STAGE 2 REMEDIAL ACTION PLAN UPDATE

for the

LOWER GREEN BAY AND FOX RIVER AREA OF CONCERN

DRAFT 10/26/2012

December 2012

Wisconsin Department of Natural Resources
Office of the Great Lakes

Stage 2 Remedial Action Plan Update
for the
Lower Green Bay and Fox River Area of Concern
December 2012

Compiled by:
Laurel Last, WDNR Lower Green Bay and Fox River Area of Concern Coordinator. This update is based on the 2011 Stage 2 RAP Update, which was compiled by Erin Hanson.

With input and assistance from WDNR staff, including:
Christina Anderson
Kendra Axness
Andrew Fayram
Mary Gansberg
Gary Kincaid
Aaron Larson
Steve Hogler
John Huff
Chris Pracheil
Dick Sachs
James Schmidt

With special thanks to members of the Lower Green Bay Technical Advisory Committees (Biota & Habitat Workgroup, Science and Technical Advisory Committee, and Social Use Workgroup) and the Citizen Advisory Committee for their assistance in developing and reviewing earlier drafts of this document.

Several committee members were especially generous with their time and shared data and charts for this report including: Bart De Stasio (Lawrence University), Steve Hogler (WDNR), Jerry Kaster (University of Wisconsin – Milwaukee), Theresa Qualls (University of Wisconsin – Sea Grant Institute), and Tracy Valenta (Green Bay Metropolitan Sewerage District).

<u>Disclaimer</u>
The Great Lakes Water Quality Agreement (GLWQA) 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 Stage 2 Remedial Action Plan 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 AOC.

EXECUTIVE SUMMARY

The Lower Green Bay and Fox River are one of 43 Great Lakes Areas of Concern (AOC) established in the mid 1980s because of major environmental problems caused by toxic substances (primarily polychlorinated biphenyls, or PCBs), excessive nutrient and sediment loads from point and nonpoint sources, and physical habitat alterations. Thirteen beneficial use impairments (BUIs) were identified for this AOC, two of which were listed as suspected at that time. In the twenty-three years since the original Remedial Action Plan (RAP) local, state, and federal partners have made significant progress toward addressing the causes of impairments within the AOC. However, no BUIs have been removed and the Lower Green Bay and Fox River is still very much an Area of Concern.

The original Toxic Substances Management report stated that "cleaning up contaminated river sediments will be our greatest challenge" (Allen et al., 1987) and the last phase of the Lower Fox River Contaminated Sediment Remediation began in May 2009. This cleanup project is expected to last through 2017 and will address approximately 13 miles of the Lower Fox River from the mouth to just upstream of the Little Rapids Dam. Nine beneficial use impairments are at least partially, if not completely, dependent on completion of this remediation to meet the RAP Targets.

Eight BUIs also depend on reductions in nutrient and sediment loads to meet the RAP Targets. The U.S. Environmental Protection Agency approved the Wisconsin Department of Natural Resources' (WDNR's) Lower Fox River Watershed Total Maximum Daily Load (TMDL) for total phosphorus and suspended solids in May 2012. This TMDL identifies substantial reductions needed to meet water quality goals in the AOC. Next steps include implementation planning and actions to reduce phosphorus and sediment loading to the AOC.

The sediment cleanup and TMDL projects are critically important for the AOC but are being implemented through other programs. There are several additional areas where the AOC program can build momentum for addressing BUIs, and these are reflected in the Lower Green Bay and Fox River AOC Coordinator priority actions for 2013. These priorities include the following:

- Work collaboratively with stakeholders to develop a monitoring plan and determine the appropriate timing to assess the Bird or Animal Deformities or Reproduction Problems BUI;
- Establish a work group to explore the status and actions needed for the Restrictions on Drinking Water BUI;
- Examine options for expanding the benthos study to additional parts of the AOC, building on the 2012 U.S. Geological Survey sample data and exploring potential partnerships with the Green Bay Metropolitan Sewerage District and UW-Milwaukee for sample collection;
- With assistance from the Great Lakes Monitoring Coordinator in WDNR's Office of the Great Lakes, generate angler survey questions and evaluate the status of the Tainting of Fish and Wildlife Flavor BUI;
- Continue to expand and improve the Volunteer Aesthetics Monitoring program to gather the opinions of more citizens;
- Use the results of the Volunteer Aesthetics Monitoring program to identify issues that contribute to degraded aesthetics and work with local stakeholders to identify potential remedial actions, and,
- Seek opportunities to implement projects that will help to achieve fish and wildlife population and habitat objectives. Specifically, seek funding to implement a *Phragmites* inventory and mapping project in the AOC.

This Stage 2 RAP Update builds upon the 2011 RAP Update and concisely lists the current status of each beneficial use impairment, the next actions needed, potential issues, and stakeholder outreach needs associated with each. Citizen engagement has been an integral component of the Area of Concern program since the beginning and continues to be a priority as additional actions are identified and implemented.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **I**
TABLE OF CONTENTS ..... **III**
DEFINITIONS ..... **V**
PURPOSE STATEMENT **1**
INTRODUCTION **2**
BENEFICIAL USE IMPAIRMENT UPDATES **11**
RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION 13
TAINTING OF FISH AND WILDLIFE FLAVOR 15
DEGRADATION OF FISH & WILDLIFE POPULATIONS 17
FISH TUMORS OR OTHER DEFORMITIES 24
BIRD OR ANIMAL DEFORMITIES OR REPRODUCTION PROBLEMS 26
DEGRADATION OF BENTHOS 29
RESTRICTIONS ON DREDGING ACTIVITIES 33
EUTROPHICATION OR UNDESIRABLE ALGAE 35
RESTRICTIONS ON DRINKING WATER CONSUMPTION, OR TASTE AND ODOR PROBLEMS 40
BEACH CLOSINGS 42
DEGRADATION OF AESTHETICS 48
DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS 51
LOSS OF FISH & WILDLIFE HABITAT 53
REFERENCES **58**
APPENDICES **62**

List of Figures

Figure 1. The boundaries of the Lower Green Bay and Fox River Area of Concern 4
Figure 2. Walleye Open Water Harvest (2006-2011) 21
Figure 3. Yellow Perch Open Water Harvest (2006-2011) 21
Figure 4. Mean Summer Total Phosphorus (TP) in Lower Green Bay (1970-2010) 37
Figure 5. Mean summer Total Suspended Solids (TSS) in Lower Green Bay (1991-2010) 37

Figure 6. Recreation areas in the Lower Green Bay and Fox River AOC 44
Figure 7. Mean summer secchi depth for Lower Green Bay (1986-2010) 54

List of Tables

Table 1. Primary causes of Beneficial Use Impairments in the Lower Green Bay and Fox River Area of Concern 5
Table 2. Current Status of Beneficial Use Impairments in the Lower Green Bay and Fox River AOC (Refer to Appendix A for more detail) 9
Table 3. Stakeholder Engagement……11

List of Appendices

Appendix A Lower Green Bay and Fox River BUI Tracking Matrix
Appendix B WDNR and DHS Fish Consumption Advisory Fact Sheet (summer 2012)
Appendix C Fish and Wildlife Populations and Habitat Actions Table
Appendix D WDNR Assessment Criteria for Fish Tumors or Other Deformities BUI

List of Acronyms

AOC	Area of Concern
BUI	Beneficial Use Impairment
GBMSD	Green Bay Metropolitan Sewerage District
GLRI	Great Lakes Restoration Initiative
LaMP	Lakewide Management Plan
PCB	Polychlorinated biphenyl
ppm	Part per million
RAP	Remedial Action Plan
TMDL	Total Maximum Daily Load
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WDNR	Wisconsin Department of Natural Resources
WisCALM	Wisconsin Consolidated Assessment and Listing Methodology

DEFINITIONS

Area of Concern (AOC)
Defined by Annex 2 of the 1987 Protocol to the U.S.-Canada Great Lakes Water Quality Agreement as "geographic areas that fail to meet the general or specific objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life." These areas are the "most contaminated" areas of the Great Lakes, and the goal of the AOC program is to bring these areas to a point at which they are not environmentally degraded more than other comparable areas of the Great Lakes. When that point has been reached, the AOC can be removed from the list of AOCs in the Annex, or "delisted."

Beneficial Use Impairment (BUI)
A "beneficial use" is any way that a water body can improve the quality of life for humans or for fish and wildlife (for example, providing fish that are safe to eat). If the beneficial use is unavailable due to environmental problems (for example if it is unsafe to eat the fish because of contamination) then that use is impaired. The International Joint Commission provided a list of 14 possible beneficial use impairments in the 1987 Great Lakes Water Quality Agreement amendment.

Delisting Target
Specific goals and objectives established for beneficial use impairments, with measurable indicators to track progress and determine when delisting can occur. Targets should be locally derived.

Escherichia coli (E. coli)
A bacterium commonly found in natural bodies of water that serves as an indicator of the possible presence of other health risks in the water, such as bacteria, viruses, and other organisms.

Goal
Goals are broad ideas that may take a long time to achieve. They usually don't change significantly over the life of a project. An example goal statement is, "*Nesting populations of a diverse array of wetland-dependent and riparian-associated birds are consistently present within the AOC."* The delisting targets for the impairments may also be considered the goal statements (in some cases they may be objectives).

Objective
Objectives are the detailed activities that are needed in order to meet goals. Objectives are normally accomplished in less time than goals. They are important because they provide a means of measuring progress toward plan implementation. Objectives should be SMART: Specific, Measurable, Achievable, Realistic, Time-Constrained.

Project
As defined for this document, a project is a specific activity that has been defined with enough detail to understand who will do the work, how it will be done, and where it will be done. The end result of the activity should be visible and concrete. One or more projects may be defined to meet the goals and objectives for the impairments, if the AOC is not yet eligible for delisting. With this definition, "Coordinating with partners to make sure data is consistently collected and used" would not be a project. However, "XY Agency will Host a data 'slam' and write a set of standards for data collection and analysis for the Example AOC" would be a project.

Remedial Action Plan (RAP)

According to the 1987 Protocol to the U.S.-Canada Great Lakes Water Quality Agreement, a RAP is a document that provides "a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Areas of Concern…" RAPs are required to be submitted to the International Joint Commission at three stages:

- Stage 1: Problem definition
- Stage 2: When remedial and regulatory measures are selected
- Stage 3: When monitoring indicates that identified beneficial uses have been restored

Remedial Action Plan (RAP) Update

A RAP Update fulfills the requirement for biennial progress reporting described in Annex 2 of the 1987 Protocol to the U.S.-Canada Great Lakes Water Quality Agreement. Some RAP updates are more comprehensive than others, and contain some of the elements of an AOC delisting strategy (e.g., remedial measures). Most RAP Updates for Wisconsin's AOCs have not included project-specific information regarding who will do each project and how much each will cost.

Total Maximum Daily Load (TMDL)

A TMDL is the amount of a pollutant a waterbody can receive and still meet water quality standards. It can be thought of as a pollution "budget" for a water body or watershed that establishes the pollutant reduction needed from each pollutant source to meet water quality goals.

PURPOSE STATEMENT

The purpose of this document is to serve as a Stage 2 Remedial Action Plan (RAP) Update. It builds upon the 2011 Stage 2 RAP update (WDNR, 2011). Stage 2 RAPs are described in the 1987 Protocol amending the *Revised Great Lakes Water Quality Agreement of 1978* as plans that evaluate and describe remedial measures needed to restore the beneficial uses. The Protocol indicates that the Stage 2 RAP should also contain a schedule and identify the organization responsible for implementation.

This Stage 2 RAP Update is intended to be a concise summary of beneficial use impairment status and specific actions that will be important for reaching the delisting targets. "Actions" may include on-the-ground restoration projects, monitoring and assessment projects, and stakeholder engagement processes. It is also a tool for documenting and communicating progress to agency partners and technical stakeholders. The Stage 2 RAP will be updated as needed to incorporate new information that may become available.

This Stage 2 RAP Update was prepared by the Wisconsin Department of Natural Resources (WDNR) in consultation with its partners. Wisconsin's AOC Program is guided by a set of core values, including strong citizen and stakeholder engagement, scientific defensibility, environmental stewardship, achieving timely progress, and documenting results. These values are reflected in this document.

INTRODUCTION

Areas of Concern (AOC) are severely degraded geographic areas within the Great Lakes. The areas – 43 within the Great Lakes region – were designated as AOCs primarily due to contamination of river and harbor sediments by toxic pollutants (sometimes referred to as "legacy" pollutants due to the historical industrial development that often was the source of the pollution). Cleaning up these severely degraded areas is a first step toward restoring the chemical, physical, and biological integrity of the lakes as required by the Great Lakes Water Quality Agreement. When the areas have been cleaned up to the point where they are not more degraded than other, comparable non-AOC areas, they are "delisted" as AOCs; they are then considered to be part of the Lakewide Management Plan (LaMP) program, a "whole lake" program that is also set forth in the Agreement. The Agreement provides the framework for the U.S. and Canada to work together to restore the chemical, physical, and biological integrity of the lakes.

The Lower Green Bay and Fox River AOC is one of five AOCs in Wisconsin. This AOC spans seven miles of the Lower Fox River (downstream from the De Pere Dam to the mouth) and approximately 22 mi^2 of southern Green Bay (from the Fox River mouth to an imaginary line drawn between Long Tail Point and Point au Sable, Figure 1). The relatively small geographic area officially recognized as the AOC is the location where cumulative impacts from the much larger Fox-Wolf watershed are manifested and the environment is most severely impaired.

The Lower Green Bay Remedial Action Plan (RAP; WDNR, 1988) and RAP Update (WDNR, 1993) provide extensive descriptions of the historic and environmental setting of the AOC, the original environmental problems that led to designation of this area as an AOC, and the sources of those problems. These plans also include goals, objectives, and strategies to address these problems and restore the Lower Bay and Fox River. Interested readers are encouraged to consult these documents (available at http://dnr.wi.gov/topic/greatlakes/greenbay.html) for a complete description of the AOC that is not included here.

At the time of the first RAP, the major environmental problems in the Lower Bay and Fox River that led to AOC designation were caused by sources that can be divided into four broad categories:

- Toxic Substances: Polychlorinated biphenyls (PCBs), historically discharged by mills during the manufacture and recycling of carbonless copy paper, were of primary concern although the RAP mentions several chemicals including 20 that were on the U.S. Environmental Protection Agency's (USEPA's) priority pollutant list at that time.
- Point Source and Runoff Pollution: Phosphorus and sediment discharges from municipalities and industries lining the Fox River corridor and nonpoint sources in the Lower Fox Watershed.
- Physical Habitat Alterations: including wetland filling and draining, shoreline erosion and filling.
- Other: water level fluctuations and non-native invasive species.

These sources of impairment led to designation of eleven of the possible fourteen beneficial use impairments (BUIs) as applicable to this AOC (Table 1). Additionally, two of the fourteen beneficial use impairments were listed as "suspected," meaning that they were likely to be a problem but data were lacking or inconclusive.

The original RAP (WDNR, 1988) and RAP Update (WDNR, 1993) contained Goals and Objectives for restoring beneficial uses in the AOC. In the twenty-four years since these were first developed, local, state, and federal partners made significant progress towards addressing the causes of impairments. However, no beneficial use impairments were removed and the Lower Green Bay and Fox River still remain very much an Area of Concern. In an effort to recognize progress towards meeting RAP goals, USEPA requested that States generate "Delisting Targets" for each BUI. The targets clearly define when

impairments are to be considered sufficiently addressed so that they can be removed from the AOC. WDNR worked with local stakeholders in early 2009 to develop the targets for the Lower Green Bay and Fox River AOC (WDNR, 2009).

In 2011, WDNR worked with partners and stakeholders to develop a Stage 2 RAP Update (WDNR, 2011) to summarize the current status of the BUIs and identify actions needed to reach the delisting targets. This document is a 2012 update to account for changes in status, projects, and priorities since 2011, and to provide more details on the actions that will help us reach our AOC goals and targets.

Very brief updates of past activities are provided in the following sections of this introduction. The current status of each beneficial use impairment is summarized in Table 2 and described more fully in the sections that follow. The 2009 target is also listed in each section along with any modifications that have been suggested since that time.

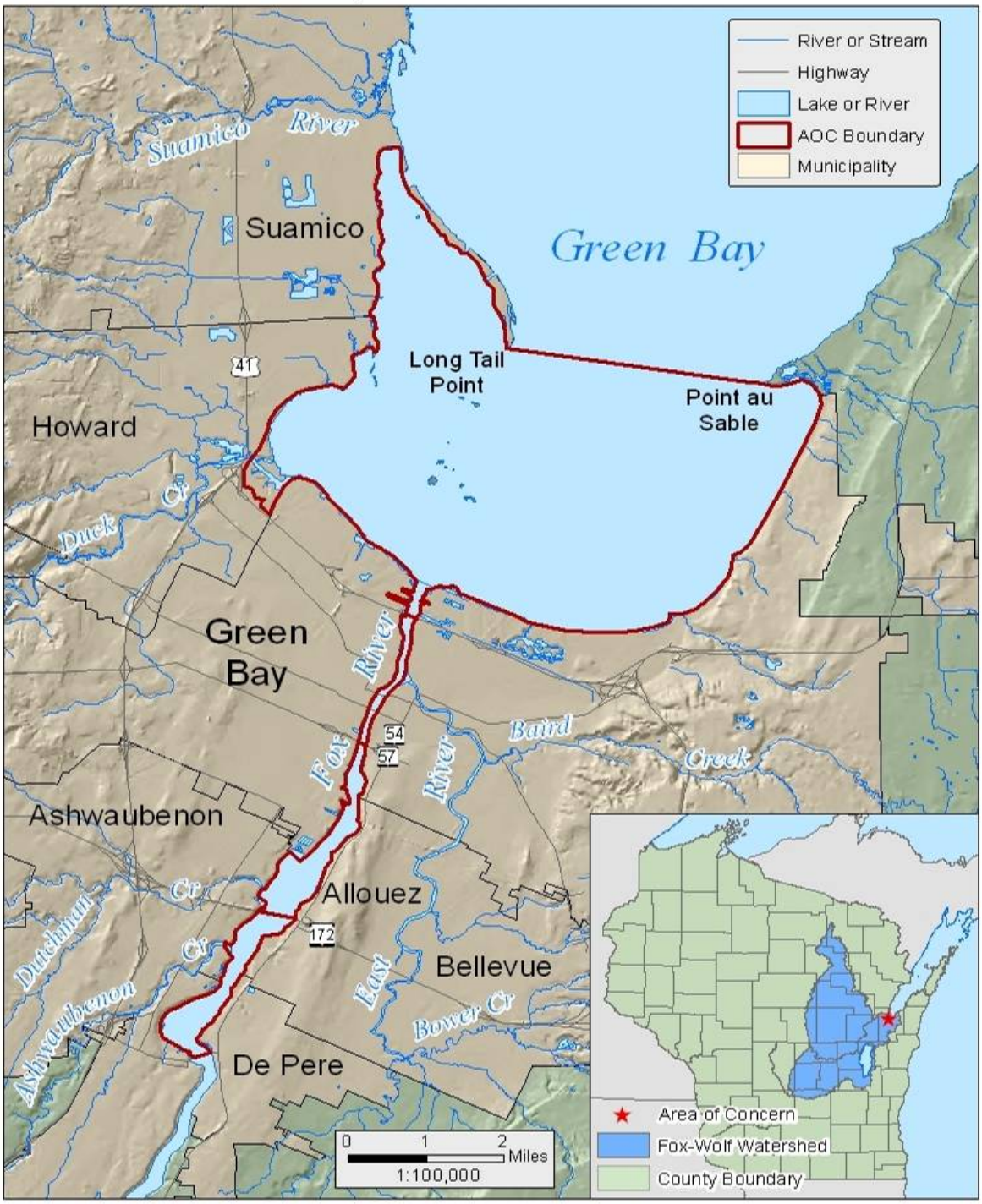


Figure 1. The boundaries of the Lower Green Bay and Fox River Area of Concern

Table 1. Primary causes of Beneficial Use Impairments in the Lower Green Bay and Fox River Area of Concern

Beneficial Use Impairments	Toxic Substances	Point Source & Runoff Pollution	Physical Habitat Alterations	Other
Restrictions on Fish and Wildlife Consumption	**X**			
Tainting of Fish and Wildlife Flavor (*suspected*)	**X**			
Degradation of Fish and Wildlife Populations	**X**	**X**	**X**	**X**
Fish Tumors or Other Deformities (*suspected*)	**X**			
Bird or Animal Deformities or Reproduction Problems	**X**			
Degradation of Benthos	**X**	**X**		
Restrictions on Dredging Activities	**X**			
Eutrophication or Undesirable Algae		**X**		
Restrictions on drinking water consumption, or taste and odor problems	**X**	**X**		
Beach Closings		**X**		
Degradation of Aesthetics		**X**		
Degradation of Phytoplankton and Zooplankton Populations	**X**	**X**		
Loss of Fish and Wildlife Habitat		**X**	**X**	**X**

"Added costs to agriculture or industry" is the only Beneficial Use Impairment identified in the Great Lakes Water Quality Agreement that is not identified for the Lower Green Bay and Fox River Area of Concern.

Toxic Substances

The last phase of the Lower Fox River Contaminated Sediment Remediation project began in May 2009 and includes remediation of all sediment with total PCB concentrations greater than or equal to 1.0 part per million (ppm) in the area from the mouth of the Fox River (and a short distance into Green Bay) to just upstream of the Little Rapids Dam (an approximately 13 mile stretch of River). Details about the project are available to the public online at http://ua.dnr.wi.gov/topic/ImpairedWaters/FoxRiver/original/, including an overview of the project's history and information on the background studies and plans that led to the final cleanup decisions.

At the time the original RAP was developed, concerns were also noted about the presence of more than 100 chemicals, including 20 then listed on USEPA's priority list of pollutants that pose a risk to the environment and human health (Allen et al., 1987). The current contaminated sediment remediation project will address many of those chemicals, though the emphasis has been placed on PCBs in sediments since the remedy to address PCB exposure effectively addresses the other compounds as well. The project includes a combination of dredging, dredging and capping, and sand covering over an estimated 7 years of dredging (from 2009 through 2015) and 9 years of capping and sand covering (from 2009 through 2017).

The upstream Little Lake Butte des Morts (LLBdM) remediation, in which approximately 370,000 cubic yards of sediment was dredged, was completed in 2009. Remediation in OU 2-3 (just above the Little Rapids Dam to De Pere Dam) was completed in 2011 and included a combination of dredging 235,900 cubic yards and capping approximately 26 acres of sediment. The total volume of sediment dredged in LLBdM and the first four years of operation (2009 through 2012) in the current phase is approximately 2.5 million cubic yards, which was dewatered and disposed of in a landfill. Annual dredge volumes are anticipated to be approximately 500,000 to 660,000 cubic yards per year, providing remediation proceeds on schedule.

