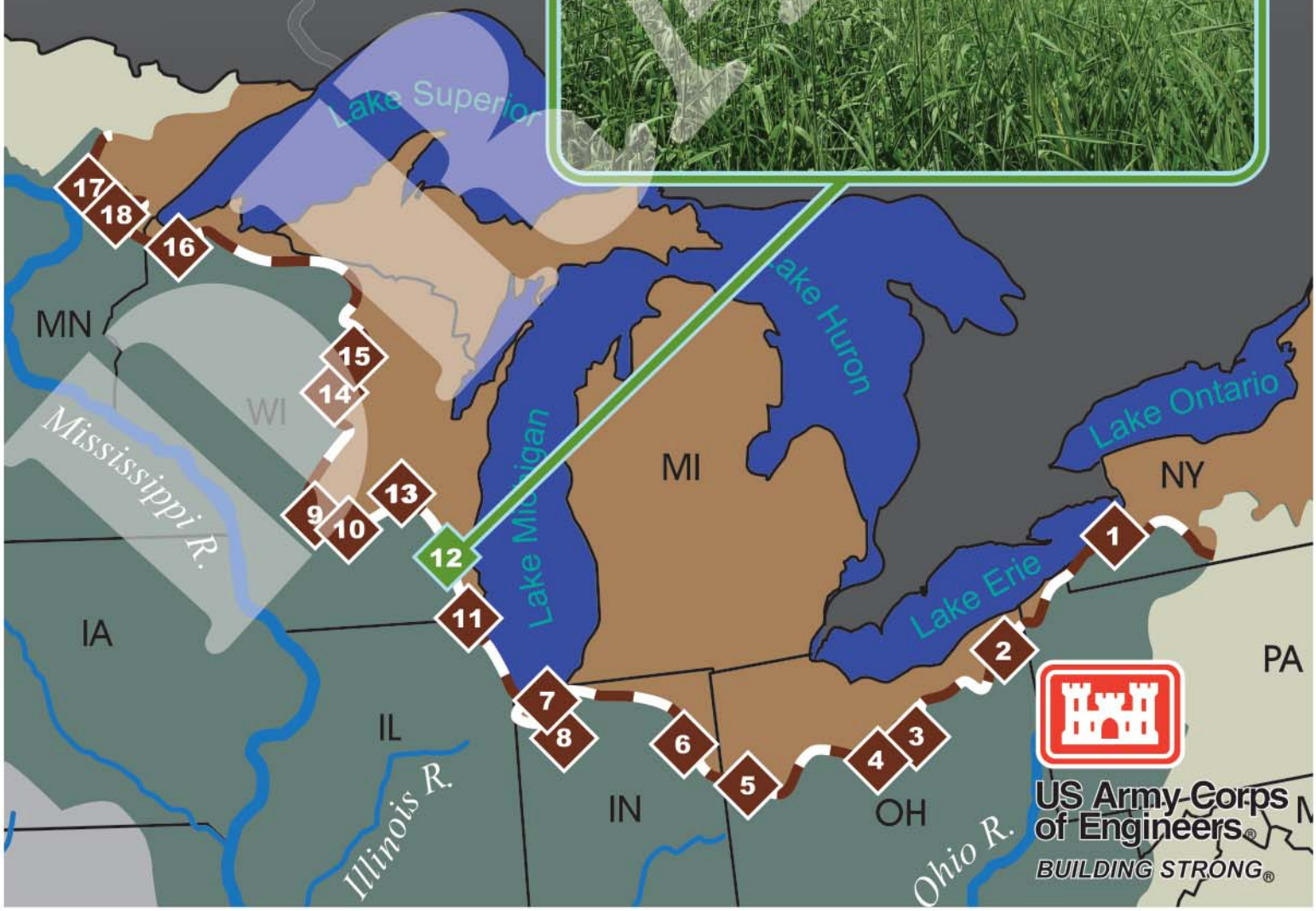
GLMRIS

Great Lakes and Mississippi River Interbasin Study

Aquatic Nuisance Species | Ecosystems | Navigation | Recreation | Flood Risk Management | Water Use

Focus Area 2 Aquatic Pathway Assessment Report

Menomonee Falls, Wisconsin



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Executive Summary

The Menomonee Falls potential aquatic pathway is located in the village of Menomonee Falls, Wisconsin and is comprised of two potential separate pathways: West Menomonee Falls and South Menomonee Falls. Both sites are located along the divide between the Great Lakes and Mississippi River Basins. West Menomonee Falls is a wetland located between Willow Creek (Great Lakes Basin) and the Fox River (Mississippi River Basin). South Menomonee Falls is also a wetland that extends between a storm drain connecting to the Menomonee River (Great Lakes Basin) and the Fox River (Mississippi River Basin). This assessment characterizes the potential for a viable aquatic pathway to form at these two aquatic pathways at Menomonee Falls in southeast Wisconsin that would enable the transfer of Aquatic Nuisance Species (ANS) between the Great Lakes and Mississippi Rivers Basins.

West Menomonee Falls is capable of conveying water across the basin divide for days to weeks, multiple times per year, and was therefore given a "high" probability rating for the existence of an aquatic pathway from up to a one percent annual recurrence interval flood event. The wetland area between the basins is entirely within the Federal Emergency Management Agency (FEMA) floodplain and is directly connected with ponds and ditches that ultimately connect with named streams within either basin. It is located approximately 1,850 feet (563 meters) between the headwater of Willow Creek which drains this wetland into the Great Lakes Basin and the ditch that drains this wetland into the Mississippi River Basin. The habitat over this distance is comprised of thickly vegetated wetland grasses and shrubs.

For the South Menomonee Falls location, the probability of the existence of an aquatic pathway was rated medium. This area also consists of a wetland spanning the basin divide and contains areas of standing water that could become interconnected during flood events, and then connect with streams on both sides of the basin divide continuously for multiple days from a 10 percent annual recurrence interval storm, but this rating is only for flow into the Great Lakes Basin. The probability rating for flow into the Mississippi River Basin across South Menomonee Falls was rated "low", as a surface water connection between the basins would likely require greater than a one percent recurrence interval flood event.

Aquatic Nuisance Species of Concern	
Species	**Common Name**
Hypophthalmichthys molitrix	Silver Carp
Hypophthalmichthys nobilis	Bighead Carp
Mylopharyngodon piceus	Black Carp
Menidia beryllina	Inland Silverside
Channa argus	Northern Snakehead
Gasterosteus aculeatus	Threespine Stickleback
Gymnocephalus cernua	Ruffe
Proterorhinus semilunaris	Tubenose Goby
Novirhabdovirus sp.	Viral Hemorrhagic Septicemia virus (VHSv)

After establishing where aquatic connections exist or may form at these locations, the aquatic pathway viability for specific ANS of concern at these locations were then evaluated by looking at the biological requirements and capabilities of the nine ANS listed in the table above.

The species evaluated as threatening the Great Lakes Basin are the bighead, black, and silver carp (Asian carps), northern snakehead, and the inland silverside. The species representing a threat to the Mississippi River Basin are viral hemorrhagic septicemia virus (VHSv), ruffe and tubenose goby (benthic fishes), and the threespine stickleback. Based on physical barriers downstream of the two sites, topography, habitat conditions, and the available hydrologic data, the aquatic pathway viability ratings for all these species at both sites was determined to be low.

For species threatening the Great Lakes Basin, dams on the Fox River were found to be a barrier to any upstream movement of ANS toward Menomonee Falls, although a more detailed evaluation of the Dayton Dam on the Fox River may be warranted. For species threatening the Mississippi River Basin, the Lepper Dam on the Menomonee River serves as a barrier for upstream movement to the West Menomonee Falls potential pathway site. The only available entrance from

the Menomonee River to the South Menomonee site is downstream (south) of the Lepper Dam. The storm drain which acts as the connection between the Menomonee River and the wetland at the basin divide has a 40-foot (12 m) incline over a distance of about 2,000 feet (610 m) before entering a 1,500-foot (457 m) long culvert. As flow is expected to only enter the Great Lakes Basin from the South Menomonee location, any ANS would have to swim upstream while traversing these elevation differences and other obstacles.

Additional data and analyses are needed for a more complete understanding of the hydrology of these connecting streams during large flood events to determine with greater certainty the flow dynamics at the dams and connecting streams. This would assist in making a more definitive determination as to whether or not these dams are barriers to upstream movement for ANS. In addition, more complete and comprehensive monitoring of ANS locations and territorial ranges would assist in determining habitat requirements, capabilities, and a timeline as to when ANS may advance (if unobstructed) to the basin connections. Information available at the time of the study was not always current and/or complete which could adversely affect the designated probability ratings.

While a hydraulic connection between the Great Lakes Basin and Mississippi River Basin could form during certain storm events at these locations, the overall aquatic pathway viability that would enable ANS to transfer between the basins through these connections was determined to be low. Habitat conditions and lack of available food supply at the pathway locations, steep topography, and the remote likelihood of any ANS being able to find the appropriate culverts during intermittent flood events all contribute to this overall low probability rating. Although this rating may suggest that immediate actions at these locations to reduce or eliminate the probability of ANS aquatic transfer are not necessary, opportunities still exist to conduct further research to gain a better understanding of current ANS locations and movements, and to educate the public about potential threats. A thorough ANS monitoring plan would be of great help for both sides of the basin. Such a plan could be developed through the involvement of Federal, State, and local entities to ensure greatest coverage and success. Since climate and species movements cannot always be accurately predicted, such future data gathering and analysis can lead to the identification of ANS trends that could lead to improved management decisions within both basins.

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Acronyms

ANS . . . . . Aquatic Nuisance Species
ANSTF. . . . Aquatic Nuisance Species Task Force
CAWS . . . . Chicago Area Waterway System
CEQ. . . . . Council on Environmental Quality
CMP. . . . . Corrugated Metal Pipe
DEM. . . . . Digital Elevation Model
FEMA. . . . . Federal Emergency Management Agency
GIS . . . . . Geographic Information System
GLB . . . . . Great Lakes Basin
GLFC. . . . . Great Lakes Fishery Commission
GLMRIS. . . Great Lakes and Mississippi River Interbasin Study
HUC. . . . . Hyrdologic Unit Codes
INDNR . . . . Indiana Department of Natural Resources
MNDNR . . . Minnesota Department of Natural Resources
MRB. . . . . Mississippi River Basin
NAS . . . . . Nonindigenous Aquatic Species
NCDC . . . . National Climatic Data Center
NEPA . . . . . National Environmental Policy Act
NOAA. . . . . National Oceanic and Atmospheric Administration
NRCS . . . . Natural Resources Conservation Service
RCP. . . . . Reinforced Concrete Pipe
USACE . . . U.S. Army Corps of Engineers
USFWS . . . U.S. Fish and Wildlife Service
USGS . . . . U.S. Geological Survey
WDNR . . . . Wisconsin Department of Natural Resources
WRDA . . . . Water Resources Development Act

1 Introduction

The Great Lakes and Mississippi River Interbasin Study (GLMRIS) was authorized in Section 3061(d) of the Water Resources Development Act of 2007, and therein, it prescribes the following authority to the Secretary of the Army and the U.S. Army Corps of Engineers (USACE) (WRDA, 2007).

> *"(d) FEASIBILITY STUDY. - The Secretary, in consultation with appropriate Federal, State, local, and nongovernmental entities, shall conduct, at Federal expense, a feasibility study of the range of options and technologies available to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins through the Chicago Sanitary and Ship Canal and other aquatic pathways."*

This GLMRIS Focus Area 2 Aquatic Pathway Assessment report addresses the West and South Menomonee Falls locations, in Waukesha County, Wisconsin. This location is one of 18 locations identified in the Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization as a potential aquatic pathway spanning the watershed divide between the Great Lakes and Mississippi River Basins outside of the Chicago Area Waterway System (CAWS) (USACE, 2010). This report is downloadable from the GLMRIS web site (glmris.anl.gov/).

The dashed line in Figure 1 depicts the nearly 1,500-mile basin divide from the New York - Pennsylvania state line to north eastern Minnesota, and it depicts each of the 18 potential aquatic pathway locations that were previously identified. The Menomonee Falls locations are represented as number 12 on Figure 1.

The GLMRIS is a very large and complicated task involving multiple USACE Districts and Divisions. Program Management of the study is conducted by the Great Lakes and Ohio River Division. The study considers several ANS of concern, however, the proximity of Asian carp in the Mississippi River Basin to the basin divide near two locations lends a sense of urgency and national significance to completion of the GLMRIS. These two locations are the CAWS in Chicago, Illinois and Eagle Marsh in Fort Wayne, Indiana. To help accelerate completion of the feasibility study, the Great Lakes and Ohio River Division split management of the GLMRIS into two separate focus areas. Focus Area 1 is managed by the USACE, Chicago District and addresses the CAWS. Focus Area 2 is managed by the USACE, Buffalo District and evaluates all other potential aquatic pathways that exist or are likely to form across the basin divide separating runoff that flows into the Mississippi River and its tributaries from runoff that flows into the Great Lakes and its tributaries.

1.1 Study Purpose

The preliminary report from 2010 and the subsequent analysis contained in this report have been produced for a broad audience ranging from the scientific community to the general public, and are specifically intended to identify any locations where an aquatic pathway exists or may form between the basins, and to evaluate the probability that specific ANS would be able arrive at that pathway and cross into the new basin. The information in this and the other Focus Area 2 reports are intended to provide a sound scientific basis for helping to prioritize future funding of GLMRIS and/or other actions at these potential aquatic pathway locations.

This report is part of a tiered approach to assess the likelihood of ANS spreading between the Great Lakes and Mississippi River Basins via aquatic pathways, and it was prepared in accordance with the detailed procedures and criteria specified in the GLMRIS Focus Area 2 Study Plan (USACE, 2011a). The primary purpose of this report is to present the evidence and explain the procedures used to qualitatively estimate the likelihood that a viable aquatic pathway exists at the Menomonee Falls locations that will enable the interbasin spread of ANS. It is also intended to contribute to the accomplishment of each of the four objectives identified in the plan by including the following:

- A definitive determination of whether the Menomonee Falls location should be included in the inventory of locations where a viable surface water connection between headwater streams on both sides of the drainage divide

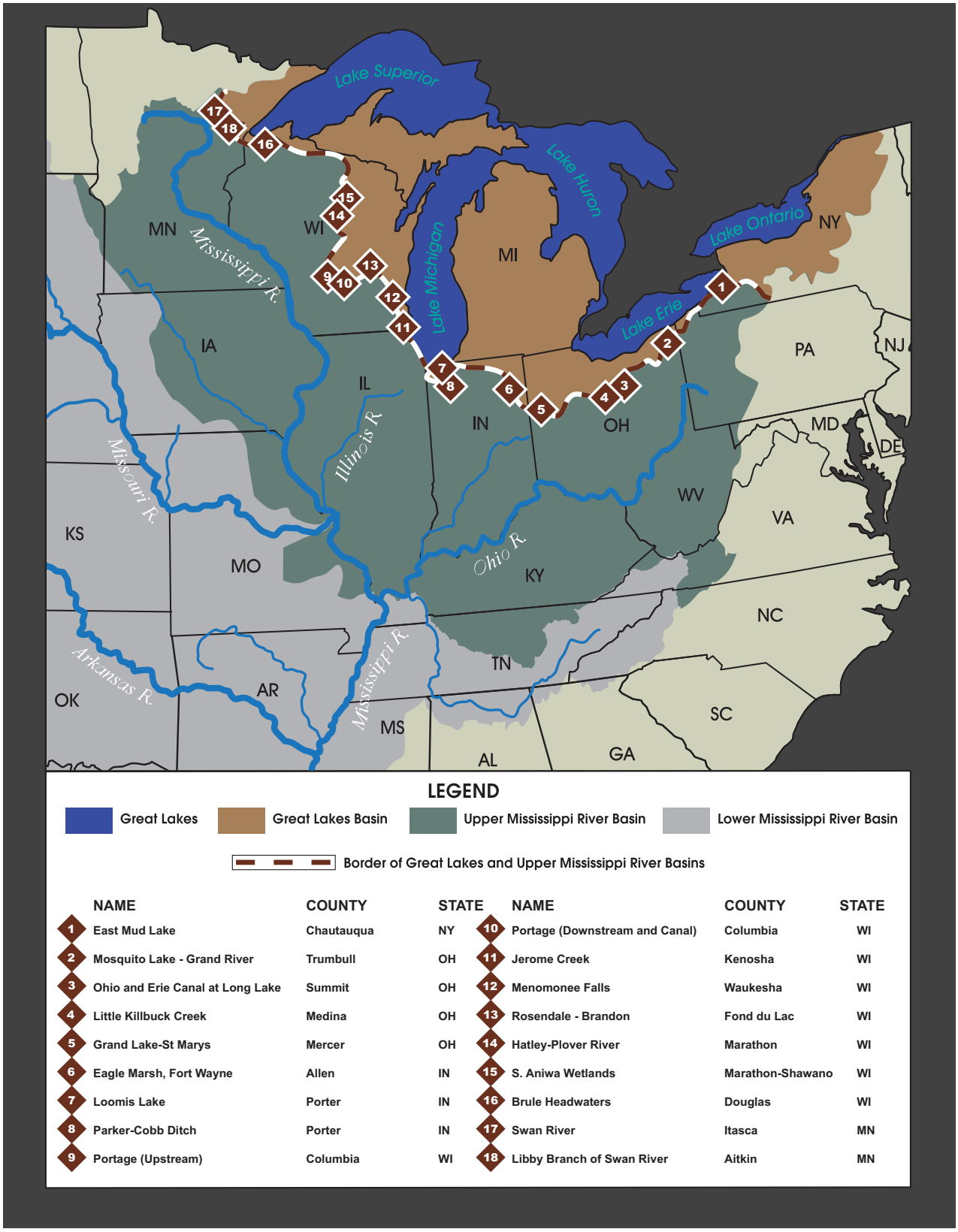

Figure 1. Potential aquatic pathway locations identified in the GLMRIS Preliminary Risk Characterization Study (USACE, 2010).

exists or is likely to form between the Great Lakes and the Mississippi River basins;

- A standalone report that characterizes the probability of aquatic pathway formation and the probability that a viable aquatic pathway exists at the Menomonee Falls and will enable the interbasin spread of ANS;

- Development of clear problem statements that frame the means, constraints, and likelihood of the interbasin spread of ANS via the potential aquatic pathway at the Menomonee Falls location; and

- Development of clear opportunity statements that illustrate how the collective authorities, resources and capabilities of USACE and other applicable federal, state, local, and non-governmental stakeholder organizations may best be coordinated and applied to prevent the interbasin spread of ANS through the Menomonee Falls location.

1.2 Summary of 2010 Preliminary Risk Characterization for Menomonee Falls, Wisconsin

The Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization was designed as the first step of a tiered approach to rapidly conduct a study intended to accomplish two objectives (USACE, 2010). The first and primary objective was to determine if there were any locations within the GLMRIS, aside from the CAWS, where a near term risk for the interbasin spread of ANS exists. Near term, in this case, indicates that implementation of some measure(s) might be warranted to reduce the potential for ANS transfer at that particular location in the short term versus setting that site aside for further analysis. The second objective was to refine the scope of the other aquatic pathways portion of the GLMRIS by developing a list of potential aquatic pathways that could form anywhere along the divide separating the Great Lakes and Mississippi River Basins, and help provide a basis for prioritizing future feasibility study efforts based upon relative risk.

The USACE solicited the input and collaborated with the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), Great Lakes Fishery Commission (GLFC) and the natural resource agencies in the states of Minnesota, Wisconsin, Indiana, Ohio, Pennsylvania, and New York. A total of 36 potential locations were initially identified along the divide where it appeared that interbasin flow could occur. These were locations situated in a mixture of rural, forested, suburban, and urban areas, and included locations where surface water flow patterns have been modified through the building of navigation canals, excavation of ditches, and construction of sewers to facilitate storm water management for agricultural, flood damage reduction, or other water management purposes. Also, many of the potential aquatic pathways identified in 2010 were locations where extensive natural wetlands exist in close proximity to, and in some instances appear to span, the basin divide. The lack of prior hydrologic studies and the level of uncertainty in the hydrology information led to a conservative approach in estimating the individual aquatic pathway risk ratings.

At 18 of these locations the interagency group determined that it would likely require an epic storm and flooding event for an aquatic pathway to ever form across the basin divide. These were not recommended for further investigation because this was considered a low level of risk. However, at the remaining 18 locations the group did recommend that a more detailed assessment be conducted (Figure 1). Only one location, Eagle Marsh in Fort Wayne, Indiana, was determined to pose a near term risk for the potential spread of Asian carp into the Great Lakes Basin, and this led to the installation of a temporary barrier by Indiana Department of Natural Resources (INDNR) until a more complete assessment and remedy could be implemented.

The Menomonee Falls locations were characterized as both urban and suburban potential interbasin surface water connections. The hydrologic evaluation at South Menomonee Falls deemed the location to be an intermittent pathway, only capable of conveying significant water or having standing water for a period of

days from the 0.2 - 1.0 percent annual recurrence interval storm, and the preliminary assessment found that flow passing across the basin divide in either direction was unlikely. While no additional study was recommended at the South Menomonee location in the preliminary characterization conducted in 2010, a site visit by two hydraulic engineers in June 2011 caused this particular site to be added back into the study for re-analysis, along with the West Menomonee Falls site.

A recurrence interval relates any given storm, through statistical analysis, to the historical records of rainfall and runoff for a given area. The recurrence interval is based on the statistical probability that a given intensity storm event will be equaled or exceeded in any given year. For instance, a one percent recurrence interval storm is a rainfall event that has a one percent probability, one chance in 100, of being equaled or exceeded in any given year. This level of storm event was commonly referred to as a 100-year storm event, but this term has led people to incorrectly conclude that a 100-year storm event is one that only occurs once in any given 100 year period. A ten percent annual recurrence interval storm (formerly referred to as a ten year event) is a smaller event that has a one in ten chance of being exceed during any given year, and a 0.2 percent annual recurrence interval storm (formerly referred to as a 500-year event) is a larger event that has a one in 500 chance of being exceeded in any given year.

Although the preliminary risk characterization did not identify the Menomonee Falls sites as locations where there is a near term risk for the interbasin spread of ANS, there was some uncertainty with this rating. This was mainly due to the presence of the large wetland areas and lack of readily available hydrological evidence found during the preliminary study effort to discern the relative frequency and potential magnitude of any aquatic pathway at this location and how the downstream dams might prevent upstream movement of ANS. The preliminary effort recommended that a more detailed assessment be conducted at this location. This was subsequently done in collaboration with the Wisconsin Department of Natural Resources (WDNR), USFWS, USGS, and other government agencies. The following actions were taken:

- Federal, State, and local stakeholders (i.e., USGS Water Science, WDNR Division of Water, County Surveyor, and local Natural Resource Conservation representatives) were briefed on the preliminary risk characterization results. Detailed site visits to observe potential connection locations were conducted and the available topographic mapping and flood hazard information was compiled and reviewed.

- The dams on the connecting streams to the Great Lakes and Mississippi River were evaluated relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.

- Habitat and abiotic conditions in proximity to the location were analyzed relative to the needs and preferences of ANS in proximity to each location.

- The hydrologic and ANS ratings and characterization for each site were revised based on the new information.

- Measures that could be most effectively and efficiently implemented at the State or local level were identified to mitigate the concerns.

1.3 Aquatic Pathway Team

Due to the large amount of unknowns and natural variability associated with the hydrology and the biology of such a large geographic area, the Study Plan specified formation of a “team of teams,” combining the best available local, state, and national hydrologists and biologists to assess conditions at each potential aquatic pathway. The results of this assessment reflect the collective experience, expertise, and focused effort of these biologists and hydrologists from the NRCS, USGS, USACE, Illinois Department of Natural Resources Region I and WDNR. The results also reflect the guidance, input, review comments, and concurrence of the multi-organization Agency Technical Review of experts from the USGS and USACE.

2 Study Methodology

The GLMRIS risk analysis process is an adaptation of the generic model and process described in the Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (For Estimating Risk Associated with the Introduction of Nonindigenous Aquatic Organisms and How to Manage for that Risk) (ANSTF, 1996). The Aquatic Nuisance Species Task Force (ANSTF) defines the first step in this process as identification of interested parties and solicitation of input.

2.1 Coordination

The USACE identified interested parties and solicited input early in the process for Focus Area 2 and has included individual visits and discussions with the state agencies responsible for water resources, and fish and wildlife management in the eight states bordering the Great Lakes. The process used for the Focus Area 2 assessments has also been discussed in meetings with representatives of the Council on Environmental Quality (CEQ), USGS, USFWS, NOAA, NRCS, and GLFC. Development of this plan also included input from the public and interested non-governmental organizations received during formal National Environmental Policy Act (NEPA) public scoping meetings which were held at 12 locations across the region in both basins between December 2010 and March 2011. The USACE requested the support and participation of the best available experts from the State and Federal agencies responsible for water resources, and fish and wildlife management in the states along the Great Lakes and Mississippi River Basin divide to address the critically important issue of preventing interbasin transfer of ANS. The USGS, NRCS, and each state DNR assigned personnel to assist each USACE pathway assessment team. In addition, a technical review team comprised of 16 senior level experts from the USACE and these external partner agencies, including NOAA and GLFC, was assembled to review and guide the work of these teams. Overall, extensive collaboration among partner agencies, the review team, and other subject matter experts has led to detailed Focus Area 2 pathway assessments.

2.2 Identification of Potential Pathways

At 18 of the potential aquatic pathways identified during the 2010 Preliminary Risk Characterization, it was determined it would likely require an epic storm and flooding event (i.e., greater than a one percent annual recurrence interval storm event) for an aquatic pathway to ever form across the basin divide. These locations were not recommended for further investigation because areas that might require a flooding event in excess (greater magnitude, less frequency) of the one percent annual recurrence interval flood are less likely, and therefore present a low level of risk. This one percent threshold criterion was established through collaboration with the USGS, USFWS, NRCS, GLFC, and the departments of natural resources in the states of MI, MN, WI, IL, IN, OH, PA, and NY. This threshold is also widely used in flood risk management and is typically aligned with most readily available hydrologic information. The one percent annual recurrence interval threshold only indicates at what level event an aquatic connection can begin to form and would indicate a location that should then be subjected to a more labor intensive evaluation of the probability of ANS being able to utilize that pathway. At the remaining 18 locations, it was recommended that a more detailed assessment be conducted (Figure 1). This was subsequently done in 2011-2012 in collaboration with USGS, NRCS, USFWS, state natural resource agencies, and county surveyors (where applicable), and the results are presented in this report.

Although the focus of this assessment is on aquatic pathways, it should also be mentioned that there are other non-aquatic pathways that may enable ANS to transit across the aquatic pathway or across the basin divide. Although these other pathways do not influence the overall pathway rating outlined in this report, they are included to point out potential other pathways (e.g., anthropogenic) and their potential influence on the same list of ANS as evaluated in Section 4 of this report. Any further analysis of these non-aquatic pathways outside of this study should develop a separate list of ANS that will likely differ from the list of ANS evaluated as part of this aquatic pathway report.

2.3 Aquatic Nuisance Species of Concern

This report addresses the problem of ANS invading, via surface-water pathways, the Great Lakes Basin from the Mississippi River Basin and vice versa. ANS is defined by the ANSTF as "… nonindigenous species that threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters." The USGS Nonindigenous Aquatic Species (NAS) information resource http://nas.er.usgs.gov/about/faq.aspx defines NAS as "…a species that enters a body of water or aquatic ecosystem outside of its historic or native range." (USGS, 2012). Based on discussions between the USACE, USGS, and USFWS the following definitions were established for the purposes of the GLMRIS. All non-indigenous aquatic species (per the USGS definition above), that are present in the Great Lakes but not known to be present in the Mississippi River and its tributaries are defined as ANS of concern for GLMRIS. Likewise, all non-indigenous aquatic species present in the Mississippi River or its tributaries but not known to be present in the Great Lakes are also considered as ANS of concern for the GLMRIS. Therefore, the term ANS is synonymous with the term non-indigenous aquatic species in this report.

2.3.1 Lists of Nonindigenous Species in Great Lakes and Mississippi River Basins

The list of ANS of concern for a particular location was developed by first consulting the USACE white paper titled, *Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study* released in September 2011 (USACE, 2011b). This technical paper, prepared by a multi-disciplinary USACE natural resources team, took a broad look at the potential range of species that could be of concern to the GLMRIS. The paper is Appendix C of the GLMRIS Focus Area 2 Study Plan and it is an integral component of the plan. This USACE white paper included a review of 254 aquatic species that are either non-indigenous to either basin or native species that occur in one basin or the other. The list of 254 aquatic species were iteratively screened to identify all potential ANS that could be of concern in either basin and to systematically focus the study toward those species judged to pose the highest potential risk of ecological impacts if they became established in the other basin.

In the first screening iteration, 119 of the 254 aquatic species reviewed were determined to pose a potential threat of infiltrating the other basin and were carried into the second iteration of the analysis. The other 135 species were rejected for further analysis for several reasons. Initially, 104 species were dropped from further consideration because they were determined to already be established in both basins. Another 31 species were removed from further analysis because they were not yet located in either basin, could bypass any aquatic control mechanism by terrestrial movement, or had no potential to cause adverse affects to the invaded ecosystem.

2.3.2 List of ANS of Concern for GLMRIS

To determine species of concern that are pertinent for the GLMRIS from the list of 119 species, the USACE natural resources team compiled, reviewed, and analyzed the best available information. Literature reviews, species proximity to aquatic interbasin connections (in particular the CAWS), ecological tolerances and needs, and vagility of the species were all included in the analysis. The team ranked each species as high, medium, or low risk according to these parameters. The result was the establishment of a list of 39 species, each identified as having both a high level of potential risk for both transferring from one basin to another, and potentially a high risk in that if they do disperse, and the invaded ecosystem could be moderately to severely affected by their colonization (Table 1). A fact sheet was developed for each of these species of concern detailing morphological characteristics useful for identification, including color photographs of the species, information on their ecology, habitat, distribution, and current status in the Mississippi River or Great Lakes Basins.

