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

Grand Lake St. Marys, Ohio

US Army Corps of Engineers
BUILDING STRONG®

Executive Summary

This assessment characterizes the likelihood that a viable aquatic pathway exists at Grand Lake St. Marys on the border of Mercer and Auglaize Counties in west-central Ohio, and that it would allow transfer of aquatic nuisance species (ANS) between the Great Lakes and Mississippi Rivers Basins. This was accomplished by evaluating the hydrologic and hydraulic characteristics of the site based on readily available information, and a species-specific assessment of the abilities of potential ANS to arrive at the pathway and cross into the adjacent basin.

Grand Lake St. Marys is a 13,500-acre (5,463 hectares) reservoir that is very shallow with a mean depth of only 3-5 feet (1-1.5 meters). The only connection this lake has with either the Great Lakes or Mississippi River Basins is through outflow structures located on either end of the lake. Other than direct precipitation, the only inflows to the lake are from a series of small tributary streams located on the south side of the lake which are not directly connected with the Great Lakes or Mississippi River Basins.

The outflow at the west end of the lake presents an impassible barrier for any ANS that might attempt to enter Grand Lake St. Marys from the Mississippi River Basin through Beaver Creek. There is an approximately 17 foot (5.1 m) vertical drop from the lake into Beaver Creek, which is a tributary of the Wabash River. Any ANS moving upstream in the Mississippi River Basin would also encounter the Roush Dam on the Wabash River near Huntington, Indiana, which is also an impassible fish barrier. A pair of sluice gates control the outflow on the east end of the lake and also present an impassible barrier for any ANS that might attempt to enter the lake from the Great Lakes Basin through the Miami and Erie Canal Feeder Channel.There is an approximately seven foot (2.1 m) drop in elevation from the lake to the bottom of the Miami and Erie Canal Feeder Channel which is ultimately connected with the Maumee River and Lake Erie. Since there is a perennial outflow from the lake into either basin, a rating of “high” was assigned to denote the probability that an aquatic pathway exists at Grand Lake St. Marys for flow in both directions.

As a result of this high rating for the probability of an aquatic pathway existing at Grand Lake St. Marys, the viability of this pathway for specific ANS of concern was then evaluated by looking at the biological requirements and capabilities of the nine ANS listed in the table above.

Aquatic Nuisance Species of Concern	
Species	**Common Name**
Hypophthalmichthys molitrix	silver carp
Hypophthalmichthys nobilis	bighead carp
Mylopharyngodon piceus	black carp
Channa argus	northern snakehead
Gasterosteus aculeatus	threespine stickleback
Gymnocephalus cernua	ruffe
Proterorhinus semilunaris	tubenose goby
Neoergasilus japonicus	parasitic copepod
Novirhabdovirus sp	viral hemorrhagic septicemia virus (VHSv)

Based on the hydrology of the aquatic pathway and consideration of the above species, the biological evaluation found that ANS transfer between the basins by natural aquatic means could not occur in either direction at Grand Lake St. Marys. An ANS that might attempt to access the pathway from the Great Lakes Basin would not be able to get up and through the sluice gates at the east end of the lake, and an ANS that might attempt to access the pathway from the Mississippi River Basin would be blocked by Roush Dam on the Wabash River and the U-shaped weir at the west outlet of Grand Lake St. Marys. As a result, the overall pathway viability rating for this site is “low”.

Grand Lake St. Marys is a large waterbody uniquely situated on the basin divide and that is heavily used for recreational boating and fishing. Since the likelihood of ANS transfer by natural aquatic means between the basins at Grand Lake St. Marys was found to be “low”, it is therefore likely that the potential pathways and vectors of greater concern are anthropogenic at this location. These could include the collection of bait in one basin and its subsequent release in the adjacent basin, ANS adhering to recreational boats in one basin and then being released when the vessel is placed in a water body in the adjacent basin, release of imported aquaria fish and other exotic species, hitchhiking on waterfowl flying between basins,

and so on. However, it is outside the scope of this study to examine the probabilities associated with ANS transfer from such vectors.