Point Source and Runoff Pollution

The USEPA approved the WDNR's Total Maximum Daily Load (TMDL) for total phosphorus and total suspended solids in the Lower Fox Watershed in May 2012 (available online at http://dnr.wi.gov/topic/tmdls/foxriver/documents/LFR_TMDL_EPA_Submittal_Aug_2011.PDF). This report includes a summary of "current" land use and total phosphorus and suspended solids loads and reductions needed to meet water quality targets. Overall, a reduction of 59% in total phosphorus and 55% in total suspended sediments is required from baseline loads (2004-2005) within the Lower Fox Watershed to meet water quality goals. The TMDL lists reductions for each 303(d) listed stream segment in the Lower Fox Watershed including wasteload allocations for point sources and load allocations for nonpoint sources. Achieving the water quality targets established in this report is expected to result in improved water clarity and dissolved oxygen and conditions in the Lower Bay that will restore beneficial use impairments in the AOC.

Statewide efforts to control phosphorus separate from the TMDL have also moved forward in recent years. These include changes to Wisconsin rules resulting in a ban on phosphorus in fertilizer applied to most lawns or turf (April 2010), a reduction in phosphorus in household dishwasher detergents (June 2010), establishment of phosphorus water quality standards criteria and rule changes to allow water quality based phosphorus limits for wastewater discharges from industries and municipalities in addition to categorical limits (December 2010), and changes aimed at reducing phosphorus runoff from farms (January 2011).

Physical Habitat Alterations

Two large restoration efforts stand out among the many projects initiated to restore environmental conditions within and adjacent to the AOC: Cat Island Chain Restoration and Green Bay's west shore wetlands.

The Cat Island Chain Restoration project developed out of the RAP process as a top priority for habitat restoration. During times of high water and storms in the 1970s this island chain in the southwestern portion of lower Green Bay disappeared. Brown County, the U.S. Army Corps of Engineers (USACE), and other partners are currently focused on beneficially reusing dredge materials from navigation dredging of outer Green Bay to rebuild these islands that once sheltered large areas of shallow water and coastal wetlands, providing important fish and wildlife habitat. Beginning in June of 2012, Brown County began construction of a rock spine structure that will act as a wave barrier and provide the foundation for restoring the Cat Island Chain. The wave barrier provides the base for constructing three islands which will be built from beneficially reused fine sands dredged from the outer navigation channel. The islands will be then be filled by the USACE using clean dredge material from the maintenance of the Green Bay Harbor over the next thirty years. More information about the history and progress of this project is available online at the Port of Green Bay website: http://www.portofgreenbay.com/.

The extensive coastal wetlands along the west shore of Green Bay have also been a top priority for habitat restoration and protection by multiple partners for many years. It's commonly stated that 70% of the original wetlands along or adjacent to Green Bay's west shore have been lost. The West Shore area includes approximately 140 miles of streams, a quarter of which are considered critical for northern pike spawning and rearing habitat. Recent efforts supported by 2010 Great Lakes Restoration Initiative (GLRI) funding from USEPA that overlap the AOC include the following: northern pike habitat restoration (Brown County Land and Water Conservation Department), integrated stream and wetland restoration in the Duck-Pensaukee watershed (The Nature Conservancy), and efforts to control invasive common reed grass in conservation opportunity areas along Wisconsin's Lake Michigan shoreline (WDNR).

Other

Although water level fluctuations and the impact of non-native invasive species are now considered largely outside of the scope of the Area of Concern program, they were previously identified as contributing to impairments. In the time since the original RAP, new invasive species that have a substantial impact on impairments have become established within the AOC, notably zebra and quagga mussels (Dreissenids) and common reed grass (*Phragmites australis*). Whenever possible, projects to control the impact of invasive species may need to be considered to restore impairments within the AOC.

Public Involvement

The original RAP and RAP Update were the result of significant public consultation and involvement and included multiple technical advisory committees and a citizen advisory committee. For the 2011 Stage 2 RAP Update and this 2012 Stage 2 RAP Update, WDNR involved established technical advisory workgroups (Biota & Habitat Workgroup, Social Use Workgroup, and Science and Technical Advisory Committee) and a newly re-formed citizen advisory committee (first met in August 2011) in developing the RAP to varying degrees.

Future plans include broadening general public participation in AOC activities using funds provided by USEPA to WDNR to support Citizen Advisory Committees. There are multiple other efforts to involve the public and gain their support for actions to improve environmental conditions in the Lower Fox River and Green Bay. WDNR will attempt to coordinate with these groups as much as possible when their goals overlap with the AOC program goals. WDNR will also attempt to use existing avenues of communicating

with the public, for example incorporating AOC updates into University of Wisconsin – Sea Grant Institute's State of the Bay report and website as they become available.

Table 2. Current Status of Beneficial Use Impairments in the Lower Green Bay and Fox River AOC (Refer to Appendix A for more detail)

Beneficial Use Impairment	Beneficial Use Remains Impaired	Summary Status
Restrictions on fish and wildlife consumption	Yes	Wildlife consumption assessment has been funded. Sampling to occur 2013-2015. Fish consumption advisories for PCBs specific to the AOC will be addressed by the Fox River Contaminated Sediment Remediation.
Tainting of fish and wildlife Flavor	Suspected	WDNR should determine if impairment applies to the AOC by conducting a survey of Brown County anglers. Need to determine best survey method (creel survey, online, etc.), create survey, and conduct survey in 2013.
Degradation of fish and wildlife populations	Yes	No one discrete project will be sufficient to address the complex needs of this BUI. Various monitoring, planning, and projects are listed in Appendix C. Also depends on completion of ongoing Fox River Contaminated Sediment Remediation and TMDL implementation.
Fish tumors or other deformities	Suspected	USFWS-USGS "Chemicals of Emerging Concern" histopathology results will be used as a screening tool to determine the appropriate timing for a more extensive fish tumors study to definitively establish the status of this BUI.
Bird or animal deformities or reproduction problems	Yes	BUI removal will depend on completion of contaminated sediment remediation; however, WDNR should take the opportunity to request funds through GLRI if needed. Data from GLRI award to USGS (C. & T. Custer) will assist in determining the current status of this BUI once they are available. Next step is to work collaboratively with stakeholders to develop a monitoring plan to assess this BUI.
Degradation of benthos	Yes	The 2012 USGS benthos study will provide baseline information for assessing the status of this BUI in the Fox River portion of the AOC. Additional funding is needed for samples from the Lower Bay portion of the AOC. Next step is to examine options for expanding the benthos study to additional parts of the AOC, building on the 2012 USGS sample data and exploring potential partnerships with GBMSD and UW-Milwaukee for sample collection.
Restrictions on dredging activities	Yes	This use will remain impaired until the ongoing Fox River Contaminated Sediment Remediation has been completed and the delisting target has been met.
Eutrophication or undesirable algae	Yes	A TMDL report for total phosphorus and total suspended solids in the Lower Fox Watershed was approved by USEPA in 2012 and identifies reductions needed to meet goals for the AOC. TMDL Implementation planning is still needed. A WDNR TMDL Project Manager was hired in October 2012. Ongoing & new monitoring of Harmful Algal Blooms will be compared to the target for undesirable algae.
Restrictions on drinking water consumption, or taste and odor problems	Yes	A technical workgroup should be convened in 2013 to evaluate the current status of this impairment.
Beach closings	Yes	Beach program monitoring at locations used by the public for recreation indicate *E. Coli* levels are good overall. Additional monitoring at Bay Beach is needed given current effort to revitalize a public beach in this location. Bay-Lake Regional Planning Commission has received funding to perform *E. Coli* monitoring, identify pollution sources, and write a Restoration Action plan for Bay Beach. Recent monitoring of Harmful Algal Blooms indicates that toxins are present in the AOC at unhealthy levels. Additional monitoring should be done, particularly near Bay Beach, to further evaluate the status of this impairment.
Degradation of aesthetics	Yes	WDNR initiated a pilot volunteer monitoring program in 2011 that was expanded in 2012. This program will be continued for at least 5 more years. Results will be used to identify the current status and causes of this impairment and to identify priority projects, such as clean-up efforts, to address the problems revealed in the surveys.
Degradation of phytoplankton and zooplankton populations	Yes	The 2012 USGS phytoplankton and zooplankton study will provide baseline information for assessing the status of this impairment and determining if additional information is needed.
Loss of fish and wildlife	Yes	No one discrete project will be sufficient to address the complex needs of this BUI. Various monitoring, planning,

habitat		and projects are listed in Appendix C. Key projects include Cat Island Chain and Point Sable habitat restoration projects, both of which made significant progress in 2012, and additional *Phragmite*s inventory and control. Also depends on TMDL implementation.

Table 3. Stakeholder Engagement.

Information/Education/Outreach Campaign
To keep the local community of residents, businesses and tourists updated on and supportive of projects, and aware of needed actions/cooperation

Media	Target Audience	Messages	Implementer(s)	Collaborators	Funded by
BUI Videos	General public, high school students, museum and wildlife sanctuary visitors	Green Bay and Fox River are polluted. Awareness of BUIs	Pulaski High School AP Environmental Science Class	UWEX, WDNR	WDNR
Guest Presentations	Citizen Advisory Committee Members	Various messages surrounding ongoing AOC-related projects	WDNR and UWEX		NA
Water Words That Work Workshop	Citizen Advisory Committee Members, WDNR staff	Telling people the action you want them to take. Use good photos, with people. Use common language that all will understand. Use the right words to get action.	UWEX	WDNR	UWEX, WDNR

BENEFICIAL USE IMPAIRMENT UPDATES

The following pages summarize the current status of each Beneficial Use Impairment using the format below. An explanation of each section is provided after the heading.

2009 Target and Status

Beneficial Use Impairment Name	Status
The 2009 Lower Green Bay and Fox River AOC delisting targets (WDNR, 2009) are listed here as separate target components on each row to clearly show status of each part of the target.	May be: - "Complete" - "In progress" - "Action needed" - "Unknown" - "Assessment in progress" (data collection occurring in years listed in parentheses) - "TBD" (to be determined)

Note: may list one or more of the following:
- potential concerns about the target, particularly if the target is not specific enough to define a measurable endpoint for the BUI
- if revisions are anticipated and how such changes might be approached including responsible party and timeline
- if the 2009 target was modified and details of any changes

Rationale for Listing

The section briefly summarizes the reason the BUI was known or suspected at the time of listing. If sources contributing to the impairment have been identified since listing, those are included in this section as well.

Summary of key remedial actions since the 2011? RAP/RAP Update and current status

"Key remedial actions" are those that directly contributed to the current status of the BUI. A table may be included as an appendix to capture a detailed list of past projects. The narrative here explains and leads to the "Next action needed".

Next action(s) needed

1. This section is a narrative listing of assessments, on-the-ground projects, and stakeholder engagement processes that are clearly delineated and directly address the specific BUI.
2. Project titles that are underlined are also included in Appendix A "Lower Green Bay and Fox River AOC BUI Tracking Matrix".
3. Plans for verifying achievement of delisting targets are listed here if known.

Issues (challenges, risks) affecting progress on this BUI

This section lists project contingencies (i.e., one thing has to happen before another can occur), funding obstacles and any other considerations that could affect the timeline for delisting.

Stakeholder Engagement

The role of Technical and Citizen Advisory Committees are listed here. Key outreach activities or needs related to the specific BUI are listed and connected to overall timelines for implementing actions.

RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION

2009 Target and Status

Restrictions on Fish and Wildlife Consumption	Status
The Fox River Contaminated Sediment Remediation has been completed and meets the target established in the plan (Surface Area Weighted Concentration of 0.25 ppm or that determined acceptable by the agencies for completion of the PCB remedial action)	In progress
Fish and wildlife consumption advisories are the same or lower than those in the associated Great Lake or appropriate control site.	Assessment in progress (for waterfowl)

Rationale for Listing

This impairment was originally identified because of the presence of persistent, bioaccumulative, and toxic substances, primarily PCBs, in sediments that resulted in consumption advisories for certain species of fish and waterfowl specifically in AOC waters. At the time the RAP was developed concerns were also noted about the presence of more than 100 chemicals including 20 then listed on USEPA's priority list of pollutants that pose a risk to the environment and human health (Allen et al., 1987).

Summary of key remedial actions since the last RAP and current status

Sources of PCB discharges to the river have been largely eliminated and completion of the ongoing Fox River Contaminated Sediment Remediation will address PCBs remaining in sediments along with mercury and other potentially toxic chemicals. The long-term goal of the remediation is to protect human health by removing fish consumption advisories as quickly as possible, although it may take years before this occurs. Encouraging signs that the remediation will be successful in reducing fish consumption advisories were seen upstream of the AOC in the Lower Fox River from Little Lake Butte des Morts to the De Pere dam in summer 2011. There, the PCB advisory for smallmouth bass was revised after testing appeared to "reflect improvements due to river cleanup in this first and most upstream River segment" (WDNR news release: http://dnr.wi.gov/news/weekly/Article_Lookup.asp?id=1849).

Current fish consumption advisories are listed on page 20-21 of Wisconsin's 2012 "Choose Wisely—A health guide for eating fish in Wisconsin" available at http://dnr.wi.gov/topic/fishing/documents/FishAdvisoryweb2012low.pdf. In 2012, consumption advisories for PCBs specific to the Fox River below the De Pere dam ranged from "eat no more than 1 meal/month" to "do not eat" for a variety of size classes of 15 different fish species. Slightly different specific consumption advisories for PCBs are also in place for Green Bay south of the City of Marinette. Additional fish species not listed for the Fox River are included in the Green Bay advisories (Brown Trout, Chinook Salmon, Musky, and others) and in some cases advisories for larger fish are less strict in Green Bay than they are in the Fox River. For example, in the Fox River, northern pike larger than 33" should not be consumed more than once every two months, whereas anglers may eat all sizes of northern pike from Green Bay no more than once a month. Anglers should consult the most recent "Special Advice for PCBs and other chemicals" for current fish consumption advisories.

The current wildlife advisory is listed on page 27 of the 2012 Wisconsin Migratory Bird Regulations available at http://dnr.wi.gov/files/pdf/pubs/wm/wm0010.pdf. In 2012, hunters were advised to "Remove all skin and visible fat before cooking" and "Discard drippings or stuffing because they may retain fat that contains PCBs" for mallards harvested from the AOC and an upstream segment of the Lower Fox River from Lake Winnebago to Kaukauna. The advisory has been in place since 1987, and has not been re-evaluated since then. The WDNR has recently received funding for three years of legacy contaminants

analyses from three types of waterfowl (a dabbler species: mallards, a diving species: scaup, and resident Canada geese) to determine if the existing advisory is still warranted. Sampling will occur summer-winter in 2013, 2014, and 2015 and a final report will be completed in spring 2016.

Next action(s) needed

1. Waterfowl Consumption Advisory Update: Complete 3-year waterfowl consumption advisory evaluation to determine if the existing advisory is still warranted.
2. Complete the Lower Fox Contaminated Sediment Remediation
3. Complete fish consumption advisory (PCB) analysis as required by Fox River Contaminated Sediment Remediation approved Long Term Monitoring Plan.

Issues (challenges, risks) affecting progress on this BUI

- Removal of this impairment depends on completion of the Lower Fox Contaminated Sediment Remediation. Any delay in the sediment remediation will also delay removal of this impairment.
- Time may be needed for the fish and wildlife contaminant levels to decline after completion of the Lower Fox Contaminated Sediment Remediation.
- Comparing fish or wildlife contaminant concentrations to samples from Lake Michigan or another control site will be difficult due to expense and potential differences in species and growth rates. Likewise, comparing consumption advisories to another control site will be difficult due to these potentially confounding factors.

Stakeholder Engagement

Appendix B is a fact sheet developed by WDNR and the Wisconsin Department of Health Services in 2012 listing current fish consumption advisories. There are no additional outreach or communication needs identified at this time; however, this will change as remediation progresses and adjustments are made to consumption advisories.

TAINTING OF FISH AND WILDLIFE FLAVOR

2009 Target and Status

Tainting of Fish and Wildlife Flavor	Status
No target was developed in 2009 as this is a suspected impairment.	Unknown

Rationale for Listing

This impairment was briefly mentioned in the 1993 RAP Update as suspected based on 1) occasional angler reports of problems with fish taste and odor and 2) the potential for components in industrial and municipal effluents (resin acids, chlorophenols) to cause off-flavors in fish (WDNR, 1993).

Summary of remedial actions since the last RAP and current status

The RAP Update stated "With the application of effluent treatment to all municipal and industrial wastewater discharges and the closing of most pulp mills on the Fox River, the likelihood of fish tainting has been greatly reduced" (WDNR, 1993). WDNR continues to regulate wastewater discharges following Wisconsin Administrative Code, including Ch. NR 102.14 that includes a list of compounds regulated based on taste and odor criteria. No wastewater discharge permits in Lake Winnebago or the Lower Fox River downstream to the mouth include limits based on taste and odor criteria, which indicates that discharge levels of these compounds are not high enough to be a potential water quality concern (James Schmidt, WDNR, personal communication).

This suspected impairment is likely not a problem within the Lower Green Bay and Fox River AOC; however, the current status is listed as "unknown" as WDNR does not routinely collect reports about problems with fish taste. WDNR fisheries and enforcement staff who have regular contact with local anglers indicate that comments about flavor of AOC fish are highly variable, ranging from "I never eat them" to "they taste fine."

Next action(s) needed

1. 2013 Survey of Lower Fox and Green Bay Anglers: A survey of anglers in the AOC is needed to determine the current status of this impairment. WDNR should consider adapting questions from those used within the last 5 years by other Great Lakes Areas of Concern (e.g., St. Clair River and Detroit River) to identify angler concerns related to fish flavor that are specific to the AOC. There may be potential for this survey to be conducted in conjunction with WDNR's creel survey that is conducted to estimate fishing effort, catch, and harvest rates using angler counts and interviews. By coordinating with the ongoing creel survey, WDNR might efficiently collect information and target anglers who are actively fishing in the Area of Concern.

Issues (challenges, risks) affecting progress on this BUI

- Fish flavor is a subjective judgment and subject to personal bias based on previous experiences and anecdotal information shared by other anglers.
- Some anglers simply will not eat any fish from the AOC. This will confound attempts to solicit opinions on fish flavor from local anglers.
- Fish flavor can be impacted by other factors such as season, species and fish condition (e.g., recently spawned or not). It may be difficult to frame the questions to remove the impact of these potentially confounding factors and identify problems specific to the AOC. Questions will need to be carefully worded to collect data relevant to this impairment. It's not clear whether blue-green algae also have potential to influence fish flavor and this factor may need to be considered when developing the survey.

- Fish consumption advisories limit the amount and types of fish from the AOC consumed by anglers.
- Coordinating the flavor survey with the creel survey will be difficult given the limited time and resources available for the creel clerks. An increase in the number of questions posed to each angler will lessen the total number of interviews conducted and impact the variability in the data collected and catch and effort estimates. It may not be possible to ask the questions succinctly enough to allow the flavor survey to be coordinated with the creel survey, thereby increasing the cost. An alternative format might be to ask anglers, ice fishers, and/or local fishing group members to fill out an online survey.

Stakeholder Engagement

WDNR will engage established technical advisory work groups in the development of the survey.

WDNR will target anglers actively using the Area of Concern when determining the current status of this impairment. Other local fishing groups, such as Walleyes for Tomorrow, might be consulted when assessing the status of this BUI.

DEGRADATION OF FISH & WILDLIFE POPULATIONS

2009 Target and Status

Degradation of Fish & Wildlife Populations	Status
The AOC contains healthy, self-sustaining, naturally reproducing, and diverse populations of native fish species (including walleye, northern pike, yellow perch, lake sturgeon, Great Lakes spotted muskellunge, and centrarchids) in abundances sufficient to provide ecological function in the fish community	Action needed
Populations of traditionally harvested fish species are capable of supporting some level of exploitation	Action needed
The AOC contains healthy, self-sustaining, naturally reproducing, and diverse populations of native furbearers (including mink, muskrats, and otter), amphibians (including spring peepers, leopard frogs, American toads, eastern gray tree frogs, green frogs, bullfrogs, and salamanders), reptiles (including snapping and painted turtles), terns (common and Forster's), migratory diving ducks, dabbling ducks, marsh nesting birds and island-dependent colonial nesting birds in abundances sufficient to provide ecological function	Action needed
Populations of traditionally harvested wildlife species are capable of supporting some level of exploitation	Action needed
Invasive species (lamprey, carp, gobies, white perch, and others) expansion is minimized and controlled as needed to protect native species within the AOC and upstream	Action needed
Contaminant levels in forage fish populations do not impair the reproductive success of fish-eating birds and wildlife (including predatory fish) and meet the criteria established in Annex 1 of the Great Lakes Water Quality Agreement, specifically "the concentration of total polychlorinated biphenyls in fish tissues (whole fish, calculated on a wet weight basis), should not exceed 0.1 micrograms per gram for the protection of birds and animals which consume fish"	Action needed
The AOC supports fish and wildlife populations at levels consistent with extant fish and wildlife management plan objectives. Specifically, the following objectives should be met unless extant management plans have updated criteria. (Specific objectives are listed below)	Action needed

Notes: 1) The last portion of the 2009 Target "Fish and wildlife community structures within the AOC are statistically similar to populations in unimpacted reference sites of highly productive, warm water freshwater estuaries of the Great Lakes" was determined to be an unrealistic target by the Lower Green Bay and Fox River AOC Biota & Habitat Committee in early 2011. It would be extremely difficult to determine an appropriate comparison location for the Lower Fox River and Green Bay AOC (few areas exist with comparable depth, substrate, temperature, etc) that are not also AOCs. Thus, this portion of the target has been deleted.

2) The Lower Green Bay and Fox River AOC Biota & Habitat Committee made only minor modifications to the objectives below from the specific objectives listed in the 2009 Targets. As more monitoring data becomes available other modifications to these objectives may also be necessary. WDNR should consult with the Lower Green Bay and Fox River AOC Biota & Habitat Committee when considering future revisions to the 2009 Target.

Fish Objectives

- Average sport angler harvest over a 3-4 year period of 7,000 walleyes harvested annually and 150,000 yellow perch harvested annually
- Predator-prey biomass ratio of fish species in the AOC is 1:10 to 1:20
- Lower Fox River capable of supporting a Lake sturgeon spawning population of a minimum of 750 mature adults (per Welsh et al., 2010).

Wildlife Objectives

Colonial Waterbirds:

- Presence of a diverse array of colonial waterbirds such as, but not limited to: great egrets, great blue herons, black-crowned night herons, double-crested cormorants, white pelicans, common terns, Forster's terns, black terns, herring gulls, and ring-billed gulls.

Waterfowl:

- Resident nesting waterfowl production in the Area of Concern of mallards, blue-winged teal, wood ducks, and Canada geese totals at least 1 young produced per acre of brood water.
- Migratory concentrations of dabbling ducks reach peak numbers of 5,000 in the Area of Concern.
- Bay habitat improves so that diving duck migratory populations increase on the West Shore of Green Bay. Divers should have access to ample submergent vegetation in addition to fingernail clams. A diverse assemblage of diving ducks should be present during migration. Diving duck use of the Bay from the Fox River to the Wisconsin border in Green Bay should reach 2,000,000 use days during fall migration and the species using the Bay should be a mixture of mussel feeding ducks and vegetation feeding ducks.

