	3.98	1.78
Population Variance	4.14	0.56	0.68	3.58	1.72

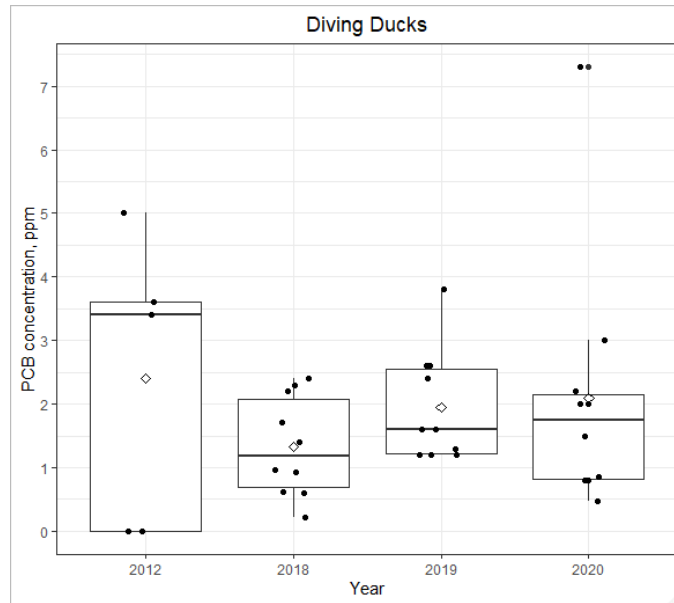


Figure 1. Diving Ducks 2012-2020 Quartile Box Plots (dots represent data points. diamonds represent means).

Dabbling Ducks

Dabbling duck concentrations ranged from 0.13 – 3.9 µg/g (Table 4). The overall mean of the three years is 1.2 µg/g, well within the 6 meals per year advisory range (1.0 – 2.0 µg/g). The pooled median and 75th percentile values are also within this advisory range. These results indicate that advisories could be reduced for dabbling ducks in the Sheboygan River AOC. Overall, results suggest an improvement from the previous sampling seasons with notable reductions in maximum concentrations and reduced variance (Figure 2).

Table 4: Summary Statistics for PCB concentrations (µg/g) in Dabbling Ducks

Dabbling Ducks	2011	2012	2018	2019*	2020	Pooled 2018-2020
N	10	11	10	10	13	33
MIN	0.91	0.11	0.13	0.29	0.047	0.047
Median	2.4	1.5	0.72	0.93	1.1	1.5
75 th Percentile	8.2	2	1.8	2.0	1.10	1.8
MAX	11	6.7	2.1	3.9	2.9	3.9
Mean	4.22	1.84	1.02	1.36	1.22	1.20
Standard Deviation	3.64	1.77	0.78	1.17	0.76	0.89
Sample Variance	13.24	3.14	0.61	1.37	0.57	0.79
Population Variance	11.91	2.86	0.55	1.23	0.53	0.76

* June collection date rather than August

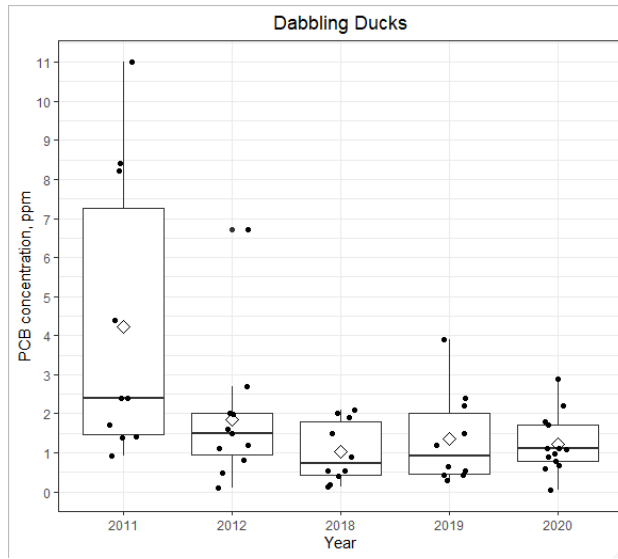


Figure 2. Dabbling Duck PCBs 2011 - 2020 Quartile Box Plots (dots represent data points; diamonds represent mean values).