Table 1. ANS of Concern for GLMRIS.				
Taxon	**Scientific Name**	**Common Name**	**Basin**	**Interbasin Dispersal Mechanism**
fish	*Alosa aestivalis*	blueback herring	GL	swimmer
fish	*Alosa chrysochloris*	skipjack herring	MS	swimmer
fish	*Alosa pseudoharengus*	Alewife	GL	swimmer
crustacean	*Apocorophium lacustre*	a scud	MS	ballast water
algae	*Bangia atropupurea*	red macro-algae	GL	ballast / recreational boating
annelid	*Branchuris sowerbyi*	tubificid worm	GL	sediment transport
crustacean	*Bythotrephes longimanus*	spiny waterflea	GL	ballast water/sediment transport
plant	*Carex acutiformis*	swamp sedge	GL	recreational boating & trailers
crustacean	*Cercopagis pengoi*	fish-hook water flea	GL	ballast / recreational boating
fish	*Channa argus*	northern snakehead	MS	swimmer
algae	*Cyclotella cryptica*	cryptic algae	GL	unknown / any water
algae	*Cyclotella pseudostelligera*	cylindrical algae	GL	unknown / any water
crustacean	*Daphnia galeata galeata*	water flea	GL	ballast water
crustacean	*Echinogammarus ischnus*	a European amphipod	GL	ballast water
algae	*Enteromorpha flexuosa*	grass kelp	GL	ballast / recreational boating
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer
plant	*Glyceria maxima*	reed sweetgrass	GL	recreational boating & trailers
fish	*Gymnocephalus cernua*	Ruffe	GL	swimmer
crustacean	*Hemimysis anomala*	bloody red shrimp	GL	ballast water
fish	*Hypophthalmichthys molitrix*	silver carp	MS	swimmer
fish	*Hypophthalmichthys nobilis*	bighead carp	MS	swimmer
plant	*Landoltia (Spirodela) punctata*	dotted duckweed	MS	recreational boating & trailers
bryozoan	*Lophopodella carteri*	bryozoans	GL	with aquatic plants
fish	*Menidia beryllina*	inland silverside	MS	swimmer
plant	*Murdannia keisak*	marsh dewflower	MS	recreational boating & trailers
fish	*Mylopharyngodon piceus*	black carp	MS	swimmer
crustacean	*Neoergasilus japonicus*	a parasitic copepod	GL	parasite to fish
plant	*Oxycaryum cubense*	Cuban bulrush	MS	recreational boating & trailers
fish	*Petromyzon marinus*	sea lamprey	GL	swimmer
mollusk	*Pisidium amnicum*	greater European pea clam	GL	ballast water
fish	*Proterorhinus semilunaris*	tubenose goby	GL	swimmer
protozoan	*Psammonobiotus communis*	testate amoeba	GL	ballast water
protozoan	*Psammonobiotus dziwnowi*	testate amoeba	GL	ballast water
protozoan	*Psammonobiotus linearis*	testate amoeba	GL	ballast water
crustacean	*Schizopera borutzkyi*	parasitic copepod	GL	ballast water
mollusk	*Sphaerium corneum*	European fingernail clam	GL	ballast water
algae	*Stephanodiscus binderanus*	Diatom	GL	ballast water
plant	*Trapa natans*	water chestnut	GL	recreational boating & trailers
mollusk	*Valvata piscinalis*	European stream valvata	GL	ships

2.3.3 List of ANS of Specific Concern at the Menomonee Falls Location

The Menomonee Falls aquatic pathway team then subdivided the set of species listed in Table 1 into two groups: ANS threatening the Great Lakes, and ANS threatening the Mississippi River and its tributaries. Each of these two lists was then sorted into subgroups in accordance with taxonomy and common dispersal mechanism. Table 2 and Table 3 reflect these groupings of species that were found to pose a significant risk to the Mississippi River and its tributaries, and to the Great Lakes and its tributaries, respectively (USACE, 2011b).

Additionally, the Menomonee Falls aquatic pathway team reviewed the information on the 119 species initially determined to pose a potential threat of infiltrating the other basin to see if any were in close enough proximity to the Menomonee Falls locations to be of concern. The team reviewed information on the NOAA Watchlist of species threatening the Great Lakes from international waters, and information on other species cited by the review team as high risk potential invaders not yet in either basin (NOAA, 2011). No additional species from the NOAA Watchlist were added to the species of concern for the Menomonee Falls locations. However, the NOAA Watchlist was utilized as a resource, at the recommendation of agency team members, to identify any additional potential future species that could be introduced into either basin and possibly spread from there to the other basin.

Each Focus Area 2 aquatic pathway team was granted flexibility in determining whether to add additional species to their assessment based on their review of available information and the actual location of the specific potential pathway relative to the known location of those ANS being considered. Based on concerns from local agencies about the potential for spread of viral hemorrhagic septicemia virus (VHSv, Novirhabdovirus sp), each Focus Area 2 aquatic pathway team evaluated whether VHSv should be included on the ANS of concern list for each of the Focus Area 2 aquatic pathways. Although VHSv has been identified in both basins (i.e., VHSv was confirmed in the Clark Fork Reservoir, Ohio, in the Ohio River Basin), it is yet to be determined that VHSv has established in the Mississippi River Basin. Minimizing the spread of VHSv remains a priority for the state of Wisconsin (Great Lakes Commission, 2011; USGS, 2011b). It was therefore included as an ANS of concern threatening the Mississippi River Basin for the Menomonee Falls aquatic pathways.

Each of the three subgroups in Tables 2 and Table 3 were evaluated based on the dispersal mechanisms and general mobility of the species within each group. Since West and South Menomonee Falls is positioned on the basin divide, well upstream of any known ANS listed in this assessment, any organism that moves solely through the aquatic pathway must possess either self-propelled mobility or the ability to hitchhike on other organisms to travel upstream. Thus, this eliminates organisms that rely on current for dispersal, such as plants and algae.

Neither site supports a recreational fishery, which virtually eliminates the threat of ANS transfer via water craft and associated equipment or fishing gear. Dumping of ANS (discarded aquarium pets, ceremonial release, etc.) within the site is considered unlikely because of the lack of available open water. Additionally, dumping of exotic pets is just as likely to occur in suitable aquatic areas within either basin or elsewhere along the basin divide. The intestinal tract of warm-blooded animals inactivates the VHS virus and VHSv is not known to replicate in aquatic insects (Pennsylvania Sea Grant Fact Sheet, not dated). Therefore mammals, waterfowl, insects, and parasites of these organisms are unlikely VHSv vectors.

Any organism that possesses the ability to hitchhike over land and therefore may be able to bypass an obstacle in the aquatic pathway was not included in the final list. State hatcheries only use brood stock determined to be VHSv-free and collected from non-VHSv waters. Commercial fish hatcheries also are regulated under Wisconsin Administrative Code 10.61, and live bait dealers are regulated. The Wisconsin rules prohibit the harvest of wild minnows, both commercially and for personal use, from all VHSv known and suspected waters (WDNR, 2012a). It is illegal to possess or use minnow harvesting gear on any of the VHS waters.

Based on the evaluation by subgroups, only fish and parasites of fish were considered to have the requisite

Table 2: ANS of Concern Threatening the Mississippi River Basin.			
Taxon	**Scientific Name**	**Common Name**	**Interbasin Dispersal Mechanism**
fish	*Alosa aestivalis*	blueback herring	swimmer
fish	*Alosa pseudoharengus*	Alewife	swimmer
fish	*Gasterosteus aculeatus*	threespine stickleback	swimmer
fish	*Gymnocephalus cernua*	ruffe	swimmer
fish	*Petromyzon marinus*	sea lamprey	swimmer
fish	*Proterorhinus semilunaris*	tubenose goby	swimmer
crustacean	*Neoergasilus japonicus*	a parasitic copepod	parasite to fish
crustacean	*Bythotrephes longimanus*	spiny waterflea	ballast water/sediment
crustacean	*Cercopagis pengoi*	fish-hook water flea	ballast / rec. boating
crustacean	*Daphnia galeata galeata*	water flea	ballast water
crustacean	*Echinogammarus ischnus*	a European amphipod	ballast water
crustacean	*Hemimysis anomala*	bloody red shrimp	ballast water
crustacean	*Schizopera borutzkyi*	parasitic copepod	ballast water
mollusk	*Pisidium amnicum*	greater European pea clam	ballast water
mollusk	*Valvata piscinalis*	European stream valvata	ships
mollusk	*Sphaerium corneum*	European fingernail clam	ballast water
protozoan	*Psammonobiotus communis*	testate amoeba	ballast water
protozoan	*Psammonobiotus dziwnowi*	testate amoeba	ballast water
protozoan	*Psammonobiotus linearis*	testate amoeba	ballast water
annelid	*Branchuris sowerbyi*	tubificid worm	sediment transport
plant	*Carex acutiformis*	swamp sedge	recreational boats & trailers
plant	*Glyceria maxima*	reed sweetgrass	recreational boats & trailers
plant	*Trapa natans*	water chestnut	recreational boats & trailers
bryozoan	*Lophopodella carteri*	bryozoans	with aquatic plants
algae	*Bangia atropupurea*	red macro-algae	ballast / rec. boating
algae	*Cyclotella cryptica*	cryptic algae	unknown / any water
algae	*Cyclotella pseudostelligera*	cylindrical algae	unknown / any water
algae	*Enteromorpha flexuosa*	grass kelp	ballast / rec. boating
algae	*Stephanodiscus binderanus*	diatom	ballast water

Table 3: ANS of Concern Threatening the Great Lakes.			
Taxon	**Scientific Name**	**Common Name**	**Interbasin Dispersal Mechanism**
fish	*Alosa chrysochloris*	skipjack herring	swimmer
fish	*Channa argus*	northern snakehead	swimmer
fish	*Hypophthalmichthys molitrix*	silver carp	swimmer
fish	*Hypophthalmichthys nobilis*	bighead carp	swimmer
fish	*Menidia beryllina*	inland silverside	swimmer
fish	*Mylopharyngodon piceus*	black carp	swimmer
crustacean	*Apocorophium lacustre*	a scud	ballast water
plant	*Landoltia (Spirodela) punctata*	dotted duckweed	recreational boats & trailers
plant	*Murdannia keisak*	marsh dewflower	recreational boats & trailers
plant	*Oxycaryum cubense*	Cuban bulrush	recreational boats & trailers

means of reaching the West and South Menomonee Falls pathway sites from either direction. Eight fish and one virus were ultimately identified as species of concern for the West and South Menomonee Falls area. These were chosen based on their history of invasiveness and physical capabilities to utilize this aquatic pathway within the next 20 years (Table 4).

2.3.4 Key Attributes of Selected Organisms

Excluding the information for VHSv, a significant amount of ANS information was obtained from the USACE White Paper listing the non-native species of concern and dispersal risk for GLMRIS (USACE, 2011b). The VHSv was not identified as a species of concern in this white paper. However, during interagency coordination VHSv was identified as a species of concern for Menomonee Falls. Additional information was obtained from the USGS Nonindigenous Aquatic Species (NAS) website (USGS, 2011).

2.4 Study Methodology

The GLMRIS risk analysis process is an adaptation of the generic model and process described in the Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (For Estimating Risk Associated with the Introduction of Nonindigenous Aquatic Organisms and How to Manage for that Risk) (ANSTF, 1996). ANSTF defines the risk associated with an ANS as:

Equation 1

$R_{Establishment} = P_{Establishment} \times C_{Establishment}$

Where:

$R_{Establishment}$ = Risk of Establishment
$P_{Establishment}$ = Probability of Establishment
$C_{Establishment}$ = Consequence of Establishment

Note the risk is defined as a multiplicative function. That means, if either of these components is zero or low, the overall risk will also be zero or low. In order to work most efficiently given the large number of potential pathways, the GLMRIS Other Aquatic Pathways Team (Focus Area 2) concentrated its effort on characterizing the probability of establishment, while the GLMRIS Focus Area 1 Team for the CAWS is focusing on both components. An estimate of the consequences of any ANS establishment from the Focus Area 2 aquatic pathways will be deferred until possible future study by USACE or others.

ANSTF divides the probability of establishment component shown in Equation 1 into four basic elements which describe the basic events that must occur for an ANS to establish in the new environment:

Equation 2

$P_{Establishment} = [P_1 \times P_2 \times P_3 \times P_4]$

Where:

$P_1 = P_{ANS\ associated\ with\ pathway}$
$P_2 = P_{ANS\ survives\ transit}$
$P_3 = P_{ANS\ colonizes\ in\ new\ environment}$
$P_4 = P_{ANS\ spreads\ beyond\ colonized\ area}$

Table 4: Species of Greatest Concern for Transfer at Menomonee Falls.

Taxon	Scientific Name	Common Name	Basin	Interbasin Dispersal Mechanism
fish	*Hypophthalmichthys molitrix*	silver carp	MS	swimmer
fish	*Hypophthalmichthys nobilis*	bighead carp	MS	swimmer
fish	*Mylopharyngodon piceus*	black carp	MS	swimmer
fish	*Menidia beryllina*	inland silverside	MS	swimmer
fish	*Channa argus*	northern snakehead	MS	swimmer
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer
fish	*Gymnocephalus cernua*	ruffe	GL	swimmer
fish	*Proterorhinus semilunaris*	tubenose goby	GL	swimmer
Virus	*Novirhabdovirus sp*	VHSv	GL	Pathogen to Fish & Water Column

Each of the four elements of Equation 2 is qualitatively rated as High (H), Medium (M), or Low (L)based on the available evidence. They are also qualitatively assigned a level of certainty (Very Certain, Reasonably Certain, Moderately Certain, Reasonably Uncertain, Very Uncertain). The overall probability rating is the rating of the element with the lowest probability. Thus, in a quartet of HLHH the overall probability rating is L. The multiplicative nature of the function assures this is actually a somewhat conservative estimate. With actual numbers the overall probability would always be smaller than the smallest of the four factors. These elements have been modified for use in GLMRIS (Equation 3) to describe the basic sequence of events that must occur for an ANS to successfully cross the basin divide through an aquatic pathway and establish in the new basin:

Equation 3 [FA1 Model]

$P_{Establishment} = [P_0 \times P_1 \times P_2 \times P_3 \times P_4]$

Where:

$P_0 = P_{Pathway\ exists}$

$P_1 = P_{ANS\ has\ access\ to\ pathway}$

$P_2 = P_{ANS\ transits\ pathway}$

$P_3 = P_{ANS\ colonizes\ in\ new\ waterway}$

$P_4 = P_{ANS\ spreads\ in\ new\ waterway}$

This model works well in areas where a viable pathway is already known to exist, such as the CAWS. However, for many of the 18 locations identified in GLMRIS Focus Area 2, it was uncertain at the outset whether or not an aquatic pathway does in fact ever form. The team recognized that formation of a pathway at these locations would likely be infrequent, and with a limited duration and magnitude (width, depth, and rate of surface water flow across the basin divide). Consequently, the model in Equation 3 was modified further for Focus Area 2.

Greater efficiency in analysis can be gained by modifying Equation 3 by eliminating evaluation of the last two elements because if a pathway does not exist there is no reason to collect data on colonization (P3) and spread (P4) in the new basin. In addition, the third element of Equation 3, ANS transits pathway (P2), is broken down into its own sequence of necessary events to characterize in greater detail those variables being evaluated to determine whether or not a viable pathway exists. In setting aside the last two elements in Equation 3 (P3 and P4), no attempt is therefore made in this report to assess the probability that an ANS will colonize in or spread through the receiving waterway or basin. USACE or others may assess the last two elements of Equation 3 in the future when evaluating specific measures that could be taken to eliminate the probability of transfer at certain aquatic pathways.

Once again, in order to work efficiently in assessing ANS risk for Focus Area 2, the initial assessment focuses narrowly on the question of whether or not a viable aquatic pathway exists. Equation 4 shows how the third element of Equation 3 has been broken down to provide greater resolution for evaluating the pathway itself:

Equation 4 [Modification of Equation 3 – P2 Element]

$P_2 = [P_{2a} \times P_{2b} \times P_{2c}]$

Where:

$P_2 = P_{ANS\ transits\ pathway}$

$P_{2a} = P_{ANS\ surviving\ transit\ to\ aquatic\ pathway}$

$P_{2b} = P_{ANS\ establishing\ at\ the\ aquatic\ pathway}$

$P_{2c} = P_{ANS\ spreading\ across\ aquatic\ pathway\ into\ new\ basin}$

Delaying consideration of the last two elements of Equation 3 and substituting the more detailed consideration of the third element as expressed in Equation 4 yields the following model used in the GLMRIS Focus Area 2 assessments:

Equation 5 [FA2 Modified]

$P_{Viable\ pathway} = [P_0 \times P_{1'} \times P_{2a} \times P_{2b} \times P_{2c}]$

Where:

$P_0 = P_{Pathway\ exists}$

$P_{1'} = P_{ANS\ occurring\ within\ either\ basin}$

$P_{2a} = P_{ANS\ surviving\ transit\ to\ aquatic\ pathway}$

$P_{2b} = P_{ANS\ establishing\ at\ the\ aquatic\ pathway}$

$P_{2c} = P_{ANS\ spreading\ across\ aquatic\ pathway\ into\ new\ basin}$

Notice the overall probability is now the "probability a viable pathway exists" ($P_{Viable\ pathway}$) and is no longer the original "probability of establishment" from Equation 3. The probability of establishment for certain aquatic

pathways may be assessed in future studies by USACE or others, but likely only for those pathways with an unacceptable rating for the "probability of a viable pathway" existing. Note also that (P1), ANS has access to pathway from Equation 3 has been renamed (P1'), ANS occurring within either basin". This did not change the element being evaluated but made it clearer to team members what "access to the pathway" actually meant.

This model remains consistent with the overall GLMRIS risk assessment approach and the ANSTF methodology, and the refinements enabled the assessors to focus more appropriately on the relevant evidence. At those locations along the basin divide where the first element in Equation 5 (i.e., likelihood that an aquatic pathway exists at up to a one percent annual recurrence interval event) was estimated to be low, no further assessment of that location was necessary. The low rating of this initial element assures that the overall probability of a viable pathway existing (Equation 5), the overall probability of establishment (Equation 3), and the ANS risk potential (Equation 1), will all be low because of the multiplicative nature of the model. This approach assured a more prudent use of public resources in data collection and assessment by minimizing the collection of unnecessary data, and the conduct of unnecessary analyses. It should also be understood that a low rating for probability of a pathway existing (P_0) is not necessarily the same as there being no probability of a pathway existing. At all other locations including the Menomonee Falls pathway, the remaining four elements in Equation 5 were evaluated for each ANS of concern specific to that particular location over a 50 year period of analysis.

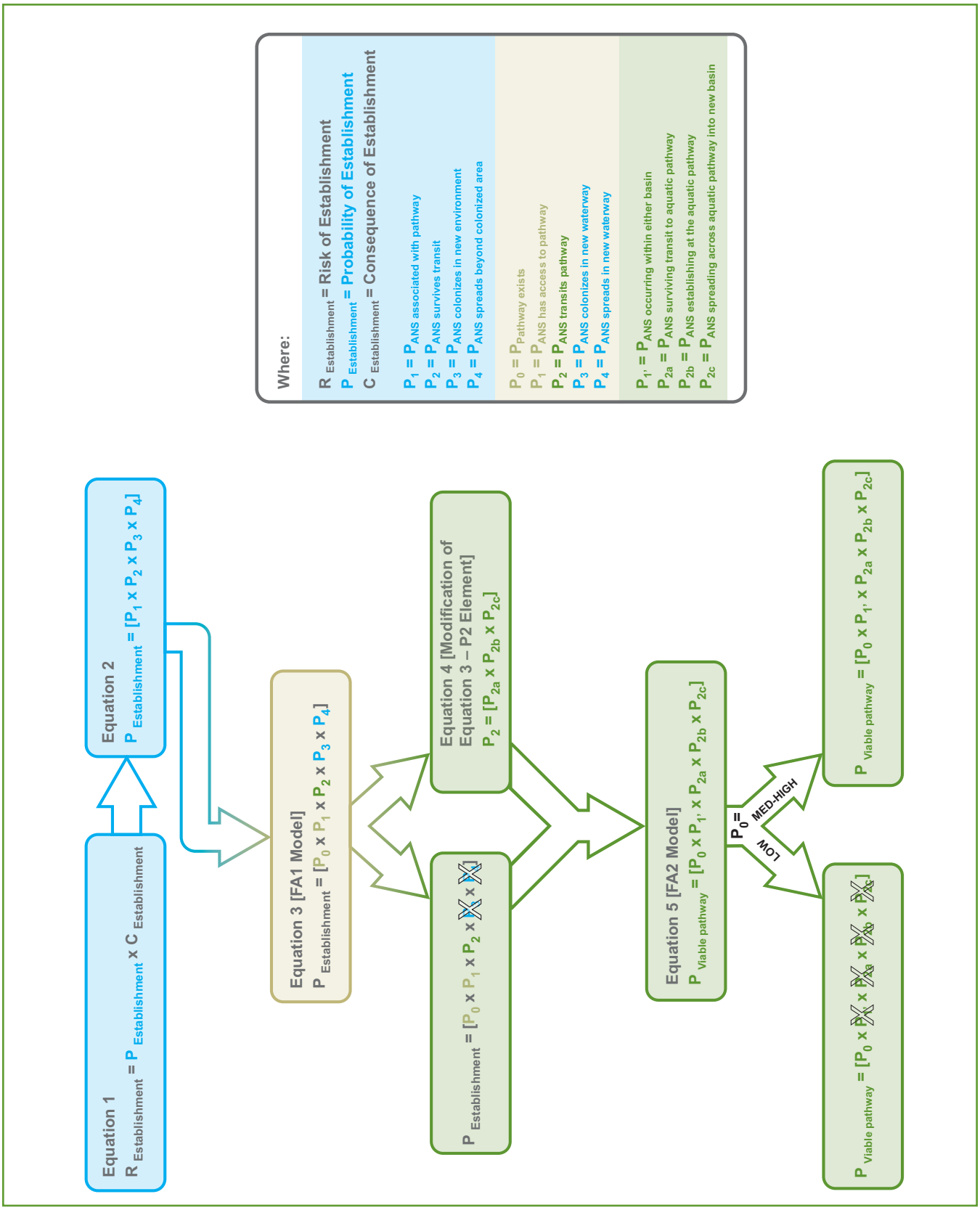

Figure 2. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

2.5 Example Calculation of Overall Aquatic Pathway Viability

As described in Section 2.2, a list of ANS of concern for the Menomonee Falls pathways was developed with input from Federal, State, and local agencies responsible for water resources, and fish and wildlife management in the state of Wisconsin and neighboring states along the Great Lakes and Mississippi River Basin divide. ANS of concern were grouped according to which basin they were currently established in to determine the viability of the aquatic pathway to transfer species across the divide in either direction. The determination of the likelihood of a viable aquatic pathway for each ANS of concern is the product of five probability elements (Equation 5). Thus, the probability of a viable pathway for a particular ANS of concern is equal to the lowest rating determined for each of the five probability elements (Table 5 and Table 6). The overall pathway viability for transferring ANS of concern from the Mississippi River Basin to the Great Lakes Basin was equal to the highest probability of a viable pathway for each ANS of concern in Table 4. In this example, all were rated low and thus the overall pathway viability for transferring species from the Mississippi River Basin to the Great Lakes Basin is “low”. The overall pathway viability for transferring species from the Great Lakes Basin is calculated the same way and is shown in Table 5. In this example, the overall pathway viability for transferring species from the Great Lakes Basin to the Mississippi River Basin is “medium”.

The last calculation is to determine the overall pathway viability for interbasin spread of ANS which is calculated by taking the highest of the overall ANS ratings for unidirectional transfer which were calculated in Tables 5 and 6. Thus, in Table 6, the overall probability that a viable aquatic pathway exists is “medium”. The ratings given for each element as well as the overall pathway viability ratings shown in Tables 5 and 6 were coordinated amongst the members of the pathway team until agreement was reached regarding the probability rating (H, M, or L) and the level of certainty (VC, RC, MC, RU, or VU).

Table 5. Example calculation of Pathway Viability for ANS Spreading from Mississippi River Basin to the Great Lakes Basin.

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**ANS Establishing at Aquatic Pathway?**	**ANS Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way Viability Rating**
fish	Asian carp, silver carp, bighead carp, black carp	swimmer	M (RC)	M (RC)	L (RC)	L (MC)	M (RU)	L
fish	inland silverside	swimmer		M (VC)	L (MC)	L (RC)	L (RC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

VC=Very Certain (as certain as going to get), RC=Reasonably Certain (reasonably certain), MC=Moderately Certain (more certain than not), RU=Relatively Uncertain (reasonably uncertain), VU=Very Uncertain (a guess)

Table 6. Example calculation of Pathway Viability for ANS Spreading from Great Lakes Basin to the Mississippi River Basin.

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**ANS Establishing at Aquatic Pathway?**	**ANS Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way Viability Rating**
fish	threespine stickleback	swimmer	M (RC)	M (VC)	L (RC)	L (MC)	L (MC)	L
pathogen	VHSv	fish pathogen / water column		H (VC)	H (MC)	H (RC)	H (RU)	M
Overall Pathway Viability for Spread of ANS from Great Lakes Basin to Mississippi River Basin								**M**

3 Aquatic Pathway Characterization

This section describes and illustrates the topography and features in the vicinity of the potential pathways and is intended to help inform the biological evaluations contained later in this report with a compilation of any readily available and applicable information of this area as it may influence local hydrology. Maps, photographs, and figures are included to aid understanding of the key hydrologic and hydraulic conditions near the drainage divide. Also, this section identifies any known significant data gaps and uncertainties related to the available topographic information and hydrologic modeling in the area of interest.

3.1 Location

The West and South Menomonee Falls potential pathways are located in the village of Menomonee Falls, Waukesha County, Wisconsin. Menomonee Falls is approximately 30 miles (48 km) Northwest of Milwaukee, Wisconsin and is in the northeast corner of Waukesha County near Washington and Milwaukee Counties. The West Menomonee Falls location is at a latitude of 43°11'5.69"N, and a longitude of 88° 9'23.97"W in a wetland near the intersection of County Line Road (County Road Q) and Lannon Road. The South Menomonee Falls location is at a latitude of 43°9'17.48"N, and a longitude of 88° 7'2.29"W, and is located in a Tamarack Swamp between Tamarack Trail Road and County Highway W (also known as Good Hope Road). Figure 3 is a general location map for the Menomonee Falls aquatic pathway locations along the Great Lakes and Mississippi River Basin divide line. The West and South Menomonee Falls locations, along with the basin divide, the Federal Emergency Management Agency (FEMA) one percent annual recurrence interval floodplains, and other relevant features in the area are shown in Figure 4. Figure 4 also indicates the location of the key culverts that provide for the hydrologic connections between both basins at the South Menomonee site.

3.2 Climate

Climate is looked at in this section just in terms of identifying any applicable elements of climate (e.g., temperature, rainfall) and how they may influence the likelihood of an aquatic connection forming at the subject pathway that could be utilized by ANS to spread between basins. This area of central Wisconsin is classified as continental with large temperature variance, four distinct seasons, and relatively small or moderate precipitation. Temperature extremes range from an all-time high of 107ºF (41.6ºC) which was observed on July 14th, 1936 to a record low of -37ºF (-38ºC), which occurred on January 30th, 1951. The average daily temperature in the winter (Dec-Feb) typically ranges from 12ºF to 30ºF (-11ºC to -1ºC), while summers (Jun-Aug) are usually around 64ºF to 74ºF (18ºC to 23ºC). Normal annual precipitation is about 30 inches (76 cm) and the normal snowfall is around 40 inches (101 cm). Daily temperatures average below 32ºF (0ºC) about 120 days and above 40ºF (4.4ºC) about 210 days of the year. Fond du Lac lakes are normally frozen from mid-December to early April. See Table 7 for National Climatic Data Center (NCDC) normals, from 1971-2000.

The highest precipitation accumulation occurs in the summer months from July to August. Although rainfall amounts do not always conform to averages, they are suggestive that substantial precipitation does not occur frequently and a much greater amount of precipitation would be necessary to cause a surface water connection. However, this is an area of uncertainty due to a lack of data linking precipitation amounts to the behavior of surface hydrology at the potential pathway locations. An aquatic pathway is most likely to occur at either the West or South Menomonee Falls sites during either the spring, when rain and snowmelt runoff coincide, or during summer rainstorm events. In addition, given that annual temperatures reach down to or below the freezing mark on an annual basis, purely climatic conditions will restrict the time during which any ANS movement might occur by natural vectors.