Marsh Birds:

- A diverse assemblage of marsh-nesting birds should be present in suitable habitat in the lower Bay. An aggregate total of 5 nesting pairs per acre of marsh habitat would indicate a healthy marsh bird community. Rails, grebes, herons, wrens, and blackbirds are some of the groups of birds which should be present.

Mammals:

- Furbearers in the AOC should recover to the point that otters and mink are present. Abundant muskrat populations should be present particularly when water conditions in the lower Bay result in emergent marshes.

Amphibians and Reptiles:

- A diverse assemblage of anurans including: wood frogs, spring peepers, leopard frogs, American toads, eastern gray tree frogs, green frogs and bullfrogs.

Rationale for Listing

The major causes of degraded fish and wildlife populations in the AOC listed in the original Remedial Action Plan (WDNR, 1988) and Update (WDNR, 1993) include the following:

- Changes in habitat due to wetland filling, hardened shorelines, and development associated with urban and industrial areas
- Impact from exotic species of fish (alewife, sea lamprey, rainbow smelt, gobies, white perch, and carp) and vegetative invasive species
- Toxic chemicals – suspected impacts of toxics on other wildlife (mink, bald eagle, osprey, otter, terns nesting in unsuitable locations such as Renard Island)
- Unbalanced fish community with low abundance and diversity of top predators (northern pike) and native forage fish (spot tail shiner)
- Waterfowl – lack of preferred foods (invertebrates, submerged aquatic plants)
- Periods of low dissolved oxygen caused by hypereutrophication

– Loss of habitat, including reduced submerged aquatic vegetation due to poor light transmissivity through turbid waters and reduced hydrologic connections between the Bay and coastal wetlands.

Summary of remedial actions since the last RAP and current status

Fish

WDNR Lake Michigan Management Reports contain annual updates for several fish populations including Green Bay yellow perch, walleye in southern Green Bay, Great Lakes Muskellunge, and Green Bay forage trawls (available online at http://dnr.wi.gov/topic/fishing/lakemichigan/ManagementReports.html).

Walleye are the only species in the AOC with data available to suggest the 2009 Target and Objectives are being met. Brown County open water harvest exceeded 7,000 walleye each year in the period between 2006 – 2011, ranging from a low of 13,000 in 2006 to a high of 44,000 in 2009, with a 4-year average (2008-2011) of 33,000 (Figure 2, WDNR creel census data provided by Steve Hogler). The walleye population in southern Green Bay and the Lower Fox River (AOC) is considered self-sustaining since stocking has not occurred in southern Green Bay since 1984. Overall, with five strong year classes "the future of the southern Green Bay/lower Fox River walleye stock and sport fishery appears to be very promising" (Rowe, Hogler, & Lange, 2011).

Brown County yellow perch open water harvest did not meet the 2009 Target and Objectives of an average above 150,000 perch in the period between 2006 and 2011. Although the target was met in 2006 and 2007 (380,000 and 178,500, respectively), harvest declined in the following 4 years (2008-2011). The most recent 4-year average was 47,000 and the 3-year average was 41,000. This decline was not specific to Brown County waters and also occurred in harvest numbers for the entire Bay (Figure 3, WDNR creel census data provided by Steve Hogler). It may be difficult to achieve the AOC goal because the perch population and therefore sport harvest is bay-wide issue. Annual assessments of the Wisconsin waters of Green Bay for yellow perch indicate that recruitment has been steady for the last nine years, with peak year classes occurring in 2003, 2005, and 2010. The lack of a corresponding increase in the total adult population is a concern. (Paoli, 2011).

WDNR does not currently collect information that could be used to calculate a predator-prey biomass ratio of fish species in the AOC, though it is unlikely that the 1:10 to 1:20 ratio is being met.

Visual observations conducted by Agency Biologists (USFWS and WDNR) and Thilmany Paper Nicolet Mill staff every spring indicate that approximately 25-75 adults spawn in the Lower Fox River below the De Pere dam each year (Elliott and Gunderman, 2008, Steve Hogler, WDNR, and Robert Elliott, USFWS,personal communication), and that spawned eggs do hatch and larvae drift downstream from the spawning grounds into the lower Fox River (Elliott and Gunderman, 2008).

While abundance of the lake sturgeon population spawning in the lower Fox River could be increased through stocking additional fish using techniques such as Streamside Rearing, questions remain about the recruitment success resulting from spawning at this location. Further studies may be required to establish that larvae produced in the lower Fox River do survive and recruit to adulthood at sufficient rates to support a self-sustaining population independent of periodic or gradual immigration of fish from the large upriver population residing in Lake Winnebago.

One of the original RAP Key Recommendations was to "increase numbers of predator fish" and included an action to reintroduce Great Lakes strain muskellunge in the AOC (WDNR, 1988). WDNR began a reintroduction program in 1989 with the goal of reestablishing a self-sustaining population in Green Bay. Since that time the Green Bay population has grown as stocked fish mature and increase in size; however, no natural reproduction has been documented within the AOC (WDNR, 2012). Current research is focused on determining habitat attributes that favor natural reproduction. Once the

characteristics of preferred habitat are determined, that information can be used to develop new habitat and improve stocking techniques that increase the likelihood of increased natural reproduction. Muskellunge fishing in Green Bay has grown in popularity to a point where local fishermen consider Green Bay a world class musky fishing destination with a reputation for large fish.

Wildlife Species

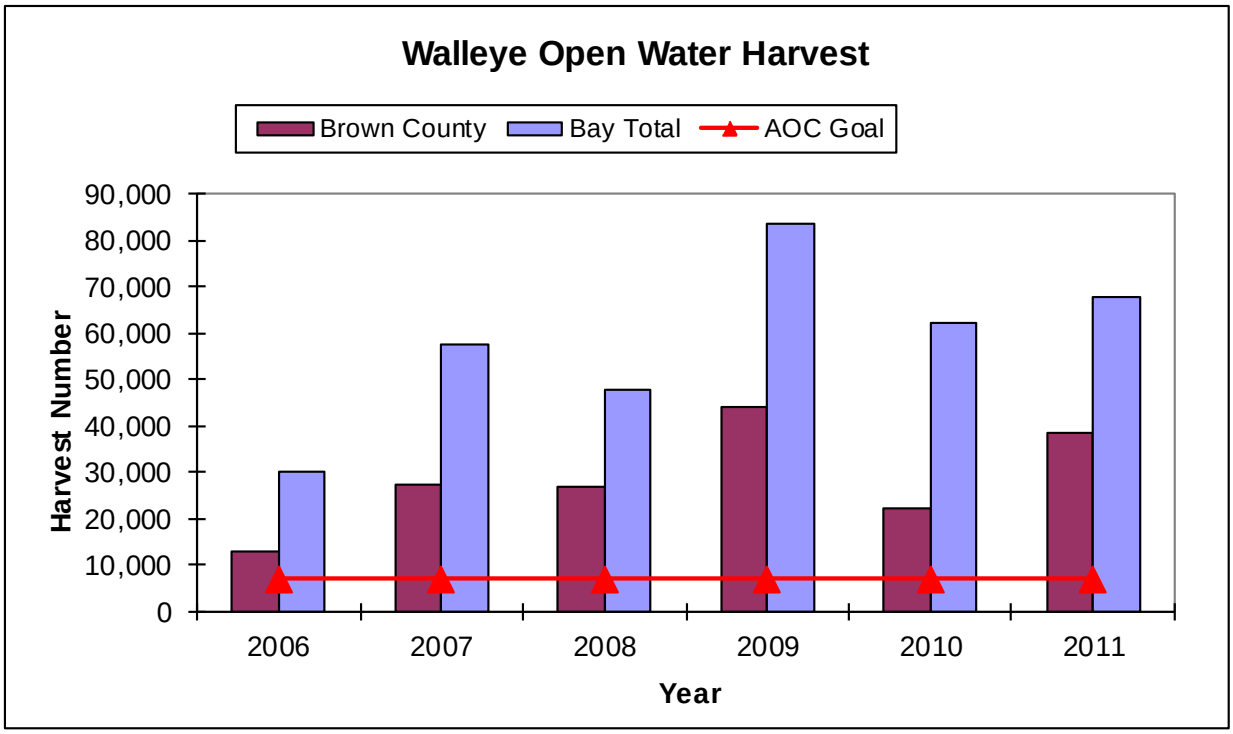
Wildlife objectives were established for several broad types of birds (colonial waterbirds, waterfowl, and marsh birds), mammals, and anurans (amphibians and reptiles) as these are important populations within the AOC. These types of wildlife are managed on a broader scale than just the AOC, and there is little recent information on the abundance and distribution of these populations specific to the AOC area. Consequently, several of the next actions identified for wildlife are monitoring projects.

Cat Island, which is a remnant of a larger chain of islands, is listed as an important colonial bird nesting area. In the 1990s, American white pelican, double-crested cormorants, great egrets, black-crowned night herons, and herring gulls were documented as nesting on the island (Wires et al., 2010). Nest counts have been conducted on Cat Island during cormorant control efforts periodically through the 2000s. The species assemblage may have changed over time with habitat changes on the island. Proposed plans for restoration of the Cat Island chain include monitoring of wildlife use.

A survey of migratory waterfowl scheduled for fall 2011 has been postponed until fall 2012. Surveys in the 1990s (Harris, 1998) and incidental observations of waterfowl indicate increased use of the Bay in recent years with large concentrations of diving ducks including scaup, goldeneye, lesser and greater redheads, ruddy ducks, and canvasbacks. Mussel-eating ducks have dramatically increased use of the bay since the invasion of Dreissenid mussels (Harris, 1998). The mid-winter waterfowl survey is conducted annually, and in years when ice cover permits use of the Bay, concentrations of mallards, goldeneyes, and mergansers have been documented.

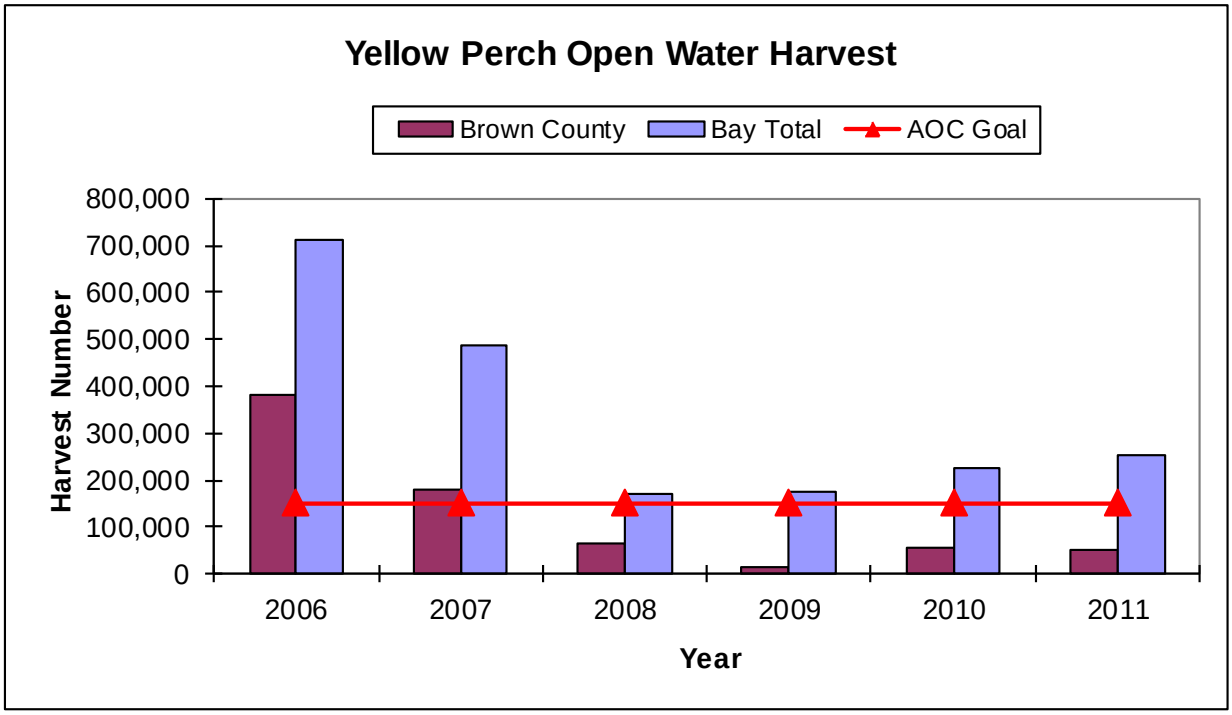
WDNR Bureau of Science Services staff members have been contacted about questionnaire surveys to determine furbearer presence in the AOC. Locations for anuran and marsh-bird surveys for the Marsh Monitoring Program have been identified in the AOC and recruitment of volunteers to conduct surveys is ongoing.

Recent contaminant data will soon be available for tree swallows in the AOC as a result of a GLRI-funded project conducted by the U.S. Geological Survey (USGS; T. & C. Custer, USGS, personal communication). Tree swallows are a well-accepted model of monitoring reproductive success in birds and provide information about specific areas because of their limited feeding range when nesting. In the past, tree swallows were used to suggest that although exposure to PCBs is higher in those nesting on Renard Island (near the mouth of the Fox River) than at reference sites there is no impact on hatching success (Custer et al., 1998). Tree swallow nesting studies were repeated at Renard Island in 2010-2011 and will be conducted at sites further upstream in the Fox River AOC in 2012-2013 (T. & C. Custer, USGS, personal communication). Results should be evaluated once they are available to assist in determining the next actions needed for this impairment. Data assessments could include the following: comparing reproductive success rates to other appropriate areas, comparing tissue contaminant concentrations to levels known to cause adverse effects, and modeling contaminant exposure in higher trophic level birds (T. & C. Custer, USGS, personal communication).



Bay Total refers to Wisconsin Waters of Green Bay.

Figure 2. Walleye Open Water Harvest (2006-2011)



Bay Total refers to Wisconsin Waters of Green Bay.

Figure 3. Yellow Perch Open Water Harvest (2006-2011)

Next action(s) needed

1. Various monitoring, planning, and projects listed in the table in Appendix C. No one discrete project will be sufficient to address the complex needs for restoration of fish and wildlife populations within the AOC.
2. Assessment projects, including a survey of Brown County trappers for the presence of furbearers and an aerial survey of muskrat huts in the Bay, will need to be conducted to see whether the fish and wildlife populations targets are being met. The trapper surveys could be conducted in 2013 providing funding is available (approximately $1,500-$2,000). Muskrat hut surveys should wait until the water levels in the Bay increase enough from current historic lows to support emergent marshes.
3. Completion of Lower Fox contaminated sediment remediation
4. TMDL implementation planning and actions to reduce phosphorus and sediment loading to the AOC to meet water clarity goals.

Issues (challenges, risks) affecting progress on this BUI

- Natural events (such as flooding or drought) create variability in assessments of fish and wildlife populations.
- Natural variability between the Fox River and lower Bay creates two very different systems and provide additional complexity when assessing current conditions relative to the delisting targets.
- Fish and Wildlife populations are mobile and not restricted to the area simply within the AOC boundary and as such, actions to address local populations will need to occur in a broad area, beyond the AOC boundary.
- Restoring connectivity of wetlands to Bay and areas of important habitat is hampered by continuing development. Habitats are increasingly fragmented.
- The fish objectives do not include a specific target for northern pike and this could be further discussed by the Biota & Habitat committee given the extensive work being done on Green Bay's west shore.

Stakeholder Engagement

The Lower Green Bay Biota & Habitat Committee met actively in 2011 to identify restoration actions for "Degraded Fish and Wildlife Populations" and "Loss of Fish and Wildlife Habitat" impairments. This group will continue to be consulted on the planning and prioritization of projects.

FISH TUMORS OR OTHER DEFORMITIES

2009 Target and Status

Fish Tumors or Other Deformities	Status
No target was developed in 2009 as this is a suspected impairment.	Unknown

Note: Andrew Fayram, WDNR Great Lakes Monitoring Coordinator, developed assessment criteria to be used for this BUI in Wisconsin AOCs that include minimum sample size and tumor incidence rate for white suckers (Appendix D). The current status of this BUI will be evaluated against these criteria when it is deemed appropriate by WDNR in consultation with the Lower Green Bay and Fox River AOC Science and Technical Advisory Committee.

Rationale for Listing

This BUI was listed as suspected due to the presence of persistent, bioaccumulative, and toxic substances, primarily PCBs, in Lower Fox River sediments thought to induce external and liver tumors in fish. At the time the RAP (WDNR, 1988) and RAP Update (WDNR, 1993) were developed there was not enough evidence of tumors or other deformities in fish collected from the AOC to definitively list this BUI. Baumann et al. (1991) only identified 1 hepatocellular neoplasm in 40 walleye and no liver neoplasms in brown and black bullheads collected from the Fox River. It was then recognized that only a small number of fish (10 per location) were taken at random for histopathology and that “a larger study would be required to determine a frequency of neoplasms or cellular alteration with confidence” (Baumann et al., 1991).

More recently, walleye samples collected in 1996-7 for the Fox River / Green Bay Natural Resources Damage Assessment “demonstrate significant elevation in hepatic preneoplastic lesions and hepatocellular adenomas and carcinomas in assessment area walleye exposed to elevated concentrations of PCBs” (Barron et al., 1999). This supports continued consideration of this BUI as suspected in the Lower Green Bay and Fox River AOC.

Summary of remedial actions since the last RAP and current status

The last phase of the Lower Fox River Contaminated Sediment Remediation project began in May 2009 and includes remediation of all sediment with PCB concentrations greater than or equal to 1.0 ppm in the area from the mouth of the Fox River (and a short distance into Green Bay) to just upstream of the Little Rapids Dam (approximately 13 mile stretch of River). This project is expected to run through 2017 and includes a combination of dredging, dredging and capping, and sand covering in selected areas.

A U.S. Fish and Wildlife Service (USFWS) and USGS GLRI project to evaluate the impacts of “Chemicals of Emerging Concern” will soon provide histopathology data that can be used to evaluate current tumor incidence rates in the Lower Green Bay and Fox River Area of Concern. USFWS collected smallmouth bass (20 in fall 2010, 20 in spring 2011, and 20 in spring 2012) and white suckers (19 in fall 2010) for a complete fish health assessment by USGS (Steve Choy, USFWS, personal communication). Once these histopathology results are available, they will be used to evaluate 1) current liver tumor incidence rates and 2) the potential need for additional data collection for this BUI.

Next action(s) needed

1. BUI Assessment following WDNR criteria (when appropriate): The samples collected in the USFWS-USGS "Chemicals of Emerging Concern" study will not provide sufficient evidence to definitively conclude whether or not this BUI should be considered impaired. However, histopathology data from the three combined sampling years will allow USFWS-USGS to determine a tumor incidence rate for these two species. Tumor incidence rates above WDNR's criteria will demonstrate the need for additional progress on the Lower Fox River contaminated sediment remediation project prior to conducting a larger assessment of this BUI. Tumor incidence rates below WDNR's criteria may suggest the need for a more extensive evaluation of the current status of this BUI.
2. Completion of the Lower Fox Contaminated Sediment Remediation.

Issues (challenges, risks) affecting progress on this BUI

- Determining the appropriate time to conduct histopathology analyses on sufficient numbers of fish since full completion of the Lower Fox River contaminated sediment remediation is not expected until 2017 and smallmouth bass and white suckers may live fifteen years or more (Scott and Crossman, 1998).
- Accounting for other factors likely to influence tumor incidence rates, such as fish age (relative to remediation progress) and residence time in the AOC.
- PAH (polycyclic aromatic hydrocarbon) contamination is more often associated with fish tumors than PCBs. Depending on the results of the fish tumor sampling it may be worthwhile to conduct a review of current research on these compounds in the Lower Green Bay and Fox River AOC.
- Determining an appropriate reference site for comparison with data from the AOC, if necessary.

Stakeholder Engagement

There has not been any recent stakeholder engagement related to this BUI. WDNR may consult with the Lower Green Bay and Fox River AOC Science and Technical Advisory Committee on the appropriate course of action for this BUI after results of the USFWS-USGS study are available.

BIRD OR ANIMAL DEFORMITIES OR REPRODUCTION PROBLEMS

2009 Target and Status

Bird or Animal Deformities or Reproduction Problems	Status
PCB remedial actions have been implemented and the AOC is in recovery	In progress
Studies indicating the incidence rates of deformities (e.g., crossbill syndrome) or reproductive problems (e.g., eggshell thinning) in sentinel wildlife species (avian, amphibian, mammalian, predatory fish, and reptilian) do not exceed background levels of reference populations from unimpacted sites of comparable physical and chemical characteristics. A stepwise approach will be used to conduct both of the following evaluations in the AOC to determine when the BUI can be delisted: 1. If fish tissue or other food sources (e.g., insects and amphibians) concentrations of contaminants of concern identified in the AOC are: a. at or lower than the Lowest Observable Effect Level (LOEL) known to cause reproductive or developmental problems in fish, fish-eating birds, and mammals, the BUI can be delisted, or b. not statistically different than Lake Michigan (at 95% confidence interval), then the BUI can be delisted. Fish and other food sources (e.g., insects and amphibians) should be of a size and species considered prey for the species under consideration; 2. Field studies including observational data and direct measures of birds and other wildlife (including predatory fish) exhibit deformities or reproductive problems are verified through an: – Evaluation of observational data of bird and other animal deformities for a minimum of two successive monitoring cycles in indicator species identified in the initial studies as exhibiting deformities or reproductive problems. If deformity or reproductive problem rates are not statistically different than 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 delisted. If the rates are statistically different than 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: – Evaluation of 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 that are not statistically different than those at minimally impacted reference sites (at a 95% confidence interval), then the BUI can be delisted.	Assessment Needed (within 5 years)

Note: The 2009 target calls for extensive studies of food sources and birds and/or wildlife. This target may need to be modified if research in Great Lakes AOCs or elsewhere develop metrics that are more sensitive or reliable indicators of the status of this impairment.

Rationale for Listing

This BUI was originally listed because of the impact of contaminants on bird reproduction and suspected impacts on mammals (WDNR, 1993). Strong evidence of adverse impacts on reproductive success and/or embryonic deformations linked to PCB exposure were documented in fish-eating birds, including Forster's, Common, and Caspian terns and less conclusively in double-crested cormorants and bald eagles (Stratus, 1999). Only circumstantial evidence, primarily the lack of their presence in potential

habitat, existed to suggest mink and river otter were impacted by contaminants in the AOC (Allen et al., 1987).

Summary of remedial actions since the last RAP and current status

The last phase of the Lower Fox River Contaminated Sediment Remediation project began in May 2009 and includes remediation of all sediment with PCB concentrations greater than or equal to 1.0 ppm in the area from the mouth of the Fox River (and a short distance into Green Bay) to just upstream of the Little Rapids Dam (approximately 13 mile stretch of River). This project is expected to run through 2017 and includes a combination of dredging, dredging and capping, and sand covering in selected areas. It's expected that the remediation project will also effectively address other potentially toxic compounds in the AOC.

