Monitoring to Address 7 of 11 BUI's – Milwaukee River Estuary AOC
Task 1: Fish Community Surveys
Final Project Report

Final Report for the Great Lakes Restoration Initiative Grant #GL-00E00607-0

Funded by the Great Lakes Restoration Initiative and the United States Environmental Protection Agency

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March 31, 2015

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Acknowledgements

The authors would like to thank the multitude of organizations and 216 individuals that supplied 835 hours of volunteer assistance to support the project, without whom the project could not have been completed. The authors would also like to thank the various landowners that provided access to sampling sites, the Ozaukee County Environment and Land Use Committee (2009 – 2010 County Board Supervisors Donald Dohrwardt, John Hazelwood, William Niehaus, Glenn Stumpf, Timothy Kaul), Ozaukee County Natural Resources Committees (2010 – 2011 County Board Supervisors William Neihaus, Donald Dohrwardt, Timothy Kaul, Joeseph Dean, John Slater), (2011 – 2012 County Board Supervisors Patrick Marchese, Jennifer Rothstein, Joseph Dean, Glenn Stumpf, Timothy Kaul, Rose Hass Leider), (2012 – 2013 County Board Supervisors Patrick Marchese, Jennifer Rothstein, Glenn Stumpf, John Slater, Donald Korinek), (2013-2014 County Board Supervisors Jennifer Rothstein, Donald Dohrwardt, Glenn Stumpf, John Slater, Donald Korinek), (2014 – 2015 County Board Supervisors Jennifer Rothstein, Donald Dohrwardt, Barbara Jobs, Richard Bauzenberger, Thomas Grabow), Steve Galarneau, Will Wawryzn, Brad Eggold, John Lyons, Pradeep Hirethota, Matt Groppi, and Tony Young (Wisconsin Department of Natural Resources); Burke O'Neal (ETS Electrofishing); and Murray Hall (Halltech Aquatic).

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Introduction

The Ozaukee County (County) Planning and Parks Department (Department) Fish Passage Program (Program), a component of the Department's Ecological Division, and its project partners began monitoring activities during 2011 (Project) to address seven of the Milwaukee Estuary Area of Concern (AOC) Beneficial Use Impairments (BUI's). These activities were federally funded through the Great Lakes Restoration Initiative (GLRI) and administered by the United States Environmental Protection Agency (USEPA) under grant #GL-00E00607-0, entitled "Monitoring to Address 7 of 11 BUI's – Milwaukee River Estuary AOC." The Project included water quality monitoring, sediment, and fish community surveys with analyses in portions of the AOC within Ozaukee County and other relevant reaches of the Milwaukee River Watershed in Ozaukee County. Significant benefits for portions of the AOC far beyond Ozaukee County are anticipated. This final report documents the progress and results for Task 1, Fish Community Surveys, under the aforementioned grant.

Through a measured, scientific approach, the Project served as a pilot project that began generating information that may, to certain degrees, be a suitable guide for subsequent efforts targeting two AOC BUIs identified by the Wisconsin Department of Natural Resources (WDNR) and USEPA, specifically:

- Degradation of Fish and Wildlife Populations
- Loss of Fish and Wildlife Habitat

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Project Implementation Personnel

Personnel involved in Project implementation are listed in Table 1.

Table 1: Project Implementation Personnel

Individual	Role in Project	Organizational Affiliation
Rajen Patel	Project Officer	U.S. Environmental Protection Agency
Louis Blume	QA Manager	U.S. Environmental Protection Agency
Andrew Struck	Project Coordinator (Department Director)	Ozaukee County Planning and Parks Department
Thomas Dueppen	Planning & Parks Specialist	Ozaukee County Planning and Parks Department
Matt Aho	Program Manager and QA/QC Manager/Officer	Ozaukee County Planning and Parks Department
Ryan McCone	Program Assistant	Ozaukee County Planning and Parks Department
Luke Roffler	Program Assistant	Ozaukee County Planning and Parks Department
Beth Stuhr	Program Assistant	Ozaukee County Planning and Parks Department
Kristina Kroening	Program Assistant	Ozaukee County Planning and Parks Department
Cynthia DeGroot	Office Assistant	Ozaukee County Planning and Parks Department
Multiple	Department Intern(s)	Ozaukee County Planning and Parks Department

Project Timeline

On 1/20/10, the Ozaukee County Environment and Land Use Committee authorized the Ozaukee County Planning and Parks Department (Department) to submit a grant application to USEPA for water quality monitoring, sediment contamination sampling, and fish community surveys in Milwaukee River Watershed in Ozaukee County. On 8/30/10, the Department, with the support of several Department partners, submitted a grant application to the United States Environmental Protection Agency (USEPA) Region V Offices entitled "Monitoring to Address 7 of 11 BUI's – Milwaukee Estuary AOC" under the 2010 Great Lakes Restoration Initiative (GLRI) Request For Proposals (RFP). On 9/30/10, USEPA announced that Ozaukee County was awarded $491,000 in GLRI funding for its "Monitoring to Address 7 of 11 BUI's – Milwaukee Estuary AOC" project (Project). The Ozaukee County Board of Supervisors formally accepted this award at its 10/6/10 meeting and the contract was executed by the Ozaukee County Administrator on 10/10/10.

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2012 No Cost Time Extension

The original project end date listed in the initial award document was 12/31/12. After discussions with USEPA staff, Ozaukee County submitted a formal no-cost one year time extension request to USEPA staff on 9/14/12. The request extended the project period from 1/1/13 through 12/31/13, outlined remaining work to be completed and addressed scheduling deficiencies caused by:

- Equipment and consultant procurement delays as a result of the QAPP approval process.
- 2012 drought conditions and abnormally low water levels throughout the entire year, which likely resulted in non-baseline fisheries and continuous water quality data, did not produce necessary "high flow" conditions and rain events to complete discrete water sampling activities, and delayed access to sediment sampling sites and activities.

The no-cost time extension was formally approved by USEPA on 10/25/12.

2013 No Cost Time Extension

After additional discussions with USEPA staff, Ozaukee County submitted a formal no-cost one year time extension request to USEPA staff on 11/13/13. The request extended the project period from 1/1/14 through 12/31/14, outlined remaining work to be completed and addressed scheduling deficiencies caused by:

- 2013 abnormal spring precipitation and summer drought conditions not producing field conditions safe or adequate to preform Task 2 discrete water sampling activities per the standard operating procedures outlined in the QAPP.

The no-cost time extension was formally approved by USEPA on 11/14/13. Both time extensions and approval letters and included as Appendix E.

Problem Definition/Background:

Milwaukee Estuary Area of Concern (AOC) Beneficial Use Impairments (BUI's)

The Milwaukee Estuary was designated an Area of Concern (AOC) during the 1980s due to historical modifications and pollutant loads. The Milwaukee Estuary Remedial Action Plan and Delisting Targets Report have been subsequently released and updated. They document 11 beneficial use impairments (BUIs) effecting the AOC as well as proposed delisting targets and actions for each BUI. The original boundaries of the AOC included the lower 5 km of the Milwaukee River downstream of 35th Street; the lower 4 km of the Kinnickinnic River downstream of Chase Avenue; the inner and outer harbors; and the nearshore waters of Lake Michigan, bounded by a line extending north from Sheridan Park to the city of Milwaukee's Linnwood water intake (WDNR 2014). In 2008, the boundaries were expanded to address sites that contributed significant loads of contaminated sediments to the estuary, including Cedar Creek downstream of Bridge Road to the confluence with the Milwaukee River, in Ozaukee County (WDNR 2014). Figure 1 shows the original and expanded boundaries of the Milwaukee Estuary Area of Concern.