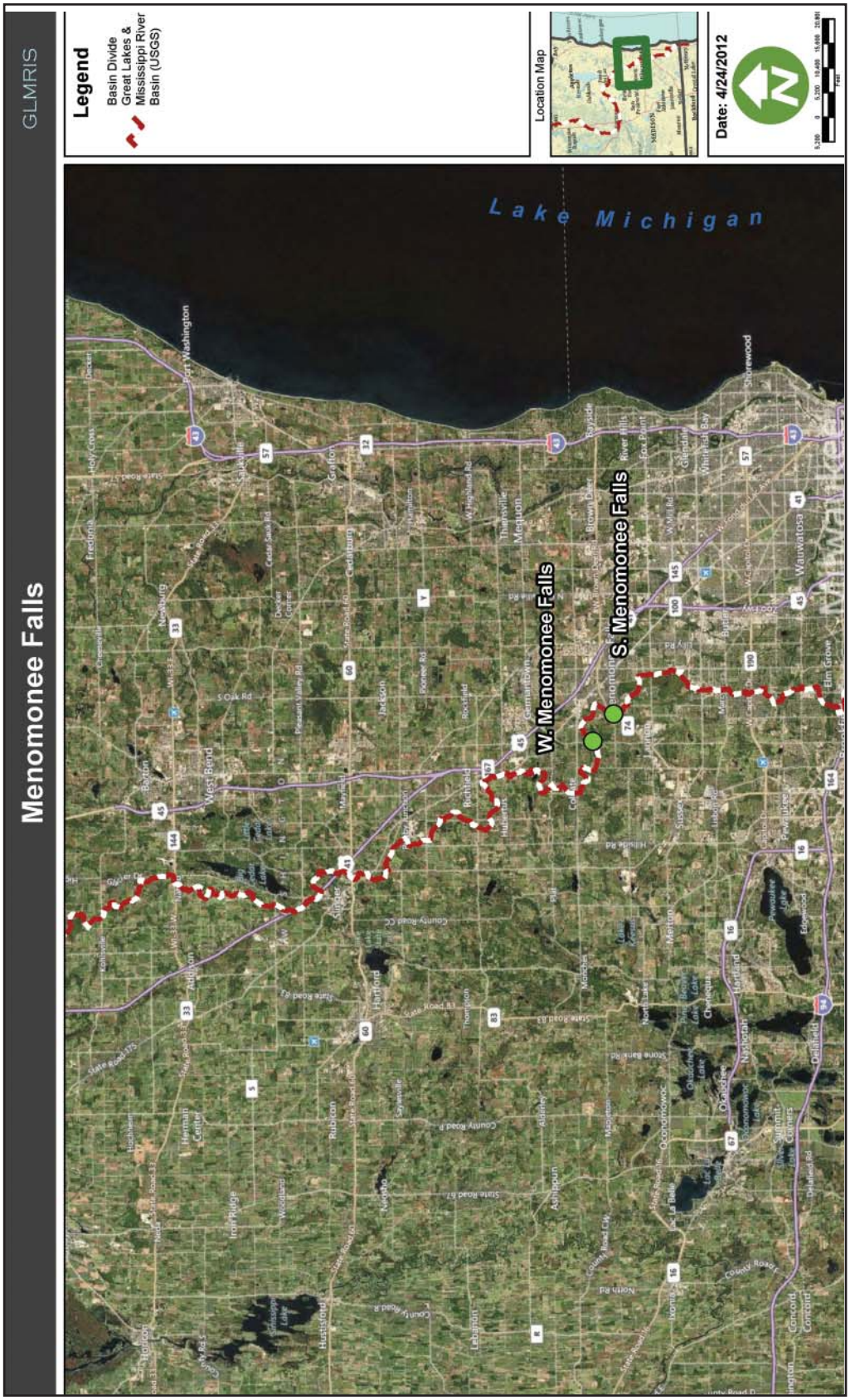

Figure 3. General location of West and South Menomonee Falls potential pathways, indicated by the green circles along basin boundary. Background aerial imagery courtesy of Bing Maps.

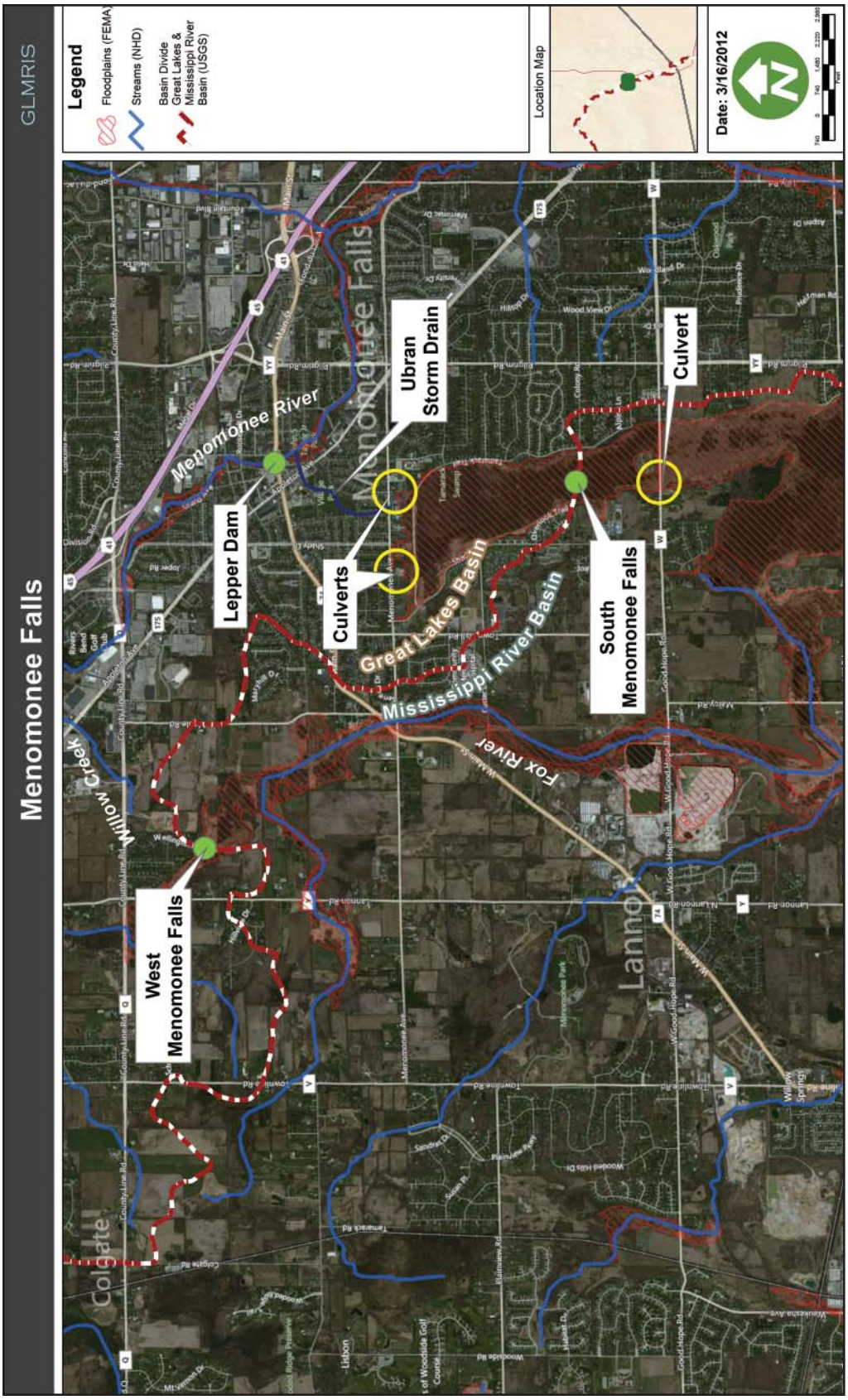

Figure 4. Location map for West and South Menomonee Falls potential pathways, with curvets associated with the South Menomonee location indicated. Blue lines are streams near the basin divide and red shaded areas are the FEMA one percent floodplain. Background aerial imagery courtesy of Bing Maps.

3.3 Location Specific Surface Water Features

This aquatic pathway report is for both the West and South Menomonee Falls potential aquatic pathways in Menomonee Falls, Wisconsin. The two will be discussed separately in this section of the report. This section is meant to present and interpret the readily available information for these locations as it pertains to surface water conditions and any aspects that may influence the behavior of surface water.

3.3.1 West Menomonee Falls Potential Pathway Location

A potential hydraulic connection at this location could occur between Willow Creek (Great Lakes Basin) and the Fox River (Mississippi River Basin). The FEMA one percent annual recurrence interval floodplains for Willow Creek and Fox River are connected in a low elevation wetland area. The FEMA base flood maps (one percent floodplain) are shown in Figure 5, along with the Hydraulic Unit Code (HUC)-12 boundary constituting the Great Lakes and Mississippi River Basin divide (red-white line).

The FEMA one percent water surface elevations, also known as Base Flood Elevations (BFEs), are depicted in Figure 4 and Figure 5. The BFE for both Willow Creek and the Fox River is 864 feet (263 m) (reference datum NGVD29) in the area of concern. The two foot (0.6 m) contours for the pathway location are shown, along with an overlay of the National Wetland Inventory (NWI) map from the USFWS, in Figure 6 and Figure 7. These figures indicate that contiguous wetland and FEMA floodplain extends across the basin divide and well into both basins, and is drained by tributaries toward the north and south. This would indicate that surface water may extend across the same area intermittently depending on recent precipitation amounts and ground conditions (e.g., frozen soil).

There is a relatively large pond located approximately 500 feet (152 m) west of the basin divide (within the Great Lakes Basin) that forms the headwater for Willow Creek. Willow Creek is a stream draining this pond and wetland area to the north where it passes through two smaller ponds near Lannon Road before it enters the Menomonee River, from where it flows into the Kinnickinnic River and then to Lake Michigan. On the Mississippi River Basin side of the divide, there is a drain approximately 1,350 feet (411 m) from the divide that connects to the Fox River, which flows to the Illinois River and then to the Mississippi River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photo in Figure 6, but this is not reflected in the two foot contour mapping due to the small scale. Based on the FEMA one percent BFE and the two foot (0.6 m) contours through the wetland, and assuming sheet flow through the wetland, a flow

Table 7: Climate Information for Menomonee Falls from the Germantown, Wisconsin NCDC Station.

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Mean Temperature°F	24.9	29.8	40.3	53.3	66.1	75.9	80.2	78.0	70.5	58.4	43.5	30.3	54.3
Mean Temperature °C	-3.9	-1.2	4.6	11.9	18.9	24.4	26.8	25.5	21.4	14.7	6.4	-0.9	12.4
Normal Precip (in)	1.35	1.20	2.04	3.30	3.03	3.82	4.05	4.28	3.53	2.47	2.59	1.79	33.45
Normal Precip (cm)	3.4	3.0	5.2	8.4	7.7	9.7	10.3	10.9	8.9	6.3	6.6	4.5	85.0
Mean Snow (in)	13.6	7.9	6.3	2.2	0.2	0.0	0.0	0.0	0.0	0.1	3.6	10.0	44.0
Mean Snow (cm)	35.5	20.0	16.0	5.6	0.5	0	0	0	0	0.3	9.1	25.4	111.8

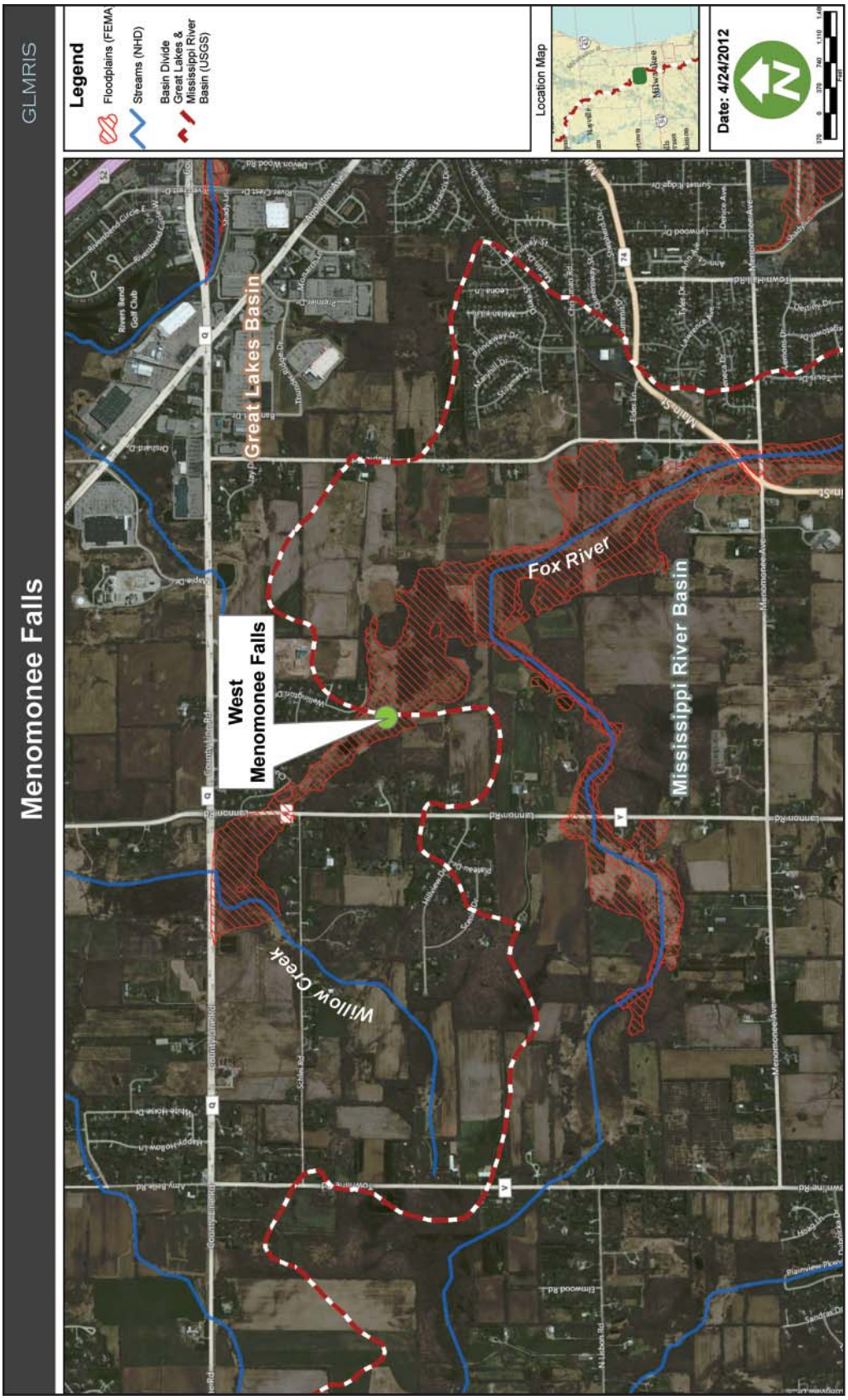

Figure 5. FEMA one percent floodplain for West Menomonee Falls, shown as the red shaded areas. The blue lines are the streams near the basin divide. FEMA floodplain areas are connected across the basin divide. Background aerial imagery courtesy of Bing Maps.

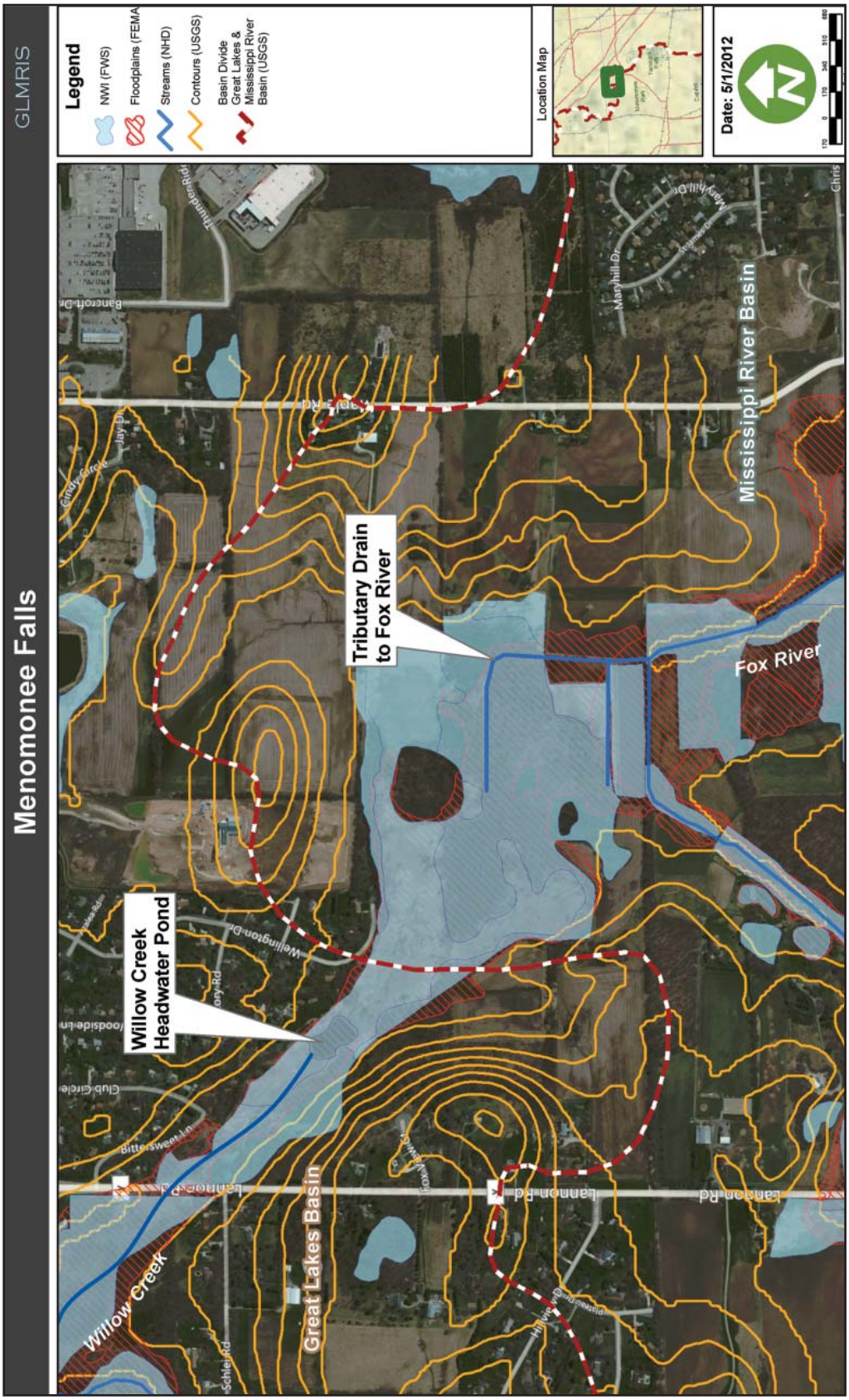

Figure 6. Elevation contours, FEMA one percent floodplain, and National Wetland Inventory wetlands (blue shading) at West Menomonee Falls site. Blue lines indicate streams near the basin divide. NAD 1983 State Plan Wisconsin. Background aerial imagery courtesy of Bing Maps.

Figure 7. Aerial view of the West Menomonee Falls showing National Wetland Inventory mapped wetlands (blue shading) without FEMA floodplain. Blue lines are streams and ditches near the basin divide. Background aerial imagery courtesy of Bing Maps.

depth up to 1.5 feet (0.46 m) of water could be expected for the one percent annual recurrence interval event. This flow would be about 550 feet (167 m) wide at its narrowest point near the basin divide. The total length of wetland flow between the Willow Creek pond and the Fox River tributary drain is about 1,850 feet (564 m). The known one percent annual recurrence interval discharge for the Fox River along this reach (adjacent to the West Menomonee Falls site) is 290 cubic feet per second (cfs) (8.2 cubic meters per second (cms)), the two percent discharge is 240 cfs (6.8 cms), and the 10 percent discharge is 105 cfs (3 cms). Interbasin flow, when it occurs, is most likely in the form of backflow from the Fox River (Mississippi River Basin) to Willow Creek (Great Lakes Basin).

During a site visit on June 7, 2011, water was observed flowing out of the large pond on the Great Lakes Basin side of the divide into Willow Creek, and continuing through the two smaller ponds and then through a 1.5-foot (0.46 m) corrugated metal pipe (CMP) culvert at Lannon Road. The total distance from the headwater pond of Willow Creek to Lannon Road is approximately 1,500 feet (457 m), and it is about 2,000 feet (610 m) to the basin divide (Figures 8 through 11). No ditches or channels were identified in the field connecting the drainage toward the Fox River with the Willow Creek headwater pond.

The soil type distribution for the area is shown in Figure 12. The three major soils in the area of interest are Ogden muck (Oc), pella silt loam (Ph), and Pella silt loam, moderately shallow variant (PM). The Oc soil is listed as being very poorly drained with a very high runoff coefficient and is listed as being frequently wet with a very high potential of wet basements. The hydric nature of these soils conforms with the information from the FEMA floodplain and NWI mapping, in that the area is frequently wet.

Figure 13 shows a representative cross-section through the area of interest, based on the best available geographic information system (GIS) data. For this pathway, the elevations are based on two-foot (0.6 m) contours from Waukesha County with a vertical accuracy of +/- one-foot (30 cm). It shows a profile along the HUC boundary to depict the 'saddle point' along the basin divide and a cross-section that cuts through the HUC boundary to indicate the typical ground elevation along the flow path between the two basins. The saddle point is the location of the lowest elevation along the basin divide and the point at which a hydrologic connection is most likely to be established. These cross-sections do not depict any channel(s) or other low elevation conveyances for water that may occur at this location. These cross-sections show the approximate ground elevations only and their vertical accuracy is limited, but still of great value in understanding the topography of the area and how it might influence surface water flow patterns. For example, it is evident by the cross section through the basin boundary that the predominant flow direction at the basin divide is toward the Great Lakes Basin, even though it is likely that a surface water connection may most readily form at the basin divide wetland via backflow from the Fox River.

In summary, for the West Menomonee Falls location, a flow depth up to 1.5 feet (0.46 m) of water could be expected for the one percent annual recurrence interval event. This flow could be about 550 feet (168 m) wide at the basin divide and about 300 feet (91 m) wide at the narrowest point near the pond at the headwaters to Willow Creek. The total length of wetland flow between the Willow Creek pond and the Fox River tributary ditch is about 1,850 feet (564 m). During a site visit, water was observed flowing out of the large pond in the wetland into Willow Creek, and continuing through the two smaller ponds before going through a 1.5-foot (0.46 m) CMP at Lannon Road. Other key surface water features at the West Menomonee Falls location include the following:

- Contiguous wetland (NWI mapping) between headwater streams in either basin and across the basin divide;
- Contiguous FEMA one percent recurrence interval floodplain area between headwater streams in either basin across the basin divide;
- Contiguous hydric soils between headwater streams in either basin;
- A series of ponds that form the headwater of Willow Creek draining to the Mississippi River Basin;
- Relatively flat surface slopes downstream of the ponds on Willow Creek; and

Figure 8. Looking southeast towards the headwater ponds of Willow Creek in the wetland area that spans the basin divide. Note thickness of vegetation. Photo from USACE, June 2011.

Figure 9. Willow Creek upstream face (east side) of 1.5 foot (0.46 m) CMP culvert at Lannon Rd. Photo from USACE, June 2011.

Figure 10. Willow Creek upstream face (east side) of CMP culvert at Lannon Rd, with water visible in the drain near the road. Photo from USACE, June 2011.

Figure 11. Representation of typical habitat conditions within wetland area near the basin divide. Photo from USACE, June 2011.

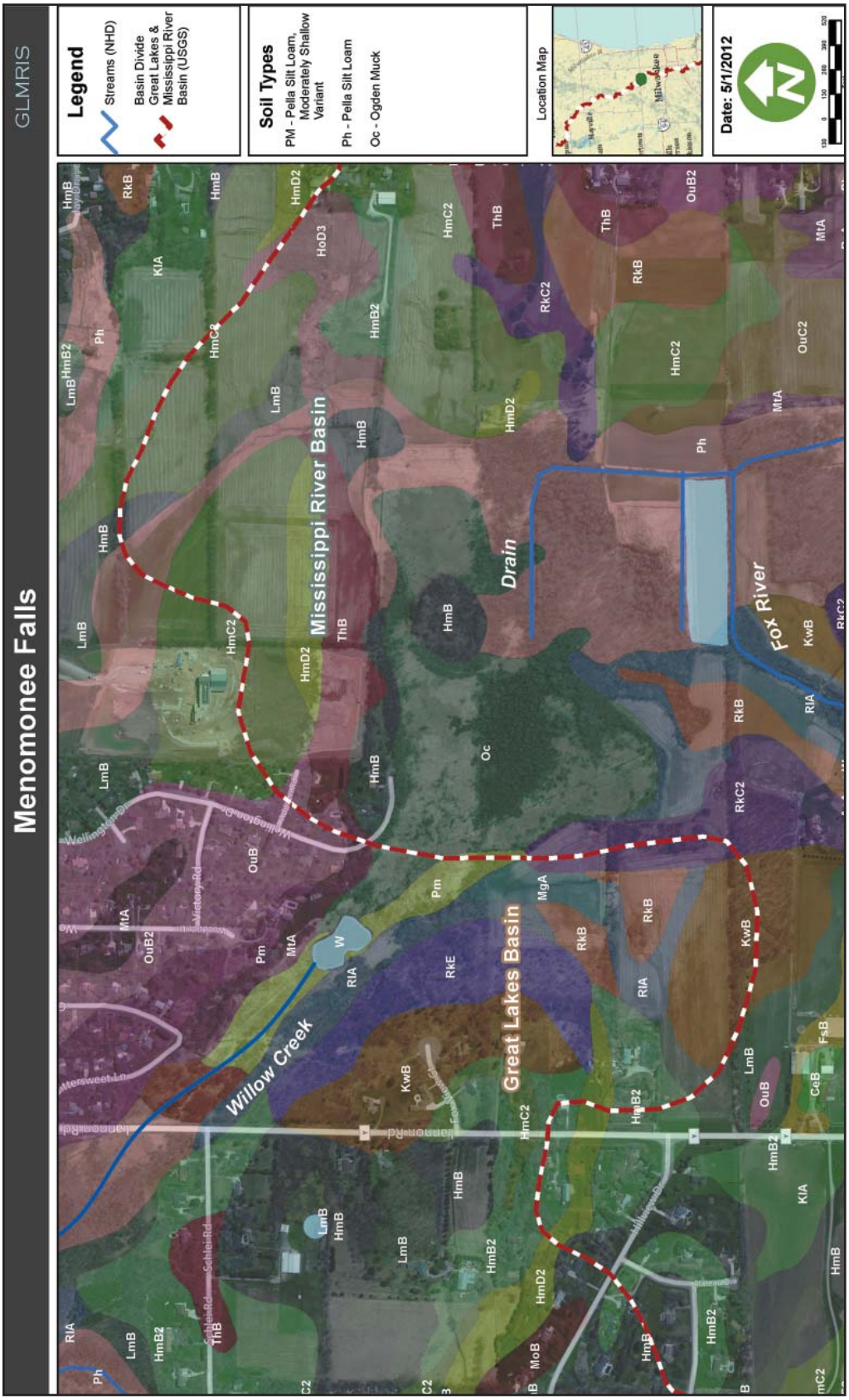

Figure 12. Soils map for the West Menomonee site indicating soils distribution (USDA-NRCS, 2012). Background aerial imagery courtesy of Bing Maps.

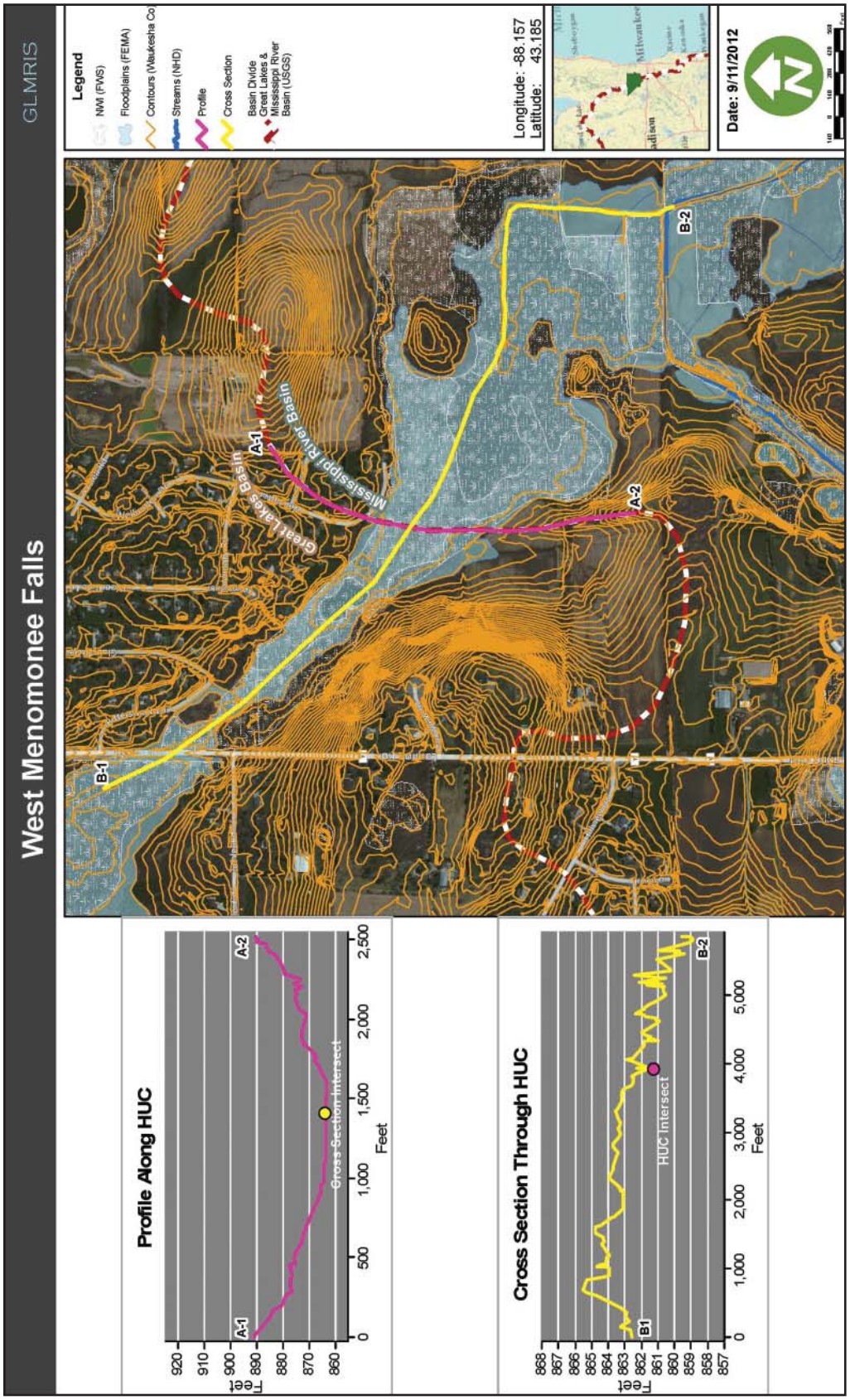

Figure 13. Location and basin divide profile and cross-section, based on two-foot (0.6 m) contours from Waukesha County, with a vertical accuracy of +/- one-foot (30 cm). The red/white line is the basin divide and the blue lines are streams near the basin divide. The pink line in the aerial photograph and the graph on the top left is the profile along the basin divide. The yellow line that intersects the pink line in the aerial photograph, and the graph on the bottom left, is the cross section through the basin divide. Background aerial imagery courtesy of Bing Maps.