Stratus (1999) summarized PCB accumulation in bird tissues as having been "greatest in the early 1970s (the first dates for which data are available), declined through the 1970s and through the early 1980s, and has remained relatively stable since then." Few current reports exist on bird deformities in the species listed in the section above; however, physical deformities have not been observed in recent years during double-breasted cormorant chick banding in northern Door County (Ken Stromborg, USFWS-retired, personal communication). Tree swallows are a well-accepted model of monitoring reproductive success and have been used in the past to suggest that, although exposure to PCBs is higher in tree swallows nesting on Renard Island (near the mouth of the Fox River) than those at reference sites, there is no impact on hatching success (Custer et al., 1998). Tree swallow nesting studies were repeated at Renard Island in 2010-2011 and will be conducted at sites further upstream in the Fox River AOC in 2012-2013 (T. & C. Custer, USGS, personal communication). Results should be evaluated once they are available to assist in determining the next actions needed for this impairment.

Next action(s) needed

1. Define necessary monitoring & seek additional funding (if needed): WDNR should identify appropriate species, metrics, sampling methods, timing, locations, and a lead entity to collect sufficient data to demonstrate whether or not this BUI is still impaired. Although remediation of contaminated sediments in the Lower Fox River is still underway, the current Great Lakes Restoration Initiative may provide an opportunity if additional funds are needed to support this work. Tree swallow monitoring results from Christine and Thomas Custer, USGS, should be evaluated during this process, possibly considering the following: comparison of reproductive success to other, appropriate locations; comparison of tissue concentrations to levels known to cause adverse effects on avian reproduction; models of exposure of birds in higher trophic levels; and rates of deformities or other malformations in nestlings.
2. Completion of the Lower Fox River Contaminated Sediment Remediation.

Issues (challenges, risks) affecting progress on this BUI

– It will be costly and time intensive to collect sufficient data to statistically document whether or not this use remains impaired following the procedures outlined in the 2009 Target. WDNR should consider whether other appropriate metrics are available to evaluate the current status of the impairment. The Lower Fox Contaminated Sediment Remediation project long term monitoring plan does not include bird or wildlife monitoring.

Stakeholder Engagement

There has not been any recent stakeholder engagement related to this BUI. WDNR may consult with the Lower Green Bay and Fox River AOC Science and Technical Advisory Committee when making future decisions about whether or not current conditions meet the 2009 targets, any potential changes to the

targets, and development of additional actions to remove this BUI. No outreach needs for the general public specific to this impairment have been identified at this time.

DEGRADATION OF BENTHOS

2009 Target and Status

Degradation of Benthos	Status
All remediation actions for known contaminated sediment sources are completed and monitored according to the approved plan and have met their remedial action goal	In progress
The benthic community IBI within the site being evaluated is statistically similar to a reference site with similar habitat and minimal sediment contamination	Partial assessment in progress (2012) *
Burrowing mayfly (*Hexagenia*) populations return to the AOC in stable annual abundances between 100-400 nymphs/m^2 (measured as a 3-year running average) or as otherwise indicative of adequate levels of dissolved oxygen in overlying waters and uncontaminated surficial sediments in Lake Michigan	Action needed
Sediment toxicity (due to ammonia, PCB, or dissolved oxygen) is not present at levels that are acute or chronically toxic (as defined by relevant, field validated, bioassays with appropriate quality assurance/quality controls) to the benthic community	Unknown
Native benthic communities adequately support the trophic levels that depend upon them	Unknown

* USGS benthos study will only sample Lower Fox River, not Lower Green Bay.

Notes: 1) *Hexagenia* densities proposed in this delisting target (100-400 nymphs/m^2) are within the range considered “good” or “excellent” for Lake Erie populations and may need to be revised if future monitoring indicates other densities are more appropriate for Lake Michigan. The *Hexagenia* target may be evaluated by WDNR and AOC Technical Advisory Committees (Biota & Habitat, Science and Technical Advisory Committee) using recent data for the River and Bay as they become available.

2) Established invasive species are likely to have an impact on native benthic communities and will need to be considered when evaluating the current status of this impairment. Strict controls on sources of new invasive species are critical and should be maintained.

3) WDNR should consult with a multi-stakeholder AOC Technical Advisory Committee (Biota & Habitat and/or Science and Technical Advisory Committee) when determining the appropriate threshold for delisting this BUI.

Rationale for Listing

This impairment was originally identified based on studies indicating low species diversity, low numbers of individuals and a benthic community dominated by oligochaetes and chironomids in the AOC (WDNR, 1993). A burrowing mayfly, *Hexagenia*, was not collected from Green Bay since 1955 and its return was suggested to be a key indicator of macroinvertebrate recovery in Green Bay (Ball et al., 1985). Tests of sediment pore water toxicity from the Lower Fox River determined that ammonia was toxic to a variety of aquatic organisms and possibly the result of not only direct inputs from point sources but also enrichment of the system by various nutrients (Ankley et al., 1990).

Summary of key remedial actions since the last RAP and current status

The last phase of the Lower Fox River Contaminated Sediment Remediation project began in May 2009 and includes remediation of all sediment with PCB concentrations greater than or equal to 1.0 ppm in the area from the mouth of the Fox River (and a short distance into Green Bay) to just upstream of the Little

Rapids Dam (approximately 13 mile stretch of River). This project is expected to run through 2017 and includes a combination of dredging, dredging and capping, and sand covering in selected areas.

Current Status: Fox River

Macroinvertebrate populations within the Fox River below the De Pere dam have remained impaired since the time this impairment was identified. A 1999 study of depositional substrates within the AOC stated that the benthic community "throughout the past 19 years has remained relatively poor and suggests compromised physiochemical conditions" (Integrated Paper Services, 2000). More recently, WDNR deployed a Hester-Dendy artificial substrate sampler in the Lower Fox River in 2005 and 2011 following standardized procedures for baseline assessment of nonwadeable rivers (Weigel, 2011). The 2005 and 2011 Lower Fox River calculated overall Index of Biotic Integrity (IBI) scores were 10 and 9, respectively, or "very poor" on a qualitative ratings scale of 20-point increments between 0 (worst) and 100 (best; Weigel & Dimick, 2011). Macroinvertebrate monitoring is a new addition to WDNR's Tier I Monitoring Program and will be repeated in the Lower Fox River on a 5 year cycle. Results of this monitoring may be used by WDNR and AOC Technical Advisory Committees to reassess the status of this impairment in the future.

USEPA provided funding for the USGS to evaluate the current status of this BUI in four Wisconsin Lake Michigan AOCs by comparing them to six relatively unimpacted or less-impacted non-AOCs. Benthos samples were collected using ponar grabs and artificial substrate samplers three times at each site in spring and summer of 2012. In the Lower Green Bay and Fox River AOC, benthos samples were collected from two sites in the Fox River. The results of this assessment are not yet available.

Current Status: Lower Green Bay

Great Lakes WATER Institute collected benthos samples from twenty-one stations in mid and upper Green Bay in June 2011 for comparison with historic data collected by Harris 1978, Howmiller 1969, and Surber 1952 (Rupp and Kaster, 2011). Rupp and Kaster (2011) list changes from historic samples that include "notable decline in populations of worms (*Oligochaeta*), midge larvae (*Chironomidae*), isopods, and fingernail clams within the past thirty years," and no *Hexagenia* were recorded in any of the samples. Adult *Hexagenia* mayflies have been occasionally observed in the area and a single nymph was found during an educational sampling activity by the RV Jackson near the GBMSD outfall (Victoria Harris, UW-Sea Grant Institute, personal communication). *Hexagenia* may be present in the AOC but in quantities insufficient to be documented in recent studies.

A small study is in progress to test the viability of *Hexagenia* in Green Bay sediments. Results of laboratory experiments on *Hexagenia* egg viability in Green Bay sediments have suggested that sediment quality did not limit *Hexagenia* egg hatching or nymph survival when dissolved oxygen was plentiful. Preliminary 2012 studies using *Hexagenia* enclosure traps in Green Bay indicated that eggs entered a dormancy rather than hatching. *Hexagenia* eggs commonly do this when environmental conditions are not satisfactory. When two of the dormant egg enclosures were re-deployed in an area confirmed to have adequate dissolved oxygen levels, the eggs hatched within days and the nymphs grew for a month before the enclosures were retrieved. To date, these events suggest that low dissolved oxygen in the area of the original enclosure deployment in the Bay induced H*exagenia* egg dormancy. Several of the enclosures remain at this original location in the Bay and will be retrieved in summer of 2013, to determine if *Hexagenia* can complete their egg and nymphal life cycle. (Jerry Kaster, School of Freshwater Sciences, UW-Milwaukee, personal communication)

Next action(s) needed

1. 2012 USGS Benthos Assessment: The results of the 2012 assessment should be evaluated to determine if it is necessary to do the following:

- Expand the study to other Rivers and/or Bays in eastern Lake Michigan or the Great Lakes region to find a more suitable location to compare to the Fox River and Lower Bay.
- Include additional years to adequately characterize local conditions.

2. Additional Green Bay Benthos Assessment: Additional assessment work will be required to complete an evaluation of the status of this BUI in the Bay portion of the AOC not included in the USGS study or Great Lakes WATER Institute 2011 samples. Sampling should be sufficient to determine fauna associations (isopods, gammarids, etc.) and sediment characteristics.

Potential follow-up steps based on the results of the assessments:

3. Laboratory determination of the viability of *Hexagenia* in AOC sediment (early life history assays).
4. Based on the outcome of 3, establish *in situ* enclosure cage studies in the bay.
5. Based on the outcome of 4, the stocking of *Hexagenia* populations at high density levels in selected areas of the bay (to achieve reproductive threshold levels).

   Potential cage studies and stocking in the Bay should consider if other species (e.g., fingernail clams) are appropriate to include. Local populations, perhaps from Lake Winnebago or Sturgeon Bay, should be considered as a source to ensure appropriate species are selected.

6. WDNR should develop the following, in consultation with a multi-disciplinary AOC Technical Advisory Committee:
   - conditions that will trigger the start of monitoring for the 3-year rolling average for *Hexagenia*, and
   - an appropriate sampling scheme and timetable for monitoring.

Issues (challenges, risks) affecting progress on this BUI include:

- It is difficult to determine an appropriate comparison location for the Lower Fox River and Green Bay AOC as few areas exist with comparable depth, substrate, temperature, and nutrient conditions.
- Invasive species impact benthic community structure and function yet are outside of the control of the AOC program.
- System manipulations (such as remedial and navigation channel dredging) and natural events (such as flooding or drought) create unknowns and variability in assessment results and the benthos communities.
- Natural variability between the Fox River and lower Bay creates two very different systems and provides additional complexity when assessing current conditions relative to the delisting targets.
- *Hexagenia* are sensitive to low dissolved oxygen and their populations may be impacted by periods of hypoxic conditions in Green Bay.

Stakeholder Engagement

A multi-disciplinary AOC Technical Advisory Committee (Biota & Habitat and/or Science and Technical Advisory Committee) that includes members with technical background in this specific area should be involved in future decisions about whether or not current conditions meet the 2009 targets, any potential changes to the targets, and development of additional actions to restore this BUI.

No outreach needs for the general public specific to this impairment have been identified at this time. Other groups not currently represented on AOC committees may be brought in when specific information is available. Future outreach to engage the general public in supporting AOC restoration goals could possibly consider using the return of the mayfly as a symbol of improved conditions in the River and Bay as described by the Wisconsin State Committee on Water Pollution (1939):

The burrowing mayfly, Hexagenia sp., locally called the “Green Bay fly”, is quite abundant in this region. The adults are known to gather under outdoor electric lights in the City of Green Bay, literally by the bushel on many summer evenings.

RESTRICTIONS ON DREDGING ACTIVITIES

2009 Target and Status

Restrictions on Dredging Activities	Status
All remediation actions for known contaminated sediment sources are completed and monitored according to the approved remediation plans, the remedial action goals have been achieved, and institutional controls have been implemented.	In progress

Note: This delisting target is not intended to create specific measures that would restrict agency decision-making and will not be used as the basis for cleanup levels for contaminated sites or for regulatory enforcement.

Rationale for Listing

This impairment was originally identified due to the presence of toxic substances in sediments that prevented unrestricted dredging and sediment disposal in the AOC. At that time concerns were noted about the presence of more than 100 chemicals including 20 then listed on USEPA's priority list of pollutants that pose a risk to the environment and human health (Allen et al., 1987). Emphasis has been placed on PCBs in the sediments since the remedy to address PCB exposure effectively addresses the other compounds as well.

Summary of key remedial actions since the last RAP and current status

The last phase of the Lower Fox River Contaminated Sediment Remediation project began in May 2009 and includes remediation of all sediment with PCB concentrations greater than or equal to 1.0 ppm in the area from the mouth of the Fox River (and a short distance into Green Bay) to just upstream of the Little Rapids Dam (approximately 13 mile stretch of River). This project is expected to run through 2017 and includes a combination of dredging, dredging and capping, and sand covering in selected areas.

The upstream Little Lake Butte des Morts (LLBdM) remediation, in which approximately 370,000 cubic yards of sediment was dredged, was completed in 2009. Remediation in OU 2-3 (just above the Little Rapids Dam to De Pere Dam) was completed in 2011 and included a combination of dredging 235,900 cubic yards and capping approximately 26 acres of sediment. The total volume of sediment dredged in LLBdM and the first four years of operation (2009 through 2012) in the current phase is approximately 2.5 million cubic yards, which was dewatered and disposed of in a landfill. Annual dredge volumes are anticipated to be approximately 500,000 to 660,000 cubic yards per year, providing remediation proceeds on schedule.

Next action(s) needed

1. Completion of the ongoing Lower Fox Contaminated Sediment Remediation will address the PCB contamination that is the basis for restrictions on dredging in the AOC. The institutional controls that will remain in place once the remediation project has been completed have not yet been finalized, but will be defined within the context of that program.

Issues (challenges, risks) affecting progress on this BUI

– Removal of this impairment depends on completion of the Lower Fox Contaminated Sediment Remediation. Any delay in the sediment remediation will also delay removal of this impairment.

Stakeholder Engagement

There are no current outreach needs related to this impairment although future needs might arise once the contaminated sediment remediation has been completed and the institutional controls have been negotiated by the agencies and responsible parties.

EUTROPHICATION OR UNDESIRABLE ALGAE

2009 Target and Status

Eutrophication or Undesirable Algae	Status
Total phosphorus and total suspended solids concentrations at the mouth of the Lower Fox River meet water quality standards and/or water quality targets specified in a State and US EPA approved Total Maximum Daily Load. The approved TMDL targets are summer median concentrations of 0.10 mg/L TP and 20 mg/L TSS at the mouth of the river.	Action Needed
There are no violations of the minimum dissolved oxygen concentrations established in Wisconsin Administrative Code Chapter NR 102 within the AOC due to excessive sediment deposition or algae growth.	Action Needed
No waterbodies within the AOC are included on the 303(d) list of impaired waters due to nutrients or blue-green algae in the most recent Wisconsin Impaired Waters list.	Action Needed
– Blue-green algae will be evaluated using the following methodology: 90% of the geometric means of at least 5 monthly samples (collected between May 1 and September 30th in at least 2 years) of phytoplankton samples from waterbodies in the AOC contain less than 20,000 cyanobacterial cells/ml or less than 1 µg/L of microcystin-LR. – Blue-green algae may also be evaluated using the predicted relative biomass of blue-green algae in phytoplankton when total phosphorus at the mouth of the Lower Fox River reaches the TMDL target of 100 µg/L (0.1 mg/L) (based on Trimbee and Prepas 1987). Delisting of this BUI could occur when less than 50 - 60% of the relative biomass of phytoplankton is blue-green algae.	Action Needed

Notes: 1) Total phosphorus and blue-green algae should be evaluated for the 303(d) list in accordance with Wisconsin's Monitoring Strategy and most recent Consolidated Assessment and Listing Methodology (WisCALM) document available at http://dnr.wi.gov/topic/surfacewater/assessments.html. As of October 2012, the WisCALM has been temporarily rescinded for modification related to the new Wisconsin phosphorus water quality criteria. It is anticipated that the WisCALM will be back in use as an even more effective guidance document by spring of 2013.

2) The Lower Green Bay and Fox River AOC Social Uses Workgroup decided in 2012 to keep the original targets for blue-green algae and microcystin-LR, although the April 2012 WisCALM (Amended Version 1) calls for higher thresholds (100,000 cyanobacterial cells/ml and 20 µg/L of microcystin-LR).

3) If total phosphorus levels at the mouth of the Lower Fox reach the TMDL target but the percentage of blue-green algae in phytoplankton does not decrease as expected, the applicability of the Trimbee and Prepas model to this area will be evaluated and other factors examined (for example: nitrogen concentrations).

4) The Lower Green Bay and Fox River AOC Social Uses Workgroup decided in 2012 to add the numerical targets from the approved TMDL for total phosphorus and total suspended solids to the first portion of the delisting target.

Rationale for Listing

The original listing of eutrophication or undesirable algae was based on historically elevated phosphorus levels that resulted in hypereutrophic (overly productive) conditions, excessive algal blooms in the AOC,

and low dissolved oxygen concentrations in the Lower Bay (WDNR, 1993; also refer to Figure 4). These algae blooms contributed to decreased water clarity in the AOC that restricted the growth of underwater plants. More recently, since the invasion of zebra mussels, these blooms are increasingly dominated by potentially toxic blue-green algae (De Stasio et al., 2008). Blue-green algal blooms are considered undesirable as they are a less preferred food source for zooplankton and fish and contribute to depleted oxygen and ammonia toxicity in sediments when decomposed by bacteria (WDNR, 1993). These blue-green algal blooms also have the potential to produce toxins that are potentially harmful to humans, pets, and livestock.

Summary of remedial actions since the last RAP and current status

The current 303(d) list of impaired waters includes the Lower Fox River and the AOC portion of Green Bay as impaired by total phosphorus causing low dissolved oxygen levels. WDNR did not complete a thorough analysis of oxygen conditions within the AOC as part of this Stage 2 RAP Update since other portions of the 2009 Target are not met. However, GBMSD's Ambient Water Quality Monitoring Program does collect data that could be used for this purpose when appropriate. Periods of oxygen depletion have been observed in the AOC and likely occur on a regular basis during intrusions of cold, hypoxic water from upper Green Bay (Tracy Valenta, GBMSD, personal communication). Nutrient loading from the Fox-Wolf Watershed likely exacerbates these hypoxic conditions. The nature and extent of these problems in Green Bay is currently the focus of a National Oceanic and Atmospheric Administration (NOAA)-funded hypoxia research project led by the Great Lakes WATER Institute.

University of Wisconsin – Sea Grant Institute recently updated graphs of historic mean summer total phosphorus (Figure 4) and total suspended solids (Figure 5) in the Lower Bay of Green Bay (also known as Zone 1) using data from the Green Bay Metropolitan Sewerage District's (GBMSD's) Ambient Water Quality Monitoring Program (Qualls et al., 2012). The RAP target shown on the total phosphorus graph is the target mentioned in the 1988 and 1993 RAPs and is included here for reference only. The TMDL established numeric targets only for the mouth of the Lower Fox River and included a narrative statement for the Lower Bay. The expectation is that achieving the TMDL targets will result in the following:

> "improved water clarity in Lower Green Bay is expected, as well as other conditions suitable to support a diverse biological community, including a robust and sustainable area of submersed aquatic vegetation (e.g., *Vallisneria americana*) in shallow water areas" (Cadmus, 2012).

Factors responsible for the apparent decline in mean summer total phosphorus measured in the Lower Bay in recent years are not yet known and it will be interesting to observe whether or not these levels are sustained in future years.

Efforts to decrease phosphorus loads delivered to Lower Green Bay have been ongoing since the first RAP was developed. Past activities include, but are not limited to, the Duck / Apple / Ashwaubenon Creeks and East River priority watershed projects that directed substantial resources and cooperative efforts to reduce phosphorus and sediment loading in these watersheds. More recently, USEPA approved WDNR's TMDL for total phosphorus and sediment in the Lower Fox Watershed in May 2012. This, combined with statewide efforts to control phosphorus in waterways (see introduction), are significant steps forward. The Lower Fox Watershed is recognized in several plans as a priority for phosphorus reductions, including the Federal FY 2010-2014 GLRI Action plan (http://greatlakesrestoration.us/pdfs/glri_actionplan.pdf) and Wisconsin's 2009 Great Lakes Strategy (http://dnr.wi.gov/topic/greatlakes/documents/GLStrategy2009Final.pdf).

USEPA recently announced that the Lower Fox River will be one of three priority areas in FY 2012-2013 targeted for phosphorus reductions. Other GLRI awards from USEPA for phosphorus reduction in the Lower Fox Watershed include funds for riparian restoration in Plum and Kankapot Creeks (Outagamie

County LCD, 2011) and Baird Creek riparian restoration (Brown County LWCD, 2010). These are just two examples of funded projects and many other local, state, and federal projects are ongoing in this watershed.

Next action(s) needed

1. TMDL Implementation Planning: The TMDL approved by USEPA calls for the development of detailed implementation plans to meet the reductions specified in the TMDL. "The next step following approval of the TMDL is to develop an implementation plan (or multiple implementation plans – one for each sub-basin) that specifically describes how the TMDL goals will be achieved. The implementation planning process may develop strategies to most effectively utilize existing federal, state, and county-based programs to achieve wasteload and load allocations outlined in the TMDL. Details of the implementation plan may include project goals, actions, costs, timelines, reporting requirements, and evaluation criteria." (Cadmus, 2012) A WDNR TMDL Project Manager was hired in October 2012 to assist with planning and implementation of the TMDL. The current target date for completion of the TMDL Implementation Plan is summer of 2013.
2. Complete actions identified in the detailed implementation plan.
3. Complete non-point projects, such as agricultural best management practices, to reduce TSS and TP loading to Lower Green Bay as opportunities arise (do not wait for Plan to be finalized).
4. Identify and delineate tile-drained fields in the Lower Fox River and Duck-Pensaukee watersheds through the analysis of remotely-sensed data (aerial photos) and ground-truth validation of the assumptions of the analysis. This project proposed by the Nature Conservancy will provide the essential knowledge necessary to begin addressing excess soluble phosphorus contributions to the AOC. $88,500 will be needed for the project.
5. Fully implement Wisconsin's runoff management administrative rules, including Chapters NR 151 and NR 243, and ensure that the state and counties have the staff to enforce them.
6. Explore whether the P Index will need to be lower in some subwatersheds in order to meet the TMDL goals.
7. Encourage use of adaptive management as a more flexible and cost-effective way for facilities to achieve phosphorus limits.
8. Encourage municipalities (MS4's) to fully implement their stormwater plans and install green infrastructure.
9. Determine if conditions meet the water quality targets established in the TMDL following the evaluation criteria outlined during the TMDL implementation planning.
10. Evaluate available blue-green algae data to determine the current status of this impairment following the current delisting target methods.
11. Complete the Upper Fox River TMDL.