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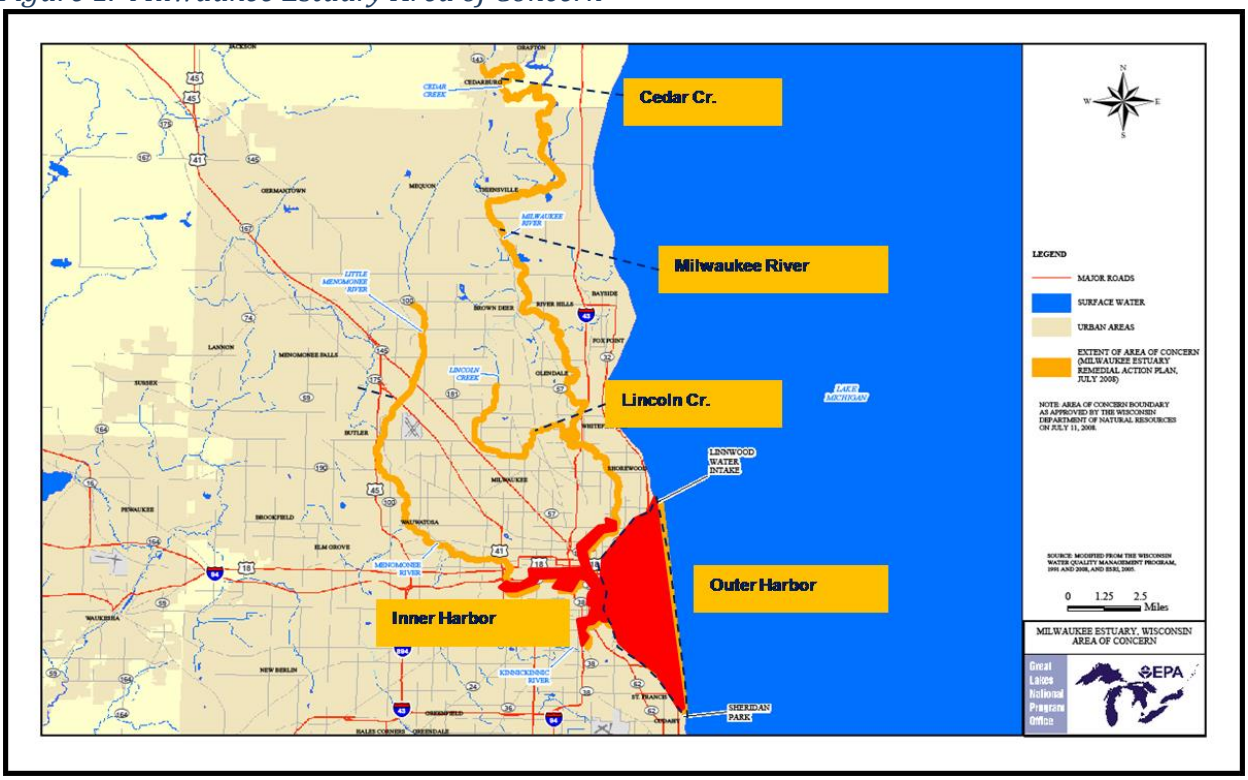
Figure 1. Milwaukee Estuary Area of Concern



This Project included the sampling and assessment of existing fish communities and potential native indicator fish species populations in Ozaukee County portions of the Milwaukee River Watershed. Through a measured, scientific approach this can serve as a pilot project that begins generating information that may be a suitable guide for subsequent efforts targeting two AOC BUIs identified by the WDNR and USEPA, specifically:

- Degradation of Fish and Wildlife Populations
- Degradation of Fish and Wildlife Habitat

A number of specific BUI delisting targets and actions established in the 2008 Milwaukee Estuary AOC report guided Project goal determinations (SEH and ECT 2008). These delisting targets and actions included:

- Establishes site specific local population targets for native indicator fish and wildlife species within the AOC.
- Populations for native indicator fish species are statistically similar to populations in reference sites with similar habitat but little to no contamination.
- Determine population trends for native fish species in the AOC.
- A local fish and wildlife habitat management and restoration/rehabilitation plan has been developed for the entire AOC that, amongst other things, establishes site-specific habitat and population targets for fish and wildlife species within the AOC.
- The programs and actions necessary to accomplish the recommendations identified in the fish and wildlife management and restoration plan (see above) are implemented, and modified as needed to ensure continual improvement.

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Ozaukee and Milwaukee Counties each contain a portion of the Milwaukee Estuary AOC. These two counties also contain 55 miles of mainstem Milwaukee River channel, approximately 28 miles (50.9%) of which is in the AOC and 37 miles (67.3%) of which are in the Project Area. Free flowing channel comprises 83.6% (46 miles) of the 55 mainstem river miles, with only 16.4% being comprised of standing water in the Bridge Street Dam (1.0 mile, 1.8%) and Mequon-Thiensville Dam (5.5 miles, 10%) Impoundments or potentially standing water in the Estabrook Dam (2.5 miles, 4.5%) Impoundment (NOAA 2010; WDNR 2005). Further, the Estabrook Dam Impoundment is currently dewatered under state order, thus increasing the total proportion of non-impounded, free-flowing reach to 88.2%.

The Environmental Assessment for Fish Passage in the Milwaukee River Watershed Project presents fish community data collected by the WDNR in impounded and free-flowing portions of the Milwaukee River in Ozaukee County (NOAA 2010). Specifically:

- Sampled free-flowing reaches contained 25 native fish species (83% of the total catch) while sampled impoundments contained only 8 native species (23% of the total catch). That is more than a three-fold difference in native fish species richness.
- The relative abundances of all fish species and native fish species were well over twice as great in free flowing reaches as in sampled impoundments.
- Common carp (*Cyprinus carpio*), an invasive, non-native "tolerant" species were relatively scarce (17% of the total catch) in sampled free-flowing reaches. In fact, in one free flowing reach (i.e., downstream of the now former Lime Kiln Dam impoundment) common carp were absent altogether. Conversely, they comprised the overwhelming majority (77%) of captured fish in sampled impoundments.

Many BUI delisting targets and actions place emphasis on restoring native indicator fish species in the AOC (SEH and ECT 2008). The information available to date suggests native fish species prefer lotic habitats in the Ozaukee County portions of the Milwaukee River.