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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
DEM. . . . . Digital Elevation Model
FEMA. . . . . Federal Emergency Management Agency
FIS. . . . . Flood Insurance Study
GIS . . . . . Geographic Information System
GLFC. . . . . Great Lakes Fishery Commission
GLMRIS. . . Great Lakes and Mississippi River Interbasin Study
HUC. . . . . Hydrologic Unit Codes
INDNR . . . . Indiana Department of Natural Resources
NAS . . . . . Nonindigenous Aquatic Species
NEPA. . . . . National Environmental Policy Act
NOAA. . . . . National Oceanic and Atmospheric Administration
NRCS . . . . Natural Resources Conservation Service
ODNR . . . . Ohio Department of Natural Resources
USACE . . . U.S. Army Corps of Engineers
USFWS . . . U.S. Fish and Wildlife Service
USGS . . . . U.S. Geological Survey
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 Grand Lake St. Marys location. This 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/).

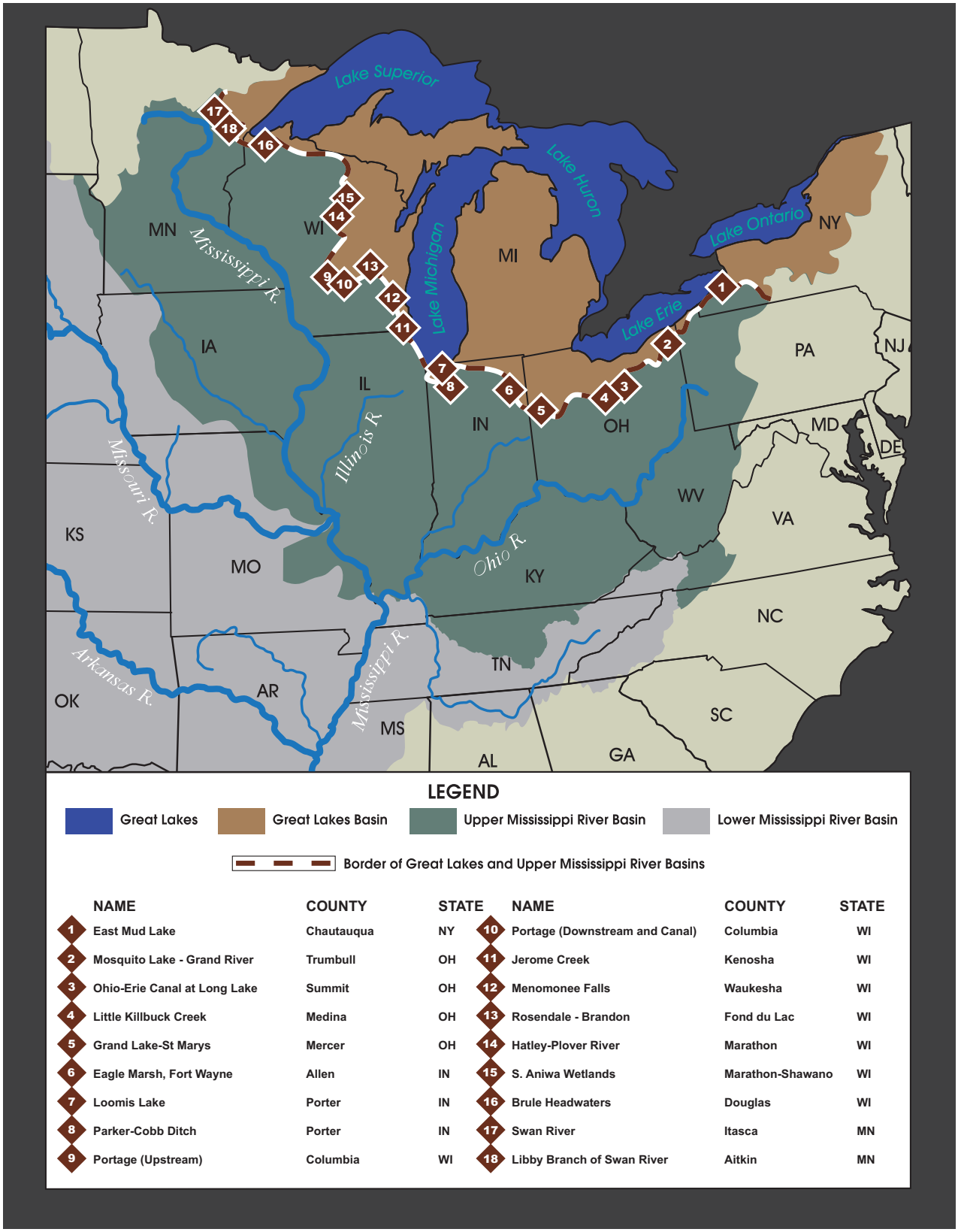
The dashed line in Figure 1 depicts the nearly 1,500-mile (2,414-kilometer) long basin divide from the New York - Pennsylvania state line to north eastern Minnesota, and it depicts each of the 18 potential aquatic pathway locations that were previously identified. The Grand Lake St. Marys location is shown as site number 5 in western Ohio (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 lend a sense of urgency and national significance to completion of the GLMRIS. These two locations are the CAWS southwest of 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 that open to Lake Michigan. 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 from up to a one percent annual recurrence interval flood event, and to evaluate the probability that specific ANS would be able to 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.