- A more pronounced slope from the basin divide boundary to surface drains forming a tributary to the Fox River.

3.3.2 South Menomonee Falls Potential Pathway Location

A potential hydraulic connection at this location could occur between the Menomonee River (Great Lakes Basin) and the Fox River (Mississippi River Basin). The FEMA one percent annual recurrence interval floodplain for the Fox River and the Tamarack Swamp spans the basin divide from the Mississippi River Basin side and then continues north toward the Menomonee River. The FEMA base flood map and the 12-digit boundary representing the basin divide is shown in Figure 14. Urban storm drains or culverts for the roads that cross the wetland near the basin divide are also indicated, which are drained by the partially underground urban storm drain to the north and to the Menomonee River.

The basin divide at the South Menomonee Falls location runs through a low elevation area known as Tamarack Swamp located between Tamarack Trail Road and County Highway W (also known as Good Hope Road). Moving south from the basin divide to the Fox River (Mississippi River Basin), Tamarack Swamp is divided into a northern and southern area by County Highway W, which is located about 2,500 feet (762 m) south of the basin divide. From there, the connection to the tributary of the Fox River is through approximately 1.5 miles (2.4 km) of wetlands. However, there are many ditches in this wetland area, some of which can be seen in the aerial photos shown in Figure 15.

A civil engineer from the Village of Menomonee Falls was able to provide some valuable information on County Road W and the hydrology of Tamarack Swamp. A study was performed in 2006 to determine the water surface elevation of the one percent annual recurrence interval flood. A one percent precipitation amount of 7.1 inches (18 cm) of rain provided a water surface elevation of 841.95 feet (257 m) (NGVD29). There is a 24-inch (61 cm) CMP culvert under County Highway W, with an invert elevation of 841.61 feet (256.5 m) (NGVD29). The lowest road elevation of County Highway W is 844.4 feet (257 m) (NGVD29). The position of the existing culvert under the road would allow for about 4 inches (10 cm) of flow through the culvert with a 7.1-inch (18 cm) rain event, but no overtopping of the road (B. Hornickel, P.E., City Engineer for Menomonee Falls, personal communication, September 3, 2010 and November 3, 2011). The width of County Highway W is approximately 65 feet (19.8 m), as measured off of Google Earth.

From the Waukesha County two-foot (0.6 m) contours, the average elevation of the Tamarack Swamp is about 840 feet (256 m) (NGVD29). This would mean a flow depth of about two feet (0.6 m) throughout the swamp for a one percent flood event. No other analysis was preformed, but the two percent precipitation is still six inches (15 cm) of rain and the 10 percent precipitation is five inches (12.7 cm) of rain. Since these are still high precipitation values, the water surface elevation could remain near the one percent annual recurrence interval event. As water would likely still be in the culvert at events less than the one percent event for multiple days at a time during high flow events, this pathway was added back into the study for further consideration (2010 Preliminary Risk Characterization Report did not recommend this site for further analysis). This roadway is the only structural impediment to flow through the wetland to the tributary of the Fox River.

Moving north from the basin divide located in Tamarack Swamp towards the Menomonee River (Great Lakes Basin), the surface water flow path is through approximately one mile (1.6 km) of wetlands. However, there are ditches in this wetland, some of which can be seen in the aerial photo in Figure 16. Continuing to the north, the Tamarack Swamp drainage to the Great Lakes Basin passes through two culverts under Tamarack Trail Road (Figure 17), and then into the inlet of an underground storm drain that eventually comes above ground before draining into the Menomonee River (Figures 17 and 18).

The urban storm drain that connects the Fox River Basin to the Menomonee River Basin is a three-foot (0.9 m) diameter CMP that is approximately 1,500 feet (457 m) in length, and is depicted in Figures 17 and 18 by a yellow line. This urban storm drain starts just south of Menomonee Avenue and continues underground until it surfaces just north of Ann Avenue. There is an open channel stream that connects this storm drain to the

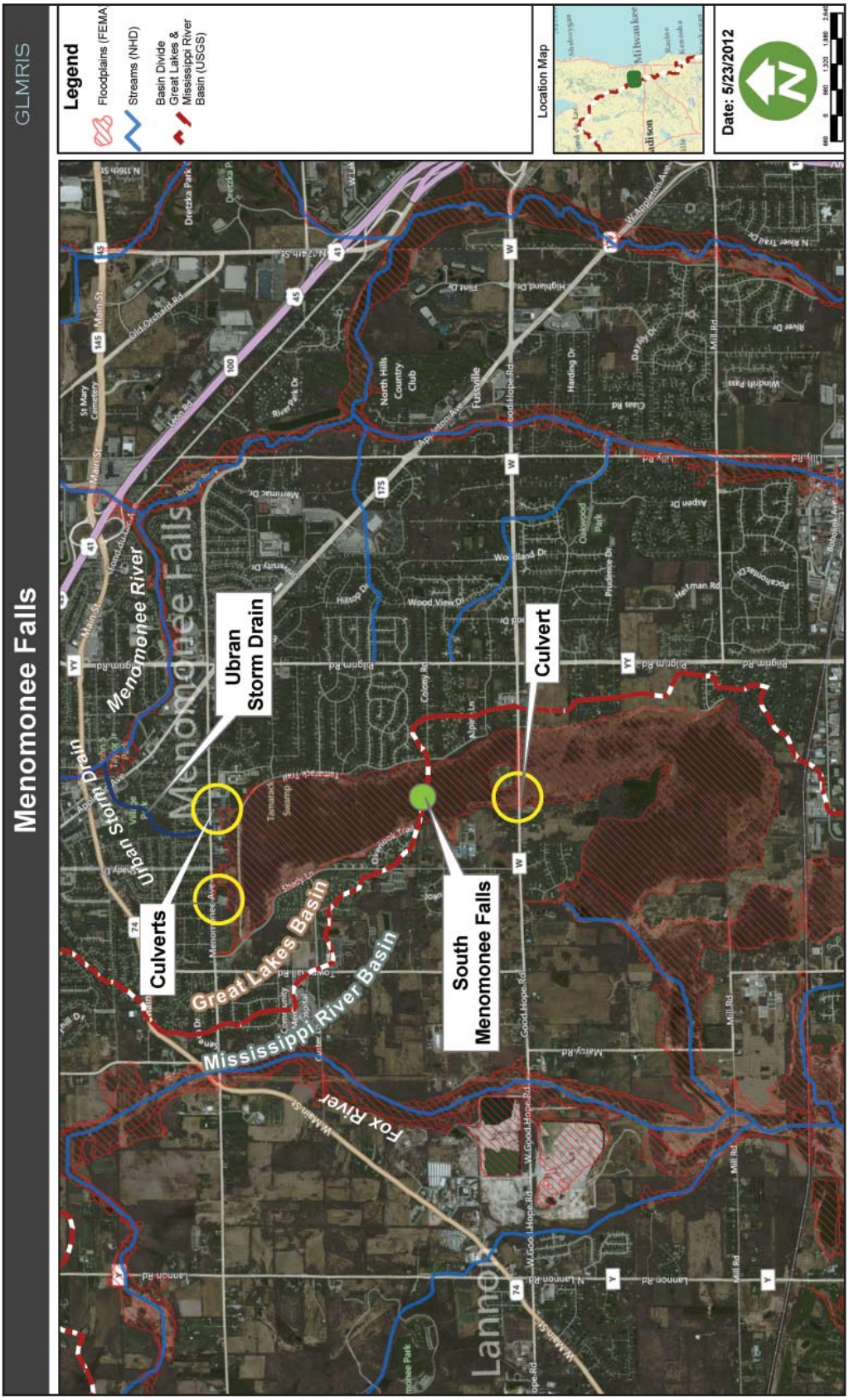

Figure 14. FEMA one percent floodplains for South Menomonee Falls. Blue lines are streams and ditches, and black lines are culverts and storm drain. Background aerial imagery courtesy of Bing Maps.

Figure 15. Tamarack Swamp just south of County Highway W (left photo) and just south of Tamarack Trail Road (right photo). Ditches seen as darker lines in the wetlands. Background aerial imagery courtesy of Bing Maps.

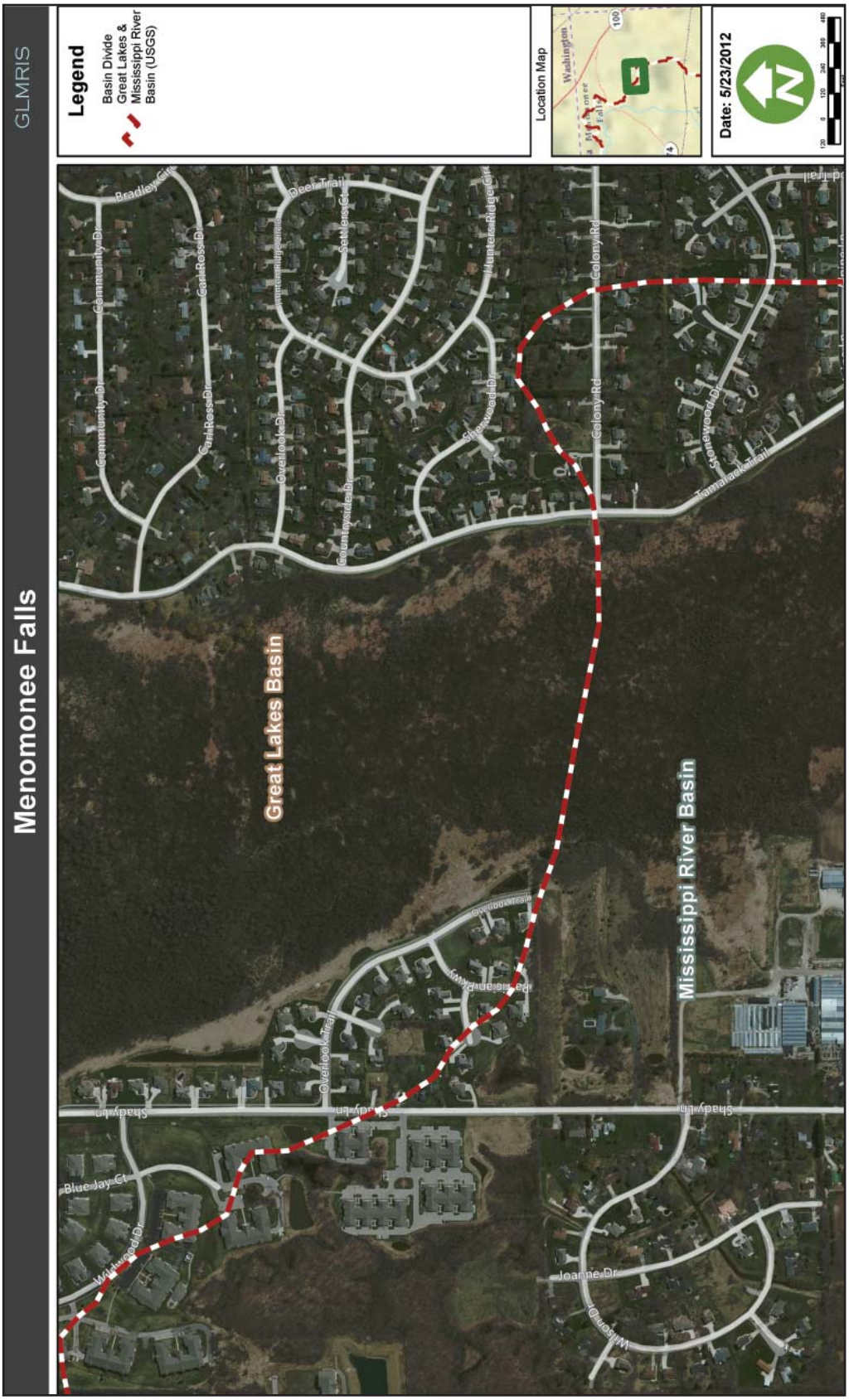

Figure 16. Ditches and habitat in Tamarack Swamp just north of County Highway W. Background aerial imagery courtesy of Bing Maps.

Figure 17. Culverts under Tamarack Trail Road connecting with the underground urban storm drain that leads to the Menomonee River. Background aerial imagery courtesy of Bing Maps.

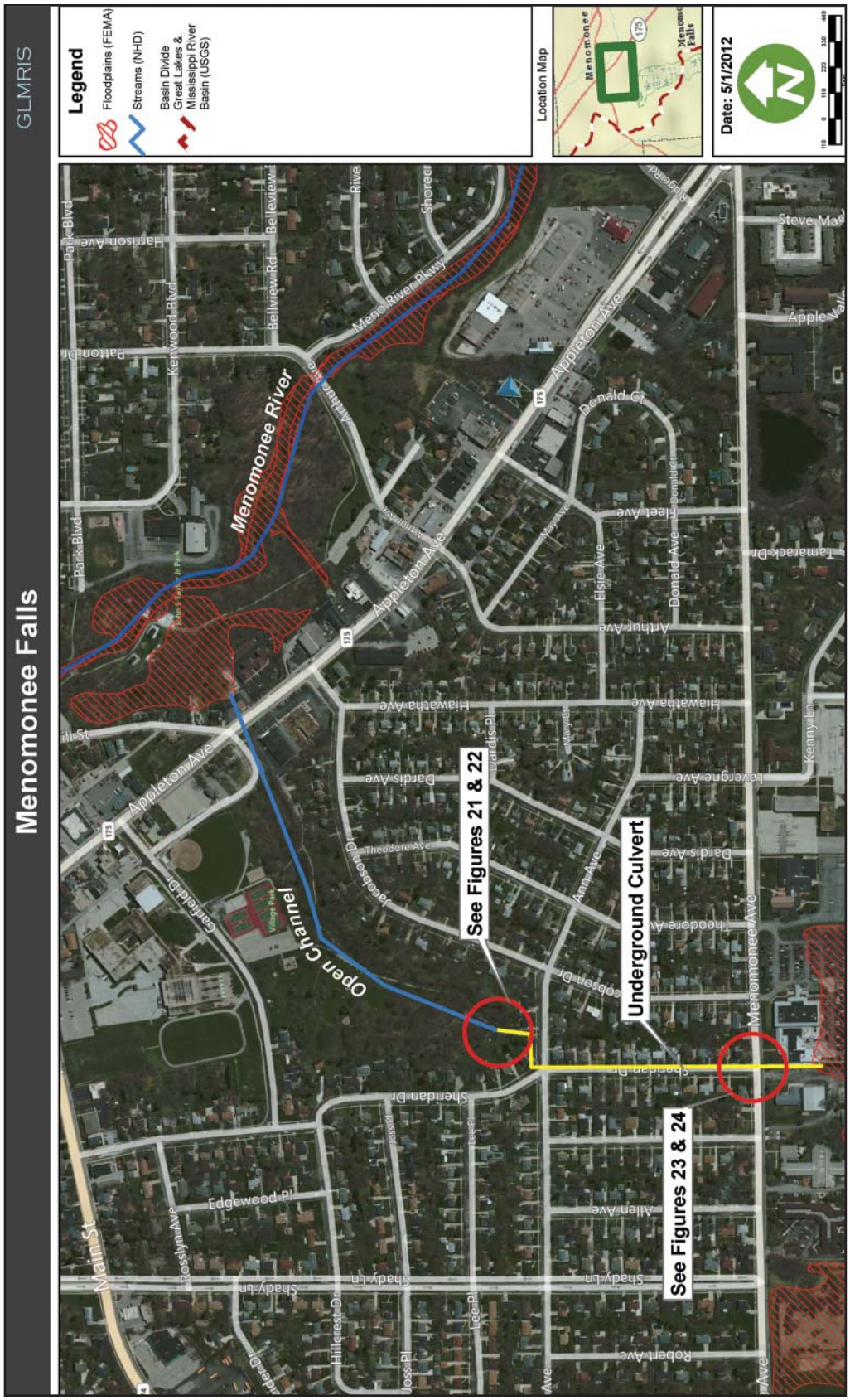

Figure 18. South Menomonee Falls urban storm drain (yellow line) and open water stream (blue line) that connects Tamarack Swamp to the Menomonee River. Red hatched area indicates FEMA one percent floodplain of Tamarack Swamp and Menomonee River. Background aerial imagery courtesy of Bing Maps.

Menomonee River and is approximately 2,000 feet (610 m) long (Figure 18).

Flow from this wetland area is toward the north and two-foot (0.6 m) contour mapping of the area of open channel shows there to be a 40-foot (12 m) drop in elevation from the storm drain outlet to the confluence with the Menomonee River located approximately 2,000 feet (610 m) downstream. This area is circled in red on Figure 19. Because of these steep topography, the flow direction of concern at the South Menomonee location is only toward the Great Lakes Basin.

The wetland classification for the area is shown in Figure 20. Three of the major soils in the area of interest are Ogden muck (Oc), Palms Muck (Pa), and Houghton Muck (HtA). The OC, Pa, and HtA soils are all listed as being very poorly drained with a very high runoff coefficient. These soils were also listed as being frequently wet with a very high likelihood of wet basements. Just as with the West Menomonee site, the hydric nature of these soils conforms with the information from the FEMA floodplain and NWI mapping, in that the area is frequently wet.

Representative cross-sections through the area of interest, based on the best available GIS data, are shown in Figure 21. The elevations for this pathway are again based on two-foot (0.6 m) contours from Waukesha County with a vertical accuracy of +/- one-foot (30 cm) and include a profile along the HUC boundary to depict the saddle point along the basin divide and a cross-section that cuts through the HUC boundary to depict the typical ground elevation along the flow path. These cross-sections do not depict the urban storm sewer at this location, but they do show the general ground elevations. For example, the profile along the HUC shows that the wetland is a narrow depressional area about 10-15 feet (3-4.5 m) lower in elevation than the surrounding developed area, and the cross section through the HUC (flow path) indicates the steep elevation difference between the wetland and the Menomonee River within the Great Lakes Basin.

A site visit on June 7, 2011 confirmed that there was a defined channel with water flowing to the north from the urban storm drain toward the Menomonee River (Figure 22 and 23). This same site visit showed there to be a steel grate on the urban storm drain where it crosses underneath Menomonee Avenue, also indicating a moderate amount of flow through this area based on the amount of debris pressed against the grate (Figures 24 and 25).

In summary, for the South Menomonee Falls location, there could be a surface water depth of up to about two feet (0.6 m) throughout much of the wetland during a one percent event. The only major impediment to flow between the basins is the culvert under County Highway W, which would have about four inches (10 cm) of water in it for the one percent event. It is unknown what the depth of flow in the culvert would be for lower events, but the difference in rainfall between the one percent and two percent events is only about one-inch (2.54 cm), and the difference is only about two inches (5 cm) between the one percent and 10 percent events. Other key surface water features at the South Menomonee Falls location include the following:

- Contiguous wetland between headwater streams in either basin and across the basin divide;
- Contiguous FEMA one percent recurrence interval floodplain area between headwater streams in either basin across the basin divide;
- Contiguous hydric soils between headwater streams in either basin;
- Two culverts under Tamarack Trail Road allow flow north out of the wetland and into the underground storm drain passing under Menomonee Avenue;
- Steep slopes between the Menomonee River and the outlet of the urban storm drain is 40 feet (12 m) vertical over approximately 2,000 feet (610 m) horizontal, and very flat slopes between the basin divide and the nearest tributary to the Fox River;
- The predominant flow direction of concern at this location is toward the Great Lakes Basin due to the steep slopes between the Menomonee River and the urban storm drain; and
- There is a culvert underneath County Highway W, allowing flow to pass between the Fox River drainage and the area of the basin divide.

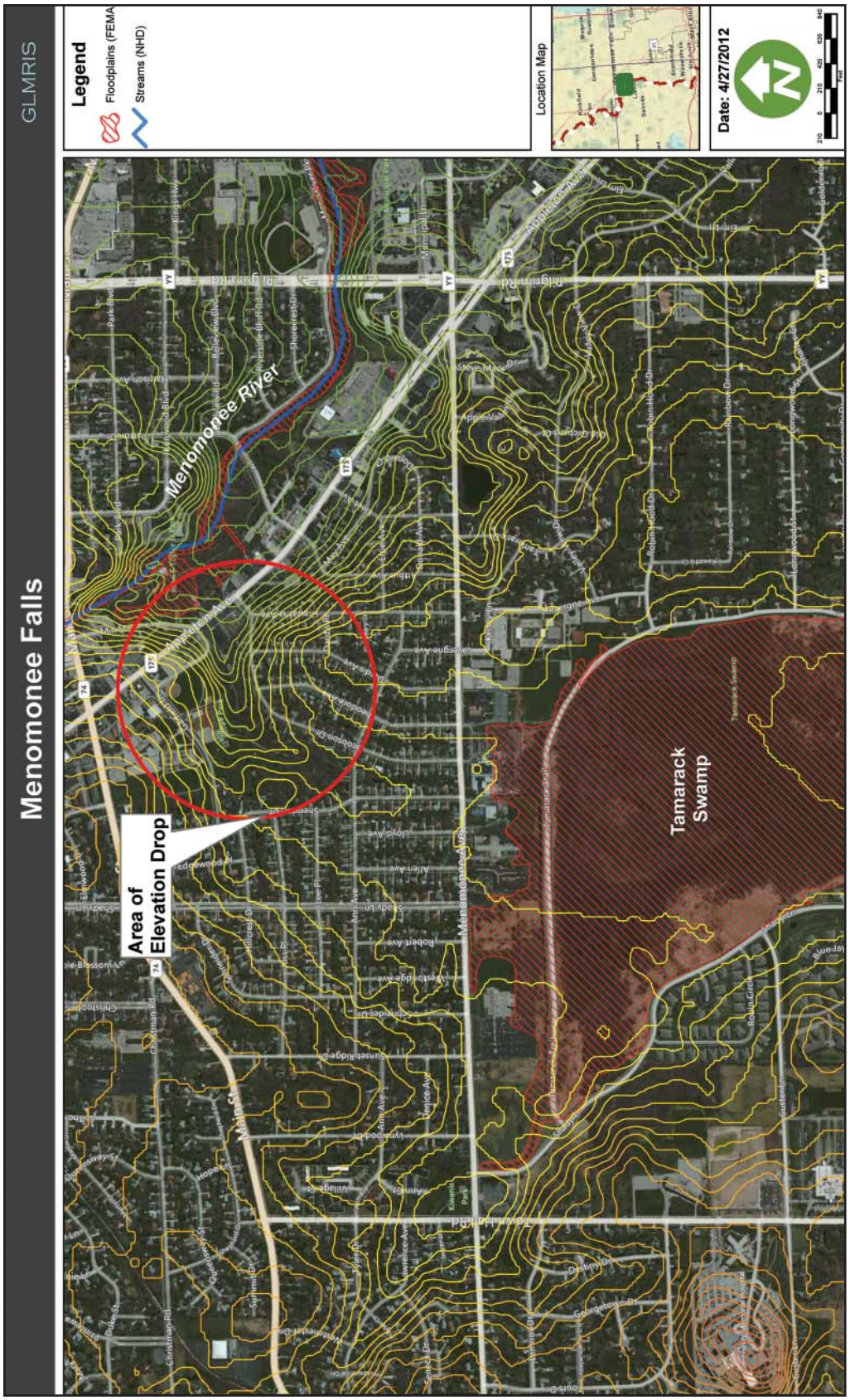

Figure 19. Elevation contours for South Menomonee Falls, north of Tamarack Trail, showing steep topography as the tributary approaches the Menomonee River. Background aerial imagery courtesy of Bing Maps.

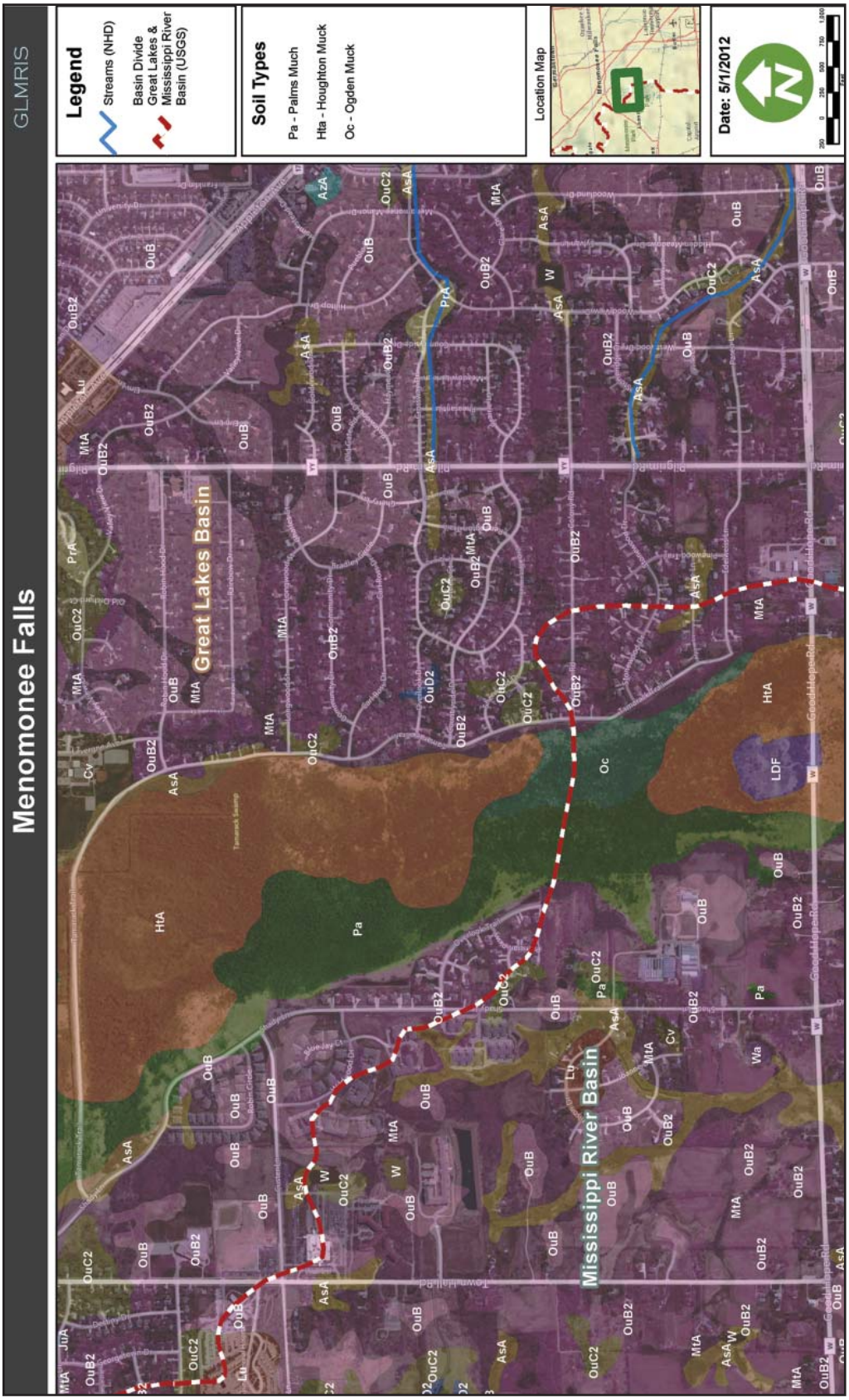

Figure 20. Soils map for the South Menomonee site indicating soils distribution in the area of interest (USDA-NRCS, 2012). Background aerial imagery courtesy of Bing Maps.

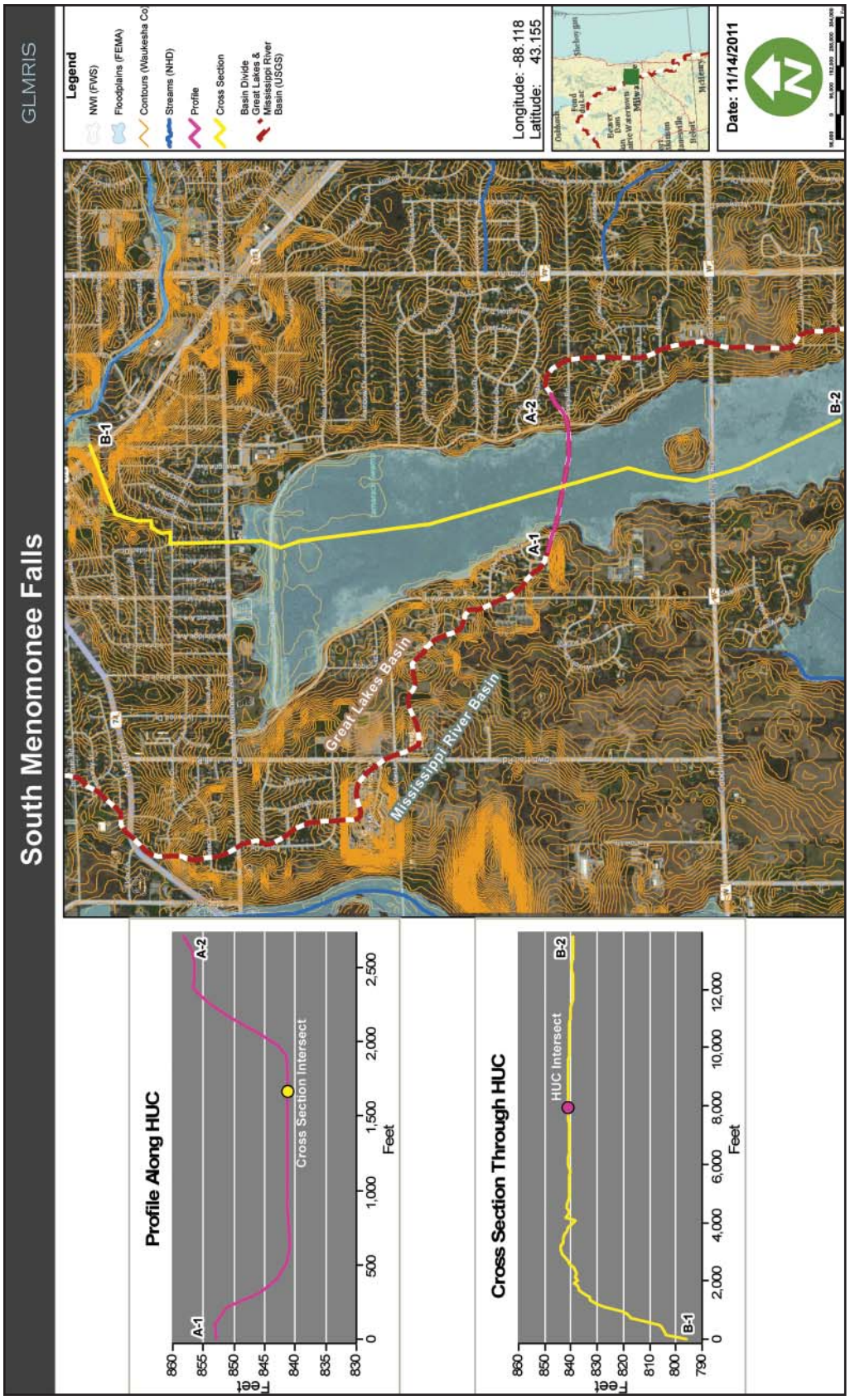

Figure 21. Typical location and HUC profile cross-sections, based on two-foot (0.6 m) contours from Waukesha County with a vertical accuracy of +/- one-foot (30 cm). The red/white line is the basin divide and the blue lines are streams near the basin divide. The pink line and the graph on the top left is the profile along the basin divide. The yellow line that intersects the pink line in the photograph and the graph on the bottom left is the cross section through the basin divide. Note sharp elevation drop toward Menomonee River (Great Lakes Basin) and very gradual drop toward Fox River (Mississippi River Basin). Background aerial imagery courtesy of Bing Maps.