Milwaukee Estuary AOC Polychlorinated Biphenyl Contamination in Ozaukee County

Cedar Creek, a major Milwaukee River Watershed tributary in Ozaukee County, was historically contaminated with polychlorinated biphenyls (PCBs) from industrial sources in and near Cedarburg, Wisconsin (Baird and Associates Undated). This contamination resulted in an upstream extension of the original Milwaukee Estuary AOC boundary to include contaminated portions of Cedar Creek and all of the mainstem Milwaukee River reaches downstream of the terminal Cedar Creek confluence (SEH and ECT 2008; Figure 2). The Milwaukee River Watershed upstream of the terminal Cedar Creek confluence does not have known historical sources of PCB contamination. PCBs typically adhere to fine sediment particles, a condition that tends to accumulate the contaminant in dam impoundments and other fine sediment accretion locations. The Environmental Assessment for Fish Passage in the Milwaukee River Watershed Project presents WDNR sediment sampling results for two Milwaukee River impoundments within Ozaukee County located upstream of the Cedar Creek terminal confluence (NOAA 2010). Specifically, sediment sampled in the Lime Kiln Dam and Bridge Street Dam impoundments were not found to contain significant levels of PCB contamination. As such, Project fish community sampling conducted in Milwaukee River reaches upstream of the terminal Cedar Creek confluence will be referred to as sampling "uncontaminated" reaches. Conversely, Project fish community sampling conducted in Milwaukee River reaches downstream of the terminal Cedar Creek confluence will be referred to as sampling "contaminated" reaches. Task 3 (Sediment Contamination Sampling) of this overall project further located and evaluated sediment contamination in Ozaukee County portions of the Milwaukee River Watershed. Task 3 activities occurred consecutively with Task 1 activities, and PCB contamination was found in all sampled mainstem areas downstream of Cedar Creek at significantly higher quantities

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than in sampled locations upstream of Cedar Creek. These findings confirm the Task 1 "contaminated" and "uncontaminated" terminology and locations as noted above.

Potential Milwaukee River Reference Conditions

County staff discussions with WDNR staff directly involved with the AOC revealed WDNR interest in potentially using "uncontaminated" Ozaukee County reaches (i.e., those outside the AOC) as "reference reaches" or benchmark control sites for evaluating future restoration activities in other portions of the AOC (M. Burzynski and M. O'Shea, WDNR, personal communication, December 17, 2010). Similarly, it has been suggested that data gathered from the Project's "uncontaminated" reaches could potentially provide initial guidance to subsequent projects designed to establish restoration "targets" for BUI efforts. It should be noted that this Project does not include an experimental design intended to provide inferential statistics applicable to the entire AOC and though the validity of such inferences could be tested, it is not a Project objective. With that disclaimer, County staff members agree that with proper conditions and study designs (and taking into consideration a seemingly deficient number of alternatives) these data uses may be possible. Such comparisons and target values may only be valid for evaluating impacts associated with sediment contamination and in cases where Ozaukee County sites are adequately representative of habitat (or potential habitat) in other AOC sites targeted for restoration. The estuary, harbor, near shore areas of Lake Michigan, and potentially non-wadeable reaches of the Milwaukee River (i.e., downtown Milwaukee) are likely important exceptions.

Another important point is that current habitat assemblages and fish communities in Ozaukee County "uncontaminated reaches" most likely do not represent historical, pre-disturbance (i.e., "ideal") conditions. Site-specific and systematic improvements to fish habitat and populations in the Milwaukee River Watershed and AOC (particularly in regard to potential native indicator species) should lead to corresponding improvements in Ozaukee County "uncontaminated reaches". As such, County staff members suggest using selected "uncontaminated reaches" for current conditions in the Milwaukee River Watershed and AOC. To the degree practicable, the following are also suggested:

- Ozaukee County and other AOC sampling results be compared and contrasted to available standardized fish population data (Brouder et al 2009).
- A "sliding scale" approach to the accepted habitat and fish community qualities that constitute a "reference" condition. The cumulative effects of systematic restoration of the watershed and AOC should ultimately result in improvements to fish and habitat far beyond specific treatment sites. As such, it is hoped that over time actual conditions (e.g., water quality, native species abundance, etc.) in "uncontaminated" reaches will increasingly resemble those of the pre-disturbance watershed thus increasingly refining the standards by which remediation activities and treatment sites are assessed and evaluated. Maintaining current standards in the future would ultimately be counterproductive.

Potential Native Indicator Fish Species

A primary AOC BUI remediation target is to establish site specific local population targets for native indicator fish and wildlife species within the AOC; however, at the time of workplan and QAPP development, native species suited to be "indicators" were not identified. Regardless, great potential exists for improving native fish species (indicators or otherwise) presence, abundance, and diversity in the Project Area, both within and outside the AOC. Much of the Milwaukee River Watershed in Ozaukee County has recently been managed to improve biological connectivity. Further, municipal and county efforts to improve water quality have been ongoing for decades. Specific native species, such as northern pike (*Esox lucius*), walleye (*Sander vitreus*), and lake sturgeon (*Acipenser fulvescens*) are thought to exist

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in only very limited numbers in the AOC and Project Area. Despite some select species stocking efforts, dramatic abundance increases for these native species are unlikely during the next few years due to slow growth rates, low initial population abundances, inconsistent recruitment, and/or other factors. As such, other suitable native species are suggested as potential "indicators" of overall fishery condition, including smallmouth bass (*Micropterus dolomieu*), golden redhorse (*Moxostoma erythrurum*), rock bass (*Ambloplites rupestris*) and to a lesser extent greater redhorse (*M. valenciennesi*). Milwaukee River electrofishing by WDNR and Ozaukee County staff during 2010 confirmed the presence of these native species. Further, Lyons (1992) classifies smallmouth bass and greater redhorse as "intolerant" of environmental degradation. Finally, each of these three species preys on organisms inhabiting the benthic surface where contact and uptake of contaminated sediments is likely and degradation to benthos would be directly detrimental. As such, they are proposed as potential native indicators of fish habitat and population degradation. Positive presence/absence and relative abundance trends detected for these species, as well as for other, seemingly less abundant potential native indicator species (e.g., northern pike, walleye, lake sturgeon, etc.) could support the effectiveness of actions targeting BUIs.

Project Objectives

Project objectives, derived directly from salient points of the WDNR/USEPA BUI delisting targets and actions, included:

1. Collecting information about existing fish communities and potential native indicator fish species in up to six Ozaukee County reaches of the Milwaukee River within and outside the Milwaukee Estuary AOC (Project Area) to:
    i. Compare and contrast existing Project Area fish populations within and outside the Milwaukee Estuary AOC using sample statistics for descriptive, quantifiable population or community characteristics, metrics, and/or indices (Guy and Brown 2007; Kohler and Hubert 1993; Lyons 1992; Murphy and Willis 1996).
    ii. Compare and contrast existing fish community and population samples in the Project Area to standard sampling indices or other suitable references to the degree practicable in lieu of a known, suitable control or reference system (Brouder et al. 2009; Lyons 1992)
    iii. Collect baseline data to facilitate trending of sample statistics of fish population and/or community characteristics in the Project Area, concentrating on potential native indicator fish species.
2. Collecting some of the baseline information beneficial to the development and implementation of a fish and wildlife management and restoration plan for the AOC.

Applying robust statistical inferences to the entire Project Area or AOC was not a Project objective. This Project is an initial effort or pilot project to describe the fish communities and potential native indicator fish species populations sampled in the Project Area, both qualitatively and with some quantified sample statistics. Estimates of sample variability for many of the fish population and community characteristics listed late in this section may prove useful for estimating requisite sample sizes for subsequent projects. Further, WDNR staff indicated interest in examining the potential to infer Project findings to the Project Area and/or AOC in a statistically valid manner (A. Fayram and D. Dinsmore, Wisconsin Department of Natural Resource, personal communication, March 18, 2011).