Canada Geese

Canada geese concentrations ranged from 0.13 – 0.39 µg/g (Table 5). The overall mean of the three years is 0.12 µg/g, in the middle of the 1 meal per week advisory range (0.05-0.22 µg/g). Median and 75th percentile values also fall within this advisory range, representing no change in consumption advice. Overall, results suggest little to no change from previous sampling seasons.

Table 5: Summary Statistics for PCB concentrations (µg/g) in Geese

Geese	2011	2012	2018	2019	Pooled 2018-2020
N	11	10	10	10	20
MIN	<0.04	<0.04	<0.004	0.005	<0.04
Median	0.096	0.083	0.125	0.105	0.115
75 th Percentile	0.140	0.122	0.140	0.198	0.152
MAX	0.3	0.31	0.39	0.21	0.39
Mean	0.114	0.109	0.115	0.133	0.124
Standard Deviation	0.078	0.096	0.112	0.061	0.088
Sample Variance	0.006	0.009	0.013	0.004	0.008
Population Variance	0.005	0.096	0.011	0.003	0.007

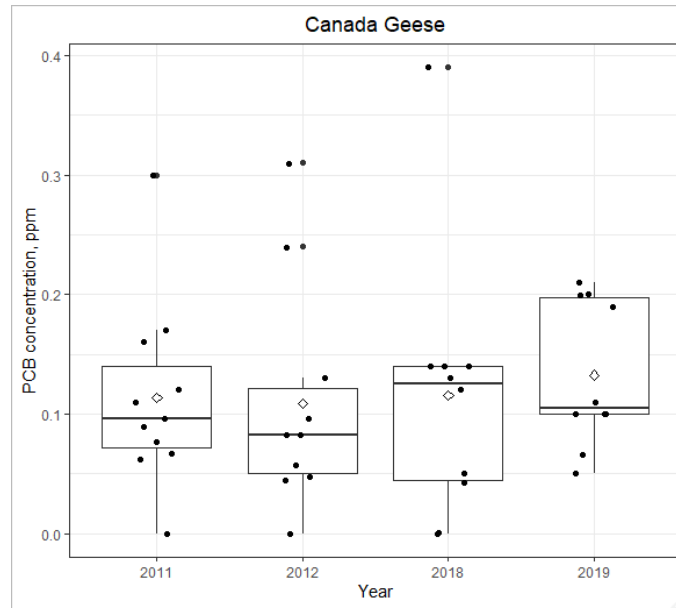


Figure 3. Geese PCBs Quartile Box Plots (dots represent data points; diamonds represent mean values).

Because both diving and dabbling ducks are migratory and other locations within their flyway are contaminated with PCBs, we recognize the difficulty in issuing consumption advice specific for any location. To address this issue, we focused on collecting adult dabbling ducks and Canada geese known to be members of a resident flock. Scaup, a diving duck, are known to over-winter on Lake Michigan so collecting diving ducks in the late winter/early spring allows for the collection of ducks which have been in the area for 4-5 months, better reflecting local contamination.

SUMMARY:

In summary, PCB concentrations in both diving and dabbling ducks have declined since the sediment remediation was completed, with more modest improvements in the diving ducks than dabbling ducks. This may be related to feeding patterns. As their name implies, diving ducks dive far beneath the surface of the water, at times rooting in the sediments in search of food, including fish, insects, benthic macroinvertebrates and aquatic plants so their diet is more likely to be influenced by PCB-contamination. On the other hand, dabbling ducks feed primarily along the surface of the water, grazing on aquatic plants, vegetation, larvae, and insects in shallow water and marshes. PCB concentrations in resident Canada geese are relatively steady. Geese feed mainly on riparian and upland vegetation, with a smaller proportion of their diet influenced by residual PCB-contamination in the Sheboygan River.