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 annual 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



	NAME	COUNTY	STATE		NAME	COUNTY	STATE
1	East Mud Lake	Chautauqua	NY	10	Portage (Downstream and Canal)	Columbia	WI
2	Mosquito Lake - Grand River	Trumbull	OH	11	Jerome Creek	Kenosha	WI
3	Ohio-Erie Canal at Long Lake	Summit	OH	12	Menomonee Falls	Waukesha	WI
4	Little Killbuck Creek	Medina	OH	13	Rosendale - Brandon	Fond du Lac	WI
5	Grand Lake-St Marys	Mercer	OH	14	Hatley-Plover River	Marathon	WI
6	Eagle Marsh, Fort Wayne	Allen	IN	15	S. Aniwa Wetlands	Marathon-Shawano	WI
7	Loomis Lake	Porter	IN	16	Brule Headwaters	Douglas	WI
8	Parker-Cobb Ditch	Porter	IN	17	Swan River	Itasca	MN
9	Portage (Upstream)	Columbia	WI	18	Libby Branch of Swan River	Aitkin	MN

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

event that has a one in 500 chance of being exceeded in any given year.

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 Grand Lake St. Marys location 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 Grand Lake St. Marys 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 exists or is likely to form between the Great Lakes and the Mississippi River basins;

- A definitive determination of whether the Grand Lake St. Marys 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 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 Grand Lake St. Marys location and will enable the interbasin spread of ANS;

- Develop clearer understanding of the means, constraints, and likelihood of the interbasin spread of ANS via the potential aquatic pathway at the Grand Lake St. Marys 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 Grand Lake St. Marys location.

1.2 Summary of Preliminary Risk Characterization for Grand Lake St. Marys, Ohio.

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. Only one location, Eagle Marsh in Fort Wayne, Indiana, was determined to pose such 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 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), Natural Resources Conservation Service (NRCS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), Great Lakes Fish 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 assigning the individual qualitative 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).

Although the preliminary risk characterization did not identify the Grand Lake St. Marys location as a location where there is a near term risk for the interbasin spread of ANS, there was some uncertainty with this rating largely due to the unknown frequency and duration of the potential hydrologic connections at the two outflows from the lake. It was therefore recommended that a more detailed assessment be conducted. Water exits this lake through vertical drop spillways into both Beaver Creek, a tributary of the Wabash River in the Mississippi River Basin, and into a remnant section of the Miami and Erie Canal, a tributary to the St. Marys and Auglaize rivers in the Great Lakes Basin. This more detailed assessment has been conducted in collaboration with the Ohio Department of Natural Resources (ODNR), USFWS, USGS, and other government agencies. The following actions were taken:

- Federal., State, and local (e.g. USGS Water Science, ODNR, County Surveyor, and local NRCS representatives) were briefed on the preliminary risk characterization results. Detailed site visits to observe potential connection locations were made and the available topographic mapping and flood hazard information were compiled and reviewed.

- An evaluation of the dams on the connecting streams to the Great Lakes and the Ohio River relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.

- Consultation with the ODNR and county surveyors in some counties along the basin divide in Ohio to assure there are no other viable surface water pathways across the basin divide (including those evaluated in this report that were determined not to pose a significant ANS transfer risk), and identify simple and inexpensive measures that could be implemented at the local or state level to mitigate significant risks at rural locations where there is potential for interbasin flow of surface water.

- An evaluation of habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to each location.

- Meeting with stakeholders at Grand Lake St Marys to observe conditions and compile and review available information on the design and operations of Grand Lake, and identify modifications to operations or structures that could be implemented to effectively mitigate the risks to insignificant levels.

- Revision of ANS transfer ratings for each location based upon a more detailed evaluation of ANS transfer potential via the aquatic pathway in both directions.

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 USACE, NRCS, and ODNR. The results also reflect the guidance, input, review comments, and concurrence of the multi-organization agency technical review team of experts from the USFWS and USGS. In addition, the Michigan Departments of Natural Resources and Environmental Quality participated on the ATR team and jointly concluded their reviews by stating that "we have reviewed the Grand Lake St. Marys pathway report and we don't have any objections to it moving forward."