The monitoring was designed to yield sample statistics valuable as preliminary guides when considering fish community and population targets and to guide and facilitate subsequent projects larger in scale and sufficient to produce inferable statistics to fish populations and communities in similar reaches of the Milwaukee River Watershed.

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Quality Assurance Project Plan Approvals

A Quality Assurance Project Plan (QAPP) was required for all project tasks per the USEPA contract award document. Department staff met with numerous Program partners and preformed significant research to determine specific data collection metrics and procedures to provide the most benefit to AOC BUI removal criteria. Staff initiated a conference call with the local WDNR AOC coordinator on 12/17/10. WDNR did not provide specific comments or recommendations on the fish survey component during workplan development. A draft QAPP was submitted to WDNR on 2/15/11. General WDNR comments were received on 3/9/11, and a meeting was held on 3/15/11. Elements of WDNR's recommendations were included in the final draft QAPP. The QAPP was divided into three individual QAPP's per WDNR's recommendation on 3/15/11 (Revision 1) and the final draft QAPP was submitted for USEPA approval on 4/1/11 (Revision 2) and approved by USEPA on 5/24/11. QAPP Revision 3 was submitted to USEPA on 10/14/11, which included minor modifications in the QA/QC manager role, scheduling, and references to the final consultant workplans and SOP's, and was approved by USEPA on 10/17/11. QAPP Revision 4 (Appendix F) was submitted to USEPA on 1/4/13, which included timeline modifications and other changes as part of the approved 2012 no-cost one year time extension request, and was approved by USEPA on 1/17/13. All workplan activities followed procedures as outlined in the QAPP's and no data-gathering activities occurred until the initial QAPP was approved.

Electrofishing Sample Sites

The fish communities were sampled in six accessible, wadeable reaches within and outside AOC portions of the Project Area (Appendix A). Of the six reaches sampled, three were within the AOC portion of the Project Area (i.e., "Contaminated" sites) and three were upstream (i.e., "Uncontaminated" sites) of the AOC portion of the Project Area:

- "Contaminated" sites:
    - Con A ("Zarling's")
      Immediately downstream of the Cedar Creek terminal confluence.
      Township 10N, Range 21E, Section 36, Southwest Quarter of Northeast Quarter
    - Con B ("Pioneer Road")
      Downstream of Pioneer Road (County Highway C). Township 9N, Range 22E, Section 6, Northwest Quarter or Northwest Quarter
    - Con C ("River Barn")
      Adjacent to River Barn Park in the City of Mequon
      Township 9N, Range 21E, Section 35, Southeast Quarter of Northeast Quarter
- "Uncontaminated" sites:
    - Uncon A ("Newburg")
      Adjacent to Firemen's Park and downstream of the Newburg Dam in the Village of Newburg. Township 11N, Range 20E, Section 12, Southwest Quarter of Northeast Quarter
    - Uncon B ("Ehlers")
      Adjacent to Ehlers Park in the Town of Saukville. Township 11N, Range 21E, Section 23, Northeast Quarter of Northeast Quarter
    - Uncon C ("Lime Kiln")
      Former Lime Kiln Dam impoundment. Township 10N, Range 21E, Section 25, Northwest Quarter of Northeast Quarter

Sampling site boundaries were documented using a GPS unit with sub-foot accuracy and verified for accuracy and precision by collecting location data for known points (benchmarks) before and after sample site boundary locations are documented.

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Additional "non-wadeable" sample sites were also added in 2013 following the acquisition of a jon boat mounted electrofishing conversion kit. Of the five additional reaches sampled, three were within (i.e., "Contaminated" sites) and two were upstream (i.e., "Uncontaminated" sites) of the AOC portion of the Project Area:

- "Contaminated" sites:
    - Con D ("Upstream of MT Impoundment")
      Milwaukee River upstream of the Mequon-Thiensville Dam impoundment (approximately river mile 25)
    - Con E ("MT Impoundment")
      Milwaukee River Mequon-Thiensville Dam Impoundment in the City of Mequon and Village of Thiensville (river mile 20 through approximately river mile 25)
    - Con F ("MT Tailwater")
      Milwaukee River Mequon-Thiensville Dam Tailwater in the City of Mequon and the Village of Thiensville (approximately river mile 19 to river mile 20)
- "Uncontaminated" sites:
    - Uncon D ("Waubedonia")
      Milwaukee River Waubedonia Park in the Town of Fredonia (approximately river mile 45 to approximately river mile 46)
    - Uncon E ("BSD Impoundment")
      Milwaukee River Bridge Street Dam in the Village of Grafton (river mile 31 to approximately river mile 32)

Field Sampling Methods

All Task 1 activities followed established procedures and protocols as described in the WDNR reviewed and USEPA-approved Quality Assurance Project Plan (QAPP) (Attachment F). All fisheries field data collection was led by experienced Department staff familiar with the Milwaukee River Watershed fish community and all QA/QC oversight procedures as outlined in the QAPP were completed. Fish collection targeted all species present and generally conformed to the "all species" portion of the WDNR protocol for assessing smallmouth bass in wadeable and non-wadeable streams (WDNR Undated a; WDNR Undated b). All sampling was completed during periods of ice-free flow, during safely accessible river discharge levels (as measured at USGS gaging station 04086600). Each site was sampled twice per year, once in summer and once in fall.

Wadeable sampling crews consisted of eight to 21 members, including Department staff and trained volunteers. Sampling was conducted in an upstream direction following a serpentine path to cover all areas of the channel. The Department utilized two barge shockers (SDC-1 Electrofishing Unit, ETS Electrofishing) and six ¼" mesh dipnets (trapezoid dipnet, Loki Nets) for each sampling run. Each electrofishing unit was staffed by three collectors, each using an electrofishing probe and dipnet, and multiple crew members to drag the unit and/or assist with fish handling.

Non-wadeable sampling crews consisted of two to three members, including Department staff and trained volunteers. Sampling was typically conducted in an upstream direction along one contiguous mile of the stream bank. The Department utilized a backpack electrofishing conversion kit (HT-2000, Halltech Aquatic) and one ½" mesh dipnet (square dipnet, Loki Nets) during sampling.

Per QAPP revisions 1-3, all captured fish were identified to species, measured to the nearest tenth centimeter, and checked for external tags/marks and deformities, eroded fins, lesions, and tumors

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(DELTs). After QAPP revision 4 was approved, length distribution was limited to game, indicator, and other target species during 2013 activities. Though not specified in the QAPP, in general, all captured fish greater than 20 cm long received a fin clip correspondent to river section per WDNR guidance. Certain gamefish (e.g., smallmouth bass, northern pike) and redhorse species received passive integrated transponder tags (PIT tags) downstream of the MT Dam as supplies allowed. These same fish were also marked with floy tags with a unique ID number and Department phone number (regardless of location) as supplies allowed. All fisheries field data collection was documented on standardized forms kept on file in the Ozaukee County Planning and Parks Department (Appendix B). Voucher specimens of fish unidentifiable in the field were preserved in general accordance with techniques recognized by the American Fisheries Society (Kelsch and Shields 1996). All voucher specimens were analyzed for taxonomic identification by experienced Department staff using recognized reference documents (Becker 1983, Eddy and Underhill 1978) and kept in Ozaukee County's Planning and Parks Department.