Issues (challenges, risks) affecting progress on this BUI

– Even though "this TMDL will be implemented through enforcement of existing regulations, financial incentives, and various local, state, tribal, and federal water pollution control programs" (Cadmus, 2012), significant challenges exist to meet the substantial reductions identified for total phosphorus at the mouth of the Lower Fox River. "Development of a TMDL implementation plan will require a continued collaborative effort that utilizes the funding and technical expertise of various agencies and private organizations" (Cadmus, 2012).

Stakeholder Engagement

WDNR included a substantial effort to involve local stakeholders during development of the Lower Fox Watershed TMDL. These efforts are detailed in TMDL Section 8 (Public Participation) and included an Outreach Team led by Victoria Harris, UW-Sea Grant Institute, an Ad-Hoc Science Team, and a

Technical Team. There has not been more recent stakeholder engagement related to this BUI since the TMDL draft was submitted to USEPA in August 2011, but plans are underway for a variety of outreach programs. WDNR may consult with the Lower Green Bay and Fox River AOC Science and Technical Advisory Committee when making future decisions about whether or not current conditions meet the 2009 targets, any potential changes to the targets, and development of additional actions to remove this BUI.

The TMDL Outreach Team identified a need to improve the knowledge and support of multiple audiences (stakeholders, elected officials, general public) for the phosphorus reductions needed to restore the Lower Fox River and Lower Green Bay. There are multiple other efforts underway in this area to fill this need and WDNR will attempt to partner with these groups as much as possible when their goals overlap with the AOC program goals.

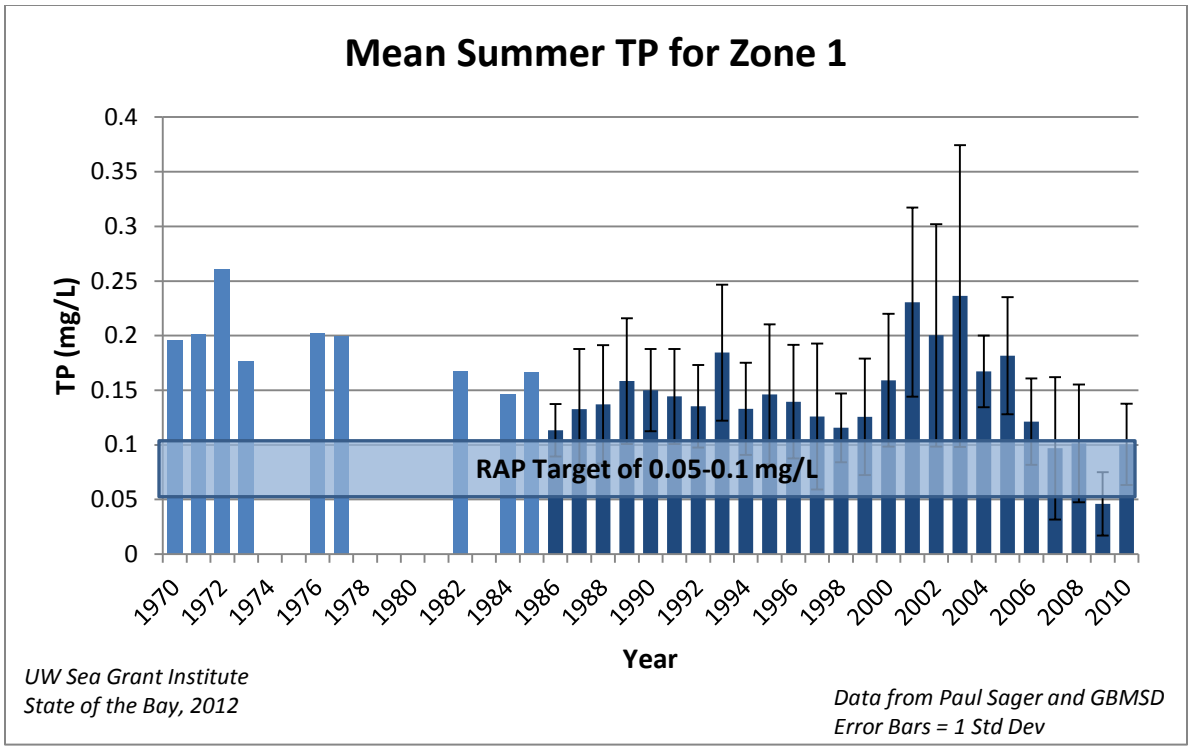


Figure 4. Mean Summer Total Phosphorus (TP) in Lower Green Bay (1970-2010)

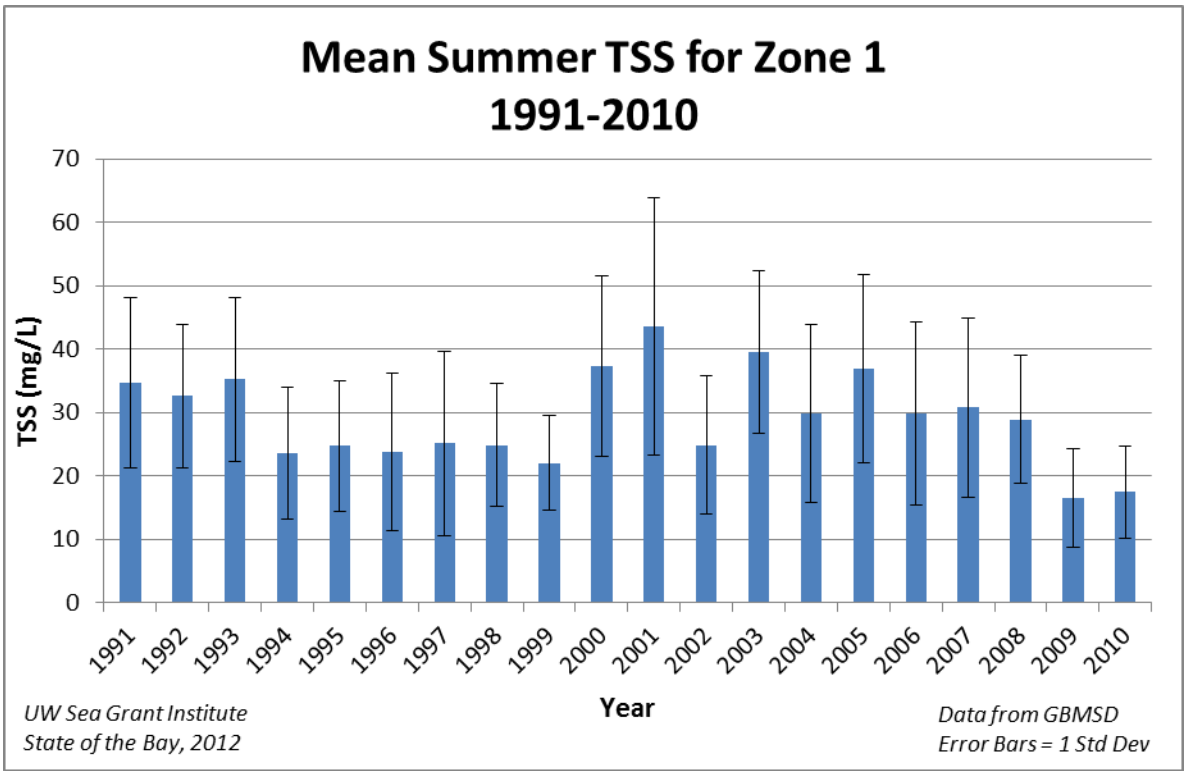


Figure 5. Mean Summer Total Suspended Solids (TSS) in Lower Green Bay (1970-2010)

RESTRICTIONS ON DRINKING WATER CONSUMPTION, OR TASTE AND ODOR PROBLEMS

2009 Target and Status

Restrictions on Drinking Water Consumption, or Taste and Odor Problems	Status
Densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances do not exceed human health standards, objectives, or guidelines	TBD
Taste and odor problems are not present	TBD
Treatment and costs needed to make raw water suitable for drinking is the standard treatment used in comparable portions of the Great Lakes which are not degraded, specifically disinfection, coagulation, sedimentation and filtration	TBD

Notes: 1) This target refers to treated drinking water supplies, not the raw source water. WDNR's standards for drinking water in Wisconsin Administrative Code Ch. NR 809 apply after treatment and are evaluated based on samples collected at the point of distribution to the public water supply. WDNR has not yet defined criteria to determine the cost threshold above which this BUI should be considered impaired.

2) The recommendation under "Next action(s) needed" (below) is to convene a technical work group that would examine this impairment, hence the "TBD" (to be determined) target status.

Rationale for Listing

The original listing of restrictions on drinking water as an impaired use was based upon the "unknown risks of toxic substances to human health" and the "health risks of exposure to the multitude of chemicals suspected" to exist in the AOC (Allen et al., 1987). Additional concerns were raised about potential taste and odor problems and high cost of water treatment related to removal of suspended solids, bacteria, and viruses from the water (Allen et al., 1987). An earlier comprehensive water study for Brown County had concluded that Lake Michigan was a preferable water supply over the Fox River or Green Bay because of water quality considerations (Donohue, 1976). Other factors favoring Lake Michigan as a water supply included the potential for accidental discharges from industries along the Fox River, the long distance from shore to reach an adequate depth for an intake in Green Bay, and potential high operating costs in a treatment plant related to algal growth impacting filtration and taste/odor problems (Donohue, 1976).

Summary of remedial actions since the last RAP and current status

No communities adjacent to the Area of Concern use Lower Green Bay or the Lower Fox River below the De Pere dam as a public drinking water supply. The City of Green Bay has used Lake Michigan water from a point near Kewaunee for drinking water since the mid-1950s and also currently supplies this water to the Village of Ashwaubenon and the Town of Scott. Concerns about long term supply and elevated radium levels in groundwater wells prompted six other communities in the Green Bay area to join together as the Central Brown County Water Authority. A second pipeline was completed in 2007 to access Lake Michigan water purchased from the City of Manitowoc and Manitowoc Public Utilities for these communities.

Lake Michigan water is a viable option for communities adjacent to the AOC and relatively few communities in Wisconsin use surface water as a drinking water supply. Those that do, draw mainly from lakes including Lake Winnebago, Lake Superior and Lake Michigan. Since other practicable sources (including groundwater and lakes) are available, many communities choose to avoid potential difficulties associated with water intake structures in shallow water and more frequent filtration associated with high sediment and algae loads.

Current status

The first two sections of the 2009 Target listed above refer to treated drinking water supplies of communities adjacent to the AOC, not raw source water. The third section of the 2009 Target applies to the treatment and costs necessary to make raw water suitable for drinking and might be considered to apply to AOC waters. The current status of this impairment will be evaluated by a technical workgroup in 2013.

Next action(s) needed

1. WDNR should convene a technical workgroup in 2013 to identify if any additional information is needed to evaluate the current status of this impairment relative to the 2009 Target. Consideration may be given to comparing the types of treatment used by communities drawing water from Lake Winnebago, upstream of the AOC.

Issues (challenges, risks) affecting progress on this BUI

– Careful consideration of the 2009 Target is needed even though surface waters in the AOC are not currently used as a drinking water supply.

Stakeholder Engagement

There are no outreach or communication needs identified at this time, however this may change depending on the technical workgroup's assessment of the current status of this impairment.

BEACH CLOSINGS

2009 Target and Status

Beach Closings	Status
Public swimming beaches within the AOC are open for 95% of the swimming season (between Memorial day and Labor Day) for any 5 year period based on Wisconsin Coastal Beach monitoring protocols for *E. coli* monitoring…	Assessment needed (within 5 years)
…and meet the blue-green algae target for 95% of the swimming season (geometric means of phytoplankton samples contain less than 20,000 cyanobacterial cells/ml or less than 1 µg/L of microcystin-LR based on at least 5 monthly samples over at least 2 years)*	Assessment in progress (2011)
No waterbodies within the AOC are included on the list of impaired waters due to pathogen contamination or blue-green algae in the most recent Wisconsin Impaired Waters list	Complete (assessment of blue-green algae data needed)

* 20,000 cyanobacterial cells/ml is the guidance level for relatively low probability of adverse health effects in recreational waters; 1 µg/L microcystin-LR is the provisional drinking-water guideline (WHO, 2003).

Notes: 1) The Lower Green Bay and Fox River AOC Social Uses Workgroup confirmed in 2012 that they would like to include Bay Beach in the evaluation of this target, although it is not currently used for swimming.

2) When this Target was established WDNR noted that it would need to be revised and updated to ensure consistency with future guidance on blue-green algae and *E. coli* from USEPA or the State of Wisconsin. Criteria listed below are from the April 2012 *Wisconsin Consolidated Assessment and Listing Methodology* (WisCALM), WDNR's guidance for 303(d) listing of impaired waters.

3) The Lower Green Bay and Fox River AOC Social Uses Workgroup decided in 2012 to keep the original targets for blue-green algae and microcystin-LR, although the April 2012 WisCALM calls for higher thresholds (100,000 cyanobacterial cells/ml and 20 µg/L of microcystin-LR).

E. coli

The current guidance for evaluating Great Lakes Beaches for recreational impairment is the following:

> WDNR aggregates by month all data collected from beaches during the "beach season" (defined as May 1 through September 30) over the past five years. The data is aggregated by month because it more closely approximates the "five samples per month" requirement of the geometric mean criterion and recognizes that typical sampling frequencies are often less than five times per month. For example, Monthly aggregate data sets with fewer than five data points are considered insufficient for assessing recreational use support. If one or more of the monthly aggregated geometric means exceeds the criterion of 126 cfu/100ml, the beach will be identified as not supporting its recreation use and placed on the Impaired Waters List. (WDNR, 2012)

A public swimming beach is closed when water samples exceed 1000 colony-forming units per 100 milliliters (cfu/100ml) of *E. coli.*

Blue-green Algae

The blue-green algae (cyanobacteria) target in parentheses above was based on an older WDNR guidance document. The current guidance calls for biologists to use "best professional judgment" to determine if "High Risk" thresholds of chlorophyll-a (> 50 µg/l), cyanobacteria cell counts (≥ 100,000 cells/ml) and microcystin (> 20 µg/l) are exceeded on a regular basis (WDNR, 2012).

Impaired Waters List

It should be noted that some areas with the potential to be public swimming beaches (e.g., Bay Beach) are not monitored and therefore their status relative to the Impaired Waters List is unknown.

Rationale for Listing

The AOC was historically used for recreational activities, including swimming at Bay Beach on the southern shore of Green Bay near the mouth of the Fox River. Bay Beach closed in 1938 due to excessive bacterial contamination and since that time sedimentation between Renard Island and the beach has reduced the area available for recreational activities (WDNR, 1993).

Summary of remedial actions since the last RAP and current status

The swimming beach at Bay Beach has remained closed since 1938, and there are no similar public beaches in the AOC. However, much of the Fox River and Bay is used for swimming, wading, water skiing and other water sports. Two locations in and adjacent to the AOC—Communiversity Park and Long Tail Point—are commonly used for swimming and other water-based recreation and are monitored by the Brown County Health Department following Wisconsin Beach Monitoring Program protocols (Figure 6, protocols available online at http://dnr.wi.gov/topic/beaches/monitoring.html). Long Tail Point samples are collected on the north side of Long Tail Point at two locations just outside the AOC boundary, but are considered here because of their immediate proximity to the AOC. *E. coli* is monitored weekly since it is an indicator species that may indicate the presence of other harmful pathogens (bacteria, viruses) in the water. Beach monitoring data are available for download at www.wibeaches.us.

In the last 5 years, between 2008 and 2012, *E. coli* levels measured at Communiversity Park and Long Tail Point indicate that water quality relative to *E. coli* is good overall. There were only two times at Communiversity Park when *E. coli* exceeded 1,000 cfu/100 ml, the level at which a public beach is closed to swimming (and thus does not meet the Target of being open). *E. coli* did not exceed the closure level of 1000 cfu/100 ml at Long Tail Point during the last five years. In addition to closures, advisories are issued when water samples exceed 235 cfu/100 ml, to advise the public of a potential increased health risk. In the last 5 years, no advisories were issued for Long Tail Point and only nine were issued for Communiversity Park.

Total coliform and *E. coli* data are also collected by GBMSD at two locations near the mouth of the Fox River (Metro Boat Launch and GBMSD's outfall); however, these data are not collected as part of the beach monitoring program. Discussion of these samples is included here for sake of completeness in evaluating all recent bacteria data available for the AOC. Total coliform bacteria live in large numbers in soils, plants, and intestines of animals and are not as sensitive an indicator of potential risk to humans as *E. coli*. WDNR does include criteria for fecal coliform (not total coliform) in flowing rivers and streams in the WisCALM guidance, but points to *E. coli* as supplementary data to be used in making judgments of impairments (WDNR, 2012). In the last five years, between 2008 and 2012, *E. coli* data at both locations rarely exceeded the closure level of 1000 cfu/100 ml (once at the Metro Boat Launch and twice at the outfall) or the advisory level of 235 cfu/100 ml (5 samples of 50). Furthermore, monthly geometric means do not exceed the WisCALM criteria for recreational restrictions and do not suggest the need for an impaired waters listing (WDNR, 2012).

No AOC waters are currently on, or proposed for addition to, the most recent Wisconsin 303(d) list of Impaired Waters for recreational restrictions due to blue-green algae or *E. coli* (list as proposed to USEPA in April 2012 available online at http://dnr.wi.gov/topic/impairedwaters/). WDNR evaluates long-

term *E. coli* data sets to determine if an area should be included on this list, aggregating data for Great Lakes Beaches by month during the typical swimming season (May – September; WDNR, 2012). For this version of the 303(d) list of impaired waters WDNR calculated monthly geometric means using data from 2007 through 2011 at both Communiversity Park and Long Tail Point. None approached or exceeded the threshold of 126 cfu/100 ml. The range of *E. coli* results and the few high values measured at Communiversity Park are typical of beaches near urban areas and don't warrant an impaired waters listing (Chris Pracheil, WDNR, personal communication). It is important to note that there is only one Wisconsin water body on the current 303(d) list for recreational restrictions due to blue-green algae. The WDNR does not generally list water bodies for algae at this time because there is no routine monitoring being done.

There has been a recent initiative to bring Bay Beach back as a public swimming beach. Toward that end, the Bay-Lake Regional Planning Commission received a USEPA Urban Waters Grant in 2012 to conduct two years of *E. coli* and other water quality monitoring at Bay Beach to identify sources of pollution and develop a restoration action plan. The Commission will work in partnership with the NEW Wilderness Alliance and the City of Green Bay to use sampling and routine and annual sanitary surveys conducted by UW-Oshkosh to develop a restoration action plan for Bay Beach that includes engineered redesign recommendations with the goal of making Bay Beach swimmable. This project will provide valuable information on the current status of Bay Beach and what it would take to make it a safe swimming beach once again.

Although *E. Coli* may not be present at levels that would pose a risk to swimmers, there is potential for blue-green algae blooms to contain toxins that pose a risk to humans and/or their pets. Risks vary depending on the type of algae, but may include skin irritation, vomiting, nausea and headaches in humans (see http://dnr.wi.gov/lakes/bluegreenalgae/#effects for more information). Green Bay Metropolitan Sewerage District (GBMSD) collected blue-green algae samples in conjunction with *E. Coli* sampling at Communiversity Park and near Long Tail Point in the summer of 2011 to assist in determining the current status of this impairment Samples were collected 5 times from July 26 to August 31 at each location for microcystin and algal composition analyses. Approximately 60% of the samples taken at the Communiversity Park station were above the delisting target of 1 µg/L of microcystin-LR, and 40% of the samples taken at the Long Tail station were above the target level. The cyanobacteria results were not directly comparable to the target, since they were in natural units/ml rather than cells/ml. Neither of these stations exceeded the *E. coli* delisting target of 235/ 100 ml during the study period. Although this was a very small study, the results show that cyanobacteria at these two locations are producing toxins that may be harmful to human health.

Past monitoring of blue-green algae also indicates that it is likely this use is impaired (Bart De Stasio, Lawrence University, personal communication). Samples collected in 2010 and 2011 from Lower Green Bay stations were generally below the microcystin threshold in the 2009 Target (1 µg/L) and April 2012 WisCALM (20 µg/L), but did exceed the 1 µg/L threshold in August 2011. Other measures were also high in both years. Cyanobacteria cell counts exceeded both the 2009 Target (20,000 cells/ml) and April 2012 WisCALM (100,000 cells/ml) in at least one of five sampling dates in 2010 and all five dates in summer 2011, at two separate locations in the AOC.These elevated cell counts usually included large numbers of *Microcystis*.

Next action(s) needed

1. Further determine the current status of this impairment as new blue-green monitoring data become available from GBMSD and Lawrence University. Additional data from an USEPA GLRI award to Michigan Technological University to use satellite imagery to generate baseline maps of

Harmful Algal Blooms in the Great Lakes (2008-2012) might also be used to help determine the status of this impairment when available.

2. Complete project at Bay Beach to confirm likely frequency of beach closures and develop restoration action plan and engineering design for construction to reduce any likely closures. (Funded for $60,000 / 2 yrs).
3. Perform monitoring for cyanobacteria and microcystin at Bay Beach. Current project focuses on recreational safety related to *E. coli,* and does not evaluate safety related to blue-green algae.
4. Consider additional monitoring for cyanobacteria and microcystin near Communiversity Park and Long Tail Point. These two locations are routinely sampled during the summer for *E. Coli* by GBMSD and the Brown County Health Department. With additional funding, samples for cyanobacteria could be taken at the same time as *E. Coli* samples.
5. TMDL implementation planning & actions to reduce phosphorus and sediment loads to the AOC.

Issues (challenges, risks) affecting progress on this BUI

- Decreased water clarity because of large amounts of suspended solids or algal blooms may impact people's willingness to swim in the Area of Concern and/or reduce natural disinfection of the upper layer of the surface water (rely on *E. coli* as indicator).
- Achieving the substantial reductions identified for total phosphorus and total suspended solids in the TMDL will be challenging and take sustained and coordinated efforts by multiple stakeholders in the Lower Fox Watershed. Recent efforts to build grassroots public support for restoring water quality at Bay Beach in the Lower Bay may assist in this effort.

Figure 6. Recreation areas in the Lower Green Bay and Fox River AOC.

Stakeholder Engagement

WDNR may consult with a multi-disciplinary AOC Technical Advisory Committee (Social Uses Workgroup) when making future decisions about whether or not current conditions meet the 2009 Target, any potential changes to the Target, and development of additional actions to restore this BUI.

Beach advisories are available online at the Wisconsin Beach Health website (www.wibeaches.us), and interested members of the public are able to enroll in customized email alerts or RSS feeds for specific beaches.