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 Great Lakes Fishery Commission (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 for the Grand Lake St. Marys location 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 nonindigenous 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 nonindigenous 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 nonindigenous 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 nonindigenous 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.

2.3.3 List of ANS of Specific Concern at the Grand Lake St. Marys Location

The Grand Lake St. Marys 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 Grand Lake St. Marys 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 Grand Lake St. Marys location 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 Grand Lake St. Marys location. 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 Ohio River Basin in the Clear Fork Reservoir in Richland and Morrow Counties, Ohio in 2008), it has not yet been determined that VHSv has established within the Mississippi or Ohio River Basins. Minimizing the spread of VHSv remains a priority for the state of Ohio (Great Lakes Commission, 2011; USGS, 2011). It was therefore included as an ANS of concern threatening the Mississippi River Basin for the Grand Lake St. Marys 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 the Grand Lake St. Marys potential pathway 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.

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 psuedoharengus*	Alewife	GL	swimmer
crustacean	*Apocorophium lacustre*	a scud	MS	ballast water
algae	*Bangia atropupurea*	red macro-algae	GL	ballast / rec. 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 / rec. 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 / rec. 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

Table 2: ANS of Concern Threatening the Mississippi River Basin.			
Taxa	**Species**	**Common Name**	**Interbasin Dispersal Mechanism**
fish	*Alosa aestivalis*	blueback herring	swimmer
fish	*Alosa psuedoharengus*	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.			
Taxa	**Species**	**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 and trailers
plant	*Murdannia keisak*	marsh dewflower	recreational boats and trailers
plant	*Oxycaryum cubense*	Cuban bulrush	recreational boats and trailers

Based on the evaluation by subgroups, only fish and fish pathogens were considered to have the ability to reach the Grand Lake St. Marys divide on their own from either direction. However, this is not to say at this point that the habitat conditions at the pathway are suitable for these fish and fish pathogens. To facilitate determination of the ANS transfer potential at the site, the team of biologists selected a smaller group of representative species for a more focused assessment. The species selected may be those most likely to arrive at the divide, may pose the greatest threat, and/or exhibit a broader range of biological characteristics that may enable them to reach the pathway and perhaps establish in the vicinity. Of all the species considered, the Grand Lake St. Marys aquatic pathway team identified four ANS as a potentially significant threat to the Great Lakes Basin, and five ANS as a potential significant threat to the Mississippi River Basin (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 Grand Lake St. Marys. Additional information was obtained from the USGS Nonindigenous Aquatic Species (NAS) website (USGS, 2011).

2.4 Pathway Assessment Process

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.

Table 4: ANS of Greatest Concern for transfer at Grand Lake St. Marys

Taxa	Species	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	*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
crustacean	*Neoergasilus japonicus*	parasitic copepod	GL	parasite to fish
virus	*Novirhabdovirus sp*	VHSv	GL	pathogen to fish/water column

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*

Each of the four elements of Equation 2 is qualitatively rated a High (H), Medium (M), or Low (L) based on the available evidence. They are also qualitatively assigned a level of certainty [Very Certain (VC), Reasonably Certain (RC), Moderately Certain (MC), Reasonably Uncertain (RU), Very Uncertain (VU)]. 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 (P_3) and spread (P_4) in the new basin. In addition, the third element of Equation 3, ANS transits pathway (P_2), 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 (P_3 and P_4), 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 in proximity to 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 in proximity to 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" ($P_{Establishment}$) 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 (P_1), ANS has access to pathway from Equation 3 has been renamed ($P_{1'}$), 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 (Po) is not necessarily the same as there being no probability of a pathway existing. At those locations where the probability of a pathway existing (P0) was determined to be medium or high which includes the Grand Lake St. Marys 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.