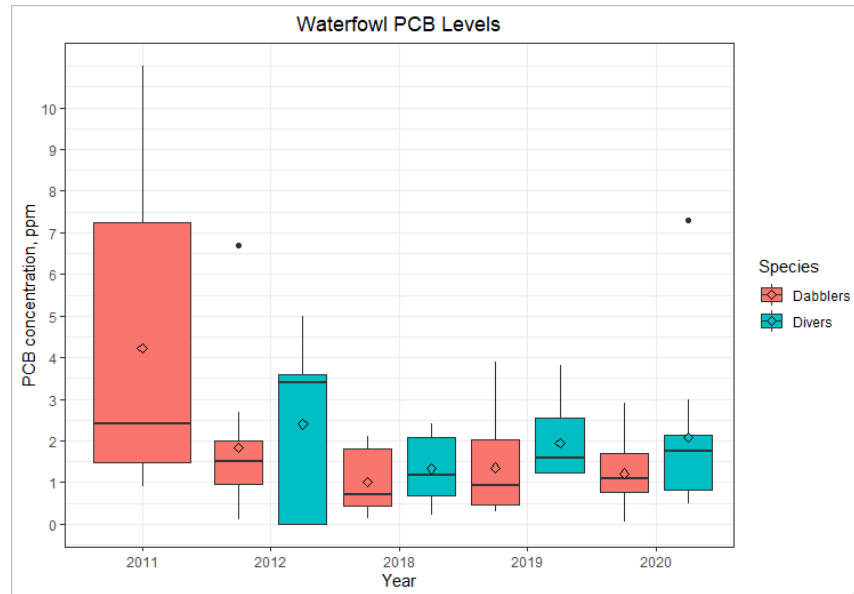


Figure 4. Diving and Dabbling Ducks PCBs Box Plots 2011-2020 (25th and 75th Percentiles with data points; diamond represents the mean).

RECOMMENDATIONS:

- Only the dabbling ducks show sufficient reductions in PCB concentrations to consider reducing the advisory level. Bureau of Wildlife Management in conjunction with the Department of Health Services has primary responsibility for adjusting advisory levels. This report and the associated data will be shared with them to consider whether any revisions to the consumption advice should be made.
- Based on the advice from Sean Strom and Dr. Anderson, consider waterfowl resampling in 3 – 5 years.
- When data from the most recent round of fish sampling for consumption advice becomes available, evaluate the rate of recovery to determine whether similar patterns occur. If the decline in concentration is more dramatic, additional investigation may be necessary to determine, to the extent feasible, whether ducks are arriving in the Sheboygan AOC with an existing PCB body burden (i.e. influences outside of the AOC).