Acquired Data

Data required to achieve the stated Project objectives falls into two basic categories, sampled fish community characteristics and sampling effort.

Fish Community Characteristics

Fish community characteristics determined through direct measurement or observation for all samples included:

1. Total species richness (i.e., the identification and enumeration of all sampled fish species)
2. Native species richness (i.e., the identification and enumeration of all sampled native fish species)
3. Familial richness (i.e., the identification and enumeration of all species with sampled fish families)
4. Intolerant species richness (i.e., the identification and enumeration of all sampled fish species classified as "intolerant" by Lyons (1992))
5. Total sample abundance (i.e., the enumeration of all fish in a sample)
6. Species-specific sample abundance (i.e., the enumeration of all individuals of a given species in a sample)
7. Tolerant species abundance (i.e., the enumeration of all individuals belonging to species classified as "tolerant" by Lyons (1992))
8. Species-specific individual length (cm) distribution (i.e., the distribution of individual fish lengths within each species listed included in a sample)
    a. Length distribution will be limited to game, indicator, and other target species in 2013, as approved on 10/25/12 as a part of the no-cost time extension
9. Sample abundance distribution amongst feeding and spawning guilds (Lyons 1992)
10. Total species frequency of external deformities and lesions (i.e., the frequency of external deformities and lesions across all species within a sample)
11. Native, species-specific frequency of external deformities and lesions (i.e., the frequency of external deformities and lesions within each sampled native fish species)

Sampling Effort

Sampling effort was gauged in three ways, specifically:

1. Sample collection duration (i.e., the enumeration of hours expended sampling each site)

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2. Sample site length (i.e., the channel centerline length measured in meters for wadeable stretches and one mile of continuous connected shoreline for non-wadeable stretches)
3. Sample site water surface area (i.e., measured in square meters, this is the channel centerline length multiplied by an estimate of average channel width determined to the nearest meter using the Ozaukee County GIS)

All Project data was processed by Department staff by entering into MS Excel spreadsheets to facilitate analysis and evaluation. A sub-set equaling no less than 10% of the data entered was verified for both accuracy and consistency with Project goals. Erroneous raw data entries were corrected by replacement with the correct data from field forms.

Analysis

Much of the data generated by the Project was qualitative in nature and intended to facilitate preliminary, non-quantitative and non-inferential comparison and contrast of fish assemblages and native indicator species sampled in "contaminated" and "uncontaminated" sites of the Project Area. Analyses are geared toward suggesting, even if only preliminarily and with some anticipated uncertainty, whether or not detectible differences exist between the sample means of community and population characteristics for sampled fish assemblages in "contaminated" and "uncontaminated" sites. These analyses included:

- Community level sample statistics
  - Total Relative Abundance
  - Native Species Relative Abundance
  - Total Species Richness
  - Native Species Richness
  - Shannon-Wiener Diversity Index – All Species
  - Shannon-Wiener Diversity Index – Native Species
  - Index of Biotic Integrity
- Potential indicator species population level sample statistics
  - Species-Specific Relative Abundance
  - Length-Frequency Distribution
  - Frequency of External Deformities and Lesions

Shannon-Wiener Diversity Index

The Shannon-Wiener Diversity Index requires the determination of the proportion of each species within a sample and is calculated as follows:

$$H = -\sum p_i \ln p_i$$

where p_i is equal to the proportion of individuals in species i. A sample made up of equal proportions of each species would return an H value of 1.0, with more disproportionate samples returning progressively higher H values (Kwak and Peterson 2007).

Index of Biotic Integrity

The Index of Biotic Integrity (IBI) is a means to assess environmental quality through fish community attributes including, but not limited to, total number of native species, total number of intolerant species, percent tolerant species, percent top carnivores, percent simple lithophilous spawners, etc (Lyons 1992). The Project utilized the Wisconsin-specific IBI for sampling in warmwater streams developed by Lyons

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(1992). The IBI calculation returns a score and rating (e.g., Excellent, Good, Fair, Poor, Very Poor) for each sample site.

Population Targets

A primary AOC BUI remediation target is to establish site specific local population targets for native indicator fish and wildlife species within the AOC. However, native species suited to be "indicators" are not identified. Native indicator species for the Project originally included smallmouth bass (*Micropterus dolomieu*), golden redhorse (*Moxostoma erythrurum*), greater redhorse (*M. valenciennesi*), and northern pike (*Esox lucius*). These species were chosen due to native origin, presence in the Milwaukee River in detectable densities, classification as "intolerant" of environmental degradation (Lyons 1992), and/or association with feeding along the benthic surface. Rock bass (*Ambloplites rupestris*) was added to the Project native indicator species following 2011 sampling as the species meets all of the characteristics listed above.

Contaminated vs. Uncontaminated Sites

Parametric data was analyzed using one-factor analysis of variance (ANOVA) to compare sample data collected in "contaminated" and "uncontaminated" sample sites (Zar 1999). Non-parametric data (e.g., diversity indices) and indicator species comparisons were analyzed using Wilcoxon Rank-Sum test. The alpha value for all analyses was set *a priori* at 0.10 because all comparisons were based on a relatively limited number of sample sites and over a fairly small number of sampling events. It should be noted that this Project does not include an experimental design intended to provide inferential statistics applicable to the entire AOC or Project Area and though the validity of such inferences may be tested, it is not a specific Project objective.

Results

All sampling results are included as Appendix D. A brief summary of notable findings is provided below for each seasonal sampling events.

Summer 2011 Sampling

Summer wadeable sampling in 2011 occurred in August during flows ranging from 128 to 333 cubic feet/second (cfs) and water temperatures ranging from 22^{o}C to 27^{o}C (Table 1.1). A total of 38 species were sampled, with the number of fish captured at each site ranging from 111 at River Barn to 1,105 at Newburg (Table 1.2). Richness, relative abundance, diversity, and IBI varied widely from site to site, with significant difference detected between "contaminated" and "uncontaminated" sites in the Shannon-Wiener Diversity Index (W=6, p=0.0500; Table 1.3).

The five indicator species were captured at most sampling locations (Table 1.4). Mean length of smallmouth bass was significantly larger at "uncontaminated" sites (W=6, p=0.0500) and catch/km^2 of rock bass was significantly greater at "uncontaminated" sites (W=6, p=0.0500).

Fall 2011 Sampling

Fall wadeable sampling in 2011 occurred in October during flows ranging from 141 to 285 cubic feet/second (cfs) and water temperatures ranging from 10^{o}C to 19^{o}C (Table 1.5). A total of 32 species were sampled, with the number of fish captured at each site ranging from 111 at Ehlers to 1,329 at

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Newburg (Table 1.6). Richness, relative abundance, diversity, and IBI varied widely from site to site, with no significant difference between "contaminated" and "uncontaminated" sites (Table 1.7).

The five indicator species were captured at most sampling locations (Table 1.8). Smallmouth bass from "contaminated" sites had a significantly greater occurrence of external DELTs (W=6, p=0.0500).