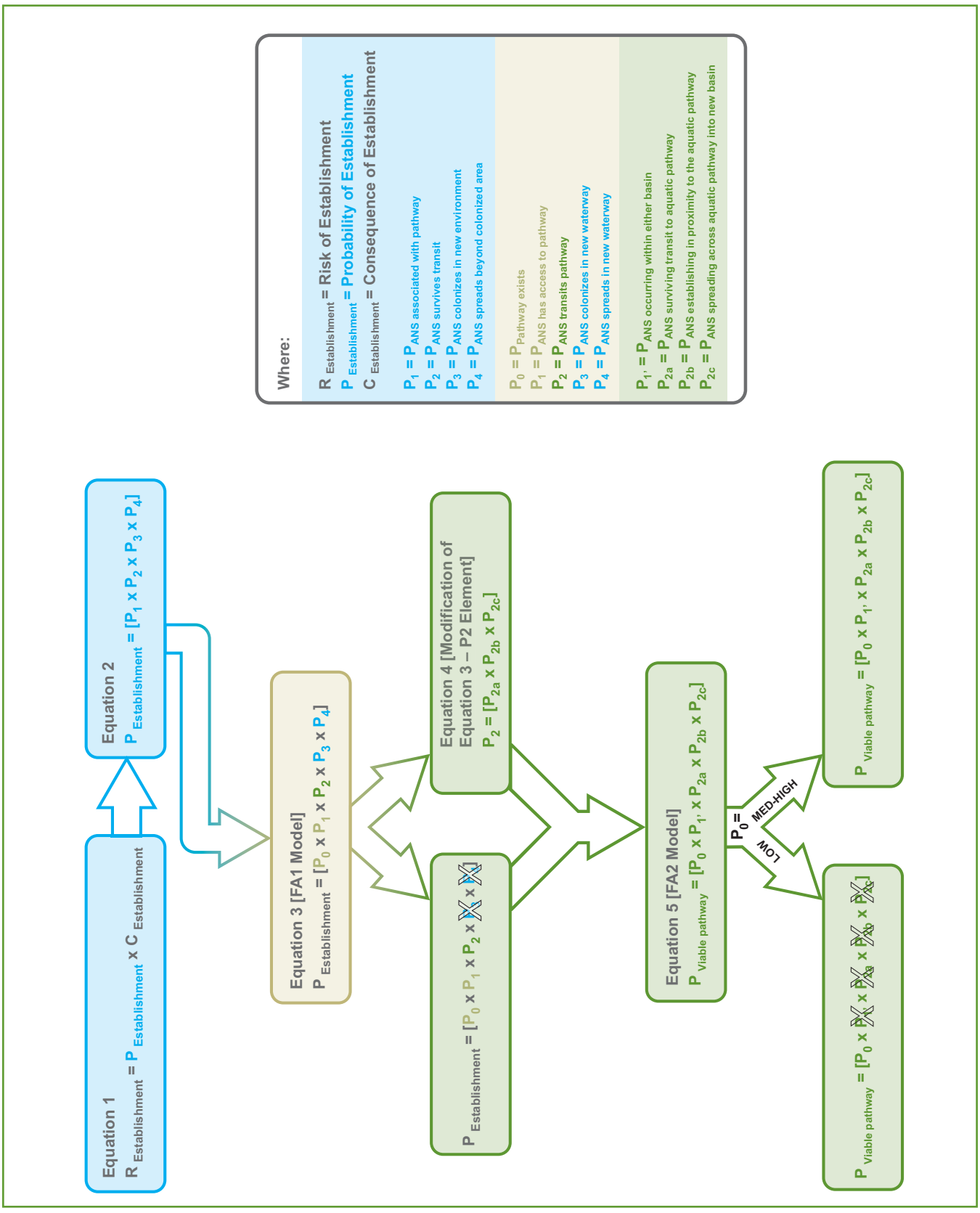


Figure 2. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

2.5 Example Calculation of Overall Aquatic Pathway Viability

As described in Section 2.2, a list of ANS of concern for the Grand Lake St. Marys pathway was developed with input from Federal, State, and local agencies responsible for water resources, and fish and wildlife management in the state of Ohio 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 5. 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. 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 in proximity to Aquatic Pathway?**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway 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 in proximity to Aquatic Pathway?**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway 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**

Table 6. 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 regarding the probability rating (H, M, or L) and the level of certainty (VC, RC, MC, RU, or VU). Final agreement was reached on team ratings for each element through collaboration and sharing of applicable information with all team members. The level of certainty in these ratings was modified during these discussions to reflect the range of opinion.