Figure 22. North end of urban storm drain near Ann Avenue (looking south). Photo from USACE, June 2011.

Figure 23. North end of urban storm drain near Ann Avenue (looking north). Photo from USACE, June 2011.

Figure 24. South end of urban storm drain near Menomonee Avenue, looking at culvert entrance. Photo from USACE, June 2011.

Figure 25. South end of urban storm drain near Menomonee Avenue, looking towards Tamarack Swamp. Photo from USACE, June 2011.

3.4 Groundwater

Groundwater was investigated as part of determining the likelihood of a pathway existing because groundwater can serve as a source of baseflow for streams. Water levels in the aquifers typically fluctuate in response to seasonal variations in recharge and discharge. Groundwater levels commonly rise in spring, when areal recharge is greatest because of snowmelt, spring rain, and minimal evapotranspiration losses. This means that heavier rainfall events, when they coincide with frozen ground conditions, snowmelt, and higher groundwater conditions, may be more likely to facilitate formation of an aquatic connection between the basins. Groundwater levels generally decline in summer because evapotranspiration rates are high, continued discharge to streams, and withdrawals by wells collectively exceed recharge. Thus, groundwater likely plays very little role in any establishment of an aquatic connection. Net recharge to the aquifers also occurs in the fall of most years, due to rainfall and low evapotranspiration rates. The nearest available groundwater data for West Menomonee Falls is from USGS Groundwater Watch site No. 430353088095901, located about nine miles (14 km) south of the pathway site. The nearest available groundwater data for South Menomonee Falls is from USGS Groundwater Watch site No. 430706087583601, located about 10 miles (16 km) south of the pathway site. Although no groundwater data in the immediate vicinity of the pathway is available, groundwater conditions are not believed to increase the likelihood of a surface water connection being maintained between these watersheds.

3.5 Aquatic Pathway Temporal Characteristics

Characterizing the temporal variability of the pathway hydrology is an important aspect of understanding the likelihood of an ANS being able to traverse the basin divide at these locations as flood events may coincide with species dispersal and reproduction patterns and abilities to survive and establish populations in various areas. The area of the Menomonee Falls potential aquatic pathway sites have both been identified by FEMA to be Zone A or AE , which means they are in the one percent annual recurrence interval floodplain. An aquatic pathway is most likely to occur at either the West or South Menomonee Falls sites during either the spring, when rain and snowmelt runoff coincide, or during some summer rainstorm events. Based on field observations and available information about the area (e.g., soils, FEMA and NWI mapping, aerial photos, elevation data, etc), it is highly likely that the wetlands at both locations have saturated soils most of the year and some ponded or standing water at least during the springtime, and likely during heavier rain events throughout the year. In addition, given that the area is subjected to freezing temperatures on an annual basis for up 120 days or longer (Table 1), biological activity and water flow would likely be restricted on a temporal basis since the water would be frozen and biological activity of ANS would be limited.

3.6 Probability Aquatic Pathway Exists

The viability ratings discussed in this section are only for the likelihood of an aquatic connection existing at these potential pathway sites (P_0) up to a one percent annual recurrence interval storm. For the West Menomonee Falls location, a surface water connection could form between the Great Lakes and Mississippi River basins based on these points:

- The FEMA one percent floodplain, hydric soils, and NWI mapping are contiguous across the area of interest, extend across the basin divide, and connect with tributaries within the Great Lakes and Mississippi River Basins.
- During a June 2011 site visit, water was observed flowing into the tributary to the Great Lakes Basin and water appears to be regularly connected to both watersheds.
- Relatively flat topographic contours suggest surface water from flooding events could connect in the low lying wetland area at the basin divide.

The team determined that for the West Menomonee Falls location, there are perennial streams and wetlands, or intermittent streams, known to convey water across the basin divide for days to weeks multiple times per year. The location of a wetland spanning the basin divide helps to maintain standing water areas (e.g., ponds) that are likely to become inter-connected and connect with streams on both sides of the basin divide from a 10 percent annual recurrence interval storm. Consequently, the probability of the existence of an aquatic pathway at the West Menomonee Falls pathway is rated high for flow into the Great Lakes Basin, and medium for flow into the Mississippi River Basin (Appendix A).

These ratings are considered moderately certain for West Menomonee Falls because of the following:

- During the site visit, no ditches in the wetland were observed connecting the tributaries to the Great Lakes and Mississippi River Basins;

- It appears that much of the water entering this wetland during flood events occurs as backflow up from the Fox River, leading to difficulty in predicting hydrologic behavior;

- Lack of modeling or specific data that calibrates precipitation events to actual surface water hydrology at this wetland (e.g., three inches (7.6 cm) of rain equates to how much standing water at the basin divide, etc).

- Different resource mapping agreed on the wet and likely saturated conditions frequenting this area.

For the South Menomonee Falls location, a surface water connection could form from the Mississippi River Basin toward the Great Lakes Basin, but it is unlikely that flow could occur in the other direction, based on the following points:

- Water is regularly connected to both watersheds via culverts under County Highway W, Tamarack Trail Road, and Menomonee Avenue. However, such a connection is only possible for flow toward the Great Lakes Basin. The probability of backwater inundation from the Menomonee River (Great Lakes Basin) all the way to the Tamarack Swamp and the Fox River drainage (Mississippi River Basin) appears unlikely as there is a rise of about 40 feet (12 m) above the river that would be necessary for this to occur;

- The FEMA one percent floodplain, NWI mapping, and hydric soils mapping are contiguous across the area of interest and extend across the basin divide in the Tamarack Swamp, and connect with headwater streams within either basin. Tamarack Swamp is connected to the Great Lakes Basin through culverts to the Menomonee River.

The team determined that for South Menomonee Falls, the location of a wetland spanning the basin divide helps maintain standing water areas that are likely to become inter-connected and connect with streams on both sides of the basin divide continuously for multiple days from a 10 percent annual recurrence interval storm for flow into the Great Lakes Basin. Also, a marsh may form a surface water connection between streams on either side of the basin divide from larger than a one percent annual recurrence interval storm for flow into the Mississippi River Basin. Consequently, the probability of the existence of an aquatic pathway at South Menomonee Falls pathway is rated medium for flow into the Great Lakes Basin, and low for flow into the Mississippi River Basin.

These ratings are considered reasonably certain for South Menomonee Falls (slightly more certain than for the West Menomonee Falls location) because of the following:

- More detailed information was available for this site from the Menomonee Falls City Engineer.

- Different resource mapping that all agreed on the wet and likely saturated conditions frequenting this area.

The team rating forms for the probability of an aquatic pathway existing for West and South Menomonee Falls can be found in Attachment A for this report.

3.7 Aquatic Pathway Habitat

3.7.1 West Menomonee Falls

The possible West Menomonee Falls interbasin connection is comprised of forested and emergent wetland, including three small ponds that form the beginning of Willow Creek. This wetland is bordered by residential subdivisions to the north and west, and by agricultural fields to the south and east. As the source of Willow Creek, the largest pond retains water throughout the year. Although no sampling was completed or available, native fish species expected to inhabit this pond would include bullheads, topminnows, tolerant sunfishes, and central mudminnows. These species can tolerate warmer temperatures and low dissolved oxygen levels that would be expected in a small wetland pond during the summer months. The area also has an assemblage of typical wetland wildlife and plants. Reed canary grass (Phalaris spp), an exotic/invasive plant species, seems to be the dominate plant species in the area. While the pond may be able to support aquatic life for most of the year, the rest of the wetland area would only be able to support sustained aquatic communities during times of inundation, such as spring snow melt and heavier rains.

The West Menomonee Falls wetland complex consists of one larger pond and two smaller ponds, along with intermittent ditches, submerged and forested wetland habitats. Aquatic nuisance species approaching from the Great Lakes Basin or Mississippi River Basin would find limited habitat available unless it was during the spring thaw or after a heavy summer storm. During the one percent annual recurrence interval flood event, a flow depth of 1.5 feet (0.46 m) is expected. This depth would be adequate to facilitate ANS movement through the wetland. However, species moving from the Great Lakes Basin would still have to navigate through the 1.5-foot (0.46 m) culvert pipe at Lannon Road in order to continue on to Willow Creek. As the pictures of this drain indicate, it is an old pipe and may not accommodate movement out of the wetland complex. Any ANS spreading from the Great Lakes Basin may also not have an opportunity to reach this pipe because of the Lepper Dam on the Menomonee River. This dam is impassible for species moving upstream from Lake Michigan. There are also numerous other road crossings in the Willow Creek watershed that would have to be navigated in order for any ANS to reach the Lannon Road drain pipe.

3.7.2 South Menomonee Falls

The possible South Menomonee Falls interbasin connection is comprised of shrub/scrub, forested and emergent wetland in an area named “Tamarack Swamp”. This area is just south of downtown Menomonee Falls, Wisconsin, and is surrounded completely by residential neighborhoods and commercial development. With no permanent standing water, it is doubtful that any fish species currently make a permanent residence within the wetland complex. As this area is in the heart of Menomonee Falls, native wildlife such as raccoon, muskrat, opossum, and other large mammals are expected to inhabit this area. Neo-tropical birds as well as native reptiles and amphibians would also be expected to be found here. Again, reed canary grass is likely a dominant species in Tamarack Swamp.

The South Menomonee interbasin connection in Tamarack Swamp has several remnant ditches running through it. There are also several culverts that convey water into and through the wetland. For ANS coming from the Great Lakes Basin via the Menomonee River, there is a 2,000-foot (610 m) open channel stream with a 40-foot (12 m) incline from the Menomonee River to the storm drain. This storm drain is three feet (0.9 m) in diameter and runs for 1,500 feet (457 m) before it reaches the northern limit of Tamarack Swamp. There is also a trash rack at the southern end of the drain that would make it difficult for larger fish to make it through from either direction, especially if woody debris or other materials have been pressed against it. After reaching the northern end of the swamp there is still a mile (1.6 km) of wetland complex extending to the south before the basin divide is reached. ANS spreading from the Mississippi River Basin would enter the Tamarack Swamp from the southwest, where the species would have to start traversing 1.5 miles (2.4 km) of ditches

before reaching County Road W. A culvert under County Road W is 24 inches (61 cm) wide and approximately 65 feet (20 m) long. During the one percent annual recurrence interval event, only about four inches (10 cm) of water is expected to flow through this culvert. This would make it difficult for species (unless small) traveling in either direction to cross under the county road. Aside from the difficult road crossings, traversing the wetland complex in either direction would be easier during flood events as it is expected that a two-foot (60 cm) flow depth could occur during the one percent recurrence interval flood event.

3.7.3 Aquatic Resources

Invasive fish species spreading upstream from the Great Lakes Basin would likely find suitable habitat in the Menomonee River upstream to the Lepper Dam. The river flows freely from below the dam to Lake Michigan. However, because of the lack of fish passage at this dam, no species are expected to be able to make their way to the basin divide at the West Menomonee Falls interbasin connection. If for some reason ANS were placed above the Lepper Dam, the habitat available to them would include small streams and ditches leading to the basin connection. Traversing the Willow Creek watershed also includes several culverts that may only be accessible during high water periods. There is a pond near the interbasin connection that is the source of hydrology for Willow Creek. This would serve as suitable habitat for fish species during times of normal flow. The rest of the wetland area may also be adequate to support fish species for periods of time during flood events. During such periods of flooding, an expected flood flow depth of 1.5 feet (0.46 m) is possible, making the connection passable by ANS if they were to arrive at the connection at exactly the right time. However, if ANS were to reach this far they would then have to navigate through thickly vegetated wetland habitat to find their way to the other basin.

Invasive fish species traveling to the South Menomonee interbasin connection would have access to the outlet of the storm drain that leads to the Tamarack Swamp, although they would have to be able to swim upsteam on this storm drain over relatively steep terrain. Habitat in the storm drain is of very limited quality as the first 2,000 feet (610 m) of open channel has an incline of 40 feet (12 m). After this there is 3 foot (0.9 m) wide metal pipe that is raised above the open channel. During times of interbasin connection, it has been determined that flow would be moving from the Mississippi River Basin towards the Great Lakes Basin. This would mean any fish on the Great Lakes Basin side of the divide would have to swim against the current and navigate the difference in head height to get into this pipe, which is 1,500 feet (457 m) long. At the end of the pipe as it flows under Menomonee Avenue is a trash rack at the end to keep woody debris and other material from entering the drain from the wetland area. This could serve as major impediment to ANS passage at this location. If ANS could get through the pipe and pass through the trash rack, there would still be a mile (1.6 km) of wetland for them to cross and reach the interbasin connection. While there are ditches in the wetland complex, most remain dry during normal flow periods. After reaching the interbasin divide, ANS would have to then negotiate another 2,500 feet (762 m) before going under County Highway W via a culvert that only has about four inches (10 cm) of water during a one percent recurrence interval event. From this point they would still have to traverse 1.5 miles (2.4 km) through emergent wetland to reach the headwater tributary to the Fox River.

Any invasive fish species heading north towards Menomonee Falls via the Fox River would run up against many barriers before ever coming close to the basin divide. The most upstream barrier is a run-of-the-river dam in downtown Waukesha, Wisconsin. This is approximately 17 river miles (27 km) from the South Menomonee interbasin connection and approximately 18 river miles (29 km) from the West Menomonee interbasin connection. The impoundment formed by the dam in Waukesha could serve as a staging area for any invading fish species. This impoundment is also the last area that could sustain a viable population of fish as the Fox River becomes largely a drainage ditch not too far north of Waukesha. Fish species heading towards the West Menomonee interbasin connection would have to travel through an agricultural drain and then through a forested wetland area, and finally through an emergent wetland area that is expected to have 1.5 feet (0.46 m) of flow depth during periods of inundation after a one percent recurrence interval

event.

Invasive fish species heading toward the Tamarack Swamp would face similar challenges as those faced by fish trying to reach the West Menomonee site. These include all the dams on the Fox River and the decreased habitat available upstream of the last dam in Waukesha, Wisconsin. If species were able to traverse the tributary of the Fox River that flows out of the Tamarack Swamp, they would then encounter a large wetland that consists of shrub/scrub, forested and emergent plant communities. Upon entering the southern portion of this wetland complex, it is 1.5 miles (2.4 km) to County Highway W, which is still in the Fox River watershed. To get past this road, ANS must travel through a 65-foot (20 m) long pipe that is two feet (0.6 m) in diameter. It takes over seven inches (17.8 cm) of rain to put four inches (10 cm) of water through the pipe. Therefore, species would have to be staged not far from this pipe to attempt a run through it when such a flood event occurred, which also would mean they would likely have to survive in this wetland complex for potentially a prolonged period of time waiting for such an event to occur. The same seven-inch (17.8 cm) rain event would allow a little over two feet (0.6 m) of flow depth throughout the wetland complex. This would make it difficult for species to be established close to the pipe under normal circumstances. If species can travel through and get passed County Highway W, there is 2,500 feet (762 m) of wetland before the interbasin connection, and another mile (1.6 km) to the next culvert. This culvert, as depicted in earlier photos, has a trash rack that would prevent larger fish from passing. Also, if this rack is covered with debris, which is depicted in the photos, it would likely eliminate passage of fishes of all sizes.

3.7.4 Water Quantity and Quality

At both the West and South Menomonee locations, water quantity and quality may be a limiting factor for fish species ability to traverse and especially establish in close proximity to the basin divide. The headwater pond for Willow Creek at the West Menomonee site may be the only area from the two sites that may sustain fish populations during non-flood periods. However, this pond may have decreased water quality during long periods without substantial precipitation and high temperatures. During periods of flooding, both divide locations seem to have enough water for fish to pass through if populations are in close proximity. However, it is not expected that there will be sustainable populations near either site except possibly certain Great Lakes Basin species in the Menomonee River if they are able to reach the entrance to the storm drain that leads to the Tamarack Swamp. The closest area for fish to stage on the Mississippi River Basin side is 17-18 miles (27-29 km) from the basin connections in Waukesha, Wisconsin. Fish from the Great Lakes Basin are not expected to reach the Willow Creek watershed as Lepper Dam is impassible.

Water quality at either divide location is marginal for sustaining fish populations. However, many invasive species can be highly tolerant of environmental degradation. Both connections are nearly surrounded by urban development. Stormwater runoff from these areas could contain oils, grease, and salt and sand from roads, excessive nutrients from lawn fertilizers, and other non-point source pollutants typical of urban stormwater. There is also a possibility of excessive nutrient runoff from the few farm fields in the area. This runoff, coupled with low dissolved oxygen and high temperatures in shallow areas, could make most of the areas at the divide locations inhospitable for many ANS.

3.7.5 Aquatic Organisms

The USFWS reports two federally listed species located in Waukesha County, Wisconsin. These species are the federal candidate poweshiek skipperling (*Oarisma poweshiek*) and the federally threatened eastern prairie fringed orchid (*Platanthera leucophaea*). There is a possibility that both of these species could be present near both basin connections as prime habitats are native prairie and wet grasslands. A rigorous survey would need to be undertaken at these sites to confirm their presence.

As mentioned in earlier sections, the areas near the basin connections may not be suitable habitats for many ANS. The headwater pond at the beginning of Willow Creek (West Menomonee) may sustain populations of

tolerant native species such as topminnows, bullheads, green sunfish, and possibly minnows. The Menomonee River near Menomonee Falls should be able to sustain a typical Midwestern stream fish community and could include such species as smallmouth bass, walleye, northern pike as the primary predators, redhorse suckers, darters, and many native minnow species.

3.8 Connecting Streams to Great Lakes and Mississippi or Ohio River

Since it has been determined that there is either a medium or high probability of an aquatic pathway existing at the Menomonee Falls locations, applicable potential barriers to ANS spread in the Mississippi River Basin have been identified. The sequence of stream connections from the potential pathway sites to the Mississippi River is:

Menomonee Falls ► Fox River ► Illinois River ► Mississippi River

For the West Menomonee Falls location, the Great Lakes connection is:

W. Menomonee Falls ► Willow Creek ► Menomonee River ► Kinnickinnic River ► Lake Michigan

Although given a low probability rating, the South Menomonee Falls location sequence of connections to the Great Lakes is:

Underground Culvert ► Unnamed Stream ► Menomonee River ► Kinnickinnic River ► Lake Michigan

The location of the known and potential in-stream barriers to ANS upstream movement are shown in Figure 26. These barriers, along with the hydraulic and dam heights from the National Inventory of Dams (NID) where available, elevation difference from tailwater to sill from FEMA FIS profiles, and whether or not there is fish passage, is listed in Table 8.

4 Aquatic Pathway Viability for ANS of Concern

The potential for species transfer was assessed by the project team for the ANS of concern for the Menomonee Falls locations in accordance with the procedures outlined in the Methodology Section of this report. This potential was characterized as high, medium or low for the following categories:

- Probability that Pathway Exists (Section 2)
- Probability of ANS being within Either Basin
- Probability ANS Surviving Transit to Aquatic Pathway
- Probability of ANS Establishing at the Aquatic Pathway
- Probability of ANS Spreading across Aquatic Pathway into New Basin

The criteria for designating probabilities of high, medium, or low are provided under each category. In addition, a certainty rating is also assigned with each probability assessment. Certainty ratings associated with any given probability ratings include:

- Very Certain (As certain as we will get with this effort)
- Reasonably Certain
- Moderately Certain (More certain than not)
- Reasonably Uncertain
- Very Uncertain (An educated guess)
- A team rating is provided based on the professional collaboration of the interagency team of biologists.

These characterizations were completed by a team of agency biologists for each species under consideration.

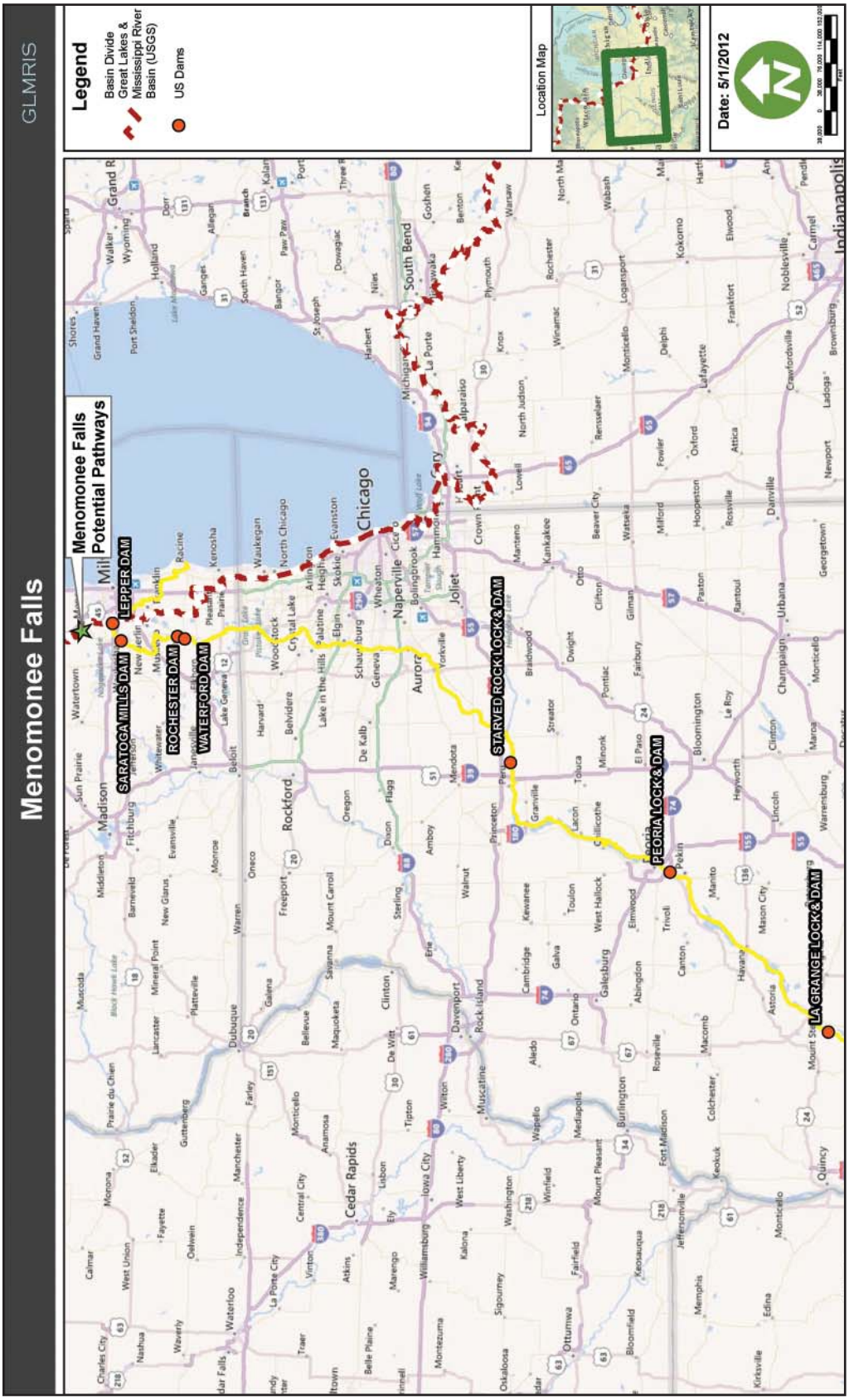

Figure 26. West and South Menomonee Falls potential barriers to ANS dispersal. Background imagery courtesy of Bing Maps.

Table 8. Potential Barriers to ANS Dispersal, Including Dam Heights, FEMA Elevations, and any Known Fish Passage (NID, 2010).

Mississippi Connection -								
	Fox River, Illinois River, Mississippi River							
Connection	**Dam Name**	**River**	**Hydraulic Height of dam (ft) from NID**	**Dam height (ft) from NID**	**Elevation difference from tail water to dam sill from FEMA FIS Profiles**			**Fish passage?**
					10 year flood (ft)	**100 year flood (ft)**	**500 year flood (ft)**	
Mississippi	Saratoga Mill	Fox River	5	10	0.5	submerged	submerged	Yes
Mississippi	Waterford	Fox River	5	10	-	-	-	Not able to verify, no FEMA FIS. WDNR believes fish passage not possible
Mississippi	Rochester	Fox River	4	9	-	-	-	Not able to verify, no FEMA FIS. WDNR believes fish passage not possible
Mississippi	Yorkville Dam	Fox River	-	12	< 1	submerged	submerged	Yes according to FEMA FIS, but ILDNR believes fish passage not possible
Mississippi	Dayton Dam	Fox River	23.5	23	18	13	10	Yes at 500 year flood
Mississippi	Starved Rock Lock and Dam	Illinois River	25	35	-	-	-	through lock
Mississippi	Peoria Lock and Dam	Illinois River	11	23	-	-	-	through lock
Mississippi	La Grange Lock and Dam	Illinois River	10	21	-	-	-	through lock
Great Lakes Connection -								
	Unnamed stream, Menomonee River, Kinnickinnic River, Lake Michigan							
Connection	**Dam Name**	**River**	**Hydraulic Height of dam (ft) from NID**	**Dam height (ft) from NID**	**Elevation difference from tail water to dam sill from FEMA FIS Profiles**			**Fish passage?**
					10 year flood (ft)	**100 year flood (ft)**	**500 year flood (ft)**	
Great Lakes	Lepper Dam	Menomonee River	18	22	No	0	-	Yes (fish ladder to be installed in next few years)

An overall team probability and certainty rating is also provided. The overall rating represents the most conservative probability assessment for each category considered. The forms describing the probability and certainty ratings from all agency professionals participating in this assessment is included at Attachment A.

4.1 Probability of the ANS Being within Either Basin

General Considerations for Assigning Probability Ratings:

> **High** - Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.
>
> **Medium** - Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.
>
> **Low** - Target ANS is not known to exist on a connected waterway.

Certainty ratings were applied as outlined above.

Asian Carp

Silver carp and bighead carp are established throughout the middle and lower Mississippi River Basin. Bighead and silver carp have been recorded in the Illinois River near the mouth of the Fox River (USGS, 2011). A silver carp was reported from the Fox River near Yorkville, Illinois. However, the Illinois DNR indicates that the fish was never confirmed to be a silver carp. Black carp may be established in portions of the lower Mississippi River Basin (USGS, 2011). A black carp has also been collected in the Illinois River at river mile 27.5 (USGS, 2011). The known distribution of black carp is not as extensive as that of the silver and bighead carp.

Team Rating: **High**
Team Certainty Rating: Reasonably Certain/Very Certain

Inland Silverside

The inland silverside's native range is eastern North America, including the Atlantic and Gulf Slopes (mostly near the coast) from Massachusetts to the Rio Grande drainage, Texas and southeastern New Mexico; north from the Mississippi River and major tributaries (mainly Arkansas and Red Rivers) to southern Illinois and eastern Oklahoma (Page & Burr, 1991). It is a marine species that ascends rivers and prefers estuaries, lagoons, brackish seas, and rivers (Fishbase, 2011). Inland silversides were stocked into the Kankakee River in Will County, Illinois and they were collected there in 1996 (Fuller & Nico, 2012a; USGS, 2011). The species has also been collected in Illinois from Lake Baldwin, Lake of Egypt, Rend Lake, Cache River, Wabash River, and the Mississippi, Ohio, and Kankakee Rivers (Laird & Page, 1996). It is believed that the presence of the species in the Mississippi River in southern Illinois and in the lower Ohio River in Illinois and Kentucky are a result of natural dispersal (Fuller & Nico, 2012b).

Team Rating: **Medium**
Team Certainty Rating: Reasonably Certain/Very Certain

Northern Snakehead

The closest established population of northern snakeheads is in Lee County, Arkansas. While this is in the Mississippi River watershed, this population does not seem to be spreading at a high rate at this time (USGS, 2011). A single specimen of giant snakehead (Channa micropeltes) was collected in the Rock River by the WDNR (a watershed not directly connected with the Menomonee Falls pathway). This specimen was unintentionally released. However, the species is considered to be tropical to sub-trocpical and not able to survive winter temperatures encountered in the Rock River (Courtenay, Jr. and Williams, 2004).