Summer 2012 Sampling

Summer wadeable sampling in 2012 occurred in June and July during flows ranging from 62 to 109 cubic feet/second (cfs) and water temperatures ranging from 20°C to 29.5°C (Table 2.1). A total of 31 species were sampled, with the number of fish captured at each site ranging from 109 at Ehlers to 945 at Newburg (Table 2.2). Richness, relative abundance, diversity, and IBI varied widely from site to site, with no significant difference between "contaminated" and "uncontaminated" sites (Table 2.3).

The five indicator species were captured at most sampling locations (Table 2.4). No significant difference was detected among indicator species in "contaminated" and "uncontaminated" sites.

Fall 2012 Sampling

Fall wadeable sampling in 2012 occurred in September and October during flows ranging from 50 to 65 cubic feet/second (cfs) and water temperatures ranging from 9.4°C to 18°C (Table 2.5). A total of 32 species were sampled, with the number of fish captured at each site ranging from 357 at River Barn to 1,489 at Newburg (Table 2.6). Richness, relative abundance, diversity, and IBI varied widely from site to site, with no significant difference between "contaminated" and "uncontaminated" sites (Table 2.7).

The five indicator species were captured at most sampling locations (Table 2.8). No significant difference was detected among indicator species in "contaminated" and "uncontaminated" sites.

Summer 2013 Sampling

Summer wadeable sampling in 2013 occurred in July and August during flows ranging from 174 to 274 cubic feet/second (cfs) and water temperatures ranging from 19°C to 28.1°C (Table 3.1). A total of 29 species were sampled, with the number of fish captured at each site ranging from 44 at Zarling's to 317 at Newburg (Table 3.3). Richness, relative abundance, diversity, and IBI varied widely from site to site, with no significant difference between "contaminated" and "uncontaminated" sites (Table 3.5).

The five indicator species were captured at most sampling locations (Table 3.7). Mean length of smallmouth bass was significantly larger at "contaminated" sites (W=6, p=0.0500).

Summer non-wadeable sampling in 2013 occurred from April – August during flows ranging from 109 to 1,590 cubic feet/second (cfs) and water temperatures ranging from 10.5°C to 27.1°C (Table 3.2). A total of 21 species were sampled, with the number of fish captured at each site ranging from 20 in the MT impoundment to 54 upstream of the MT Impoundment (Table 3.4). Richness and relative abundance varied widely from site to site, with no significant difference between "contaminated" and "uncontaminated" sites (Table 3.6). No significance testing was completed on diversity or IBI results due to having only two "uncontaminated" sampling sites (the Wilcoxon Rank-Sum test requires at least three).

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The five indicator species were captured less frequently than during wadeable sampling (Table 3.8). No significance testing was completed on the non-wadeable indicator species results, due to having only two "uncontaminated" sampling sites (the Wilcoxon Rank-Sum test requires at least three).

Fall 2013 Sampling

Fall wadeable sampling in 2013 occurred in October during flows ranging from 214 to 458 cubic feet/second (cfs) and water temperatures ranging from 5.9°C to 15.8°C (Table 3.9). A total of 32 species were sampled, with the number of fish captured at each site ranging from 62 at River Barn to 579 at Newburg (Table 3.11). Richness, relative abundance, diversity, and IBI varied widely from site to site, with no significant difference between "contaminated" and "uncontaminated" sites (Table 3.13).

The five indicator species were captured at most sampling locations (Table 3.15). Catch/km^2 of northern pike was significantly greater at "uncontaminated" sites (W=6, p=0.0500) and mean length of rock bass was significantly larger at "uncontaminated" sites (W=6, p=0.0500).

Fall non-wadeable sampling in 2013 occurred in October and November during flows ranging from 169 to 737 cubic feet/second (cfs) and water temperatures ranging from 4°C to 4.5°C (Table 3.10). A total of 25 species were sampled, with the number of fish captured at each site ranging from 6 in the MT impoundment to 188 at Waubedonia (Table 3.12). Richness, relative abundance, diversity, and IBI varied widely from site to site, with significant difference between "contaminated" and "uncontaminated" sites in species richness ($F(1,3)=7.74$, $p=0.069$) and native species richness ($F(1,3)=11.52$, $p=0.043$; Table 3.14).

The five indicator species were captured less frequently than during wadeable sampling (Table 3.16). No significance testing was completed on the non-wadeable indicator species results, due to having only two "uncontaminated" sampling sites (the Wilcoxon Rank-Sum test requires at least three).

Discussion

Analysis of Project Goals and Objectives

The Project yielded significant, relative abundance data (e.g., catches per unit time, stream length, and water surface area) and other sample statistics for comparing, contrasting, and trending fish communities and potential native indicator species populations in sampled reaches of the Project Area (described more fully below). The quality and completeness of generated data were consistent with that previously collected by WDNR in Ozaukee County portions of the mainstem Milwaukee River (NOAA 2010). Further, collected data will facilitate actions to address five BUI Delisting Targets by:

- Establishing preliminary estimates of site specific relative abundance targets for potential native indicator fish species in potentially "contaminated" reaches based on results from a limited number of samples collected from "uncontaminated" reaches in the Project Area.
- Allowing sample statistic comparison and contrast for potential native indicator species in potentially "contaminated" (e.g., PCBs) and "uncontaminated" reaches using relative population parameters, metrics, and indices.
- Making possible (to the degree practicable) comparison and contrast of sample statistics for potential native indicator species in potentially "contaminated" (e.g., PCBs), "uncontaminated" reaches, and regionally-relevant population parameters (e.g., length-frequency distribution) and indices (i.e., IBI).

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- Allowing initiation of potential native fish species sample statistic trending (e.g., relative abundance, length-frequency distribution, species richness, community diversity, guild distributions, etc.) within the Project Area of the AOC.
- Providing a pilot project that may assist subsequent projects by:
  - Suggesting potential native indicator species for population assessments, trending, and monitoring. Potential criteria may include fish species that are:
    - Native
    - Present in the Milwaukee River in detectable densities
    - Present in wadeable and non-wadeable, free-flowing portions of the Milwaukee River during the June 1 – September 30 sampling season
    - Not short-lived (i.e., life spans greater than a year or two)
    - Intolerant of environmental degradation (Lyons 1992)
    - Piscivorous and/or invertivorous
    - Associated with feeding along the benthic surface
  - Assessing/monitoring populations in "contaminated" reaches and "uncontaminated" reaches.
  - Providing sample variance values for use in an experimental design suited to produce inferential statistics.
- Materially contributing information relevant to developing a "fish and wildlife management and restoration plan" for the greater AOC, including:
  - Serving as a methods selection and implementation pilot project for subsequent work at a much larger scale.
  - Providing initial sample estimates of relative abundance for potential native indicator species.
  - Providing baseline fish community and potential native indicator species population sample evaluation for future comparison and contrast to portions of the AOC beyond Ozaukee County with similar habitat characteristics.
  - Clarifying and/or refining our understanding of BUI impacts on Project Area (and perhaps AOC) fish communities.
  - Raising awareness of AOC concerns in Ozaukee County through public outreach opportunities.
- Contributing to implementation of the aforementioned and as yet unwritten AOC "fish and wildlife management and restoration plan" through on-the-ground data collection.