3 Aquatic Pathway Characterization

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

3.1 Location

Grand Lake St. Marys is a shallow lake (mean depth 3-5 feet (1-1.5 m)) located along the Mercer and Auglaize county line in west-central Ohio (Figure 3). The ODNR operates and regulates flow from the 13,500-acre (5,463 hectare) lake through two outlets: one discharging to the Mississippi River Basin and the other to the Great Lakes Basin (Figure 4). The primary spillway at the west end of the lake discharges into Beaver Creek in the Mississippi River Basin, and a secondary spillway at the east end of the lake discharges to a feeder channel which connects to the Miami and Erie Canal within the Great Lakes Basin. The Beaver Creek outlet is located at the west end of Grand Lake St. Marys near the town of Celina, Ohio. The secondary outlet is located on the east end of Grand Lake St. Marys and south of the town of St. Marys. The Great Lakes and Mississippi River watershed boundaries near Grand Lake St. Marys are based on the 12-digit hydrologic unit code (HUC) boundaries and are illustrated by the red-white line in Figure 5. The land currently occupied by the lake was once part of a vast wet prairie and together with the St. Marys River served as an important connection between the Great Lakes and Ohio River in the development of the Northwest Territory. Construction of the lake was started in 1837 as a reservoir for the Miame-Erie Canal. It was completed eight years later and was at that time the largest man-made lake in the world (ODNR, 2011). Since this area is located directly on the basin divide, the construction of this lake is the most likely reason why the basin boundary now skirts the east end of the lake and then runs due west to reconnect with its historic location west of the lake. The latitude and longitude coordinates for the Grand Lake St. Marys outlets are as follows:

Outlet into Beaver Creek (Mississippi River Basin): N 40.535, W 84.574

Outlet into Miami and Erie Canal Feeder Channel (Great Lakes Basin): N 40.522, W 84.422

Below is depicted the flow path for water exiting Grand Lake St. Marys into the Great Lakes and Mississippi River Basins, which is also graphically illustrated in Figure 5:

Connecting stream to the Great Lakes:

Grand Lake St. Marys ► Miami and Erie Canal feeder channel ► Miami and Erie Canal ► St. Marys River ► Maumee River ► Lake Erie

Connecting stream(s) to the Mississippi River:

Grand Lake St. Marys ► Beaver Creek ► Wabash River ► Ohio River ► Mississippi River

Figure 3: Grand Lake St. Marys location and vicinity map. Background imagery courtesy of Bing Maps.