Team Rating: **Medium**
Team Certainty Rating: Reasonably Certain/Very Certain

Viral Hemorrhagic Septicemia Virus (VHSv)

Viral hemorrhagic septicemia virus can infect a wide range of host fish causing a variety of external and internal pathology, including death of the host fish (Attachment B). Variables such as host fish species and water temperature can impact the pathology of the virus. Seemingly healthy individuals that have been previously infected with VHSv can have chronic infections and be carriers of the disease (Skall et al., 2005). This virus has been reported from throughout the Great Lakes Basin including Lake Michigan (USGS, 2011). Viral hemorrhagic septicemia virus has been found in many species of fish including common carp (Cyprinus carpio). The common carp is established in Lake Michigan, as well as the Menomonee River leading to the basin divide. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species for VHSv because of the life cycle capabilities of the common carp and the likelihood the common carp could use and survive in the pathway habitats. Viral hemorrhagic septicemia virus and a necessary host species, the common carp, are in the pathway. It should also be noted that VHSv has been found in 28 different host species in the GLB and that it can survive without a host in the water column (WDNR, 2012b).

Team Rating: **High**
Team Certainty Rating: Reasonably Certain

Ruffe and Tubenose Goby

The ruffe and tubenose goby are located within the Great Lakes and are associated with river mouths and estuaries of large river systems entering the Great Lakes. Ruffe exists in northern Lake Michigan in Green Bay, but is not widespread and there are no high density populations in Lake Michigan (Bowen and Goehle, 2011). The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravels, but has a tolerance for different habitats and environmental conditions (Gray and Best, 1989). The ruffe has a high reproductive rate and spawns in clean water. Females produce up to 200,000 eggs in the first batch, and up to 6,000 eggs per subsequent batch (Global Invasive Species Database, 2012). The ruffe is an aggressive species that possesses the ability to feed in darkness, cold temperatures, and turbid conditions. The fish has extended its range rapidly and modeling predicts it will find suitable habitat in all five Great Lakes. The tubenose goby's introduced range covers three Great Lakes including Lakes Superior, Erie, and Huron (USGS, 2011). It has been collected in the lower reaches of larger Great Lakes rivers and estuaries. The tubenose goby is found in the open waters and estuaries of slow flowing rivers. Tubenose gobies are benthic species that consume a wide variety of invertebrates (USGS, 2011). They are often quite abundant in backwaters and lakes, and seem prefer dense vegetation. The tubenose goby does inhabit upper river systems, but no tubenose goby have been collected locally in tributaries of the upper Great Lakes to date. Tubenose gobies have exhibited a much slower rate of expansion in the Great Lakes than the round goby (*Neogobius melanostomus*), also an invasive species in the Great Lakes, and that is now located within both the Great Lakes Basin and the Mississippi River Basin.

Team Rating: **High**
Team Certainty Rating: Reasonably Certain

Threespine Stickleback

The threespine stickleback is found in each of the Great Lakes and has been collected in some inland river systems (USGS, 2011). While not having been identified within the Menomonee River, its close proximity indicates the potential for access and transfer to the Mississippi River Basin via the Menomonee River. Literature indicates this species prefers to live in the backwaters of smaller streams, but also occur in a variety of habitats including lakes and large rivers and occupies a more varied habitat than the brook stickleback, which has been collected in the Menomonee River (Wootton, 1976).

Team Rating: **High**
Team Certainty Rating: Reasonably Certain

4.2 Probability Target ANS Survives Transit to Aquatic Pathway

4.2.1 Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

General considerations for assigning probability ratings:

> **High** - Target ANS are established in relatively close proximity to the location and have ample opportunity, capability, and motivation to successfully navigate through the connecting streams to arrive at the subject pathway within 10 to 20 years.
>
> **Medium** - Target ANS are established at locations in close enough proximity to the location and have limited capability to survive passage through the connecting streams to arrive at the subject pathway within 20 to 50 years.
>
> **Low** - Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations through the connectin streams to arrive at the subject pathway within next 50 years.

The same certainty ratings identified above also apply here.

Asian Carp

The Dayton Dam on the Fox River, five miles from the confluence with the Illinois River, is over 20 feet (6.1 m) high and is a barrier to upstream spread. The area of the Illinois River in which the Fox River empties into holds one of the highest concentrations of bighead and silver carp in the world. Only one silver carp has been mentioned as being found above the Dayton Dam and this is an erroneous report according to the Illinois DNR. No bighead carp have been reported above the Dayton Dam. If Asian carp do find a way around or over the Dayton Dam, there are still 13 dams in Illinois and at least three in Wisconsin. None of the remaining dams upstream are as tall nor do they present as big a barrier as the Dayton Dam. Another aspect that may slow the rate of Asian carp expansion in this system is that these fish need long free-flowing reaches of stream to spawn that is initiated by rising water levels following heavy rains (Jennings, 1988; Verigin, 1978; Nico and Jelks, 2011). From the Montgomery Dam at river mile 46.8 to the Algonquin Dam at river mile 82.6, there are 12 dams. Bighead and silver carp need 35-40 miles (56-64 km) of open river to successfully spawn. While this may not stop adult Asian carp from spreading up the Fox River, it would make it difficult to establish a breeding population in that section of the Fox River.

While silver and bighead carp are highly opportunistic on their diet, bighead carp are primarily zooplanktivorous, whereas silver carp primarily consume smaller phytoplankton and fine particulate organic matter (Dong and Li, 1994; Jirasek et al., 1981; Williamson and Garvey, 2005). Adult black carp are primarily molluscivores. However, they will opportunistically consume a wide variety of food items (USFWS, 2002). Juvenile black carp have a diet more similar to silver and bighead carp, consisting primarily of zooplankton (USACE, 2011b). The diet of juvenile black carp may allow them to survive in areas unsuitable for adults. The habitat of black carp is very similar to the grass carp (Ctenopharyngodon idella) (Nico et al., 2005). It is believed that black carp should be able to colonize the same areas of the United States where the grass carp have established (USFWS, 2002).

However, the exact dispersal capability of these species remains unknown. Juvenile, sexually immature Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers, such as dams, to continue their upstream movement (D. Chapman, personal communication, September 12, 2011; N. Caswell, U.S. Fish and Wildlife Service, September 12, 2011). The gradient needed to prevent juvenile fish from moving upstream is unknown. It is important to note that young Asian carp tend to move laterally away from the river in which they were spawned and not back upstream (D. Chapman, personal communication, September 12,

2011). It has also been observed that Asian carp, as small as advanced fingerlings, have traveled up to 37 miles (60 km) though tributaries of the lower Missouri River. These tributaries were located laterally to the Missouri river segment in which these fish hatched (D. Chapman-USGS, personal communication, September 12, 2011). Adult, sexually mature Asian carp have occasionally been found in very small streams, which appear scarcely large enough to support the fishes at low water (D. Chapman, personal communication, September 12, 2011). The age of these fish when they arrived at these locations is unknown. While ongoing research by Indiana Department of Natural Resources and Purdue University may suggest that tagged Asian carp have no interest in ascending some of the smaller rivers, more long term studies are needed, and even these may not help explain the seemingly random movements of young that have been witnessed in Midwestern rivers and their tributaries (Coulter and Goforth, 2012; D. Chapman, personal communication, September 12, 2011).

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Inland Silverside

The inland silverside moves in large schools that can number in the thousands and they can travel far up streams and rivers, especially in southern part of their range (NatureServe, 2010). The species' natural spread rate through the Mississippi River Basin is not known because they have been actively stocked in lakes. The average lifespan of the inland silverside is about 16 months, with few surviving their second winter (NatureServe, 2010). It is capable of producing 30,000 eggs per month (Stoeckeand Heidinger, 1988). The inland silverside has not expanded much from the areas in which it has been initially stocked. There are 13 dams on the Fox River in Illinois and three in Wisconsin in which this species would have to negotiate to even get close to this interbasin connection. The first dam on the Fox River is the Dayton Dam, located five miles (8 km) from the confluence with the Illinois River. This dam is over 20 feet (6.1 m) high and no fish passage is present at the dam. This site is at the northern limit of the native range for this species. The USGS website shows that a stocking effort near St. Paul, Minnesota failed (USGS, 2011). Even if inland silversides could successfully navigate the lower Fox River, conditions as they traveled north may not be conducive for them to continue.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

Northern Snakehead

If the Arkansas population does begin to expand up the Mississippi River, there are many barriers to movement, including dams. Habitat preferred by northern snakeheads includes stagnant, shallow ponds or swamps with mud substrate and aquatic vegetation and slow muddy streams (Courtenay and Williams, 2004). The northern snakehead likely possesses the ability to spread through portions of interconnecting tributary streams. However, its preferred habit is not flowing waters, which will likely slow its spread up the Mississippi River and its tributaries. Unlike the Asian carp, northern snakeheads do not make long upstream spawning runs and as a result, are not likely to spread quickly through the Mississippi River Basin without the aid of anthropogenic means.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

Viral Hemorrhagic Septicemia Virus (VHSv)

Viral hemorrhagic septicemia virus has been found to infect common carp (USGS, 2011). During spring run-off events in April and May, common carp spread into the shallow waters of bays and river systems to spawn. Within the rivers, common carp spread upstream to spawn in suitable habitat such as marshes and even drainage ditches with as little as or less than one foot (30 cm) depth of water. Common carp are strong swimmers that can reach sustained speeds of 1.3-3.9 fps (0.4-1.2 mps) and burst speed of 3.9-8.5 fps (1.2-2.6 mps). Though they cannot jump (maximum height six feet or 1.8 m) like members of the salmon family, they can spread upstream during moderate flow events.

The distance from Lake Michigan to the watershed divide of the Menomonee River at Menomonee Falls is roughly 30 stream miles (48 km). The Wisconsin DNR Surface

Water Data Viewer shows that Willow Creek, which originates at the north end of the 1.3-acre (0.5 ha) pond situated approximately 600 feet (183 m) north of the basin divide, is an intermittent stream. According to the USGS, a gauge (No. 04087030) located approximately six river miles (9.6 km) downstream of the basin divide on the Menomonee River at Menomonee Falls, the average river discharge ranges from about 70 cubic feet per second (cfs) (21 mps) in April to less than 20 cfs (6.1 mps) from August to October. The West Menomonee intermittent aquatic pathway is upstream of the Lepper Dam located on the Menomonee River. The Lepper Dam, which has a 22-foot (6.7 m) dam height, is considered a total blockage to upstream fish passage by the WDNR. Therefore, it is considered highly unlikely that a common carp hosting VHSv could transfer through this pathway by natural means. However, if an infected common carp were to arrive at the emergent wetland divide, or the approximately 1.3-acre (0.5 ha) pond, during the spring a subsequent storm event sufficient to complete the intermittent aquatic pathway could facilitate that infected common carp to disperse across the basin divide. The impediment that the Lepper Dam provides is the primary basis for the assignment of the low rating to the probability a common carp infected with VHSv could survive transit solely through the aquatic pathway to the basin divide at this location. That structure is also the primary basis for the level of certainty rating for this specific ANS, as represented by the common carp as the potential host fish. It is unlikely that any of the Great Lakes Basin invasive fish species (including the common carp) could cross the South Menomonee divide from Lake Michigan to the Mississippi River Basin, up the 2,000 lineal foot (610 m) intermittent drain with a three foot (0.9 m) bottom width and high gradient, then access the 1,500 linear feet (457 m) of three foot (0.9 m) diameter culvert to reach the wetland divide. If any of the fish species arrived at the emergent wetland divide during a runoff event, passage would still be difficult even when sufficient water is available in the divide for movement to the Mississippi River Basin because of a lack of any defined channel to follow, and the thickness of the inundated wetland vegetation.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Ruffe and Tubenose Goby

As mentioned above for VHSv, there are significant obstacles for ANS to traverse in order for them to reach the interbasin divide. Therefore, it is unlikely that ruffe or tubenose goby could transfer to this pathway by natural means. The life histories of these two fish, and the impediment that the Lepper Dam provides, is the primary basis for the assignment of the low rating for the probability that either species could survive transit through the aquatic pathway to the basin divide at this location. Neither ruffe nor tubenose gobies are known to have been collected in the United States in similar upstream river habitat. The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel areas, but has a tolerance for different habitats and environmental conditions (Gray and Best, 1989). Ballast water transport has been the key means for the spread of ruffe in the Great Lakes (USFWS, 1996). Natural rates of dispersion are not well known and ruffe have not spread beyond Green Bay in the nine years since its detection in that area, and populations have been trending down (Bowen and Goehle, 2011). The ruffe's ability to swim upstream during high flow events and pass over dams is questionable, especially since it prefers still or slow moving water (Fishbase, 2010). The tubenose goby is found in the open lake waters and estuaries of slow flowing rivers and appears to be more capable of living in diverse types of riverine habitat than the ruffe (Dopazo, et al., 2008; Jude and DeBoe, 1996). At the South Menomonee Falls location, the intermittent stream and culvert appears to be a viable barrier to upstream spread for either fish species.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

Threespine Stickleback

It is considered unlikely that threespine stickleback could transfer to this pathway by natural means. As a sight feeder, the sometimes turbid waters of the Menomonee River may be unsuitable for the threespine stickleback. If the threespine stickleback arrived at the emergent wetland divide during the spring, the fish could likely survive until later summer. The emergent wetland divide, even during a flooded spring condition, is not preferred habitat. The impediment that the Lepper Dam provides

is the primary basis for the assignment of the low rating to the probability threespine stickleback could survive transit solely through the aquatic pathway to the basin divide at this location. The primary obstacle on the South Menomonee pathway is the 2,000 foot (610 m) intermittent stream and high gradient, and the 1,500 feet (457 m) of three foot (0.9 m) diameter culvert. These barriers are sufficient for impeding spread of the threespine stickleback at all flow conditions. The wetland divide does not provide the preferred or suitable habitat for the threespine stickleback. However, the fish could potentially survive in the emergent wetland divide during a storm runoff event as they are tolerant of low dissolved oxygen down to two parts per million (ppm) and temperatures up to 68ºF (20ºC) (Wootton, 1976). It is likely that sufficient forage and habitat is available throughout the Menomonee River and the Mississippi River Basin for the threespine stickleback.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

4.2.2 Probability of ANS Surviving Transit to Aquatic Pathway through Other Means

The ratings in this section do not influence the overall pathway rating outlined in this report, and are only included to point out potential other pathways (e.g., anthropogenic) and their potential influence on the same list of ANS as evaluated in Section 4.2.1. Any further analysis of these non-aquatic pathways outside of this study should develop a separate list of ANS that will likely differ from those which may exploit the aquatic pathway.

General considerations for assigning probability ratings:

> **High** - Target ANS are established in relatively close proximity to the location and have ample opportunity, capability, and motivation to successfully navigate through a non-aquatic pathway to arrive at the subject pathway within 10 to 20 years.
>
> **Medium** - Target ANS are established at locations in close enough proximity to the location and have limited capability to survive spread through a non-aquatic pathway to arrive at the subject pathway within 20 to 50 years.
>
> **Low** - Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations through a non-aquatic pathway to arrive at the subject pathway within next 50 years.

The same certainty ratings identified above also apply here.

Asian Carp

There does not appear to be any sport fishery at either the West or South Menomonee Falls locations and neither site contains enough water to support significant fish communities. Although transit across the watershed divide by anthropogenic means is possible, state regulations prohibiting transport and possession of silver carp, bighead carp, and black carp should limit this likelihood.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Inland Silverside

Transit across the watershed divide by anthropogenic means is possible. However, since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that inland silverside will arrive at the divide by anthropogenic means, such as livewell or aquarium releases even though the silverside has been stocked as a forage species.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

Northern Snakehead

Many species of snakehead, including the northern snakehead, have been popular aquarium fish. However, the state of Wisconsin prohibits the possession and

transport of this species. Since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that the northern snakehead will arrive at the divide by anthropogenic means, such as livewell or aquarium releases. These regulations, coupled with the limited access for the public to the wetland divide, makes human release of the northern snakehead in the wetland very unlikely. However, if the northern snakehead were released in the immediate vicinity of the divide, on either side, it is likely the fish would survive and establish a viable population in the area.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Viral Hemorrhagic Septicemia Virus (VHSv)

As discussed previously, many ANS could survive in the pathway if the species were dumped or discharged through anthropogenic means. Since fishing and boating do not occur in the wetland divide and public access is limited, it is highly unlikely that VHSv will arrive at the basin divide through anthropogenic means, such as livewell or aquarium releases.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Ruffe and Tubenose Goby

The ruffe and tubenose goby are listed among the "established nonnative fish species" (see WI NR 40.02(17)), which is one of four groups of "restricted" non-native fish species. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the DNR. The ruffe and tubenose goby are not normally used as live bait for river fishing or aquarium species. Although transit across the watershed divide by other anthropogenic means is possible, since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that the either species will arrive at the divide by anthropogenic means, such as livewell or aquarium releases.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Threespine Stickleback

The threespine stickleback can tolerate dissolved oxygen levels as low as two ppm at 68ºF (20ºC) which may not be met in the wetland pond in late summer. Threespine stickleback passage to the emergent wetland basin divide, even after a large storm event, is considered a low probability based on the habitat requirements of the threespine stickleback. It is believed that bait-bucket transport has aided in the movement of the threespine stickleback in the past. Wisconsin regulations do prohibit possession and transport of this species. However, since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that the species will arrive at the divide by anthropogenic means.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

4.3 Probability of ANS Establishment at the Aquatic Pathway

General Considerations for Assigning Probability Ratings:

High - Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range, and there are no known predators or conditions that would significantly impede survivability or reproduction.

Medium - Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.

Low - Habitat and abiotic conditions in proximity are outside the range where ANS has

been known to survive. There is very limited available habitat area suitable for ANS cover, sustainable food supply, and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

Asian Carp

Silver and bighead carp are fast growing species that are capable of surviving a wide range of water temperatures and reproducing quickly, provided that suitable habitat is available. Life history habitat requirements generally include diverse needs for current areas, backwater habitats, deep overwintering holes, and other habitat types needed for survival (Nico, et al., 2005). Silver and bighead carp require sufficient flow to keep fertilized eggs suspended for successful reproduction (Gorbach and Krykhtin, 1980). In some stretches of the Illinois River, silver and bighead carp make up as much as 90 percent of the biomass (MICRA, 2002).

Based on the hydrologic description, relevant data, and photos of the South Menomonee Falls site, it is not likely that a population of any Asian carp species can be established at this location. There is unlikely to be enough water to support an established fish community or provide enough food or habitat for a large bodied fish, such as an Asian carp, to establish a new and sustainable population. Successful spawning and recruitment is highly unlikely and would prevent establishment of actual populations at the divide, as all species of Asian carp require lowland rivers to complete their life cycles (Nico and Jelks, 2011). However, during periods of high water, mature Asian carp may be able to use the connection as a conduit to invade the Lake Michigan watershed. The closest staging area to this connection for Asian carp would be the impoundment above the dam in Waukesha, Wisconsin. This is approximately 17 river miles (27 km) downstream of the possible connection with the Menomonee River at the Tamarack Swamp. The Fox River below the Waukesha Dam seems to be suitable spawning habitat as the river flows unimpeded for quite a distance before reaching the impounded region above the Waterford Dam.

Based on the hydrologic description, relevant data, and photos of the West Menomonee Falls site, it is not likely that a population of any Asian carp species can be established at this location.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

Inland Silverside

As a size-selective planktivore, the inland silverside relies primarily on sight for feeding, which could be limited within and around the wetlands at the divide (Elston and Bachen, 1976). The divide location would also be unlikely to be able to support the species because of cold winter temperatures. Hubbs, et al. (1971) inferred that the native inland range for the inland silverside does not extend beyond the confluence of the Ohio and Mississippi Rivers because it cannot withstand winters farther north. However, Richards (1977) showed that the inland silverside can survive for at least two weeks at 34.7ºF (1.5ºC). Stoeckel and Heidinger (1988) demonstrated that inland silversides can be maintained over winter in aquaculture systems at temperatures above 59ºF (15ºC), when they were fed a prepared diet. They also demonstrated that inland silversides have a high mortality during extended periods of cold during the winter in unheated ponds and reservoirs. Overwintering mortality in the 80-90 percent range has been reported for the inland silverside in Rhode Island waters (Bengtson, 1982). Currently there are no records of established populations at this latitude. Spawning occurs in shallow water in areas with abundant vegetation, and includes all forms of plants, including dead leaves, tree roots, algal mats, or rooted aquatic plants of marshes (Hildebrand, 1922; Weinstein, 1986). The lack of quality habitat for this species at these basin connections would make it difficult for this species to colonize and become established in this location.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain

Northern Snakehead

The northern snakehead's native range (latitude 24-53º N) and temperature tolerance (0-30 ºC) indicates a species that, if introduced, could establish populations throughout most of the contiguous United

States (Courtenay, Jr. and Williams 2004). Northern snakeheads are naturally aggressive predators that could easily acclimate to the conditions in and around the wetland divide as long as there is an ample food supply. They prefer shallow ponds and marshes with aquatic vegetation, which is similar to the aquatic habitat at the wetland divide. While the habitat at the South Menomonee Falls basin connection may be good enough to support a small population of northern snakeheads during long periods of inundation, there may not be a sufficient food source at this location. Northern snakeheads are known to be voracious feeders, and particularly piscivores (eat fish). This site does not appear to support any type of significant fish community. However, the small pond at the headwaters of Willow Creek at the West Menomonee Falls site may provide suitable habitat for the northern snakehead, as this species prefers slow or stagnant areas with vegetation. Food source could be a limiting factor overall, leading to the Low-Medium rating for this species.

Team Rating: **Low-Medium**
Team Certainty Rating: Reasonably Certain

Viral Hemorrhagic Septicemia Virus (VHSv)

During spring run-off events in April and May, common carp spread into the shallow waters of bays and river systems to spawn. Within the rivers, common carp spread upstream to spawn in suitable habitat such as marshes and even drainage ditches with as little as one foot (30 cm) water depth. Common carp are strong swimmers and though they cannot jump like members of the salmon family, they can spread upstream during moderate flow events. Survival and reproduction of common carp as a potential carrier of VHSv is considered high at this location during the spring. During spring runoff, the wetland divide and connecting ditches and streams could provide the necessary habitat for occupation of any VHSv carrier or host fish species, at least temporarily. The virus is capable of persisting outside of a host in the water column for at least 14 days and grows best in fish when water temperatures are 37ºF - 54 ºF (2.8 ºC - 12.2 ºC). It also demonstrates a rapid reproductive cycle and is capable of utilizing up to 28 known fish species in the Great Lakes Basin, including common carp (WDNR, 2012b). However, there is uncertainty regarding the suitability of the aquatic habitat to sustain a population of VHSv-infected common carp during the drier and hotter periods of the year in proximity to this location.

Team Rating: **Medium**
Team Certainty Rating: Reasonably Certain

Ruffe and Tubenose Goby

The ruffe is an aggressive species that possesses the ability to feed in darkness, cold temperatures, and turbid conditions. Tubenose gobies are benthic species that consume a wide variety of invertebrates (USGS, 2011). They are often quite abundant in backwaters and lakes, and seem to prefer dense vegetation. Survival of a viable, reproducing population of ruffe and tubenose goby within the emergent wetlands at either divide location is unlikely due to low water quality and high temperatures in summer months. The ability of either species to spread across a flooded, emergent wetland complex and through farm or roadside ditches is considered low.

Team Rating: **Low**
Team Certainty Rating: Reasonably Certain/Very Certain

Threespine Stickleback

As a visual predator, the sometimes turbid waters of the Menomonee River and the emergent wetlands at the divides may be unsuitable for the threespine stickleback. Survival of a viable, reproducing population of threespine stickleback within the divide for other than spring runoff events is unlikely.

Team Rating: **Low**
Team Certainty Rating: Relatively Certain

4.4 Probability of ANS Spreading Across Aquatic Pathway into the New Basin

General Considerations for Assigning Probability Ratings:

High - Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.

Medium - There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.

Low - There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

Asian Carp

Asian carp have demonstrated exceptional capabilities of spreading through large river systems. However, both basin connections at Menomonee Falls contain pipes and drains that travel under roads and could serve as barriers to the spread and movement of fish. Since good spawning habitat close to either of these connections does not exist, only adult fish could potentially arrive at these locations independent of these barriers being present. While the immediate area near the basin connections is not conducive to Asian Carp establishing a population, the area is still potentially an important consideration in the movement and establishment of ANS due to its proximity to the Great Lakes via the Menomonee River.

Team Rating: **High**
Team Certainty Rating: Reasonably Certain/Very Certain

Inland Silverside

The chance of inland silversides getting to the basin divide locations and then establishing a population in the vicinity is highly unlikely. However, if this was to happen there is a possibility that they could expand beyond the colonized area via this location.

Team Rating: **Medium**
Team Certainty Rating: Moderately Certain/Reasonably Certain

Northern Snakehead

It is very likely that the northern snakehead possesses the ability to spread from the Menomonee sites if a population were to become established. As an air breather that has even been known to move short distances over land, it is likely this species would be able to quickly move into the tributary from the wetland divide. Under proper environmental conditions, this species could potentially transfer into the Great Lakes Basin from the wetland divide even with only intermittent flooding events.

Team Rating: **High**
Team Certainty Rating: Reasonably Certain

Viral Hemorrhagic Septicemia Virus (VHSv)

This virus is capable of persisting outside of a host for several days, demonstrates a rapid reproductive cycle, and is capable of utilizing many different host species. It is highly probable that VHSv would be successful in spreading into exposed fish populations already on both sides of the wetland basin divide in the event infected fish reached the Menomonee Falls pathways. The emergent wetlands at the divide is the type of habitat that carp seek in the spring during spawning season and would be considered good to excellent carp spawning habitat with one to two feet (30-60 cm) of inundation. Water depths of one foot (30 cm) or less spanning the basin divide would appear to be suitable for the passage of carp. This condition would most likely occur with heavy rains in later spring in the April and May time frame after the ground has been saturated during the melting of snowpack and several heavy rain events. If any VHSv-infected fish species were present in the wetlands or pond in proximity to the divide when such an event occurs, the fish could disperse across the basin divide

into the Mississippi River Basin and likely find suitable additional host fish species. If water temperatures are low enough for a period of time, the virus may also be able to spread across the pathway in the water column as well.

Team Rating: **High**
Team Certainty Rating: Reasonably Certain/Very Certain

Ruffe – Tubenose Goby

Ruffe and the tubenose goby have not been found in river systems similar to the upper Menomonee River. The emergent wetland at the divide is not the type of habitat that ruffe or tubenose goby would seek if the fish were introduced into the divide. If the fish were introduced adjacent to the divide during a spring runoff event, the fish could likely survive and move along established roadside ditches and waterways to the Mississippi River Basin.

Team Rating: **Medium**
Team Certainty Rating: Reasonably Certain

Threespine Stickleback

The threespine stickleback has been found in smaller river systems and movement across the aquatic pathway is possible, especially for shorter periods of time when flow conditions are higher and forage is more prevalent.

Team Rating: **High**
Team Certainty Rating: Reasonably Certain

5 Overall Aquatic Pathway Viability

As discussed in Sections 2.4 and 2.5, the determination of the likelihood of a viable aquatic pathway occurring at the Menomonee Falls location for each ANS of concern is the product of five probability elements (Equation 5). Thus, the probability of a viable pathway for a particular ANS of concern is equal to the lowest rating determined for each of the five probability elements (Table 9 and Table 10). The overall pathway viability for transferring ANS of concern from the Mississippi River Basin to the Great Lakes Basin was equal to the highest probability of a viable pathway for each ANS of concern in Table 9. At the Menomonee Falls locations, all were rated “low” and thus the overall pathway viability for transferring species from the Mississippi River Basin to the Great Lakes Basin is “low”. The overall pathway viability for transferring species from the Great Lakes Basin is calculated the same way and is shown in Table 10. At the Menomonee Falls locations, the overall pathway viability for transferring species from the Great Lakes Basin to the Mississippi River Basin is also “low”. The last calculation is to determine the overall pathway viability for interbasin spread of ANS which is calculated by taking the highest of the overall ANS ratings for unidirectional transfer which were calculated in Tables 9 and 10. Thus, the overall probability that a viable aquatic pathway exists at the Menomonee Falls Pathway is “low”.

Table 9. Summary of Individual Probability Elements and Overall Pathway Viability (Mississippi River Basin to Great Lakes Basin). Certainty ratings for each element are in parentheses

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**ANS Establishing at Aquatic Pathway?**	**ANS Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way Viability Rating**
fish	Asian Carp, silver carp, bighead carp, black carp	swimmer	H (West) (MC) M (South) (RC)	H (RC/VC)	L (RC)	L (RC/VC)	H (RC/VC)	L
fish	inland silverside	swimmer		M (RC/VC)	L (RC/VC)	L (RC)	M (MC/RC)	L
fish	northern snakehead	swimmer		M (RC/VC)	L (RC/VC)	L/M (RC)	H (RC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

Table 10. Summary of Individual Probability Elements and Overall Pathway Viability (Great Lakes Basin to Mississippi River Basin). Certainty ratings for each element are in parentheses

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**ANS Establishing at Aquatic Pathway?**	**ANS Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way Viability Rating**
fish	threespine stickleback	swimmer	H (West) (MC) M (South) (RC)	H (RC)	L (RC/VC)	L (RC)	H (RC)	L
fish	Benthic fish ruffe, tubenose goby	swimmer		H (RC)	L (RC/VC)	L (RC/VC)	M (RC)	L
virus	viral hemorrhagic septicemia	pathogen		H (RC)	L (RC)	M (RC)	H (RC/VC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

6 Conclusions

This assessment found that a viable hydraulic connection exists at both the West and South Menomonee Falls potential aquatic pathways during certain flood events that could occur with a frequency greater than the one percent annual recurrence interval storm. However, there is a low probability that any ANS could utilize these pathways when such events occur in order to transfer between the basins. This is mainly because of either the impediments to their movement at or downstream of the pathways, or because of the lack of appropriate habitat at these locations. Lack of available food supply, steep topography, and the overall likelihood of being able to find the appropriate culverts during the intermittent flood events also contributed to this overall low probability. More detailed survey data of the divide location might allow a better understanding of hydraulic connection at different flooding levels. However, it appears unlikely that the overall pathway viability rating for the sites would appreciably change with improved data. Given that ANS would have to be transported to the divide location by some non-aquatic vector, there may therefore be an equal potential that ANS could just as easily be transported into the adjacent basin at locations without headwaters in such close proximity as at Menomonee Falls.