Contaminated vs. Uncontaminated Sites

The Project occasionally detected significant differences between "contaminated" and "uncontaminated" portions of the Watershed, but such differences were sporadic and inconsistent on a year-to-year basis. Extrapolating Project results to the AOC as a whole was not a Project goal and is not possible without a larger sampling effort. However, fisheries monitoring at the locations described above helped fill critical knowledge gaps in the Milwaukee River Watershed, directly complementing ongoing WDNR monitoring. The Project provided valuable baseline information useful for the evaluation of fisheries communities within and upstream of the Milwaukee Estuary AOC. The Project identified several key nursery areas for smallmouth bass and multiple redhorse species, including the Lime Kiln, Ehlers and Newburg reaches.

Fish Movements

In conjunction with the WDNR and US Fish and Wildlife Service (USFWS), the Project also tracked the movements of several fish implanted with floy tags and passive integrated transponder (PIT) tags during monitoring activities, finding extensive movement patterns for several species. Floy tags were equipped

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with a unique ID number and a Department phone number. Each floy tag ID number was noted on field sheets and entered into the electronic database. Department staff received several calls from anglers that had recaptured fish with floy tags. Gamefish were checked for PIT tags using mobile PIT tag readers, and several fish equipped with PIT tags were documented by the automatic PIT tag reader at the exit of the M-T Fishway as they migrated past the M-T Dam.

Volunteer Support

The Project also provided valuable AOC-related education and outreach and volunteer opportunities to area residents, students, and natural resource professionals. Organizations providing volunteer assistance included the WDNR, the Bureau of Land Management, Ozaukee Washington Land Trust, Riveredge Nature Center, Milwaukee Audubon Society, Southeast Wisconsin Chapter of Trout Unlimited, Milwaukee Riverkeeper, Milwaukee Area Technical College, Washington County, Ozaukee County Board of Supervisors, Ozaukee County Land and Water Management Department, Ulao Creek Partnership, Ozaukee Treasures Network, Treasures of Oz, University of Wisconsin-Milwaukee, Stantec, Inc., Inter-Fluve, Inc., Wisconsin Youth Conservation Corps, Milwaukee Community Conservation Corps, and the AmeriCorps NCCC. In total, 216 individual volunteers donated 835 hours to the Project, and several of these volunteers have participated in subsequent Department activities including wildlife monitoring and native vegetation restoration activities at habitat restoration project sites, and have expressed interest in continuing volunteer efforts to support Department goals in the future.

Education and Outreach

As outlined in the original grant narrative, public outreach and information dissemination efforts regarding Project goals, results, and Department partners, was a joint effort between the County and other major stakeholders. Specific outreach activities used to foster public participation and education as part of this Project included:

- Detailed Program information on the Ozaukee County Planning & Parks Department Ecological Division - Fish Passage Program website (http://www.co.ozaukee.wi.us/540/Planning-Parks), as well as other partner websites.
- Detailed Program information on the Program's Facebook page (www.facebook.com/MRWFishPassage) and routine updates via Twitter (www.twitter.com/OzCoFishPassage).
- On-going active public relations outreach, with the goal of garnering a showcased example of project activity in print media, including publication of project information in local community newspapers (News Graphic, Ozaukee Press).
- Articles in the Planning & Parks Department's newsletters and articles in partner, advocacy and community action group newsletters (e.g. Milwaukee Audubon Society, Ozaukee Treasures Network).
- Presentations and/or Program information provided to over 10,441 people at 99 international, national, regional, state, and local professional and scientific conferences, technical meetings, workshops, webinars, partner meetings, field trips, tours, and other events.
- Program and Project information to 216 volunteers associated with fisheries community monitoring activities.
- Inclusion of project information in the Department's posters, pamphlets, and factsheets.
- Inclusion of project information in AOC-related documents, including pamphlets, brochures, and RAP updates.

Invasive and Rare Species

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The Project also helped identify invasive and rare species in the project area. This includes a young-of-year lake sturgeon stocked by WDNR and Riveredge Nature Center as part of the sturgeon restoration effort in the Milwaukee River (Figure 10). The fish was stocked on August 8, 2013 at Thiensville Village Park (river mile 20) and recaptured on October 11, 2013 at River Barn (river mile 17). The lake sturgeon had grown from 10.5cm to 19.8cm in just over two months. Department staff also captured a round goby on October 30, 2013 in the MT Impoundment, the farthest north this invasive species has been documented during fisheries monitoring (Figure 11).

An additional oddity detected during the Project was the capture of a male golden redhorse in full spawning condition at Newburg on October 17, 2013 (Figure 12). The species typically spawns in May and June, with tubercles and other indicators of spawning condition disappearing shortly thereafter. Fall spawning condition in a spring spawning fish species has been documented for some other fish species, but not for redhorse (J. Lyons, Wisconsin Department of Natural Resources, personal communication).

Leveraged Funds and Ongoing Work

Department staff has completed additional, complimentary fisheries monitoring from 2010 through 2014 on the mainstem Milwaukee River and multiple tributary streams in Ozaukee County under the NOAA/ARRA funding, WDNR Citizen-Based Monitoring Program funding, Great Lakes Fishery Trust (GLFT) funding, and multiple Fund For Lake Michigan and National Fish and Wildlife Foundation (NFWF) Sustain Our Great Lakes (SOGL) grants. In many cases, procedures and protocols developed under the USEPA/GLRI funding and associated QAPP have directly guided these corresponding, complimentary efforts. These fisheries monitoring activities as a whole represent a significant component of the Ecological Division's comprehensive environmental monitoring program. Summaries or additional results of the complimentary monitoring activities are available upon request. Additional fisheries monitoring has included:

Wadeable and Non-wadable Mainstem Electrofishing

Department staff continued mainstem electrofishing activities in 2014 as staff time, volunteer support, and field conditions allowed, though formal fisheries community sampling activities under this grant award were completed in 2013. Five wadeable electrofishing events were completed in fall of 2014 at Uncon A, Uncon B, Con A, and Con B. Staff was not able to complete sampling at Uncon C due to unsafe conditions (e.g., high river flows) or non-wadeable sampling due to limited staff availability. Mainstem electrofishing will continue as possible in the future.

Visual Surveying

Northern pike (*Esox lucius*), the predominant monitoring target species, typically ascend tributary streams and spawn immediately after spring ice-out (i.e., late March to early April) when flow conditions are suitable and water temperatures reach 1°-4°C (34°-40°F). During that period, many traditional fish sampling tactics (e.g., electrofishing, netting, etc.) are unfeasible or unsafe. Program tributary streams were regularly monitored and visually surveyed at the first public road crossing upstream of their terminal confluences with the Milwaukee River. This was done to gauge when stream conditions became conducive to northern pike entrance and spawning and when direct sampling for pike should be initiated.

Fyke Netting

Fyke nets were deployed in Program tributaries between April 8 and April 23, 2010 (i.e., shortly after spring thaw, immediately upon equipment receipt, and prior to impediment removals) to document the

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presence or absence of adult northern pike and other migratory fish species during the typical northern pike spawning season.

Larval Netting

Larval trap netting on select streams has been conducted in the spring each year to detect the presence or absence of egressing larval northern pike and/or other species originating in Program tributaries. The WDNR has used larval trap netting to successfully detect larval northern pike in Lake Michigan tributaries near Green Bay, WI. As such, the method was adopted and added to the Department's Ecological Division's monitoring program. Like visual surveys, larval trap netting filled a critical gap in the Department's ecological monitoring and provided a reliable, consistent method for detecting northern pike and/or other species spawning in Program tributaries.