DEGRADATION OF AESTHETICS

2009 Target and Status

Degradation of Aesthetics	Status
Total phosphorus and total suspended solid concentrations at the mouth of the Lower Fox River meet water quality standards and/or water quality targets specified in a State and US EPA approved Total Maximum Daily Load (TMDL). The approved TMDL targets are summer median concentrations of 0.10 mg/L TP and 20 mg/L TSS at the mouth of the river.	Action needed
Monitoring data within the AOC and/or surveys for any five year period indicates that water bodies in the AOC do not exhibit unacceptable levels of the following properties in quantities which interfere with the Water Quality Standards for Surface Waters: (a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the state or impair use. (b) Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in waters of the state or impair use. (c) Materials producing color, odor, taste, or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the state or impair use.	Assessment in Progress (initiated 2011)

Notes: 1) The second portion of the target is based on the "Water Quality Standards for Wisconsin Surface Waters" in Chapter NR 102 of the Wisconsin Administrative Code. In the case of these targets public rights generally refer to protection of the public interest and the use of water resources for all lawful purposes as outlined in Chapter NR 102.01(2).

2) The Lower Green Bay and Fox River AOC Social Uses Workgroup decided in 2012 to add the numerical targets from the approved TMDL for total phosphorus and total suspended solids to the first portion of the delisting target.

Rationale for Listing

This impairment was originally identified based on the appearance of the AOC's water. WDNR (1993) listed large total suspended solids loads, algal blooms (and occasional odor from decaying algae), and turbidity from wave action as the primary causes of this impairment.

Public perception of the AOC was measured in 1990 using a telephone survey of Brown County residents (Baba et al., 1990). The average ranking of water quality in the Lower Bay near the mouth of the Fox River was 4.1 on a scale of 1 (worst possible) to 10 (best possible). Although this survey did not ask specific questions about aesthetics, responses clearly indicated that people perceived the water quality to be below what would be desirable for boating and swimming.

Summary of remedial actions since the last RAP and current status

The USEPA approved the WDNR's TMDL for Total Phosphorus and Total Suspended Sediments in May 2012 (approval and report available online at http://dnr.wi.gov/water/projectDetail.aspx?key=16084305). This report specifies significant reductions to achieve water clarity goals that would also be expected to improve the water's aesthetic quality. A full implementation plan for the TMDL has not been developed; however, work to reduce nonpoint sources of phosphorus and sediment from the Lower Fox Watershed has been ongoing for years. Examples of current projects include riparian protection using USEPA GLRI funds awarded to Land and Water Conservation Districts in Brown County ($377,000 in 2010) and Outagamie County ($748,000 in 2011).

University of Wisconsin–Extension surveyed urban residents in the East River watershed to determine their perception of nonpoint source water quality issues in 2010. The same question as that posed in 1990 (rate the water quality in the Lower Bay near the mouth of the Fox River on a scale of 1 to 10) was repeated in 2010. Although the responses are not directly comparable because of differences in the survey methods, the results suggest that public perception of AOC waters has not improved. The mean response was 3.6 and half of the people rated the water quality at 3 or below (Genskow and Wood, 2010). However, the majority of respondents rated the overall water quality in Green Bay for scenic beauty as "Good" (49%) or "Okay" (39%), suggesting that aesthetics may not be a substantial concern in this area (Genskow and Wood, 2010).

The second portion of the target makes specific reference to monitoring data of "unacceptable levels" of properties including "objectionable deposits." WDNR recognizes that these judgments are more personal than scientific decisions. To incorporate local opinions of AOC aesthetics, WDNR initiated a citizen volunteer monitoring program to assess the current status of this BUI in September 2011. Volunteers are asked to determine the aesthetic quality of the water and what is, and is not, objectionable by filling out a datasheet with questions that directly correspond to the 2009 target. Each volunteer also collects supporting data to describe conditions during the time of his or her assessment. A unique aspect of this program is that volunteers rotate through monitoring sites, so that multiple volunteers complete an assessment at each location.

The volunteer monitoring program was expanded in 2012 to include eleven monitoring sites throughout the AOC. The program is still developing, with volunteer feedback and results being used to help shape the program. Preliminary results show that volunteers' perceptions of sites can differ widely, depending on their backgrounds, experiences, and other factors. This reinforces the goal of the program to expand and include more citizens in the future. In addition, there are sites in the AOC that are not aesthetically pleasing for various reasons, including excessive algae, turbid water, invasive species (primarily *Phragmites*), and garbage and other materials on the shore and in the water. Information from these surveys can be used to identify problem areas and potential solutions. Benefits of this approach include expanding public participation in AOC activities, generating needed data at minimal cost, and incorporating public perceptions in evaluation of this BUI.

Next action(s) needed

1. <u>2013 Volunteer Monitoring of Aesthetics</u>: WDNR will continue to refine and expand the Volunteer Aesthetics Monitoring program in 2013 and beyond to include the opinions of more citizens. The WDNR will fund a Volunteer Coordinator for this program with USEPA capacity funds. Along with other responsibilities, this Volunteer Coordinator would encourage the participation of larger numbers of the public through the use of "snapshot days" at local events and handing out surveys at the monitoring sites, which include fishing piers, boat launches, etc. The Coordinator could also work with WDNR staff and the Social Uses Workgroup to produce an abbreviated version of the survey, which might allow a wider range of citizens to weigh in. One possibility is that the surveys could be completed by smart phone, such as through the pilot Wisconsin Sea Grant spatial narratives project. Approximately $5,000 will be required annually for at least five years to fund the volunteer coordinator's time, provide supplies, and expand public participation in the program.
2. Identify improvement opportunities: WDNR will use the results of the volunteer monitoring to identify issues that contribute to degraded aesthetics and work with local stakeholders to identify potential remedial actions. Possible projects would include beach or river clean-ups and small invasives control projects that are focused on public access points.

3. TMDL Implementation: Achieving the reductions in total suspended solids and total phosphorus specified in the TMDL is expected to reduce turbidity, algal blooms, and the occasional odor from decaying algae that were the primary causes of this impairment at the time of listing.

Issues (challenges, risks) affecting progress on this BUI

- Although volunteer monitoring is cost effective, it is not without costs. WDNR will need to continue supporting the Volunteer Coordinator's time to maintain existing volunteers, recruit new volunteers, ensure data are consistently collected and entered into WDNR's SWIMS database, and assist the AOC Technical Advisory Committee with evaluation of the results.
- Public access to the west shore of Green Bay is limited by extensive stands of *Phragmites* that restrict access to the water and a full survey may not possible at all locations.
- An individual's determination of what is "unacceptable" and "objectionable" is a subjective decision. The challenge will be to engage sufficient numbers of individuals in the volunteer monitoring program to adequately represent the general public's perception of the AOC waters.
- Some causes contributing to degraded aesthetics may be beyond the scope of the AOC program. Whenever possible, WDNR will work with local stakeholders to identify specific solutions; however, it may be that not all aesthetic problems can be addressed by the AOC program.

Stakeholder Engagement

A multi-disciplinary AOC Technical Advisory Committee (Social Uses Workgroup) assisted WDNR in the development of the citizen volunteer monitoring program and may assist in review and interpretation of results of the project. WDNR may consult this workgroup when making future decisions about whether or not current conditions meet the 2009 targets, any potential changes to the targets, and development of additional actions to restore this BUI.

WDNR encourages local citizens to become involved in the volunteer monitoring program to offer their perceptions of the aesthetic quality of AOC waters. WDNR has tentative plans for AOC "Snapshot Days" during the 2013 monitoring season to increase public participation in the program by encouraging as many people as possible to fill out a survey on a given day. Snapshot days would likely be scheduled during times when people are already at a Fox River park for an event, such as during Earth Week activities in April or a summer waterfront festival.

DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS

2009 Target and Status

Degradation of Phytoplankton and Zooplankton Populations	Status
Plankton and zooplankton structure and function do not significantly diverge from unimpaired reference conditions with comparable physical and chemical characteristics, recognizing the uncontrollable impact of invasive species. The following specific objectives should also be met: – Sources contributing to nutrient enrichment are identified and controlled; and – AOC total phosphorus concentrations consistently meet water quality standards and/or water quality targets of a State and US EPA approved TMDL; and – In lower Green Bay, the amount of energy from phytoplankton and zooplankton that reaches the open water food chain has increased, and the amount of energy reaching the bottom sediments has decreased. (In other words, the carbon transfer efficiency of the phytoplankton and zooplankton levels of the food chain in lower Green Bay is increased such that the amount of energy channeled into the detrital food chain is decreased and the amount of energy channeled into the pelagic food chain is increased). This is expected to occur when phosphorus levels and the corresponding percentage of blue-green algae in the phytoplankton are reduced.	Assessment in progress (2012)
Phytoplankton or zooplankton bioassays confirm no significant toxicity in ambient waters in the AOC.	Unknown

Note: A metric to define the amount of energy transfer from phytoplankton and zooplankton to other levels of the food chain is needed. The target as it is now worded intends to define the desired state as a balanced energy flow in the food web. This will be complicated by the presence of Dressenid mussels.

Rationale for Listing

This impairment was originally identified because excessive nutrients altered both phytoplankton and zooplankton populations in the AOC (WDNR, 1993). Community changes noted included dominance of blue-green algae in phytoplankton populations, smaller zooplankton with low grazing effectiveness, and a large portion of primary production reaching bottom sediments rather than passing into the pelagic food web (WDNR, 1993).

Summary of remedial actions since the last RAP and current status

Recent research strongly indicates that this impairment remains in the Lower Green Bay and Fox River Area of Concern. Blue-green algae have shifted to dominate phytoplankton populations since the invasion of zebra mussels (De Stasio et al., 2008).Direct measures of trophic transfer between phytoplankton and zooplankton were conducted during 2006 and 2007. Those studies demonstrate that rates of energy transfer were not significantly different than they were in 1986-1988 or 1990-1992 (Sager and Richman, 1991). Approximately 10% or less of the phytoplankton production was grazed by the zooplankton communities in the AOC, indicative of impaired conditions. Blue-green algae blooms were present in the AOC in 2010, 2011 and 2012 and continue to dominate the phytoplankton community biomass (Bart De Stasio, Lawrence University, personal communication). Michigan Tech Research Institute will be collaborating with GBMSD to map harmful algal blooms in the Great Lakes, including work in Green Bay.

USEPA provided funding for the USGS to evaluate the current status of this BUI in four Wisconsin Lake Michigan AOCs by comparing them to six relatively unimpacted or less-impacted non-AOCs. Plankton samples were collected using a plankton tow net and a Van-Dorn-style water sampler (for integrated

water-depth profiles) three times at each site in spring and summer of 2012. In the Lower Green Bay and Fox River AOC, plankton samples were collected from one site in the Fox River and one site in Green Bay. The results of this assessment are not yet available.

Next action(s) needed

1. 2012 USGS Plankton Assessment: The results of the 2012 assessment will be evaluated to determine if it is necessary to expand the study to other Rivers and/or Bays in eastern Lake Michigan or the Great Lakes region to find a more suitable location to compare to the Fox River and Lower Bay.
2. Reductions in total phosphorus loads from the Lower Fox River watershed to Green Bay.

Issues (challenges, risks) affecting progress on this BUI

– Selection of appropriate reference conditions for comparison of plankton and zooplankton structure and function will need to carefully consider Green Bay's unique physical, chemical and biological conditions.

Stakeholder Engagement

There has not been any recent stakeholder engagement related to this BUI. WDNR may consult with the Lower Green Bay and Fox River AOC Science and Technical Advisory Committee on the appropriate course of action for this BUI after results of the 2012 USGS assessment are available.

LOSS OF FISH & WILDLIFE HABITAT

Loss of Fish & Wildlife Habitat	Status
Fish and wildlife management goals are achievable as a result of the physical, chemical, and biological integrity of the AOC waters, including wetlands	Action Needed
A balance of diverse habitat types exists within the AOC that supports all life stage requirements of fish and wildlife populations including: – Multiple wetland types (for example: submerged aquatic vegetation, emergent vegetation, sedge meadows, forested & shrub) that adequately represent historic wetland types – Quality fish spawning habitats – Islands for colonial nesting birds, amphibians, and furbearers – Intact migration corridors (both shoreline and water) – Unconsolidated beaches (for shorebirds) – Habitat for State or Federally listed species (special concern, threatened, or endangered)	Action Needed
The hydrologic connectivity between wetlands and the AOC and between the lower Fox River Basin tributaries and the AOC is maintained and restored sufficiently to support fish spawning and allow for fish passage	In progress
The Green Bay portion of the AOC contains water clarity and other conditions suitable for support of a diverse biological community, including a robust and sustainable area of submersed aquatic vegetation in shallow water areas	Action Needed
The AOC contains a diversity of plants, an abundance of submersed aquatic vegetation, and sufficient invertebrates to provide adequate food supplies to support a diverse assemblage of migratory diving ducks (both mussel and vegetation feeding), fish, and other wildlife (including aquatic invertebrates, amphibians, and reptiles)	Action Needed
The AOC meets water quality standards and/or water quality targets of a State and US EPA approved TMDL. The approved TMDL targets are summer median concentrations of 0.10 mg/L TP and 20 mg/L TSS at the mouth of the river.	Action Needed
The AOC meets Wisconsin water quality criteria for dissolved oxygen and water temperature that are protective of fish and wildlife populations	Action Needed
No waterbodies within the AOC are listed as impaired due to physical or water chemistry conditions in the most recent Wisconsin Impaired Waters List (303(d) List)	Action Needed

Notes: 1) Portions of this delisting target are goal statements that may be too broad to define specific endpoints. As specific restoration and/or monitoring projects are initiated, WDNR and the Lower Green Bay and Fox River Biota & Habitat Committee will decide if it is feasible to determine specific endpoints for this impairment.

2) The Lower Green Bay and Fox River AOC Biota & Habitat Committee decided in 2012 to modify the third portion of the delisting target to include hydrologic connectivity between the lower Fox River Basin tributaries and the AOC.

3) The Lower Green Bay and Fox River AOC Biota & Habitat Committee decided in 2012 to add the numerical targets from the approved TMDL for total phosphorus and total suspended solids to the sixth portion of the delisting target.

Rationale for Listing

The major causes of lost habitat in the AOC listed in the original Remedial Action Plan (WDNR, 1988) and Update (WDNR, 1993) include:

- Habitat destruction and fragmentation due to urban and industrial development, channelization, dredging and filling along the River corridor.
- wetland losses from human activity and changing water levels and loss of hydrologic connectivity.
- lack of submerged aquatic vegetation in the Duck Creek delta area of the lower Bay because of turbid water, hypereutrophication, destruction of the Cat Island Chain of islands by high water and storms, and carp impact on underwater plants and littoral vegetation.
- silt deposition and resuspension of sediments in the Lower Bay.
- invasive vegetative species.

Summary of remedial actions since the last RAP and current status

Many projects to improve fish and wildlife habitat have been initiated since the RAP was first developed, both within and adjacent to the AOC. Examples include fish spawning habitat enhancements adjacent to Voyageur Park in De Pere, Brown County Fairgrounds, and at South Bay Marina. Two other key restoration efforts briefly described in this document's introduction are the Cat Island Chain Restoration and efforts of multiple agencies on Green Bay's west shores.

Construction of the Cat Island Chain restoration project is now underway. Beginning in June of 2012, Brown County began construction of a rock spine structure that will act as a wave barrier and provide the foundation for restoring the Cat Island Chain. The wave barrier provides the base for constructing three islands which will be built from fine sands dredged from the outer navigation channel. The islands will then be filled by the USACE using clean dredge material from the maintenance of the Green Bay Harbor over the next thirty years. Planning for restoration of the Cat Island chain continues to include a strong emphasis on habitat values of the island, including sheltering aquatic vegetation by the barrier island chain as well as upland and nearshore island habitat. The Lower Green Bay Biota & Habitat Committee has been actively involved in discussions with Brown County on the plans and timing for the project.

Within the AOC, properties within the Green Bay West Shore Wildlife Area acquisition boundary and additional properties with hydrologic connection to the Bay have been purchased for permanent protection. Acquisition efforts for coastal wetlands continue with a number of partners. A prioritization tool for ranking wetland areas for importance (see http://maps.tnc.org/duckpentool/) has been developed and is currently in use within the AOC and elsewhere around Green Bay. This online prioritization tool also contains results from a Northern Pike connectivity survey. Barriers for fish passage have been identified in the Duck-Pensaukee subwatershed and prioritized based on both the financial cost to remove the barrier and the amount of stream and wetland spawning habitat that would be opened up if remedied. The top 2 barriers had already been removed. Historic and current phosphorus and sediment data have also been collated for the Duck-Pensaukee watershed and potential ideas to address the problems have been included.

Invasive species control efforts continue within the AOC. Large-scale aerial spraying of *Phragmites* took place in the Green Bay West Shore Conservation Opportunity Area in 2011. This included 768 acres treated in and adjacent to the AOC. Removal of dead canes and follow-up treatments will continue during the field seasons of 2012 and 2013. In addition, an effort to control buckthorn on public lands along the West Shore of Green Bay has been partially implemented within the AOC. Field work on buckthorn control occurred in late 2011 and early 2012. Control of these vegetative invasive species is important for a variety of wildlife populations (e.g., marsh nesting birds).

The Green Bay West Shore northern pike habitat project continued in 2012. This project, led by the Brown County Land and Water Conservation Department, has been funded from a variety of sources, including a GLRI grant, NRDA funds, USFWS grants, and donations from conservation groups. So far, approximately 17 miles of stream corridor have benefited from this project; 7 miles were enhanced and

protected and another 10 miles were made accessible for migrating fish by replacing perched culverts. In addition, over 30 acres of wetlands (spawning marshes), 41 acres of vegetated Riparian Buffers, and over 45 acres of critical area plantings were installed. Six perched culverts were replaced with project money and another 2 replaced by the Village of Suamico. (Mike Mushinski, Brown County Land and Water Conservation Department, personal communication)

On the other side of the bay, a project was begun in 2012 to restore approximately 114 acres of coastal wetlands and adjacent uplands at Point au Sable, a prominent peninsula that forms northeast "corner" of the AOC. The wetland complex is part of a 181.6 acre University of Wisconsin-owned natural area adjacent to approximately 70 acres of undeveloped private lands. Together, these tracts encompass the largest coastal wetland along the eastern shore of Green Bay. This project will restore and improve habitat for numerous fish and wildlife species, including species of conservation concern, and also includes components of aquatic invasive species control (*Phragmites australis*), reduction of phosphorous inputs, and providing technical assistance to private landowners. A prescribed burn was completed in June 2012 to prepare the site for aerial herbicide applications to control *Phragmites*, and aerial herbicide applications occurred in September 2012. As part of the educational component of the project, UW-Green Bay students enrolled in a Conservation Biology course visited this site in fall 2012 and are preparing restoration plans tailored to the site. Upland invasive species are being treated this fall (2012). The wetland restoration project to restore the interior marsh on the peninsula will begin in spring 2013. (Betsy Galbraith, U.S. Fish and Wildlife Service, personal communication)

Spawning conditions for lake sturgeon also have been improved through increased coordination between the US Army Corps of Engineers, who manage flows in the lower Fox River, Thilmany Papers, who use flows for hydropower generation at the De Pere Dam, and the agencies (USFWS and WDNR). Procedures are now formalized as part of a Sturgeon Protection Plan as part of the FERC license for hydro operation by Thilmany Papers. This cooperative effort has been in place since 2006 and has provided more dependable minimum flows sufficient for successful spawning and egg and larval incubation. Previously, spawning habitat was often dewatered during the spawning season.

Despite these efforts, habitat for fish and wildlife populations still remains impaired. An inventory of aquatic plants conducted in summer 2009 in the Lower Bay adjacent to the proposed Cat Island Chain Restoration area identified only sparse vegetation with the following few species: Sago (S. pectinata), Small duckweed (L. minor), Coontail (C. demersum), Large duckweed (S. polyrhhiza), Leafy pondweed (P. foliosus), Elodea (E. canadensis) and Filamentous algae (Alison Mikulyuk, WDNR, personal communication). This may be partly caused by low secchi depths in the Lower Bay (Figure 7, Qualls et al., 2012). The Lower Fox Watershed TMDL estimated that achieving the water quality goals would expand the area available for submerged aquatic vegetation growth in the Lower Bay by as much as 35-45 % because of improved water clarity (Cadmus, 2012). Improved water clarity, combined with Cat Island Chain restoration, is expected to greatly improve habitat for Fish and Wildlife within the lower Bay.

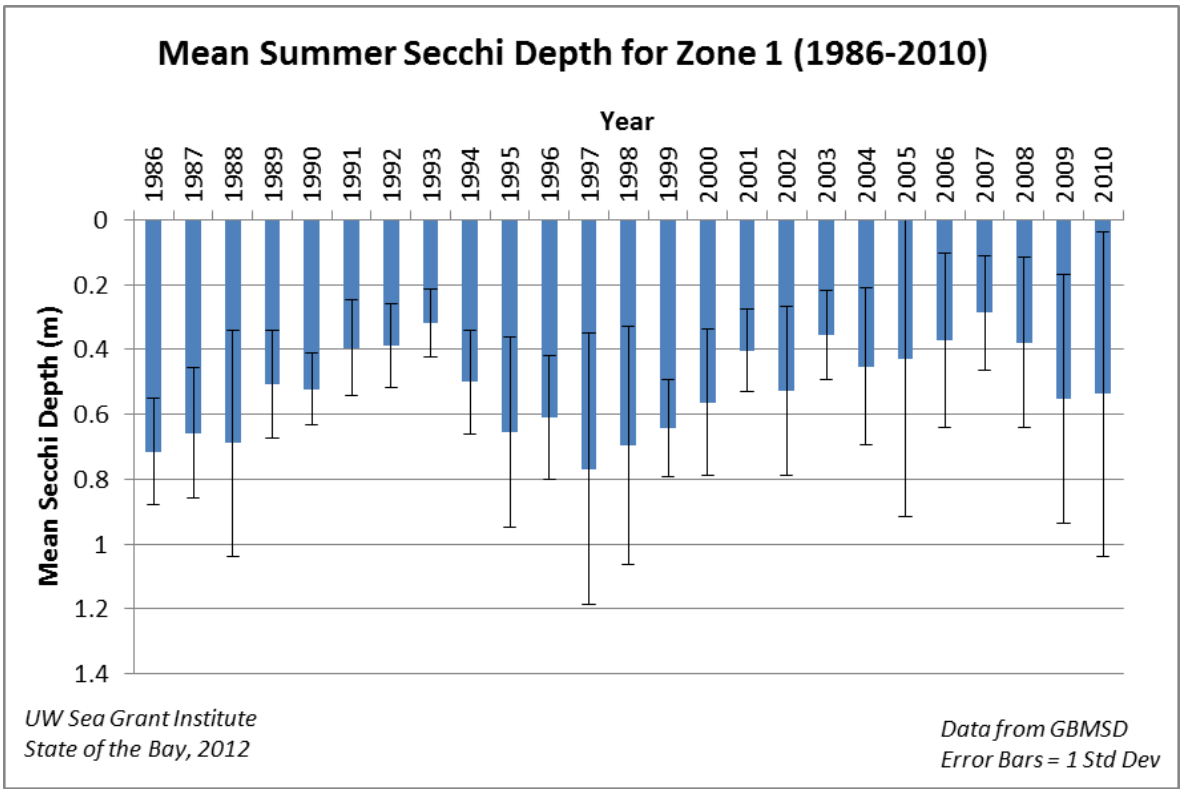


Figure 7. Mean summer secchi depth for Lower Green Bay (1986-2010).