6.1 West and South Menomonee Falls Problem Statements

This section contains a list of statements that define and frame the nature and extent of the problems associated with the potential for ANS being able to transfer through either Menomonee site, in either direction between the Great Lakes and Mississippi River basins. Following these problem statements are a list of opportunity statements which constitute an initial assortment of conceptual measures that could act to minimize or eliminate the likelihood of ANS transfer between basins via the two Menomonee locations.

- The interagency team evaluating the hydrology of the West Menomonee Falls interbasin connection rated the probability as high for flow into the Great Lakes Basin and medium into the Mississippi River Basin. It is estimated that there would be two feet of depth through the wetland area during a one percent annual recurrence interval event. The team rated the South Menomonee Falls basin connection as high for flow into the Great Lakes Basin and unlikely for flow into the Mississippi River Basin. It is estimated that there would 1.5 feet (0.6 m) of depth through the wetland area of the connection during a one percent annual recurrence interval event.

- The primary ANS of concern for interbasin transfer from the Great Lakes basin through both Menomonee Falls sites into the Mississippi River basin is VHSv, a pathogen, and three small fish (i.e., ruffe, tubenose goby and threespine stickleback. The aquatic pathway viability rating for these three ANS of concern at both locations is low. While the possibility of flow into the Mississippi River Basin is medium at West Menomonee Falls, the Lepper Dam acts a barrier for species to reach this site from Lake Michigan. It is considered unlikely that either flow or species could reach the basin connection at South Menomonee Falls from the Great Lakes Basin because of the 40-foot (12 m) incline over a 2,000-foot (610 m) channel that connects a 1,500-foot (457 m) long storm drain to the Menomonee River.

- The primary ANS of concern for interbasin transfer from the Mississippi River Basin through both Menomonee Falls sites into the Great Lakes Basin are all fish. While the probability of a hydraulic connection for flow to the Great Lakes Basin is high, transfer probability of species into the Great Lakes Basin is rated as low. The rating was for three types of fish; the Asian carps (i.e., silver, bighead and black), the inland silverside, and the northern snakehead. The Dayton Dam near the mouth of the Fox River acts as a complete barrier to upstream fish movement. The abundance of silver and bighead carp is one of the highest in the world just downstream from the Dayton Dam.

- Contributing factors to the level of uncertainty in the hydraulic estimates for the frequency, duration, and magnitude (i.e., width, depth and flow velocity) of the intermittent aquatic pathways spanning the divide at these locations, the scarcity of stream gages and real data on water levels at and in close proximity to the basin divide, as well as site specific hydraulic and hydrological modeling that could better correlate precipitation to surface water behavior at each location.

- There was uncertainty associated with biological characterization due to a variety of unknowns regarding the location and distribution of the large array of ANS that have been introduced to the waters of the United States, as well as the life history requirements of each of these ANS and the suitability of the habitat within the waterways between the nearest known locations of the ANS and both West and South Menomonee Falls sites.

6.2 West and South Menomonee Falls Opportunity Statements

While it is not the purpose of this assessment to produce and evaluate an exhaustive list of potential actions to prevent ANS transfer at these locations, some opportunities were still identified that, if implemented, could prevent or reduce the probability of ANS transfer between the basins at the Menomonee Falls sites. The following list of opportunities is not specific to the USACE, but incorporates a wide range of possible applicable authorities, capabilities, and jurisdictions at the Federal, state, and local levels.

- Since there is no immediate threat of ANS transfer at either of the Menomonee Falls sites, there remains an opportunity to develop a comprehensive monitoring plan to accurately record the movement and presence of ANS that may be slowly spreading towards these sites from both basins. This would allow for informed decision making and help to better determine species capabilities. Local, state and Federal agencies could collaborate for implementation of a monitoring program on both the Fox and Menomonee Rivers.

- There may be an opportunity for a structural measure at the West Menomonee location at the headwater to Willow Creek near the pond. This is an area of the pathway that is quite narrow and could be considered a “choke point” where some sort of ANS barrier might be most readily placed at this location.

- Stream restoration efforts, such as for fish passage of native species, should take into consideration any potential effect they might have on the factors that contributed to this rating. For example, a proposal to remove or modify an existing dam that is relied upon in this assessment for blockage of ANS might significantly alter the rating for one or more species of ANS.

- Additional data could be gathered and analyses performed for a more complete understanding of the hydrology at the dams and connecting streams during large flood events to determine with greater certainty the flow dynamics at the dams and connecting streams. This would assist in making a more definitive determination as to whether or not these dams are barriers to upstream movement for ANS.

- More detailed survey (elevation) data of the divide locations may provide further information on the nature of the hydraulic connection for this pathway at different flood levels.

- New or improved regulations or ordinances prohibiting the establishment of drainage ways that connect the Mississippi River tributaries with tributaries of the Great Lakes (e.g., ditch construction, culvert installation).

- Where possible, maintain pristine habitats as whole, intact ecosystems to help prevent any ANS establishment at or near the basin divide.

- Explore and support measures to reduce the potential source populations of ANS within either basin.

    - Increase commercial and recreational harvest, specifically bighead and silver carp
    - Implement measures to interfere with successful reproduction of ANS
    - Physical removal of ANS at their current locations within each basin.
    - Public education near the pathway and at downstream locations to:
    - Prevent bait bucket transfers of ANS
    - Prevent transfer via boating and recreational equipment
    - Prevent transfer due to religious and cultural activities
    - Improve identification and reporting of ANS to the appropriate authorities
- Support research on the biology of ANS so their movements and habitat requirements can be better understood (e.g., life history requirements, environmental tolerances).
- Prevent introductions of additional ANS within the region.
    - Regulations for bilge releases
    - Regulations on the pet industry
    - Regulations on the live bait industry
    - Regulations on the aquaculture industry

None of the opportunities identified above are exclusive of the others. In fact, any single structural measure to prevent ANS transfer through the Menomonee locations would likely benefit from corresponding development and implementation of one or more of the other types of opportunities identified. The results of this assessment may also aid in the implementation of, and future updates to, the Wisconsin comprehensive management plan.

7 References

Aquatic Nuisance Species Task Force (ANSTF). (1996). Generic Nonindigineous Aquatic Organisms Risk Analysis Review Process for Estimating Risk Associated with the Introduction of Nonindigineous Aquatic Organisms and How to Manage for that Risk. Report to the Aquatic Nuisance Species Task Force. Risk Assessment and Management Committee, Aquatic Nuissance Species Task Force (October 21, 1996). Aquatic Nuisance Species Task Force.

Bengtson, D.A. (1982). Resource partitioning by *Menidia menidia* (L.) and *Menidia beryllina* (Cope) in two Rhode Island estuaries. Ph. D. dissertation. University of Rhode Island, Kingston, RI.

Bowen, A.K. and M.A. Goehle, (2011). Surveillance for ruffe in the Great Lakes, 2011. http://www.fws.gov/midwest/alpena/documents/2011-GL-Ruffe-Report.pdf.

Coulter, A. and Goforth, R.R. (2012). An assessment of silver and bighead carp (*Hypopthalmichthys* spp.) movements and spawning activities in the Wabash River Watershed, Indiana – Phase I Annual Report. Department of Forestry and Natural Resources, Purdue University, Indiana.

Courtenay, Jr., W. R., and Williams, J .D. (2004). Snakeheads (*Pisces*, *Channidae*) – A Biological Synopsis and Risk Assessment. USGS Circular 1251.

Dong, S., and Li, D. (1994). Comparative studies of the feeding selectivity of silver carp, *Hypophthalmichthys molitrix*, and bighead carp, *Aristichthys nobilis*. Journal of Fish Biology 44:621-626.

Dopazo, S.N., Corkum, L.D. and Mandrak, N.E. (2008). Fish Assemblages and Environmental variables associated with Gobiids in Nearshore Areas of the Lower Great Lakes. Journal of Great Lakes Research 34(3): 450-460.

Elston, R. and Bachen, B. (1976). Diel feeding cycle and some effects of light on feeding intensity of the Mississippi silverside (*Menidia audens*) in Clear Lake, Claifornia. Transaction of the American Fisheries Society 105:84-88.

Fishbase. (2011). Froese, R. and D. Pauly. Editors. World Wide Web electronic publication: www.fishbase.org.

Fuller, P. and L. Nico. (2012a). *Menidia beryllina*. USGS Nonindigenous Aquatic Species Database, Gainsville, FL. http://nas.er.usgs.gov/queries/SpecimenViewer.aspx?SpecimenID=267927.

Fuller, P. and L. Nico. (2012b). *Menidia beryllina*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=321.

Global Invasive Species Database. Accessed October 1, 2011: http://www.issg.org/database/species/ecology.asp?si=544&fr=1&sts=sss&lang=EN.

Gray, J. A. B., and Best, A. C. G. (1989). Patterns of excitation of the lateral line of the ruffe. Journal of the Marine Biological Association of the United Kingdom 69:289-306.

Great Lakes Commission. (2011). Website accessed February 21, 2012: http://www.great-lakes.net/envt/flora-fauna/invasive/pdf/vhs_glc_factsheet_2011.pdf

Hildebrand, S.F. (1922). Notes on habits and development of eggs and larvae of the silversides *Menidia menidia* and *Menidia beryllina*. Bulletin of the U.S. Bureau of Fisheries, vol.38, pp.113-120.

Hubbs, C., Sharp, H. B. and Schneider, J. F. (1971). Developmental rates of Menidia audens with notes on salt tolerance. Transactions of the American Fisheries Society 100:603-610.

Jennings, D. P. (1988). Bighead carp (*Hypophthalmichthys nobilis*): a biological synopsis. U.S. Fish and Wildlife Service, Washington, DC. U.S. Fish and Wildlife Service Biological Report 88(29):1-47.

Jirasek, J., Hampl, A. and Sirotek, D. (1981). Growth morphology of the filtering apparatus of silver carp (*Hypophthalmichthys molitrix*). Gross anatomy state. Aquaculture 26:41-48.

Jude, D.J. and DeBoe, S.F. (1996). Possible Impact of Gobies and other Introduced Species on Habitat Restoration Efforts. Canadian Journal Fisheries and Aquatic Sciences 53:136-141.

Laird, C.S. and L.M. Page. (1996). Non-native fishes inhabiting the streams and lakes of Illinois. Illinois Natural History Survey Bulletin, vol.35(1), pp.1-51.

MICRA. (2002). Asian carp threat to the Great Lakes. River Crossings: The Newsletter of the Mississippi Interstate Cooperative Resource Association 11 (3):1-2.

NatureServe. (2010). NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Accessed: July 18, 2011. http://www.natureserve.org/explorer

Nico, L.G., Williams, J.D. and Jelks, H.L. (2005). Black Carp: biological synopsis and risk assessment of an introduced fish. American Fisheries Society, Special Publication 32. Bethesda, Maryland.

Nico, L.G. and Jelks, H.L. (2011). The Black Carp in North America: An Update. American Fisheries Society Symposium 74: 89-104. Bethesda, Maryland.

NID. (2010). U.S. Army Corps of Engineers, 2010 National Inventory of Dams: http://nid.usace.army.mil.

NOAA. (2011). Great Lakes Nonindiginous Aquatic Species Information System (GLANSIS). National Oceanic and Atmospheric Administration. National Oceanic and Atmospheric Administration. Retrieved from http://www.glerl.noaa.gov/res/Programs/glansis/watchlist.html.

Page, L.M. and B.M. Burr. (1991). A field guide to freshwater fishes of North America North of Mexico. The Peterson Field Guide Series. Houghton Mifflin Harcourt. Boston, MA. 688 pp.

Pennsylvania Sea Grant Fact Sheet. (Not Dated). Accessed from website on May 21, 2012: http://seagrant.psu.edu/publications/factsheets/VHS2011reduced.pdf

Richards, K. R. (1977). Evaluation of the Mississippi silversides as a forage fish in Colorado. (Master's thesis). Colorado State University, Fort Collins.

Skall, H.F., Olesen, N. J. and Mellergaard, S. (2005). Viral hemorrhagic septicemia virus in marine fish and its implications for fish farming – a review. Journal of Fish Diseases 28:509-529.

Stoeckel, J. N. and Heidinger, R. C. (1988). Overwintering of the Inland Silverside in Southern Illinois. North American Journal of Fisheries Management 8(1): 127-131.

USDA-NRCS Geospatial Data Gateway. (2012). Soil Survey Geographic (SSURGO) Database for Milwaukee and Waukesha Counties, Wisconsin. Metadata obtained on May 21, 2012 from: http://datagateway.nrcs.usda.gov/

USACE. (2010). Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization. Great Lakes and Ohio River Division. November 9, 2010. United States Army Corps of Engineers.

USACE. (2011a). GLMRIS Focus Area 2 Study Plan. Great Lakes and Ohio River Division. United States Army Corps of Engineers.

USACE. (2011b). Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study. United States Army Corps of Engineers.

USFWS, (1996). Ruffe control plan. Submitted to the Aquatic Nuisance Species Task Force by the Ruffe Control Committee. Available at: http://www.fws.gov/midwest/ashland/ruf_cont.html

USFWS. (2002). Black Carp Invasive Species Program Fact sheet. United States Fish and Wildlife Service. Retrieved from: http://www.fws.gov/southeast/hotissues/Black_Carp_FS.pdf

USGS. (2011). Nonindigenous Aquatic Species (NAS) website. United States Geological Survey. Retrieved from http://nas.er.usgs.gov.

Verigin, B. V., Makeyeva, A. P., and Zaki Mokhamed, M. I. (1978). Natural spawning of the silver carp (*Hypophthalmichthys nobilis*), the bighead carp (*Aristichthys nobilis*), and the grass carp (*Ctenopharyngodon idella*) in the Syr-Dar'ya River. Journal of Ichthyology 18(1):143-146.

WDNR. (2012a). VHS Distribution in Wisconsin. Wisconsin Department of Natural Resources. Website accessed April 25, 2012: http://dnr.wi.gov/fish/vhs/vhs_widistribution.html

WDNR. (2012b). VHS 101 Fact Sheet. Wisconsin Department of Natural Resources. Website accessed April 10, 2012: http://dnr.wi.gov/fish/vhs/vhsfacts.html#3a

Weinstein, M.P. (1986). Habitat suitability index models: inland silverside. U.S. Fish and Wildlife Service Biol. Rep. 82(10.120). 25 pp.

Williamson, C. J. and Garvery, J. E. (2005). Growth, fecundity, and diets of newly established silver carp in the middle Mississippi River. Transactions of the American Fisheries Society 134:1423-1430.

Wootton, R.J. (1976). The Biology of the Stickleback. Academic Press. London.

WRDA. (2007). Water Resources Development Act of 2007 [Section 3061(d): P.L. 110-114; amends Section 345: P.L. 108-335; 118 Stat. 1352].

Appendix A

Evaluation Forms for Each Indicator Species Selected for the Menomonee Falls Location

Menomonee Falls Report

November, 2012

Menomonee Falls Report

November, 2012

South Menomonee Falls, Waukesha County, WI - Asian Carp

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Medium	RC	Low	RC
	USACE, Rock Island - Hydraulic Engineer	Medium	RC	Low	RC
	NRCS - Hydraulic Engineer	High	RC	Low/Med	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the Fox River 1% annual chance floodplain comes right up to the inlet of a storm drain that connects the Fox River basin to the Menomonee River basin. This portion of the Fox River floodplain consists of the area known as Tamarack swamp and is backwater flooding connected to the Fox River through a 24-inch CMP under County Hwy W which is approximately 65 ft long. This culvert has a high invert, though, and only allows about 4" of water through at the 1% event. The precipitation for the 2% and 10% events are only 1" and 2" less than the 1% precipitation, though, so water would still be expected in the culvert at the lower events. Flow then goes to a storm drain north of the swamp. The urban storm drain is a 3' CMP with that is approximately 2000 feet long. A site visit on 07-June-2011 confirmed that there was a defined channel with water flowing from the Tamarack Park swamp into the storm drain and flowing out into the tributary of the Menomonee River. 2' contours from the Waukesha County GIS website show that there is a 40' drop in elevation in the tributary of the Menomonee River from the storm drain outlet to the confluence of the Menomonee River, which is approximately 2500 feet downstream. Flow is regularly connected to both watersheds, but it is professional judgment that flow is possible in downstream (Great Lakes Basin) direction only. The probably of backwater inundation of the Menomonee River (Great Lakes Basin) to allow the flow of water into the Fox River (Mississippi River Basin) appears unlikely.

West Menomonee Falls, Waukesha County, WI - Asian Carp

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	High	MC	Medium	MC
	USACE, Rock Island - Hydraulic Engineer	High	MC	Medium	MC
	NRCS - Hydraulic Engineer	Medium	MC	Medium	MC
	Team Ratings	**High**	**MC**	**Medium**	**MC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the 1% annual chance floodplains for Willow Creek (Great Lakes Basin) and Fox River (Mississippi River Basin) are connected in a low elevation wetland area. 2' contours from the Waukesha County GIS website confirm this. A relatively large pond located approximately 500 feet from the basin divide on the Great Lakes Basin side is the main source of Willow Creek. Willow Creek drains the wetland area to the north through two smaller ponds near Lannon Rd. There is a drain approximately 1350 ft from the basin divide on the Mississippi River Basin side that connects to Fox River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photos. This wetland area has a tendency to pond and flood. During a site visit on 07-June-2011, water was observed flowing out of the wetland into Willow Creek through a 1.5' CMP at Lannon Road. Due to recent rains, we were not able to hike into the wetland to confirm if there are any ditches connecting the known drain to the Fox River to the Willow Creek headwater pond. While no continuous channels or ditches were directly observed in the wetland marsh between the two rivers, heavy grassy vegetation may have obscured this evidence.

Menomonee Falls, Waukesha County, WI - Asian Carp

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	VC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	Medium	RC		
	Team Rating	**High**	**RC/VC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Silver carp (Hypophthalmichthys molitrix) and bighead carp (Hypophthalmichthys nobilis) are established throughout the Mississippi River basin, including the Illinois River. Bighead carp have been recorded in the Illinois River near the mouth of the Fox River (USGS 2006) and silver carp have been collected in the Fox River (USGS 2011). The silver carp was collected in Yorkville, IL. Black carp (Mylopharyngodon piceus) may be established in portions of the lower Mississippi River basin. A black carp has also been collected in the Illinois River at river mile 27.5 (USGS 2010). The known distribution of black carp is not as extensive as that of the silver and bighead carp. The WDNR noted that Asian carp are found many miles downstream from the Menononee Falls area with several impassable dams in between, and determined it is highly unlikely that the ANS will arrive in the area within 20 years, thus the lower WDNR rating of medium.

Menomonee Falls, Waukesha County, WI - Asian Carp

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, Rock Island	Low	RC	Low	RC
	USACE, Detroit	Low	RC	Low	RC
	Wisconsin DNR, Fisheries	Low	RC	Low	RC
	Team Ratings	**Low**	**RC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive passage through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

3A. The Dayton dam on the Fox River, 5 miles from the confluence with the Illinois River, is over 20 feet high and is a barrier to upstream migration. The area of the Illinois River in which the Fox empties holds one of the highest concentrations of bighead and silver carp in the world. Only 1 silver carp has been mentioned as being above the Dayton dam and this is an erroneous report according to the IL DNR. No bighead carp have been reported above the Dayton dam. If there was any form of fish passage at the Dayton dam, there is a good chance that more than 1 silve carp would have been reported by now. If Asian carp do find a way around or over the Dayton dam, there are still 13 dams in IL and at least 3 in WI. None of the remaining dams upstream are as tall nor do they present as big a barrier as the Dayton dam. Another aspect that may slow the rate of expansion in this system is that Asian carp need long, open free-flowing reaches of stream to spawn. From the Montgomery Dam at river mile 46.8 to the Algonquin dam at river mile 82.6, there are 12 dams. While this may not stop adult Asian carp from migrating up the Fox River, it would make it difficult to establish a breeding population in that section of the Fox River.

While silver and bighead carp are highly opportunistic on their diet, bighead carp are primarily zooplanktivorous, whereas silver carp primarily consume smaller phytoplankton and fine particulate organic matter (Dong and Li, 1994; Jirasek et al., 1981; Williamson and Garvey, 2005). Adult black carp are primarily molluscivores. However, they will opportunistically consume a wide variety of food items (USFWS, 2002). Juvenile black carp have a diet more similar to silver and bighead carp, consisting primarily of zooplankton (USACE, 2011b). The diet of juvenile black carp may allow them to survive in areas unsuitable for adults. The habitat of black carp is very similar to the grass carp (Ctenopharyngodon idella) (Nico et al., 2005). It is believed that black carp should be able to colonize the same areas of the United States where the grass carp have established (USFWS, 2002).

However, the exact migratory capability of these species remains unknown. Juvenile, sexually immature Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers, such as dams, to continue their upstream movement (D. Chapman, personal communication, September 12, 2011; N. Caswell, U.S. Fish and Wildlife Service, September 12, 2011). The gradient needed to prevent juvenile fish from moving upstream is unknown. It is important to note that young Asian carp tend to move laterally away from the river in which they were spawned and not back upstream (D. Chapman, personal communication, September 12, 2011). Newly hatched fry are not known to move significant distances upstream; however, they may move long distances up small tributaries and side channels in the vicinities of where they hatch. It has also been noted that 12-18-inch (30.4 to 45.7 cm) Asian carp have been known to travel long distances throughout river systems for no apparent reason.

Adult, sexually mature Asian carp have also been found in very small streams, which appear scarcely large enough to support the fishes at low water (D. Chapman, personal communication, September 12, 2011). The age of these fish when they arrived at these locations is unknown. While ongoing research by INDNR and Purdue University may suggest the tagged Asian carp have no interest in ascending some of the smaller rivers, more long term studies are needed, and even these may not help explain the seemingly random movements of juveniles that have been documented (Coulter and Goforth, 2012; D. Chapman, personal communication, September 12, 2011).

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

3B. As far as anthropogenic sources of migration to this site, there doesn't seem to be a sport fishery in this area, nor does it seem to be a likely place to release a pet or for a ceremonial release. Asian carp are specifically prohibited species by name in WI.

Menomonee Falls, Waukesha County, WI - Asian Carp

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Low	RC		
	USACE, Detroit	Low	RC		
	Wisconsin DNR, Fisheries	Low	VC		
	Team Ratings	**Low**	**RC/VC**		

4. How do you rate the probability of ANS establishing at the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Silver and bighead carp are fast growing species that are capable of surviving a wide range of water temperatures and reproducing quickly, provided that suitable habitat is available. Life history habitat requirements generally include diverse needs for current areas, backwater habitats, deep overwintering holes, and other habitat types needed for survival (Nico, et al., 2005). Silver and bighead carp require sufficient flow to keep fertilized eggs suspended for successful reproduction (Gorbach and Krykhtin, 1980). In some stretches of the Illinois River, silver and bighead carp make up as much as 90% of the biomass (MICRA, 2002).

Based on the hydrologic description, relevant data, and photos of the South Menomonee Falls site, it is not likely that a population of any Asian carp species can be established at this location. There is unlikely to be enough water to support an established fish community or provide enough food or habitat for a large bodied fish, such as an Asian carp, to establish a new and sustainable population. Successful spawning and recruitment is highly unlikely and would prevent establishment of actual populations at the divide, as all species of Asian carp require lowland rivers to complete their life cycles (Nico and Jelks, 2011). However, during periods of high water, mature Asian carp may be able to use the connection as a conduit to invade the Lake Michigan watershed. The closest staging area to this connection for Asian carp would be the impoundment above the dam in Waukesha, Wisconsin. This is approximately 17 river miles (27 km) downstream of the possible connection with the Menomonee River at the Tamarack Swamp. The Fox River below the Waukesha Dam seems to be suitable spawning habitat as the river flows unimpeded for quite a distance before reaching the impounded region above the Waterford Dam.

Based on the hydrologic description, relevant data, and photos of the West Menomonee Falls site, it is not likely that a population of any Asian carp species can be established at this location either. Again, there is unlikely to be enough water to support an established fish community or provide enough food or habitat for a large bodied fish to establish a new and sustained population. However, during periods of high water, mature Asian carp may be able to use the connection as a conduit to invade the Lake Michigan watershed. The closest staging area to this connection for Asian carp would also be the impoundment above the dam in Waukesha. This is approximately 18 river miles (29 km) downstream of the possible connection with Willow Creek. The Fox River below the Waukesha Dam may be suitable for spawning as the rivers flows unimpeded for quite a distance before reaching the impounded area above the Waterford Dam.

Menomonee Falls, Waukesha County, WI - Asian Carp

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	VC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	Medium	RC		
	Team Ratings	**High**	**RC/VC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Asian carp have demonstrated exceptional capabilities of spreading through large river systems. However, both basin connections at Menomonee Falls contain pipes and drains that travel under roads and could serve as barriers to the spread of fish. Since good spawning habitat close to either of these connections does not exist, only adult fish could potentially arrive at these locations independent of these barriers being present. While the immediate area near the basin connections is not conducive to Asian Carp establishing a population, the site could still possibly be a link to the Great Lakes since the Menomonee River is not far from the waters of Lake Michigan.

South Menomonee Falls, Waukesha County, WI - Inland Silverside (*Menidia beryllina*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Medium	RC	Low	RC
	USACE, Rock Island - Hydraulic Engineer	Medium	RC	Low	RC
	NRCS - Hydraulic Engineer	High	RC	Low/Med	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the Fox River 1% annual chance floodplain comes right up to the inlet of a storm drain that connects the Fox River basin to the Menomonee River basin. This portion of the Fox River floodplain consists of the area known as Tamarack swamp and is backwater flooding connected to the Fox River through a 24-inch CMP under County Hwy W which is approximately 65 ft long. This culvert has a high invert, though, and only allows about 4" of water through at the 1% event. The precipitation for the 2% and 10% events are only 1" and 2" less than the 1% precipitation, though, so water would still be expected in the culvert at the lower events. Flow then goes to a storm drain north of the swamp. The urban storm drain is a 3' CMP with that is approximately 2000 feet long. A site visit on 07-June-2011 confirmed that there was a defined channel with water flowing from the Tamarack Park swamp into the storm drain and flowing out into the tributary of the Menomonee River. 2' contours from the Waukesha County GIS website show that there is a 40' drop in elevation in the tributary of the Menomonee River from the storm drain outlet to the confluence of the Menomonee River, which is approximately 2500 feet downstream. Flow is regularly connected to both watersheds, but it is professional judgment that flow is possible in downstream (Great Lakes Basin) direction only. The probably of backwater inundation of the Menomonee River (Great Lakes Basin) to allow the flow of water into the Fox River (Mississippi River Basin) appears unlikely.

West Menomonee Falls, Waukesha County, WI - Inland Silverside (*Menidia beryllina*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	High	MC	Medium	MC
	USACE, Rock Island - Hydraulic Engineer	High	MC	Medium	MC
	NRCS - Hydraulic Engineer	Medium	MC	Medium	MC
	Team Ratings	**High**	**MC**	**Medium**	**MC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the 1% annual chance floodplains for Willow Creek (Great Lakes Basin) and Fox River (Mississippi River Basin) are connected in a low elevation wetland area. 2' contours from the Waukesha County GIS website confirm this. A relatively large pond located approximately 500 feet from the basin divide on the Great Lakes Basin side is the main source of Willow Creek. Willow Creek drains the wetland area to the north through two smaller ponds near Lannon Rd. There is a drain approximately 1350 ft from the basin divide on the Mississippi River Basin side that connects to Fox River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photos. This wetland area has a tendency to pond and flood. During a site visit on 07-June-2011, water was observed flowing out of the wetland into Willow Creek through a 1.5' CMP at Lannon Road. Due to recent rains, we were not able to hike into the wetland to confirm if there are any ditches connecting the known drain to the Fox River to the Willow Creek headwater pond. While no continuous channels or ditches were directly observed in the wetland marsh between the two rivers, heavy grassy vegetation may have obscured this evidence.

Menomonee Falls, Waukesha County, WI - Inland Silverside (*Menidia beryllina*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Medium	VC		
	USACE, Detroit	Medium	RC		
	Wisconsin DNR, Fisheries	Low	RC		
	Team Rating	**Medium**	**RC/VC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: Inland silverside were stocked into the Kankakee River in Will County Illinois. They were collected there in 1996 (USGS 2009). It appears that the majority of the locations in which this species is collected outside of its native range is due to stocking and the species is not being collected far from the initial stocking area. There is no evidence that this species is expanding beyond these stocking areas. The WDNR notes that the great distance, many barriers, and long stretches of unsuitable habitat make it extremely unlikely that the inland silverside will reach the Menononee Falls area.

Menomonee Falls, Waukesha County, WI - Inland Silverside (*Menidia beryllina*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, Rock Island	Low	RC	Low	RC
	USACE, Detroit	Low	RC	Low	RC
	Wisconsin DNR, Fisheries	Low	VC	Low	VC
	Team Ratings	**Low**	**RC/VC**	**Low**	**RC/VC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive passage through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

The inland silverside has not expanded much from the areas in which it has been initially stocked. There are 13 dams on the Fox River in Illinois and three in Wisconsin in which this species would have to negotiate to even get close to this interbasin connection. The first dam on the Fox River is the Dayton Dam, located five miles (8 km) from the confluence with the Illinois River. This dam is over 20 feet (6.1 m) high and no fish passage is present at the dam. This site is at the northern limit of the native range for this species. The USGS website shows that a stocking effort near St. Paul, Minnesota failed (USGS, 2011). Even if inland silversides could successfully negotiate the lower Fox River, conditions as they traveled north may not be conducive for them to continue.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

Transit across the watershed divide by anthropogenic means is possible. However, since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that inland silverside will arrive at the divide by anthropogenic means, such as livewell or aquarium releases even though the silverside has been stocked as a forage species.