Creel Surveying

Department staff developed and implemented a creel survey in Ozaukee, Washington, and Milwaukee Counties. It was partially based on a 1990 WDNR creel survey (Pajak 1991) and was used to:

- Establish baseline creel data for Ozaukee County to facilitate comparison/contrast of:
- Species presence and abundance prior to and following impediment removal
- Changes to target species relative abundance
- Changes to target species richness
- Recreational fishing effort prior to and following impediment removal
- Develop a methodology and baseline data regarding recreational angling effort and harvest changes in Ozaukee, Washington, and Milwaukee Counties following impediment removal
- Confirm/refute salmonid fishing above the Mequon-Thiensville Dam in Thiensville, WI
- Expand baseline information collected during the WDNR's 1990 Milwaukee River creel survey (Pajak 1991)

Creel surveys were initiated on April 7, 2010 and continued on 69 of 124 randomly chosen days though October 3, 2010. Department staff and a number of dedicated volunteers served as creel clerks.

Mark-Recapture Electrofishing

Mark-recapture electrofishing has been completed on tributary streams (Department staff and volunteers) and the mainstem Milwaukee River (Department and WDNR staff). Tributary mark-recapture electrofishing, somewhat similar to other studies undertaken to identify, assess, and/or predict the effectiveness of certain fish impediments, is being used to demonstrate fish passage at select impediment sites following impediment removal or remediation.

Mequon-Thiensville Fishway Monitoring

Ozaukee County and project partners have been actively and passively monitoring the fishway since 2010, including backpack electrofishing and installation of an underwater camera and passive integrated transponder (PIT) tag readers in the fishway exit. These monitoring techniques have provided presence/absence data for species moving through the fishway, as well as information on the timing and extent of native fish migration patterns.

Backpack Electrofishing

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Department staff and volunteers completed electrofishing surveys of the Mequon-Thiensville Fishway in September 2010 and March 2011. These surveys were used to detect the presence/absence of native fish species within the fishway immediately following construction (2010) and during a possible early migration window (2011). In addition, Department staff, partners, and volunteers have performed electrofishing surveys in tributary streams at large scale habitat restoration sites (e.g., Mole and Ulao Creek Habitat Restoration Projects) to document pre-construction baseline fish community data.

Passive Monitoring of the M-T Fishway

Since June 2011, the M-T Fishway has been monitored by an underwater camera provided and installed by the U.S. Fish and Wildlife Service and the Village of Thiensville. The enclosure also includes two PIT tag scanners to monitor the movement of lake sturgeon and other PIT tagged fish. The enclosure is located in the fishway exit, requiring any organism moving through the fishway to pass in front of the camera and tag readers. A live video feed from the camera is accessible to the public at www.ozaukeefishway.org. Project partners can also access archived video, allowing for complete documentation of presence/absence, migratory events, etc.

Environmental DNA (eDNA) Monitoring

The County originally contracted the services of eDNA Solutions to facilitate detection of upstream passage of Chinook salmon through the BS Fishway. Since the BS project was not completed, the County worked with eDNA Solutions to develop a PCR-based viral hemorrhagic septicemia virus (VHSv) assay for future usage in the Milwaukee River Watershed and to complete obligated funds under the contract. This technique allows for very swift turnaround of fish tissue tests, in contrast to the 30-day wait associated with the VHSv test utilized by WDNR and other agencies.

Recognition and Awards

The County and its partners have received numerous awards and recognition for efforts supported by the GLRI and USEPA. In 2011, the Ozaukee County Planning and Parks Department received a National Association of Counties (NACO) award for its "Fish Passage for the Milwaukee River Watershed" Program, noting promotion of quality, efficient, and responsive management and administration. In 2012, Andrew Struck received Treasures of Oz "Wizard of Oz" for environmental leadership and organization, and Dale Buser (Stantec) received this same award in 2013. In 2013, Stantec received an American Council of Engineering Companies of Wisconsin (ACEC Wisconsin) Engineering Excellence State Finalist Award for the MT Fishway project. Also in 2013, Andrew Struck and Dale Buser both received the Gathering Waters "Conservationists of the Year" award for their aquatic connectivity efforts, and Andrew Struck received the Ozaukee Washington Land Trust "Timothy Kaul Leadership Award" for outstanding leadership in conservation. In addition, the Ozaukee County Fish Passage Program received a 2013 Wisconsin Department of Natural Resources "Wisconsin Citizen Based Monitoring Program of the Year" award, and Rick Frye, a Program volunteer, received the Wisconsin Department of Natural Resources "Wisconsin Citizen Volunteer of the Year" award.

Lessons Learned

Department staff experienced occasional equipment problems during scheduled electrofishing events, including generator and electrofishing reel, cable, and or probe reliability issues. Staff largely addressed these issues in field during the events; however, these issues occasionally delayed timely completion of electrofishing events. Equipment was upgraded and or maintained as possible. Volunteer assistance was

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used during most electrofishing surveys, which required additional coordination time to ensure volunteers were properly dressed and prepared for field activities (e.g., outfitted with properly sized waders, etc). Staff developed an extensive volunteer recruitment list and sent out notices with dates well in advance of planned activities to minimize last minute coordination. On occasion, inclement weather or unsafe site conditions (e.g., high flows) prevented completion of eletrofishing events, which required rescheduling. River access to sites Con A (Zarling's) and Con B (Downstream HWY C) ideally required crossing private properties for efficiency and safety, which resulted in additional coordination with private landowners. Access for the remaining sites was generally achieved through public access points (e.g., public parks). QAPP revisions 1-3 also indicated that all fish samples would include individual lengths. However, measuring each individual sample, especially small forage fish including various species of minnows and shiners (which were caught in high quantities compared to larger fish including gamefish, indicator species and other target species), was a very time-intensive task. After a review of WDNR fisheries protocols and communications with USEPA staff via the 2012 no cost time extension justification, it was determined that length information for all samples was unnecessary given the time required to complete this effort and QAPP revision 4 included modified language to limit length distribution to game, indicator, and other target species. Finally, sampled fish were clipped and or tagged (see "Fish Movements" above) to coincide with WDNR and USFWS protocols, though these procedures were not fully described in the QAPP.

Conclusions

Project progress updates and notable findings were continually shared with WDNR fisheries staff throughout the Project, and a final, comprehensive package including all vetted, acquired data was provided to WDNR staff in December 2014. Andrew Struck is a member of the Milwaukee Estuary AOC Technical Advisory Committee (TAC). Project information informed the development of the TAC's Fish and Wildlife Plan that was included in the 2013 Remedial Action Plan update as Appendix A. Project results and ongoing Program monitoring activities within the expanded AOC will be used in conjunction with ongoing USGS fisheries studies in the original AOC to assist in further Fish and Wildlife Plan refinement and to identify projects and activities to further address and refine the Degradation of Fish and Wildlife Population BUI. In sum, the Project was a valuable addition to ongoing baseline fish community monitoring in the region and County fisheries monitoring activities will continue and expand in the future as funding and staffing allows. Such efforts fill critical knowledge gaps regarding the fisheries communities of the upper Milwaukee River Watershed, serve as early detection for invasive species and help inform AOC management and restoration activities.

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List of Appendices

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