Next action(s) needed

1. Cat Island Chain Restoration: Brown County Port and Solid Waste Department received $1.5 million of FY 2010 USEPA GLRI funds that helped fund the first phase of this project. Plans are currently underway for additional construction phases estimated to cost some $20 million that will be undertaken by the US Army Corps of Engineers in cooperation with Brown County. These include the remainder of the wave barrier and side dikes of the three islands, which are expected to be completed in 2014. Additional funding will be needed to complete planning for the final habitat design.
2. *Phragmites* inventory and control in AOC & tributaries upstream to maximum water level. This work would focus on the AOC areas not included in WDNR's current GLRI project focused on the west shore of Green Bay and other conservation opportunity areas along Lake Michigan's shoreline. Proposed 3-year project would be led by WDNR and would require approximately $1,000,000 in funding.
3. Point au Sable habitat restoration: Continue Point au Sable restoration project. First phase, to be completed in 2013, has been funded. Need to obtain funding for future phases, which may include the following: 1) improvements for fish spawning (northern pike and other species) on Wequiock Creek through a partnership with the Brown County Land and Water Conservation Department, 2) continued invasive species management and reestablishment of native vegetation, especially along shorelines, and 3) monitoring and evaluation by UWGB faculty and students. Approximately $50,000 is needed to complete the remaining phases of the project.
4. In 2012-2013, restoration work at the Sensiba Wildlife Area will improve wetland habitat for fish and wildlife. Additional coastal wetland acquisition and restoration projects are also planned. Northern pike access to spawning habitat will continue to be improved through fish passage projects. Northern pike research results will also provide answers to natal homing questions and

guide restoration recommendations. Phosphorus/sediment reduction strategies will be discussed with Duck-Pensaukee watershed stakeholders. The online tools (wetland and connectivity) will be expanded to the entire coastal zone of the bay of Green Bay.

5. TMDL implementation planning and actions to reduce phosphorus and sediment loading to the AOC to meet water clarity goals.
6. Various monitoring, planning, and projects listed in the table in Appendix C. No one discrete project will be sufficient to address the complex needs for habitat restoration within the AOC.

Issues (challenges, risks) affecting progress on this BUI

- Fish and Wildlife populations are mobile and not restricted to habitat simply within the AOC boundary. Actions to address the habitat needs of local populations will need to occur in a broad area, beyond the AOC boundary. For example, restoring hydrologic connections between wetlands and the AOC will depend on implementing projects not only within the AOC but outside the AOC as well.
- Improving water quality in the Fox River and lower Green Bay will depend on implementing projects in the upstream watersheds.
- *Phragmites,* an invasive common reed grass, has a substantial impact on habitat within the AOC. WDNR initiated control of this invasive along the west shore of Green Bay; however, other portions of the AOC and repeated follow-up work are not currently included as part of this grant.
- The continued influx of invasive species will make many goals difficult to maintain in the long term.
- Restoring connectivity of wetlands to Bay and areas of important habitat is hampered by continuing development. Habitats are increasingly fragmented.

Stakeholder Engagement

The Lower Green Bay Biota & Habitat Committee met actively in 2011 to identify restoration actions for “Degraded Fish and Wildlife Populations” and “Loss of Fish and Wildlife Habitat” impairments. This group will continue to be consulted on the planning and prioritization of projects. Efforts to engage stakeholders in restoration within the AOC, particularly in supporting reductions in total phosphorus and total suspended solids, will be necessary for this impairment.

REFERENCES

Allen, P., J. Sullivan, L. Persson and other members of the Technical Advisory Committee. 1987. Toxic Substances Management Technical Advisory Committee Report. WDNR PUBL-WR-166 87 134 pp

Ankley, G.T., A. Katko and J. Arthur. 1990. Identification of Ammonia as an important sediment-associated toxicant in the Lower Fox River and Green Bay, Wisconsin. Environmental Toxicology and Chemistry. 9:313-322

Baba, R.K., P.K. Johnsen, G.J. Knapp, and L.J. Smith. 1990. Public Perceptions and attitudes toward water quality rehabilitation of the Lower Green Bay Watershed - A report to the Green Bay Remedial Action Plan Implementation Committee and Community. Center for Public Affairs Working Paper Number 90.12. 40 pp

Ball, J.R., V.A. Harris, and D. Patterson. 1985. Lower Fox River – De Pere to Green Bay Water Quality Standards Review. Wisconsin Department of Natural Resources. September 1985.

Barron, M.G., M. Anderson, D. Beltman, T. Podrabsky, W. Walsh, D. Cacela, J. Lipton, S. Teh, D. Hinton, J. Zelikoff, A. Dikkeboom, B. Lasee, S. Woolley, D. Tillitt, M. Holey, P. Bouchard, and N. Denslow. 1999. Association between PCBs, Liver Lesions, and Biomarker Responses in Adult Walleye (*Stizostedium vitreum vitreum*) Collected from Green Bay, Wisconsin. April 13, 1999

Baumann, P., M.J. Mac, S.B. Smith, and J.C. Harshbarger. 1991. Tumor Frequencies in Walleye (Stizostedion vitreum) and Brown Bullhead (Ictalurus nebulosus) and Sediment Contaminants in Tributaries of the Laurentian Great Lakes. Canadian Journal of Fisheries and Aquatic Science 48:1804-1810

Cadmus Group Inc. 2012. Total Maximum Daily Load and Watershed Management Plan for Total Phosphorus and Total Suspended Solids in the Lower Fox River Basin and Lower Green Bay. Prepared for WDNR, Oneida Tribe of Indians, and USEPA. Accessed online 10/09/2012 at http://dnr.wi.gov/water/projectDetail.aspx?key=16084305

Custer, C.M., T.W. Custer, P.D. Allen, K.L. Stromborg, and M.J. Melancon. 1998. Reproduction and Environmental Contamination in Tree Swallows Nesting in the Fox River Drainage and Green Bay, Wisconsin, USA. Environmental Toxicology and Chemistry 17(9):1786-1798

De Stasio, B.T., M.B. Schrimpf, A.E. Beranek and W.C. Daniels. 2008. Increased Chlorophyll a, phytoplankton abundance, and cyanobacteria occurrence following invasion of Green Bay, Lake Michigan by dreissenid mussels. Aquatic Invasions 3(1): 21-27

Donohue & Associates, Inc. 1976. Brown County Water Plan. Prepared for the Brown County Planning Commission.

Elliott, R.F., and B.J. Gunderman. 2008. Assessment of Remnant Lake Sturgeon Populations in the Green Bay Basin, 2002-2006. Final Report to the Great Lakes Fishery Trust. Project Number 2001.113/2004.610. 106 pp.

Genskow, K., and D. Wood. 2010. Views on Lower Fox and Green Bay Water Resources: Responses from Urban Residents (Draft Report). University of Wisconsin – Extension Environmental Resources Center.

Harris, V.A. 1998. Waterfowl use of Lower Green Bay before (1977-78) and after (1994-1997) zebra mussel invasion. University of Wisconsin – Green Bay. 97 pp

Integrated Paper Services, Inc. 2000. A macroinvertebrate study of the depositional "soft" substrates of the Lower Fox River, Wisconsin – 1999. Project 5015. Monitoring Study Series Report No. Four

Paoli, T. 2011. Green Bay Yellow Perch. *In* Lake Michigan Management Reports – 2011. Wisconsin Department of Natural Resources

Qualls, T.M, H.J. Harris, V.A. Harris and V. Medland. 2012. The State of Green Bay (Draft)

Rowe, D., S. Hogler, and R. Lange. 2011. Walleye in Southern Green Bay. *In* Lake Michigan Management Reports – 2011. Wisconsin Department of Natural Resources

Rupp, D.L., J.L. Kaster. 2011. Benthic habitat survey and historical ecosystem evaluation of the Lower Green Bay. UW-Milwaukee WATER Institute unpublished report, 2011

Sager, P.E. and S. Richman. 1991. Functional interaction of phytoplankton and zooplankton along the trophic gradient in Green Bay, Lake Michigan. Canadian Journal of Fisheries and Aquatic Science 48:116-122.

Stratus Consulting Inc. 1999. Injuries to Avian Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment Final Report. Prepared for USFWS, USDOI, USDOJ. Accessed online 10/12/2012 at http://www.fws.gov/midwest/es/ec/nrda/FoxRiverNRDA/documents/bird.pdf

Trimbee A.M. and Prepas, E.E. 1987. Evaluation of total phosphorus as a predictor of the relative biomass of blue-green algae with emphasis on Alberta lakes. Can. J. Fish Aquatic Sci. 44:1387-1342.

Weigel, B. 2011. Introduction to Standardized Collection and Assessment of Macroinvertebrates in Nonwadeable Rivers of Wisconsin. WDNR unpublished report, June 2011

Weigel, B.J. and J.J. Dimick. 2011. Development, validation, and application of a macroinvertebrate-based Index of Biotic Integrity for nonwadeable rivers of Wisconsin. Journal of the North American Benthological Society. 30(3):665-679

Welsh, A.B., Elliott, R.F., Scribner, K.T., Quinlan, H.R., Baker, E.A., Eggold, B.T., Holtgren, J.M., Krueger, C.C., May, B. 2010. Genetic guidelines for the stocking of lake sturgeon (*Acipenser fulvescens*) in the Great Lakes basin. Great Lakes Fish. Comm. Misc. Publ. 2010-01.

Wires, L.R., S. J. Lewis, G. J. Soulliere, S. W. Matteson, D. V. "Chip" Weseloh, R. P. Russell, and F. J. Cuthbert. 2010. Upper Mississippi Valley / Great Lakes Waterbird Conservation Plan. A plan associated with the Waterbird Conservation for the Americas Initiative. Final Report submitted to the U. S. Fish and Wildlife Service, Fort Snelling, MN.

WDNR. 1988. Lower Green Bay Remedial Action Plan. 319 pp. PUBL-WR-175-87 REV 88 Accessed online 10/12/2012 at http://dnr.wi.gov/topic/greatlakes/documents/LowerGreenBayRAP.pdf

WDNR. 1993. Lower Green Bay Remedial Action Plan Update. 267 pp. Accessed online 10/12/2012 at http://dnr.wi.gov/topic/greatlakes/documents/LowerGreenBayRAPupdate.pdf

WDNR. 2009. Lower Green Bay and Fox River Area of Concern Delisting Targets. 29 pp. Accessed online 10/12/2012 at http://dnr.wi.gov/topic/greatlakes/documents/LowerGreenBayFinalReport.pdf

WDNR. 2011. Stage 2 Remedial Action Plan Update for the Lower Green Bay and Fox River Area of Concern. 84 pp. Accessed online 10/12/2012 at http://dnr.wi.gov/topic/greatlakes/documents/Stage2RAPGreenBay.pdf

WDNR. 2012. Wisconsin 2012 Consolidated Assessment and Listing Methodology (WisCALM) for Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting. 3200-2012-01, Amended Version 1. Bureau of Water Quality. 73 pp. Accessed online 10/12/2012 at http://dnr.wi.gov/topic/surfacewater/documents/FINAL_2012_WisCALM_04-02-12.pdf

WDNR. 2012. Green Bay Great Lakes Spotted Musky Management Plan. 15 pp.

Wisconsin State Committee on Water Pollution, State Board of Health, and Green Bay Metropolitan Sewerage District. 1938 - 1939. Investigation of the pollution of the Fox and East Rivers and of Green Bay in the vicinity of the City of Green Bay. 242pp

(page left intentionally blank)

APPENDICES

Appendix A – Lower Green Bay and Fox River BUI Tracking Matrix
Appendix B – WDNR and DHS Fish Consumption Advisory Fact Sheet (summer 2011)
Appendix C – Fish and Wildlife Populations and Habitat Actions Table
Appendix D – WDNR Assessment Criteria for Fish Tumors or Other Deformities BUI

Appendix A

Note that projects listed in the table below are the next clearly delineated action steps that have been identified by WDNR 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.

Appendix A

Lower Green Bay and Fox River BUI Tracking Matrix

(page left intentionally blank)

Lower Green Bay and Fox River BUI Tracking Matrix

Beneficial Use Impairment Name	Status assessment needed? If yes, is it scheduled? (If yes, provide dates)	Actions/Tasks Needed	Funding Source; estimated cost if known	Action status: In progress, Completed, Not started	Project type*	Project Lead	Timeframe for Project Completion	Comments
Restrictions on Fish and Wildlife Consumption	Yes, scheduled (2013-2015)	Waterfowl Consumption Advisory Update	USEPA	In progress	1	WDNR – Sean Strom	3 years	10 samples from 3 species (resident mallards, scaup, and resident Canada geese) would be collected each year for 3 years.
Tainting of Fish and Wildlife Flavor (suspected)	Yes, could be conducted in 2013	Survey of Lower Fox and Green Bay Anglers	Miminal cost if completed with creel survey or online	Not started	1	WDNR	1 year	Assess the current status of suspected impairment through questions targeted at anglers in the AOC.
Degradation of Fish and Wildlife Populations	Yes, some in progress, some not scheduled	See Appendix C	Various/unknown	Not started / In progress		Various		
Fish Tumors or other Deformities (suspected)	Yes, not scheduled	BUI Assessment following WDNR criteria (when appropriate)	$86,900 for intensive sampling (200 white suckers); $83,500 for comparison site sampling if needed	Not Started	1, 2	WDNR	TBD based on preliminary results of USFWS-USGS study	Evaluate data collected by USFWS-USGS in 2010 & 2011 to determine if appropriate to collect additional fish to evaluate current status relative to WDNR criteria.
Bird/animal deformities or reproduction problems	Yes	Define necessary monitoring & seek additional funding (if needed)	TBD	Not Started / In progress (tree swallows)	1 and/or 5	Not Identified	Within 5 years.	BUI removal will depend on completion of contaminated sediment remediation; however, should take the opportunity to request funds through GLRI if needed. Data from GLRI award to

Beneficial Use Impairment Name	Status assessment needed? If yes, is it scheduled? (If yes, provide dates)	Actions/Tasks Needed	Funding Source; estimated cost if known	Action status: In progress, Completed, Not started	Project type*	Project Lead	Timeframe for Project Completion	Comments
								USGS (C. & T. Custer) will assist in determining the current status of this impairment once they are available.
Degradation of Benthos	Yes. 1) Fox River assessment in 2012. 2) Green Bay Assessment not scheduled	1) 2012 USGS Benthos Assessment in Fox River 2) Additional benthos collection in the Lower Bay.	1) USEPA 2) Unknown	1) In Progress 2) Not started	1	1) USGS – Amanda Bell 2) Not identified.	1) 2 years 2) Not identified.	
Restrictions on Dredging Activities	No	No additional tasks beyond completion of contaminated sediment remediation.						
Eutrophication or Undesirable Algae	No	1) TMDL Implementation Plan Development 2) Tile drain mapping project	1) Various 2) Unknown; $88,500.	1) Not Started 2) Not started	3, 4	1) WDNR and partners 2) The Nature Conservancy		TMDL is approved. Developing a detailed implementation plan for the TMDL is the next step.

Beneficial Use Impairment Name	Status assessment needed? If yes, is it scheduled? (If yes, provide dates)	Actions/Tasks Needed	Funding Source; estimated cost if known	Action status: In progress, Completed, Not started	Project type*	Project Lead	Timeframe for Project Completion	Comments
Restrictions on Drinking Water or Taste/Odor Problems	Yes	Review of current status of this impairment	Unknown	Not started	1 and/or 5	WDNR	2013	WDNR should convene a technical workgroup in 2013 to identify the current status of this impairment relative to the 2009 Target. Consideration may be given to comparing the types of treatment used by communities drawing water from Lake Winnebago, upstream of the AOC.
Beach Closings/Recreational Restrictions	Yes	Determine current status relative to blue-green algae target; Bay Beach E. Coli monitoring and engineering to improve beach	WDNR AOC Capacity Grant $2,919; EPA Urban Waters Grant $59,995	In progress; In progress	1	WDNR with GBMSD and Technical Ctte; Bay-Lake Regional Planning Commission	As data become available	E. coli data collected by Brown County health department indicate good water quality overall. Blue-green data indicate toxin levels are above target. Bay Beach E. Coli monitoring data will be used to identify action plan to improve beach.
Degradation of Aesthetics	Yes, 2011 and subsequent years	Volunteer Monitoring of Aesthetics	WDNR capacity grant; approximately $5,000 for at least 5 more years.	In progress	1,4,5	WDNR	When target is met (at least 2017)	Target calls for 5 years of favorable monitoring data (good aesthetics scores). This BUI also depends on achieving the goals identified in the TMDL for

Beneficial Use Impairment Name	Status assessment needed? If yes, is it scheduled? (If yes, provide dates)	Actions/Tasks Needed	Funding Source; estimated cost if known	Action status: In progress, Completed, Not started	Project type*	Project Lead	Timeframe for Project Completion	Comments
								total suspended solids and total phosphorus.
Degradation of Phytoplankton and Zooplankton populations	Yes, 2012	2012 USGS Plankton Assessment	USEPA	In Progress	1	USGS – Amanda Bell	2013 (final report)	BUI removal will depend on reducing excessive nutrient loads from the Lower Fox River watershed to Green Bay.
Loss of Fish and Wildlife Habitat	Yes, some in progress, some not scheduled	See Appendix C; Point Sable habitat restoration (UWGB and USFWS lead); *Phragmites* inventory & control	Phase II of Point Sable habitat restoration: unknown; *Phragmites* inventory & control: unknown, $1,000,000 for 3 years	In progress / Not Started	3		3 years	Point Sable habitat restoration Phase I in progress; will need funding for additional phases (est. cost Phase II $50,000). Phragmites inventory and control project proposed for AOC and tributaries up to maximum water level.

*Project types:

1 Baseline assessment through data gathering
2 Compile & analyze existing data
3 On-the-ground remediation or restoration project
4 Stakeholder engagement and/or community education & outreach
5 Verification of target achievement through monitoring or other documentation

Appendix B

WDNR and DHS Fish Consumption Advisory Fact Sheet (summer 2012)

Fish Consumption Advice for Green Bay and the Lower Fox River Area of Concern

Why should I eat fish?

Young angler's catch from the Peshtigo River.

Fish are a nutritious family food. Modest amounts of fish can provide health benefits, although little additional benefit is gained by eating more than 1-2 servings per week. Some of the benefits of catching and eating fish include:

- Low cost and fun to catch your own fish
- Low in fat, yet high in protein
- Great source of vitamins, minerals, and omega-3 fatty acids

However, polychlorinated biphenyls (PCBs) in Green Bay and the Fox River pose health risks and prompt the need for fish consumption advisories *(see the next two pages for advice)*.

What are polychlorinated biphenyls (PCBs)?

PCBs are man-made chemicals that were used in electrical equipment, industrial processes, and manufacturing and recycling of carbonless copy paper. PCBs were discharged into the Fox River for decades before it was discovered that these chemicals build up in the environment and pose health risks to humans and wildlife. Restrictions on PCB use, manufacturing, and disposal began in the 1970's, but PCBs remain in the sediment of these rivers. Wisconsin and the federal government are working with responsible parties to remediate PCB contaminated sediments in the Lower Fox River and Green Bay. For more information please visit http://dnr.wi.gov/org/water/wm/foxriver/

Tell me about PCBs in fish and what types of fish are safe to eat.

- PCBs are resistant to degradation and bioaccumulate to higher concentrations through the food chain
- Younger, smaller fish have lower amounts of PCBs than larger, older predator fish
- PCBs accumulate in the fatty tissue, so fatty fish such as carp and catfish have higher levels of PCBs.

What are the health risks?

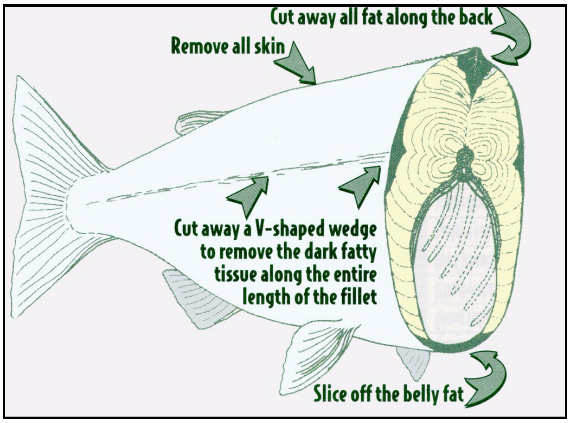
PCBs are stored in your body fat for years. Your health risk may increase as you eat more fish that are high in PCBs. Health risks include:

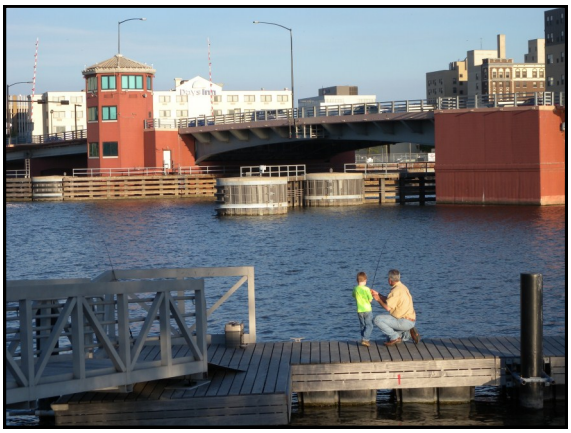
- Developmental impairments in children
- Harmful to the reproductive system
- Associated with a higher risk of cancer
- Harmful to the immune system
- Alters thyroid hormones

How should I prepare and cook my fish?

Proper cleaning and cooking techniques can reduce PCB levels by up to 70%. Follow the following preparation techniques:

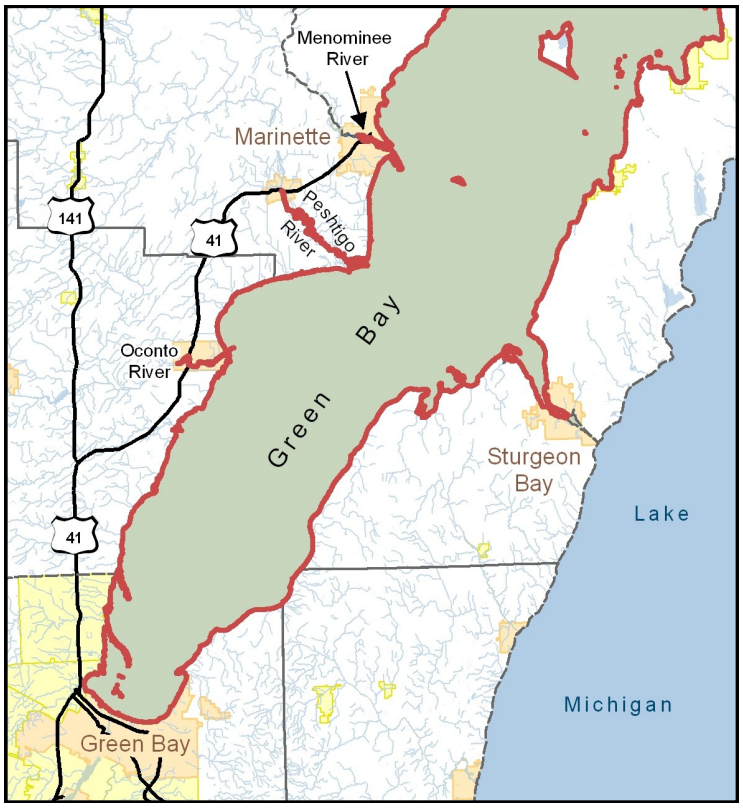
- Fillet your fish
- Remove the skin
- Trim away belly fat, fat on the backsides and fatty dark meat
- Do not eat the eggs
- Bake, broil, or grill
- Discard all liquids and frying oils





Family fishing at Leicht Park in Green Bay.