Menomonee Falls, Waukesha County, WI - Inland Silverside (*Menidia beryllina*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Low	RC		
	USACE, Detroit	Low	RC		
	Wisconsin DNR, Fisheries	Low	RC		
	Team Ratings	**Low**	**RC**		

4. How do you rate the probability of ANS establishing at the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks:

Menomonee Falls, Waukesha County, WI - Inland Silverside (*Menidia beryllina*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE, Rock Island	Medium	MC
	USACE, Detroit	Medium	RC
	Wisconsin DNR, Fisheries	Low	RC
	Team Ratings	**Medium**	**MC/RC**

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The chance of inland silversides getting to the basin divide locations and then establishing a population in the vicinity is highly unlikely. However, if this was to happen there is a possibility that they could expand beyond the colonized area via this location.

South Menomonee Falls, Waukesha County, WI - Northern Snakehead (*Channa argus*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Medium	RC	Low	RC
	USACE, Rock Island - Hydraulic Engineer	Medium	RC	Low	RC
	NRCS - Hydraulic Engineer	High	RC	Low/Med	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the Fox River 1% annual chance floodplain comes right up to the inlet of a storm drain that connects the Fox River basin to the Menomonee River basin. This portion of the Fox River floodplain consists of the area known as Tamarack swamp and is backwater flooding connected to the Fox River through a 24-inch CMP under County Hwy W which is approximately 65 ft long. This culvert has a high invert, though, and only allows about 4" of water through at the 1% event. The precipitation for the 2% and 10% events are only 1" and 2" less than the 1% precipitation, though, so water would still be expected in the culvert at the lower events. Flow then goes to a storm drain north of the swamp. The urban storm drain is a 3' CMP with that is approximately 2000 feet long. A site visit on 07-June-2011 confirmed that there was a defined channel with water flowing from the Tamarack Park swamp into the storm drain and flowing out into the tributary of the Menomonee River. 2' contours from the Waukesha County GIS website show that there is a 40' drop in elevation in the tributary of the Menomonee River from the storm drain outlet to the confluence of the Menomonee River, which is approximately 2500 feet downstream. Flow is regularly connected to both watersheds, but it is professional judgment that flow is possible in downstream (Great Lakes Basin) direction only. The probably of backwater inundation of the Menomonee River (Great Lakes Basin) to allow the flow of water into the Fox River (Mississippi River Basin) appears unlikely.

West Menomonee Falls, Waukesha County, WI - Northern Snakehead (*Channa argus*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	High	MC	Medium	MC
	USACE, Rock Island - Hydraulic Engineer	High	MC	Medium	MC
	NRCS - Hydraulic Engineer	Medium	MC	Medium	MC
	Team Ratings	**High**	**MC**	**Medium**	**MC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the 1% annual chance floodplains for Willow Creek (Great Lakes Basin) and Fox River (Mississippi River Basin) are connected in a low elevation wetland area. 2' contours from the Waukesha County GIS website confirm this. A relatively large pond located approximately 500 feet from the basin divide on the Great Lakes Basin side is the main source of Willow Creek. Willow Creek drains the wetland area to the north through two smaller ponds near Lannon Rd. There is a drain approximately 1350 ft from the basin divide on the Mississippi River Basin side that connects to Fox River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photos. This wetland area has a tendency to pond and flood. During a site visit on 07-June-2011, water was observed flowing out of the wetland into Willow Creek through a 1.5' CMP at Lannon Road. Due to recent rains, we were not able to hike into the wetland to confirm if there are any ditches connecting the known drain to the Fox River to the Willow Creek headwater pond. While no continuous channels or ditches were directly observed in the wetland marsh between the two rivers, heavy grassy vegetation may have obscured this evidence.

Menomonee Falls, Waukesha County, WI - Northern Snakehead (*Channa argus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Medium	RC		
	USACE, Detroit	Medium	RC		
	Wisconsin DNR, Fisheries	Medium	VC		
	Team Rating	**Medium**	**RC/VC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria					
High	Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.					
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.					
Low	Target ANS is not known to exist on a connected waterway.					
	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: The closest established population of northern snakeheads is in Lee County, Arkansas. While this is in the Mississippi River watershed, this population does not seem to be spreading at a high rate at this time (USGS, 2011). A single specimen of giant snakehead (Channa micropeltes) was collected in the Rock River by the WDNR (a watershed not directly connected with the Menomonee Falls pathway). This specimen was unintentionally released. However, the species is considered to be tropical to sub-trocpical and not able to survive winter temperatures encountered in the Rock River (Courtenay, Jr. and Williams, 2004).

Menomonee Falls, Waukesha County, WI - Northern Snakehead (*Channa argus*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, Rock Island	Low	RC	Low	RC
	USACE, Detroit	Low	RC	Low	RC
	Wisconsin DNR, Fisheries	Low	VC	Low	RC
	Team Ratings	**Low**	**RC/VC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive passage through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

If the Arkansas population does begin to expand up the Mississippi River, there are many barriers to migration, including dams. Habitat preferred by northern snakeheads includes stagnant, shallow ponds or swamps with mud substrate and aquatic vegetation and slow muddy streams (Courtenay and Williams, 2004). The northern snakehead likely possesses the ability to migrate through portions of interconnecting tributary streams; however, its preferred habit is not flowing waters, which will likely slow its spread up the Mississippi River and its tributaries. Unlike the Asian carp, northern snakeheads do not make long upstream spawning runs and as a result, are not likely to spread quickly through the Mississippi River Basin without the aid of anthropogenic means.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

Many species of snakehead, including the northern snakehead, have been popular aquarium fish. However, the state of Wisconsin prohibits the possession and transport of this species. Since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that the northern snakehead will arrive at the divide by anthropogenic means, such as livewell or aquarium releases. These regulations, coupled with the limited access for the public to the wetland divide, makes human release of the northern snakehead in the wetland very unlikely. However, if the northern snakehead were released in the immediate vicinity of the divide, on either side, it is likely the fish would survive and establish a viable population in the area.

Menomonee Falls, Waukesha County, WI - Northern Snakehead (*Channa argus*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE, Rock Island	Low	RC
	USACE, Detroit	Low	RC
	Wisconsin DNR, Fisheries	Low	RC
	Team Ratings	**Low/Med**	**RC**

4. How do you rate the probability of ANS establishing at the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: A range of Low-Medium was used since the team identified the small pond at the headwaters of Willow Creek at the West Menomonee Falls site as potentially suitable habitat for the n. snakehead since this species prefers more stagnant areas with vegetation.

Menomonee Falls, Waukesha County, WI - Northern Snakehead (*Channa argus*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	RC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	High	RC		
	Team Ratings	**High**	**RC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: It is very likely that the northern snakehead possesses the ability to spread from the Menomonee sites if a population were to become established. As an air breather that has even been known to move short distances over land, it is likely this species would be able to quickly move into the tributary from the wetland divide. Under proper environmental conditions, this species could potentially transfer into the Great Lakes Basin from the wetland divide even with only intermittent flooding events.

South Menomonee Falls, Waukesha County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Medium	RC	Low	RC
	USACE, Rock Island - Hydraulic Engineer	Medium	RC	Low	RC
	NRCS - Hydraulic Engineer	High	RC	Low/Med	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the Fox River 1% annual chance floodplain comes right up to the inlet of a storm drain that connects the Fox River basin to the Menomonee River basin. This portion of the Fox River floodplain consists of the area known as Tamarack swamp and is backwater flooding connected to the Fox River through a 24-inch CMP under County Hwy W which is approximately 65 ft long. This culvert has a high invert, though, and only allows about 4" of water through at the 1% event. The precipitation for the 2% and 10% events are only 1" and 2" less than the 1% precipitation, though, so water would still be expected in the culvert at the lower events. Flow then goes to a storm drain north of the swamp. The urban storm drain is a 3' CMP with that is approximately 2000 feet long. A site visit on 07-June-2011 confirmed that there was a defined channel with water flowing from the Tamarack Park swamp into the storm drain and flowing out into the tributary of the Menomonee River. 2' contours from the Waukesha County GIS website show that there is a 40' drop in elevation in the tributary of the Menomonee River from the storm drain outlet to the confluence of the Menomonee River, which is approximately 2500 feet downstream. Flow is regularly connected to both watersheds, but it is professional judgment that flow is possible in downstream (Great Lakes Basin) direction only. The probably of backwater inundation of the Menomonee River (Great Lakes Basin) to allow the flow of water into the Fox River (Mississippi River Basin) appears unlikely.

West Menomonee Falls, Waukesha County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	High	MC	Medium	MC
	USACE, Rock Island - Hydraulic Engineer	High	MC	Medium	MC
	NRCS - Hydraulic Engineer	Medium	MC	Medium	MC
	Team Ratings	**High**	**MC**	**Medium**	**MC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the 1% annual chance floodplains for Willow Creek (Great Lakes Basin) and Fox River (Mississippi River Basin) are connected in a low elevation wetland area. 2' contours from the Waukesha County GIS website confirm this. A relatively large pond located approximately 500 feet from the basin divide on the Great Lakes Basin side is the main source of Willow Creek. Willow Creek drains the wetland area to the north through two smaller ponds near Lannon Rd. There is a drain approximately 1350 ft from the basin divide on the Mississippi River Basin side that connects to Fox River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photos. This wetland area has a tendency to pond and flood. During a site visit on 07-June-2011, water was observed flowing out of the wetland into Willow Creek through a 1.5' CMP at Lannon Road. Due to recent rains, we were not able to hike into the wetland to confirm if there are any ditches connecting the known drain to the Fox River to the Willow Creek headwater pond. While no continuous channels or ditches were directly observed in the wetland marsh between the two rivers, heavy grassy vegetation may have obscured this evidence.

Menomonee Falls, Waukesha County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	RC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	High	RC		
	Team Rating	**High**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: Viral hemorrhagic septicemia virus can infect a wide range of host fish causing a variety of external and internal pathology, including death of the host fish (Attachment B). Variables such as host fish species and water temperature can impact the pathology of the virus. Seemingly healthy individuals that have been previously infected with VHSv can have chronic infections and be carriers of the disease (Skall et al., 2005). This virus has been reported from throughout the Great Lakes Basin including Lake Michigan (USGS, 2011). Viral hemorrhagic septicemia virus has been found in many species of fish including common carp (Cyprinus carpio). The common carp is established in Lake Michigan, as well as the Menomonee River leading to the basin divide. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species for VHSv because of the life cycle capabilities of the common carp and the likelihood the common carp could use and survive in the pathway habitats. Viral hemorrhagic septicemia virus and a necessary host species, the common carp, are in the pathway. It should also be noted that VHSv has been found in 28 different host species in the GLB and that it can survive without a host in the water column (WDNR, 2012b).

Menomonee Falls, Waukesha County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, Rock Island	Low	RC	Low	RC
	USACE, Detroit	Low	RC	Low	RC
	Wisconsin DNR, Fisheries	Low	RC	Low	RC
	Team Ratings	**Low**	**RC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive passage through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

Viral hemorrhagic septicemia virus has been found to infect common carp (USGS, 2011). During spring run-off events in April/May, common carp migrate into the shallow waters of bays and river systems to spawn. Within the rivers, common carp migrate upstream to spawn in suitable habitat such as marshes and even drainage ditches with as little as or less than one foot (30 cm) depth of water. Common carp are strong swimmers that can reach sustained speeds of 1.3-3.9 fps (0.4-1.2 mps) and burst speed of 3.9-8.5 fps (1.2-2.6 mps). Though they cannot jump (maximum height six feet or 1.8 m) like members of the salmon family, they can migrate upstream during moderate flow events.
The distance from Lake Michigan to the watershed divide of the Menomonee River at Menomonee Falls is roughly 30 stream miles (48 km). The Wisconsin DNR Surface Water Data Viewer shows that Willow Creek, which originates at the north end of the 1.3-acre (0.5 ha) pond situated approximately 600 feet (183 m) north of the basin divide, is an intermittent stream. According to the USGS, a gauge (no. 04087030) located approximately six river miles (9.6 km) downstream of the basin divide on the Menomonee River at Menomonee Falls, the average river discharge ranges from about 70 cubic feet per second (cfs) (21 mps) in April to less than 20 cfs (6.1 mps) from August to October. The West Menomonee intermittent aquatic pathway is upstream of the Lepper Dam located on the Menomonee River. The Lepper Dam, which has a 22-foot (6.7 m) dam height, is considered a total blockage to upstream fish migration by the WDNR. Therefore, it is considered highly unlikely that a common carp hosting VHSv could transfer through this pathway by natural means. However, if an infected common carp were to arrive at the emergent wetland divide, or the approximately 1.3-acre (0.5 ha) pond, during the spring a subsequent storm event sufficient to complete the intermittent aquatic pathway could facilitate that infected common carp to disperse across the basin divide at that time. The impediment that the Lepper Dam provides is the primary basis for the assignment of the low rating to the probability a common carp infected with VHSv could survive transit solely through the aquatic pathway to the basin divide at this location. That structure is also the primary basis for the level of certainty rating for this specific ANS, as represented by the common carp as the potential host fish. It is unlikely that any of the Great Lakes Basin invasive fish species (including the common carp) could cross the South Menomonee divide from Lake Michigan to the Mississippi River Basin, up the 2,000 lineal foot (LF) (610 m) intermittent drain with a three foot (0.9 m) bottom width and high gradient, then access the 1,500 LF (457 m) of three foot (0.9 m) diameter culvert to reach the wetland divide. If any of the fish species arrived at the emergent wetland divide during a runoff event, passage would still be difficult even when sufficient water is available in the divide for movement to the Mississippi River Basin because of there being a lack of any defined channel for them to follow and the thickness of the inundated wetland vegetation.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

As discussed previously, many ANS could survive in the pathway if the species were dumped or discharged through anthropogenic means. Because fishing and boating do not occur in the wetland divide and public access is limited, it is highly unlikely that VHSv will arrive at the basin divide through anthropogenic means, such as livewell or aquarium releases.

Menomonee Falls, Waukesha County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Medium	RC		
	USACE, Detroit	Medium	RC		
	Wisconsin DNR, Fisheries	Medium	RC		
	Team Ratings	**Medium**	**RC**		

4. How do you rate the probability of ANS establishing at the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: During spring run-off events in April/May, common carp migrate into the shallow waters of bays and river systems to spawn. Within the rivers, common carp migrate upstream to spawn in suitable habitat such as marshes and even drainage ditches with as little as one foot (30 cm) water depth. Common carp are strong swimmers and though they cannot jump like members of the salmon family, they can migrate upstream during moderate flow events. Survival and reproduction of common carp as a potential carrier of VHSv is considered high at this location during the spring. During spring runoff, the wetland divide and connecting ditches/streams could provide the necessary habitat for occupation of any VHSv carrier/host fish species, at least temporarily. The virus is capable of persisting outside of a host in the water column for at least 14 days and grows best in fish when water temperatures are 37ºF - 54 ºF (2.8 ºC - 12.2 ºC). It also demonstrates a rapid reproductive cycle and is capable of utilizing up to 28 known fish species in the Great Lakes Basin, including common carp (WDNR, 2012b). However, there is uncertainty regarding the suitability of the aquatic habitat to sustain a population of VHSv-infected common carp during the drier and hotter periods of the year in proximity to this location.

Menomonee Falls, Waukesha County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	VC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	Medium	RC		
	Team Ratings	**High**	**RC/VC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: This virus is capable of persisting outside of a host for several days, demonstrates a rapid reproductive cycle, and is capable of utilizing many different host species. It is highly probable that VHSv would be successful in spreading into exposed fish populations already on both sides of the wetland basin divide in the event infected fish reached the Menomonee Falls pathways. The emergent wetlands at the divide is the type of habitat that carp seek in the spring during spawning season and would be considered good to excellent carp spawning habitat with one to two feet (30-60 cm) of inundation. Water depths of one foot or less (< 30 cm) spanning the basin divide would appear to be suitable for the passage of carp. This condition would most likely occur with heavy rains in later spring in the April/May time frame after the ground has been saturated during the melting of snowpack and several heavy rain events. If any VHSv-infected fish species were present in the wetlands or pond in proximity to the divide when such an event occurs, the fish could disperse across the basin divide into the Mississippi River Basin and likely find suitable additional host fish species. If water temperatures are low enough for a period of time, the virus may also be able to spread across the pathway in the water column as well.

South Menomonee Falls, Waukesha County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Medium	RC	Low	RC
	USACE, Rock Island - Hydraulic Engineer	Medium	RC	Low	RC
	NRCS - Hydraulic Engineer	High	RC	Low/Med	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the Fox River 1% annual chance floodplain comes right up to the inlet of a storm drain that connects the Fox River basin to the Menomonee River basin. This portion of the Fox River floodplain consists of the area known as Tamarack swamp and is backwater flooding connected to the Fox River through a 24-inch CMP under County Hwy W which is approximately 65 ft long. This culvert has a high invert, though, and only allows about 4" of water through at the 1% event. The precipitation for the 2% and 10% events are only 1" and 2" less than the 1% precipitation, though, so water would still be expected in the culvert at the lower events. Flow then goes to a storm drain north of the swamp. The urban storm drain is a 3' CMP with that is approximately 2000 feet long. A site visit on 07-June-2011 confirmed that there was a defined channel with water flowing from the Tamarack Park swamp into the storm drain and flowing out into the tributary of the Menomonee River. 2' contours from the Waukesha County GIS website show that there is a 40' drop in elevation in the tributary of the Menomonee River from the storm drain outlet to the confluence of the Menomonee River, which is approximately 2500 feet downstream. Flow is regularly connected to both watersheds, but it is professional judgment that flow is possible in downstream (Great Lakes Basin) direction only. The probably of backwater inundation of the Menomonee River (Great Lakes Basin) to allow the flow of water into the Fox River (Mississippi River Basin) appears unlikely.

West Menomonee Falls, Waukesha County, WI - Ruffe (Gymnochephalus cernuus) / Tubenose Goby (Proterorhinus semilunaris)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	High	MC	Medium	MC
	USACE, Rock Island - Hydraulic Engineer	High	MC	Medium	MC
	NRCS - Hydraulic Engineer	Medium	MC	Medium	MC
	Team Ratings	**High**	**MC**	**Medium**	**MC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the 1% annual chance floodplains for Willow Creek (Great Lakes Basin) and Fox River (Mississippi River Basin) are connected in a low elevation wetland area. 2' contours from the Waukesha County GIS website confirm this. A relatively large pond located approximately 500 feet from the basin divide on the Great Lakes Basin side is the main source of Willow Creek. Willow Creek drains the wetland area to the north through two smaller ponds near Lannon Rd. There is a drain approximately 1350 ft from the basin divide on the Mississippi River Basin side that connects to Fox River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photos. This wetland area has a tendency to pond and flood. During a site visit on 07-June-2011, water was observed flowing out of the wetland into Willow Creek through a 1.5' CMP at Lannon Road. Due to recent rains, we were not able to hike into the wetland to confirm if there are any ditches connecting the known drain to the Fox River to the Willow Creek headwater pond. While no continuous channels or ditches were directly observed in the wetland marsh between the two rivers, heavy grassy vegetation may have obscured this evidence.

Menomonee Falls, Waukesha County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	RC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	Low/Med	RC		
	Team Rating	**High**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: The ruffe and tubenose goby are located within the Great Lakes and are associated with river mouths and estuaries of large river systems entering the Great Lakes. Ruffe exists in northern Lake Michigan in Green Bay, but is not widespread and there are no high density populations in Lake Michigan (Bowen and Goehle, 2011). The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravels, but has a tolerance for different habitats and environmental conditions (Gray and Best, 1989). The ruffe has a high fecundity and spawns in clean water. Females produce up to 200,000 eggs in the first batch, and up to 6,000 eggs per subsequent batch (Global invasive species database, 2012). The ruffe is an aggressive species that possesses the ability to feed in darkness, cold temperatures, and turbid conditions. The fish has extended its range rapidly and modeling predicts it will find suitable habitat in all five Great Lakes. The tubenose goby's introduced range covers three Great Lakes including Lakes Superior, Erie and Huron (USGS, 2011). It has been collected in the lower reaches of larger Great Lakes rivers and estuaries. The tubenose goby is found in the open waters and estuaries of slow flowing rivers. Tubenose gobies are benthic species that consume a wide variety of invertebrates (USGS, 2011). They are often quite abundant in backwaters and lakes and seem prefer dense vegetation. The tubenose goby does inhabit upper river systems, but no tubenose goby have been collected locally in upper Great Lakes river tributaries to date. Tubenose gobies have exhibited a much slower rate of expansion in the Great Lakes than the round goby (Neogobius melanostomus), also an invasive species in the Great Lakes, and that is now located within both the Great Lakes Basin and the Mississippi River Basin.

Menomonee Falls, Waukesha County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, Rock Island	Low	VC	Low	RC
	USACE, Detroit	Low	RC	Low	RC
	Wisconsin DNR, Fisheries	Low	RC	Low	RC
	Team Ratings	**Low**	**RC/VC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive passage through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

As mentioned above for VHSv, there are significant obstacles for ANS to traverse in order for them to reach the interbasin divide. Therefore, it is unlikely that ruffe or tubenose goby could transfer to this pathway by natural means. The life histories of these two fish, and the impediment that the Lepper Dam provides, is the primary basis for the assignment of the low rating for the probability that either species could survive transit through the aquatic pathway to the basin divide at this location. Neither ruffe nor tubenose gobies are known to have been collected in the United States in similar upstream river habitat. The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel areas, but has a tolerance for different habitats and environmental conditions (Gray and Best, 1989). Ballast water transport has been the key means for the spread of ruffe in the Great Lakes (USFWS, 1996). Natural rates of dispersion are not well known and ruffe have not spread beyond Green Bay in the nine years since its detection in that area, and populations have been trending down (Bowen and Goehle, 2011). The ruffe's ability to swim upstream during high flow events and migrate over dams is questionable, especially since it prefers still or slow moving water (Fishbase, 2010). The tubenose goby is found in the open lake waters and estuaries of slow flowing rivers and appears to be more capable of living in diverse types of riverine habitat than the ruffe (Dopazo, et al., 2008; Jude and DeBoe, 1996). At the South Menomonee Falls location, the intermittent stream and culvert appears to be a viable barrier to upstream migration for either fish species.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

The ruffe and tubenose goby are listed among the "established nonnative fish species" (see WI NR 40.02(17)), which is one of four groups of "restricted" non-native fish species. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the DNR. The ruffe/tubenose goby are not normally used as live bait for river fishing or aquarium species. Although transit across the watershed divide by other anthropogenic means is possible, since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that the either species will arrive at the divide by anthropogenic means, such as livewell or aquarium releases.

Menomonee Falls, Waukesha County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Low	VC		
	USACE, Detroit	Low	RC		
	Wisconsin DNR, Fisheries	Low	RC		
	Team Ratings	**Low**	**RC/VC**		

4. How do you rate the probability of ANS establishing at the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The ruffe is an aggressive species that possesses the ability to feed in darkness, cold temperatures, and turbid conditions. Tubenose gobies are benthic species that consume a wide variety of invertebrates (USGS, 2011). They are often quite abundant in backwaters and lakes and seem to prefer dense vegetation. Survival of a viable, reproducing population of ruffe and tubenose goby within the emergent wetlands at either divide location is unlikely due to low water quality and high temperatures in summer months. The ability of either species to migrate across a flooded, emergent wetland complex and through farm/roadside ditches is considered low.

Menomonee Falls, Waukesha County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE, Rock Island	Medium	RC
	USACE, Detroit	Medium	RC
	Wisconsin DNR, Fisheries	Low	RC
	Team Ratings	**Medium**	**RC**

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Ruffe and the tubenose goby have not been found in river systems similar to the upper Menomonee River. The emergent wetland at the divide is not the type of habitat that ruffe or tubenose goby would seek if the fish were introduced into the divide. If the fish were introduced adjacent to the divide during a spring runoff event, the fish could likely survive and move into the Mississippi River Basin.

South Menomonee Falls, Waukesha County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Medium	RC	Low	RC
	USACE, Rock Island - Hydraulic Engineer	Medium	RC	Low	RC
	NRCS - Hydraulic Engineer	High	RC	Low/Med	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the Fox River 1% annual chance floodplain comes right up to the inlet of a storm drain that connects the Fox River basin to the Menomonee River basin. This portion of the Fox River floodplain consists of the area known as Tamarack swamp and is backwater flooding connected to the Fox River through a 24-inch CMP under County Hwy W which is approximately 65 ft long. This culvert has a high invert, though, and only allows about 4" of water through at the 1% event. The precipitation for the 2% and 10% events are only 1" and 2" less than the 1% precipitation, though, so water would still be expected in the culvert at the lower events. Flow then goes to a storm drain north of the swamp. The urban storm drain is a 3' CMP with that is approximately 2000 feet long. A site visit on 07-June-2011 confirmed that there was a defined channel with water flowing from the Tamarack Park swamp into the storm drain and flowing out into the tributary of the Menomonee River. 2' contours from the Waukesha County GIS website show that there is a 40' drop in elevation in the tributary of the Menomonee River from the storm drain outlet to the confluence of the Menomonee River, which is approximately 2500 feet downstream. Flow is regularly connected to both watersheds, but it is professional judgment that flow is possible in downstream (Great Lakes Basin) direction only. The probably of backwater inundation of the Menomonee River (Great Lakes Basin) to allow the flow of water into the Fox River (Mississippi River Basin) appears unlikely.

West Menomonee Falls, Waukesha County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	High	MC	Medium	MC
	USACE, Rock Island - Hydraulic Engineer	High	MC	Medium	MC
	NRCS - Hydraulic Engineer	Medium	MC	Medium	MC
	Team Ratings	**High**	**MC**	**Medium**	**MC**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Waukesha County FIS mapping from 2008 shows that the 1% annual chance floodplains for Willow Creek (Great Lakes Basin) and Fox River (Mississippi River Basin) are connected in a low elevation wetland area. 2' contours from the Waukesha County GIS website confirm this. A relatively large pond located approximately 500 feet from the basin divide on the Great Lakes Basin side is the main source of Willow Creek. Willow Creek drains the wetland area to the north through two smaller ponds near Lannon Rd. There is a drain approximately 1350 ft from the basin divide on the Mississippi River Basin side that connects to Fox River. Some evidence of shallow dry ditches in the wetland area can be seen in the aerial photos. This wetland area has a tendency to pond and flood. During a site visit on 07-June-2011, water was observed flowing out of the wetland into Willow Creek through a 1.5' CMP at Lannon Road. Due to recent rains, we were not able to hike into the wetland to confirm if there are any ditches connecting the known drain to the Fox River to the Willow Creek headwater pond. While no continuous channels or ditches were directly observed in the wetland marsh between the two rivers, heavy grassy vegetation may have obscured this evidence.

Menomonee Falls, Waukesha County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	RC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	Medium	RC		
	Team Rating	**High**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria					
High	Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.					
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.					
Low	Target ANS is not known to exist on a connected waterway.					
	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: The threespine stickleback is found in each of the Great Lakes and has been collected in some inland river systems (USGS, 2011). While not having been identified within the Menomonee River, its close proximity indicates the potential for access and transfer to the Mississippi River Basin via the Menomonee River. Literature indicates this species prefers to live in the backwaters of smaller streams, but also occur in a variety of habitats including lakes and large rivers and occupies a more varied habitat than the brook stickleback, which has been collected in the Menomonee River (Wootton, 1976).

Menomonee Falls, Waukesha County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, Rock Island	Low	VC	Low	RC
	USACE, Detroit	Low	RC	Low	RC
	Wisconsin DNR, Fisheries	Low	RC	Low	RC
	Team Ratings	**Low**	**RC/VC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive passage through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

It is considered unlikely that threespine stickleback could transfer to this pathway by natural means. As a sight feeder, the sometimes turbid waters of the Menomonee River may be unsuitable for the threespine stickleback. If the threespine stickleback arrived at the emergent wetland divide during the spring, the fish could likely survive until later summer. The emergent wetland divide, even during a flooded spring condition, is not preferred habitat. The impediment that the Lepper Dam provides is the primary basis for the assignment of the low rating to the probability threespine stickleback could survive transit solely through the aquatic pathway to the basin divide at this location. The primary obstacle on the South Menomonee pathway is the 2,000 foot (610 m) intermittent stream and high gradient, and the 1,500 feet (457 m) of three foot (0.9 m) diameter culvert. These barriers are sufficient for impeding migration of the threespine stickleback at all flow conditions. The wetland divide does not provide the preferred or suitable habitat for the threespine stickleback. However, the fish could potentially survive in the emergent wetland divide during a storm runoff event as they are tolerate of low dissolved oxygen down to two parts per million (ppm) and temperatures up to 68oF (20oC) (Wootton, 1976). It is likely that sufficient forage and habitat is available throughout the Menomonee River and the Mississippi River Basin for the threespine stickleback.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

The threespine stickleback can tolerate dissolved oxygen levels as low as two ppm at 68oF (20oC) which may not be met in the wetland pond in late summer. Threespine stickleback passage to the emergent wetland basin divide even after a large storm event is considered a low probability based on the habitat requirements of the threespine stickleback. It is believed that bait-bucket transport has aided in the movement of the threespine stickleback in the past. Wisconsin regulations do prohibit possession and transport of this species. However, since fishing and boating do not occur at the wetland divide and public access is limited, it is highly unlikely that the species will arrive at the divide by anthropogenic means.

Menomonee Falls, Waukesha County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	Low	RC		
	USACE, Detroit	Low	RC		
	Wisconsin DNR, Fisheries	Low	RC		
	Team Ratings	**Low**	**RC**		

4. How do you rate the probability of ANS establishing at the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: As a visual predator, the sometimes turbid waters of the Menomonee River and the emergent wetlands at the divides may be unsuitable for the threespine stickleback. Survival of a viable, reproducing population of threespine stickleback within the divide for other than spring runoff events is unlikely.

Menomonee Falls, Waukesha County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Rock Island	High	RC		
	USACE, Detroit	High	RC		
	Wisconsin DNR, Fisheries	Medium	RC		
	Team Ratings	**High**	**RC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The threespine stickleback has been found in smaller river systems and movement across the aquatic pathway is possible, especially for shorter periods of time when flow conditions are higher and forage is more prevalent.