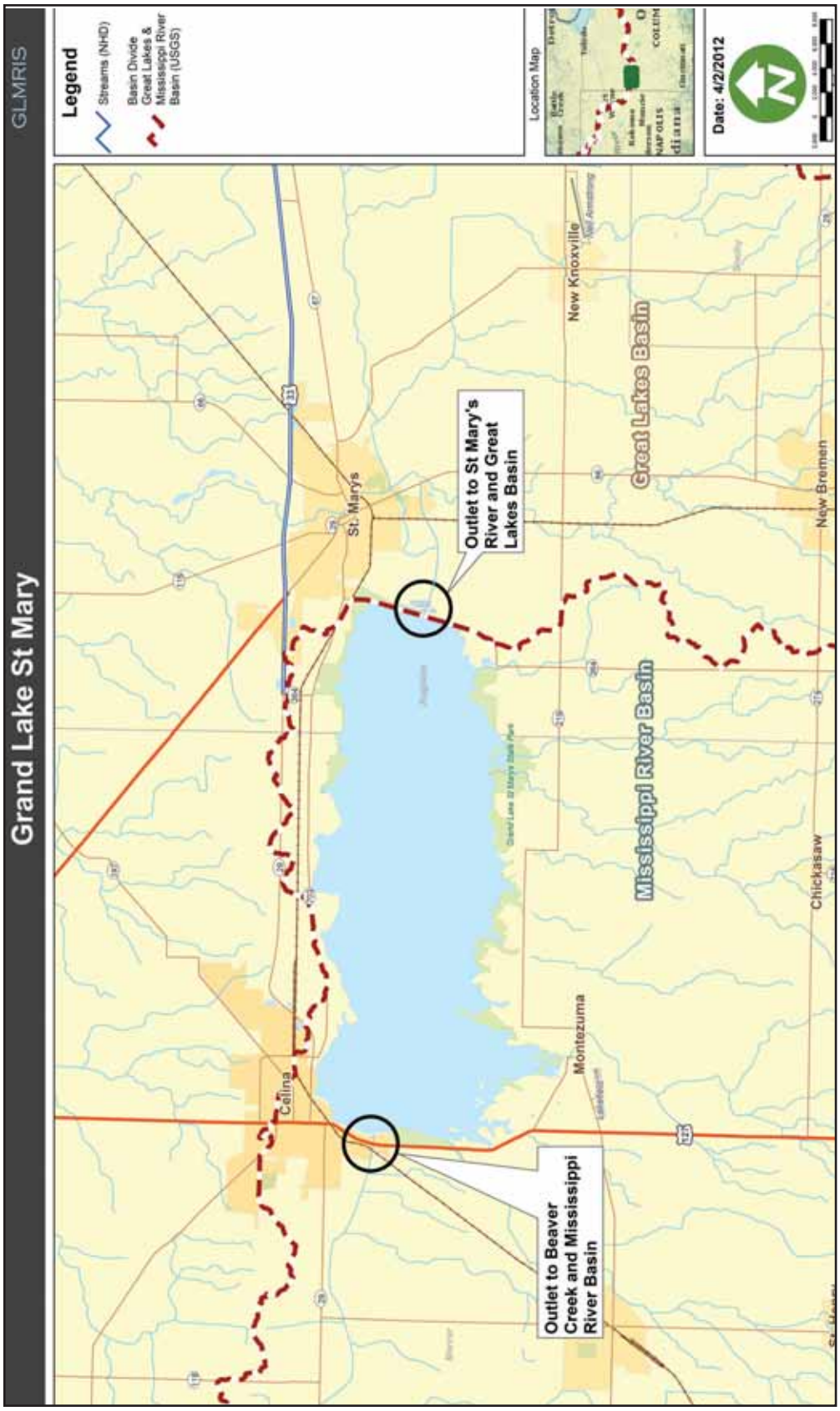


Figure 4. Grand Lake St. Marys tributaries and Great Lakes and Mississippi River Basin boundary shown by red-white line. Figure shows location of two outlets from the lake into either basin. Background imagery courtesy of Bing Maps.