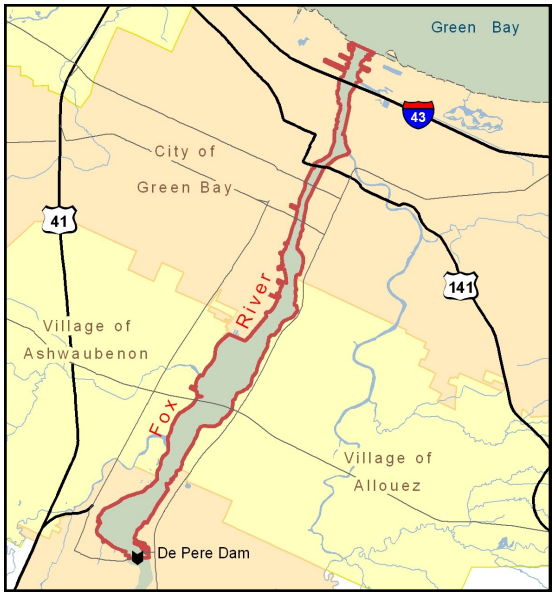
Western shore of the Fox River near the Highway 172 bridge.



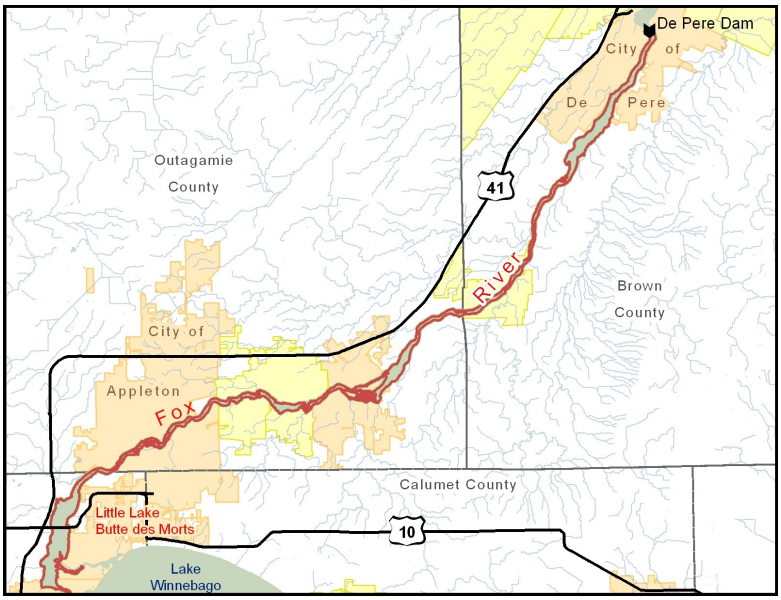
Green Bay and its tributaries (except the Lower Fox) south of Marinette

Green Bay south of Marinette and its tributaries (except the Lower Fox) including the Menominee, Oconto, and Peshtigo Rivers from their mouths up to the first Dam				
Species	Eat no more than 1 meal/week	Eat no more than 1 meal/month	Eat no more than 1 meal every 2 months	**Do Not Eat**
Yellow perch, White sucker, Burbot	All sizes			
Northern pike, Rainbow trout, Sheepshead, Walleye, Lake whitefish		All Sizes		
Smallmouth bass	Under 17”	Over 17”		
Chinook salmon		Under 30”	Over 30”	
Channel catfish, White perch			All Sizes	
Brown trout		Under 28”		**Over 28”**
Muskellunge			Over 50”	
Carp, Sturgeon, White bass				**All Sizes**

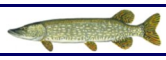
See the WDNR’s website or the *Choose Wisely* booklet for further information on fish safe-eating guidelines. http://dnr.wi.gov/topic/fishing/



Fox River from the De Pere Dam to the mouth



Fox River from Little Lake Butte des Morts to the dam in De Pere

Species	Unrestricted	Eat no more than 1 meal/week	Eat no more than 1 meal/month	Eat no more than 1 meal every 2 months	**Do Not Eat**
Fox River from the De Pere Dam downstream to the mouth					
Black crappie, Bluegill, Lake whitefish, Rock bass, Smallmouth bass, White sucker, Yellow perch			All Sizes		
White perch				All sizes	
Northern pike 			Under 33”	Over 33”	
Sheepshead			Under 19”	19” - 23”	**Over 23”**
Walleye			Under 21”	21” - 25”	**Over 25”**
Carp, Channel catfish, Big-mouth buffalo, White bass					**All Sizes**
Fox River from Little Lake Butte des Morts downstream to the dam at De Pere					
Channel catfish, Northern pike, Walleye, White bass, White perch, Yellow perch			All Sizes		
Bluegill, Crappie, Sunfish	All Sizes*	All Sizes**			
All other gamefish		All Sizes*	All Sizes**		
Carp					**All Sizes**

* Men and older women
** Women of childbearing age and children under 15

See the WDNR’s website or the *Choose Wisely* booklet for updates on fish safe-eating guidelines. http://dnr.wi.gov/topic/fishing/eatyourcatch.html

Summer 2012

Appendix C

Fish and Wildlife Populations and Habitat Actions Table

This table lists actions necessary to remove the "Degraded Fish & Wildlife Populations" and "Loss of Habitat" Beneficial Use Impairments in the Lower Green Bay and Fox River AOC.
X = action benefits listed fish/wildlife/habitat groups

				Fish							Wildlife						Habitats				
		Timeframe		Walleye	Northern Pike	Yellow Perch	Lake Sturgeon	Great Lakes Spotted Muskellunge	Centrarchids	Forage Fish	Colonial Nesting Birds	Waterfowl	Mammals	Marsh Birds	Shorebirds	Amphibians and Reptiles	Wetlands	Shoreline	Hydrologic Connections	Water Quality	Rocky Reefs
	Actions	**Start**	**Complete**																		
Global	Complete Lower Fox Contaminated Sediment Remediation Project.	Ongoing	2017 (Estimated)	X	X	X	X	X	X	X	X	X	X	X	X	X				X	
	Implement actions to achieve TMDL Total Phosphorus and Total Suspended Solids targets for improved water quality, and water clarity and growth of submerged aquatic plants in the lower Bay.	Ongoing	Long	X	X	X	X	X	X	X	X	X	X	X	X	X				X	
Habitat Assessment & Planning	1A - AOC assessment of shoreline and wetlands habitat to determine baseline conditions, establish specific objectives for habitat BUI, and evaluate success of restoration projects. Include identification of wetlands to target for acquisition, inventory of existing habitat behind bulkhead lines (especially on the west shore of Green Bay) to identify priority areas to target for protection, and a habitat threat assessment by collecting planning documents (Harbor Comission, City of Green Bay, Port Strategic Plan, and Brown County) to look for potential conflicts between remaining habitat and proposed future development.	Short	Short														X	X	X	X	X
	1B - Cat Island Restoration Planning - develop specific goals for target species and conceptual design for final habitat (desired topography, soil ammendments, substrate types, control of pioneer invasive species)	Short	Ongoing		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
	1C - Maintain aquatic invasive species barriers in local plans.	Ongoing	Ongoing															X			
Fish Populations**	**Spawning**																				
	Determine need for additional spawning rock enhancements at Joliet Park, Lone Tree Island near frying pan shoal, and/or offshore South Bay Marina and below De Pere dam	Short	Short	X (goal met)			3		1												
	Determine need for additional spawning vegetation enhancements within AOC	Short	Short		1	2		2	2	1											
	Determine need for additional habitat connectivity for all life stages	Ongoing	Short		2	3	2			2											
	Juveniles																				
	Quantify juvenile habitat use, recruitment, and predation	Short	Short		3		1	2	3	3											
	Assessment																				
	Expand WDNR creel and commercial fish census in Brown County	Short	Ongoing		4	4	1	2	4												
	Better characterize adult fish populations, growth, & survival			X (goal met)	4	1	4	3	5												
	Habitat																				
	Conduct habitat enhancement if appropriate based upon the results of habitat and recruitment surveys		Medium	X (goal met)	5	5	5	4	6												
	Stocking																				
	Initiate streamside sturgeon rearing to increase numbers of adults returning to the Lower Fox.	Long	Long				5														
	Continue stocking of Great Lakes spotted muskellunge until sufficient natural reproduction occurs to maintain population	Ongoing	Long					1													

* Ongoing, Short (0-5 years), Medium (5-10 years), Long (10+ years)
** Numbers in columns indicate priority for Fish Populations Actions

		Timeframe		Fish							Wildlife						Habitats				
	Actions	Start	Complete	Walleye	Northern Pike	Yellow Perch	Lake Sturgeon	Great Lakes Spotted Muskellunge	Centrarchids	Forage Fish	Colonial Nesting Birds	Waterfowl	Mammals	Marsh Birds	Shorebirds	Amphibians and Reptiles	Wetlands	Shoreline	Hydrologic Connections	Water Quality	Rocky Reefs
Wildlife Populations	Measure contaminants in waterfowl to determine if current consumption advisory is warranted.	Ongoing	Short									X									
	Measure contaminants in colonial waterbirds and/or tree swallows (possible surrogate for biota following contaminated sediment remediation).										X										
	Count migrating waterfowl in Green Bay to evaluate population status relative to targets.	Ongoing	Short									X									
	Count muskrat houses in emergent marshes using aerial photos to determine current population status.	Short	Short										X								
	Phone survey of local trappers (if they expect to encounter mink in the lower Bay then population has met target)	Short	Short										X								
	Conduct baseline population survey for snapping & painted turtles in Lower Bay															X					
	Frog populations survey	Short	Ongoing													X					
	Bird survey using DNR methods	Short	Ongoing											X							
Habitat Protection, Rehabilitation and Enhancement	Complete Cat Island Chain restoration	Ongoing	Long		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
	Control Phragmites in Green Bay West Shore Conservation Opportunity Area (west shore south to mouth of Duck Creek).	Ongoing	Ongoing		X							X	X	X	X	X	X	X	X		
	Restore west shore wetland hydrologic connections to Green Bay in Barkhausen Creek Watershed and other known pike spawning sites.	Ongoing	Ongoing		X	X				X	X		X			X					
	Complete currently proposed dam removals on Duck Creek in golf course and Pamperin Park.	Ongoing	Short	X	X				X	X											
	Remove Nicolet Dr. bridge blockage at cement culvert									X											
	Point Sable wetlands protection, invasive species control, and connection to bay.	Ongoing	Short		?	?		?		X	X	X	X	X	X	X	X	X	X	X	
	Enhance wetlands and manage invasive species at Corrections/DNR site, slough near Tower Dr., and near Heritage Hills.		Medium		X	?			?	X	X	X	X	X	X	X				X	
	Enhance shoreline at various locations possibly including: Ashwaubomay Park, Brown County Fairgrounds, or others identified by habitat assessment.		Medium	X																X	
	Neville public museum shoreline reconstruction - terraces to create backwater habitat & connect people to waterfront.		Medium	X					X												
	Improve in-stream habitat in Ashwaubenon and Dutchman's Creeks for fish spawning & nursery areas.		Medium		X	X			X	X											
	Peats Lake vegetation enhancement and management including research on the impact of carp on submersed aquatic plants.		Long		X	X	X	X	X	X	X	X	X	X	X	X	X			X	

* Ongoing, Short (0-5 years), Medium (5-10 years), Long (10+ years)
** Numbers in columns indicate priority for Fish Populations Actions

Appendix D

WDNR Assessment Criteria for Fish Tumors or Other Deformities BUI

Lower Green Bay and Fox River Fish Tumor Evaluation (May 2012 draft)

Causes of Habitat Impairment within AOC Addressed by Project

The International Joint Commission (IJC) lists "fish tumors or other deformities" as a beneficial use impairment (hereafter "fish tumor BUI") within areas of concern (AOC) in Annex 2 of the 1987 Protocol Amending the Great Lakes Water Use Impairment. The IJC subsequently stated that this BUI could be deemed to be not impaired when "the incidence of fish tumors or other deformities do not exceed rates at unimpacted control sites or when survey data confirm the absence of neoplastic or preneoplastic liver lesions in bullheads or suckers" (IJC 1991). The Lower Green Bay and Fox River AOC BUI listing includes the fish tumor impairment as "suspected".

Beneficial use impairment removal targets were established by Wisconsin Department of Natural Resources (WDNR) staff in collaboration with numerous partners in 2008 and 2009. A removal target in the Green Bay and Lower Fox River AOC for the fish tumor has not been set due to its "suspected" nature. However, the most recent Stage 2 remedial action plan update for the Lower Green Bay and Fox River Area of Concern states that "The current status of this BUI will be evaluated against these criteria when it is deemed appropriate by WDNR in consultation with the Lower Green Bay and Fox River AOC Science and Technical Advisory Committee."(WDNR 2011). The criteria are outlined below and although the Science and Technical Advisory Committee has not been formally consulted, efforts are in progress.

Toxic Sediments

The fish tumor BUI is inherently linked with the association between toxic sediments and fish tumor prevalence including chemical contaminants and polynuclear aromatic hydrocarbons (PAH) (Baumann et al. 1996). Some remediation has been completed in the Green Bay and Lower Fox River AOC and historical data are limited. It is possible that fish tumor incidence rates are equivalent to background rates. As such, the fish tumor BUI will be considered for removal if tumor incidence rates are lower than a rate that is generally thought to be the background rate in the Great Lakes. If fish tumor incidence rates are above or not significantly below general background rates, a comparison to a suitable reference site can be made. If neither investigation suggests that the fish tumor BUI be considered for removal, further sediment remediation should be undertaken and the tumor sampling repeated.

Site Specific Population Target for Species

Understanding the extant tumor rate within the Green Bay and Lower Fox River AOC is the first priority in determining whether the fish tumor BUI should be removed. Target rates of 5% of neoplastic tumor incidence were suggested for benthic species in the Great Lakes as indicative of "environmental degradation" (Baumann et al. 1996). Since that time, additional work has been completed to further refine the background tumor incidence rate. Baumann (2010) characterized a background tumor rate of 2% in Great Lakes areas considered as "urban or having a low/moderate pollution level without a major point source". We view a tumor incidence of 5% or lower with a 95% certainty as a threshold for fish tumor BUI removal. If sufficient sampling suggests that the fish tumor rate is below 5% we believe that the fish tumor BUI may be considered for removal.

Several of the fish tumor BUI targets developed in 2008 and 2009 by the WDNR and partners suggest that a sample size of 50 fish with a tumor incidence rate of no greater than 5% is a minimum to determine whether tumor incident rate targets have been met. However, there is uncertainty associated with any sample and in the case of tumor incidence. Tumor incidence can be described given the binomial distribution (i.e. a tumor is either present or it is not). For example, with a one sample proportion test the 95% confidence interval associated with an incident rate of 5% from a sample of 60 fish (i.e. 3 fish of the 60 have tumors) is approximately 1% to 14%, while an incidence rate of 5% from a sample of 200 fish is approximately 2% to 8% (R Core Development Team 2010). Similarly, a sample of 50 fish with an incidence rate of 0 has a 95% confidence interval of approximately 0% to 6%. Therefore, with a sample of 50 fish we would be less than 95% certain that the true tumor rate was less than 5%.

Our sampling target is 200 fish. If the 200 fish sample yields below 5% within the 95% CI (i.e. 5 or fewer tumors out of 200) we will consider the site for BUI removal. Similarly, if fewer fish are captured, we will consider the BUI for removal if the 95% confidence interval of the tumor incidence rate is less than or equal to 5%. Although a background tumor incidence rate of approximately 2% may be more appropriate (Baumann 2010), the most likely point estimate of 5 or fewer fish out of 200 is 2.5%. As such, given our conservative approach, we feel that a point estimate of 2.5% with a 95% confidence interval that does not include 5% is sufficient to consider BUI removal.

Comparison with Reference Site

If results from the intensive AOC sampling suggest that the upper 95% confidence limit of the tumor incidence rate is not below 5%, we will compare data obtained from the AOC with a suitable reference site which has available data (such as Jackfish Bay in Lake Superior) or data will be collected from a suitable reference site again with the target of 200 fish. We acknowledge that with a 200 fish sample, an $\alpha = 0.05$ (i.e. there is a 1 in 20 chance that we will incorrectly state that the reference is lower than the AOC), and a power of 0.80 (i.e. there is a 1 in 5 chance that we will incorrectly state that the reference and the AOC are the same) we can expect to detect the similarities or differences between about 10% in the reference and 18% in the AOC using a two-sample proportions test (R Core Development Team 2010) for example. Actual detection probabilities will depend on the values obtained from sampling.

Project Goals

- Determine tumor incidence rate in the Green Bay and Lower Fox River AOC for potential consideration of removal of the fish tumor BUI.

Project Coordination

One of the primary goals of remediation projects is to eliminate BUIs within AOCs. This project builds upon ongoing projects in this regard and will at the very least provide a basis for quantitative comparison to reference sites or may provide evidence for removal within the first year depending on the results.

Project Activities

We will collect up to 200 white suckers age-3 and older to and determine tumor incidence rates using methodology developed by Blazer et al. (2006). In addition, 13C content from the collected fish will be analyzed in order to help determine their relative residence time within the Green Bay and Lower Fox River AOC. These data will supplement and benefit from previous similar efforts in the St. Louis Estuary AOC and the Sheboygan River AOC.

Appropriate fish species

Although bullheads *Ameiurus spp*. and suckers *Catostomus spp*. were specifically mentioned in the IJC (1991) BUI definition, numerous species have demonstrated increased tumor rates in association with contaminants. These and other fish species may be appropriate indicators of the toxicity of contaminated sediments. However, while brown bullhead should be utilized when sample sizes are sufficient due to their limited home range and mobility (Sakaris et al. 2005) other species such as white suckers can be used as well. Other species with life history traits that lead to increased transience, such as white sucker and walleye (Becker 1983) can be utilized when it is deemed unlikely that collection of sufficient numbers of brown bullhead. The incidence of brown bullhead is likely low in the Green Bay and Lower Fox River AOC and therefore white suckers will be targeted for sampling. However, since white suckers are less resident than bullhead, we plan to attempt to determine the temporal utilization of AOC using isotope analysis.

Covariates

Fish tumors do not develop instantaneously. As such there has been a demonstrated relationship with factors such as fish age and length (which themselves are obviously correlated) and tumor incidence, older and longer fish generally have a higher tumor incidence rate (Rutter 2010). Similarly, resident fish species will have longer exposures to contaminated sediments than transient fish species. As such, all fish collected for tumor examination will be age-3 or older as this is the age of maturity for many species of fish present in AOC (Becker 1983). In addition, in the case of resident fish such as brown bullhead, covariates such as age and length may be considered. In the case of more transient fish species, covariates of age, length, and proportion of residence within the estuarine environment may be considered. As such, white suckers collected will be measured prior to sample collection, aged after sample collection to confirm the age of each fish, and stable isotope information collected in order help determine relative temporal presence within the AOC.

Tumor definition

The IJC (1991) BUI definition also included the presence of neoplastic and preneoplastic tumors as being evidence for impairment. We will only include neoplastic tumor rates for delisting purposes as defined by Blazer et al. (2006) since factors other than contamination such as viral infection and parasites (Hayes et al. 1990) have been shown to elicit external and preneoplastic tumor responses.

Sampling Strategy and Certainty

There are two nested approaches to statistically determine whether the fish tumor BUI should be removed. First, intensive sampling within the AOC to determine, with a known level of certainty (outlined above), whether the tumor incidence rate is below established target levels for the appropriate fish species (outlined above). Second, if the intensive sampling results suggest that tumor incidence rates may be above target rates, brown bullhead collection at an appropriate reference site will be conducted if data from an appropriate reference site does not currently exist.

Budget

Budget (Intensive): $86,900

External lesion and liver histopathology analyses, 200 white suckers $250/fish - $51,000.
-USGS Leetown Science Center
-13C analysis - $17/fish, 200 fish - $3,400
-University of California-Davis Isotope Laboratory
-Sucker collection – 5 days, $1,500/day - $7,500
-Contract or WDNR Fisheries
-Data management, interpretation (including ageing), and reporting - $25,000
-Contract or WDNR

Budget (Comparison with Reference): $83,500

External lesion and liver histopathology analyses, 200 white suckers $250/fish - $51,000.
-USGS Leetown Science Center
-Sucker collection – 5 days, $1,500/day - $7,500
-Contract or WDNR Fisheries
-Data management, interpretation (including ageing), and reporting – $25,000
-Contract or WDNR

References

Baumann, P. C., I. R. Smith, and C. D. Metcalfe. 1996. Linkages between chemical contaminants and tumors in benthic Great Lakes fish. Journal of Great Lakes Research 22: 131-152.

Baumann, P. C. 2010. Data analysis and fish tumor BUI assessment for the lower Great Lakes and interconnecting waterways. Submitted to Environment Canada. http://www.npca.ca/watermanagement/nrap/documents/Fish%20Tumor%20Assessment_Canadian%20Lower%20Lakes%20%20March2010.pdf

Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press. Madison, WI USA.

Blazer, V.S., J.W. Fournie, J.C. Wolf, and M.J. Wolfe. 2006. Diagnostic criteria for proliferative hepatic lesions in brown bullhead *Ameiurus nebulosus*. Disease of aquatic Organisms 72:19-30.

Hayes, M. A., I. R. Smith, T. H. Rushmore, T. L. Crane, C. Thorn, T. E. Kocal, and H. W. Ferguson. 1990. Pathogenesis of skin and liver neoplasms in white suckers from industrially polluted areas in Lake Ontario. Science of the Total Environment 94: 105-123.

IJC. 1991. International Joint Comission, Restoring beneficial uses in areas of concern, Annex 2. International Joint Commission, Windsor, ON.

R Development Core Team. 2010. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Rutter, M. A. A statistical approach for establishing tumor incidence delisting criteria in areas of concern: a case study. Journal of Great Lakes Research 36: 646-655.

Sakaris, P. C., R. V. Jesien, and A. E. Pinkney. 2005. Brown bullhead as an indicator species: seasonal movement patterns and home ranges within the Anacostia River, Washington D.C. Transactions of the American Fisheries Society 134: 1262-1270.

WDNR. 2011. Stage 2 remedial action plan update for the Lower Green Bay and Fox River Area of Concern. Wisconsin Department of Natural Resources, Office of the Great Lakes, Madison WI 53707.