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ATTACHMENT: RAW DATA

2018 Results

Species	Type	ID #	Lead (ug/g)	Mercury (ug/g)	Cadmium (ug/g)	% Fat	PCB (ug/g)
GREATER SCAUP	Diving Duck	GRSC_HRB_1	0.0121	0.0784	0.0052	5.53	0.92
GREATER SCAUP	Diving Duck	GRSC_HRB_2	0.0114	2.92	0.108	2.92	0.96
GREATER SCAUP	Diving Duck	GRSC_HRB_3	0.00841	0.0735	0.019	1.05	0.62
GREATER SCAUP	Diving Duck	GRSC_HRB_4	7.1	0.0751	0.0247	7.1	1.7
GREATER SCAUP	Diving Duck	GRSC_HRB_5	0.0153	0.0666	0.0804	4.75	1.4
GREATER SCAUP	Diving Duck	GRSC_HRB_6	0.0111	0.0497	6.48	6.48	2.4
GREATER SCAUP	Diving Duck	GRSC_HRB_7	0.0182	0.00362	0.0449	4.12	0.59
GREATER SCAUP	Diving Duck	GRSC_HRB_8	0.0109	7.02	0.0388	7.02	2.2
GREATER SCAUP	Diving Duck	GRSC_HRB_9	0.00516	0.124	0.0227	4.36	0.21
GREATER SCAUP	Diving Duck	GRSC_HRB_10	NOT DETECTED	0.361	ND	3.51	2.3
MALLARD	Dabbling Duck	MALL_KIWANIS_1	0.226	ND	ND	10.3	0.54
MALLARD	Dabbling Duck	MALL_KIWANIS_2	NOT DETECTED	ND	0.00821	12.6	0.39
MALLARD	Dabbling Duck	MALL_KIWANIS_3	0.0433	0.0133	0.0115	11.2	0.13
MALLARD	Dabbling Duck	MALL_KIWANIS_4	0.0374	NOT DETECTED	0.0138	23.1	0.9
MALLARD	Dabbling Duck	MALL_KIWANIS_5	0.0526	0.0136	0.0132	17.8	2
MALLARD	Dabbling Duck	MALL_KIWANIS_6	0.0459	0.0105	NOT DETECTED	26.8	0.54
MALLARD	Dabbling Duck	MALL_KIWANIS_7	0.041	0.0117	0.0167	17.2	0.19
MALLARD	Dabbling Duck	MALL_KIWANIS_8	0.0326	25	0.00961	25	1.9
MALLARD	Dabbling Duck	MALL_KIWANIS_9	0.0296	0.0194	0.00885	9.78	1.5
MALLARD	Dabbling Duck	MALL_KIWANIS_10	0.0397	0.0101	0.0203	5.59	2.1
CANADA GOOSE	Goose	CANG_TAYLOR_1	0.00587	ND	0.0113	13.7	0.051
CANADA GOOSE	Goose	CANG_TAYLOR_2	NOT DETECTED	ND	0.0118	9.85	<0.04
CANADA GOOSE	Goose	CANG_TAYLOR_3	0.0422	ND	0.0098	34.3	0.39
CANADA GOOSE	Goose	CANG_TAYLOR_4	0.00728	ND	NOT DETECTED	24.7	0.14
CANADA GOOSE	Goose	CANG_TAYLOR_5	0.00904	ND	0.007	22.6	0.12
CANADA GOOSE	Goose	CANG_TAYLOR_6	NOT DETECTED	ND	ND	9.08	<0.04
CANADA GOOSE	Goose	CANG_TAYLOR_7	0.00743	ND	0.00519	9.92	0.043
CANADA GOOSE	Goose	CANG_TAYLOR_8	0.0147	NOT DETECTED	0.00434	7.35	0.13
CANADA GOOSE	Goose	CANG_TAYLOR_9	0.0175	0.0237	0.0138	11.7	0.14
CANADA GOOSE	Goose	CANG_TAYLOR_10	0.118	0.0158	10.2	10.2	0.14

2019 Results

Species	Type	ID #	Lead (ug/g)	Mercury (ug/g)	Cadmium (ug/g)	% Fat	PCB (ug/g)
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_1	0.006	0.171	0.0617	1.23	2.6
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_2	0.0116	0.159	0.138	0.68	2.6
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_3	ND	0.121	0.102	2.19	1.6
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_4	0.0124	0.119	0.0802	1.75	1.3
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_5	0.0305	0.0993	0.0877	1.13	2.4
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_6	0.031	0.187	0.0506	0.79	1.2
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_7	0.0067	0.0877	0.0126	1.38	1.2
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_8	0.01	0.0823	0.0891	1.56	1.2
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_9	0.00637	0.133	0.0749	2.21	1.6
GREATER SCAUP	Diving Duck	GRSC_SHEB RIVER_10	0.00905	0.086	0.0149	2.85	3.8
MALLARD	Dabbling Duck	MALL_SHEBRIVER_1	0.0102	0.0517	0.00575	3.29	0.29
MALLARD	Dabbling Duck	MALL_SHEBRIVER_2	0.0117	0.0259	0.00697	3.34	2.2
MALLARD	Dabbling Duck	MALL_SHEBRIVER_3	0.00769	0.0571	0.00411	4.42	2.4
MALLARD	Dabbling Duck	MALL_SHEBRIVER_4	0.185	0.0586	0.01	4.55	3.9
MALLARD	Dabbling Duck	MALL_SHEBRIVER_5	0.00756	0.0406	0.0049	7.78	0.43
MALLARD	Dabbling Duck	MALL_SHEBRIVER_6	0.024	0.0359	0.00845	2.77	0.42
MALLARD	Dabbling Duck	MALL_SHEBRIVER_7	0.00868	0.0632	0.0106	2.95	1.5
MALLARD	Dabbling Duck	MALL_SHEBRIVER_8	0.00918	0.0127	0.00621	3.37	0.66
MALLARD	Dabbling Duck	MALL_SHEBRIVER_9	0.0299	0.0396	0.00632	7.77	1.2
MALLARD	Dabbling Duck	MALL_SHEBRIVER_10	0.00934	0.0113	ND	8.36	0.55
CANADA GOOSE	Goose	CANG_KIWANIS_1	0.0185	ND	ND	8.05	0.2
CANADA GOOSE	Goose	CANG_KIWANIS_2	0.012	ND	0.00377	10.3	0.2
CANADA GOOSE	Goose	CANG_KIWANIS_3	0.0159	ND	ND	13	0.1
CANADA GOOSE	Goose	CANG_KIWANIS_4	0.0111	0.00525	ND	10.9	0.05
CANADA GOOSE	Goose	CANG_KIWANIS_5	0.00952	ND	0.00652	12.4	0.1
CANADA GOOSE	Goose	CANG_KIWANIS_6	0.0104	ND	0.0119	14.8	0.066
CANADA GOOSE	Goose	CANG_KIWANIS_7	0.0188	ND	0.0105	10.1	0.19
CANADA GOOSE	Goose	CANG_KIWANIS_8	0.013	ND	ND	19.3	0.21
CANADA GOOSE	Goose	CANG_KIWANIS_9	0.0126	ND	0.00757	18.9	0.1
CANADA GOOSE	Goose	CANG_KIWANIS_10	0.0093	0.00405	ND	11.7	0.11

2020 Results

Species	Type	ID #	Lead (ug/g)	Mercury (ug/g)	Cadmium (ug/g)	% Fat	PCB (ug/g)
GREATER SCAUP	Diving Duck	RBME_MARINA_1	ND	0.384	0.0112	9.86	2.0
GREATER SCAUP	Diving Duck	RBME_MARINA_2	ND	0.554	0.027	8.80	7.3
GREATER SCAUP	Diving Duck	RBME_MARINA_3	ND	0.417	0.0296	10.90	2.2
GREATER SCAUP	Diving Duck	GRSC_MARINA_1	ND	0.0501	0.0447	4.00	0.48
GREATER SCAUP	Diving Duck	GRSC_MARINA_2	ND	0.0591	0.0509	7.82	1.5
GREATER SCAUP	Diving Duck	GRSC_MARINA_3	0.00557	0.0474	0.0821	4.24	0.86
GREATER SCAUP	Diving Duck	GRSC_MARINA_4	0.00927	0.0555	0.0611	11.60	0.79
GREATER SCAUP	Diving Duck	GRSC_MARINA_5	0.00544	0.0612	0.0917	11.50	3.0
GREATER SCAUP	Diving Duck	GRSC_MARINA_6	ND	0.0501	0.0296	6.22	0.80
GREATER SCAUP	Diving Duck	GRSC_MARINA_7	ND	0.0842	0.0827	6.71	2.0
MALLARD	Dabbling Duck	MALL_SHEBRIVER_1	0.0216	0.0176	0.00824	11.90	0.97
MALLARD	Dabbling Duck	MALL_SHEBRIVER_2	0.0146	0.155	ND	16.30	1.8
MALLARD	Dabbling Duck	MALL_SHEBRIVER_3	0.0441	0.0164	0.0277	17.00	0.67
MALLARD	Dabbling Duck	MALL_SHEBRIVER_4	ND	0.0201	ND	5.38	0.047
MALLARD	Dabbling Duck	MALL_SHEBRIVER_5	0.00684	0.0142	ND	9.79	0.58
MALLARD	Dabbling Duck	MALL_SHEBRIVER_6	0.0116	0.0103	ND	9.36	2.2
MALLARD	Dabbling Duck	MALL_SHEBRIVER_7	0.0182	0.00926	ND	10.70	1.1
MALLARD	Dabbling Duck	MALL_SHEBRIVER_8	0.0141	0.0144	ND	5.74	0.78
MALLARD	Dabbling Duck	MALL_SHEBRIVER_9	0.00883	0.0285	0.0076	1.92	1.1
MALLARD	Dabbling Duck	MALL_SHEBRIVER_10	0.0228	0.0243	0.00526	8.34	1.1
MALLARD	Dabbling Duck	MALL_SHEBRIVER_11	0.0263	0.0108	0.0285	16.90	2.9
MALLARD	Dabbling Duck	MALL_SHEBRIVER_12	0.0305	0.0118	0.00652	15.70	1.7
MALLARD	Dabbling Duck	MALL_SHEBRIVER_13	0.0164	0.0102	0.00536	5.42	0.88