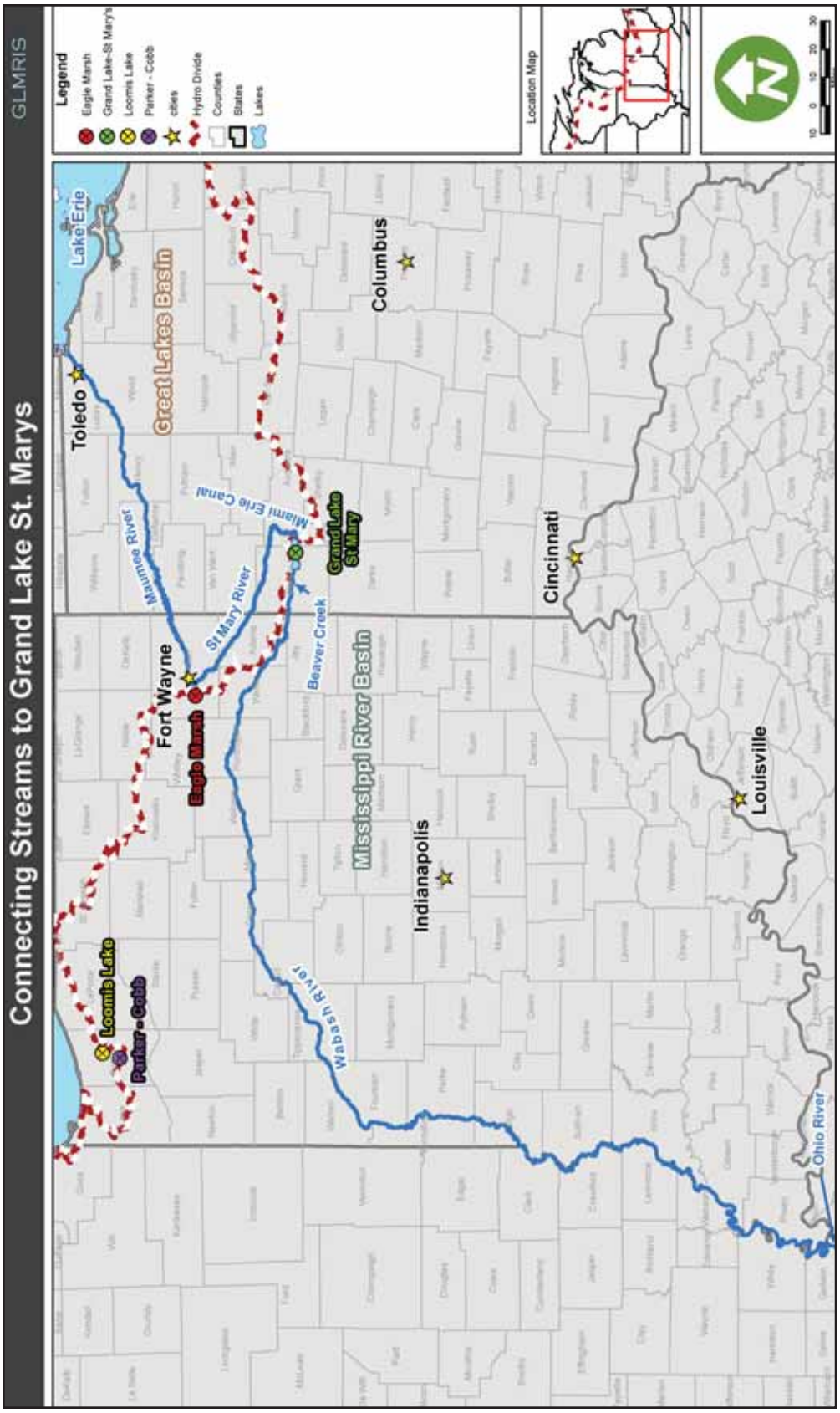


Figure 5. Surface water pathways from Grand Lake St. Marys to the Ohio River and Lake Erie are illustrated by the blue lines. The three potential other aquatic pathways in closest proximity to Grand Lake St. Marys are all in Indiana are are indicated on the figure, but are each addressed in separate reports. Background imagery courtesy of Bing Maps.

3.2 Climate

Climate is looked at briefly in this section just to identify any applicable elements of climate (e.g., temperature, rainfall) that may influence the likelihood of an aquatic connection forming at the subject pathway which might be utilized by ANS to spread between basins, and to help in the general understanding of the environmental conditions of the area. It is also important to have a general understanding of the affect that temperature is likely to have on the quality of surface water relative to the habitat requirements of aquatic plant and animal species.

An average of about 35 inches (89 cm) of precipitation falls on Auglaize and Mercer Counties annually. The average precipitation is approximately three inches (7 cm) per month, with February typically being the driest month and July the wettest month. The following climate information is extracted from the Mercer County Soil Survey (USDA, 1979):

- Winter precipitation and frequent snow results in a good accumulation of soil moisture by spring and minimizes drought during summer on most soils. Normal annual precipitation is adequate for all crops that are suited to the temperature and the length of the growing season.

- In winter the average temperature is 28°F (-2°C), and the average daily minimum temperature is 20°F (-6°C). In summer the average temperature is 72°F (22°C), and the average daily maximum temperature is 83°F (28°C).

- Average seasonal snowfall is 36 inches (91 cm).

  The greatest snow depth at any one time during the period of record was 14 inches (35 cm). On the average, 22 days have at least one inch (2.5 cm) of snow on the ground, but the number of such days varies greatly from year to year.

There can be significant variability in precipitation events between locations that are in close proximity within this study area (Beiler, 2011). Some of this variability can be seen by comparing measurements from two rain gages on the north side of Grand Lake St. Marys from rain events in 2003 and 2005 (Table 7; Figure 6).

Table 7. Comparison of two recent rainfall events from two rain gages on the north side of Grand Lake St Marys.

Celina Gage	Jul-03	Jan-05
Rainfall Duration (days)	5 (July 5-9)	12 (Jan 2-13)
Total Precipitation (in)	11.03	7.28
Approximate Frequency	> 1000 yrs	25 yrs
St. Marys Gage	**Jul-03**	**Jan-05**
Rainfall Duration (days)	5 (July 5-9)	12 (Jan 3-14)
Total Precipitation (in)	6.43	7.1
Approximate Frequency	60 yrs	25 yrs

Figure 6. Location of two rain gages on the north side of Grand Lake St. Marys, Ohio. Background imagery courtesy of Bing Maps.

3.3 Location Specific Surface Water Features

The information contained in this section is meant to present and interpret the readily available information for this location as it pertains to surface water conditions and any aspects that may influence the behavior of surface water. Grand Lake St. Marys was constructed to provide water to the Miami and Erie Canal (ODNR, 2011). The lake's primary outfall structure is a U-shaped fixed weir at the west end of the lake that allows lake water to flow the majority of the time into Beaver Creek, which then flows into the Wabash River approximately 10 miles (16 km) downstream of Grand Lake St. Marys. The exact dimensions of the U-shaped weir were not available, but based upon visual inspection, the overall height of the weir is 15-20 feet (4-6 meters) above the channel of Beaver Creek.

The topography of the west end of the lake and Beaver Creek was examined to see what barrier the slope of the land itself might offer to the spread of ANS between the basins. An aerial photograph of the headwaters of Beaver Creek at Grand Lake St Mary, along with a profile and cross section of Beaver Creek based on the best available Geographic Information System (GIS) data, is presented in Figure 7. The profile of Beaver Creek shows the lake at an approximate elevation of 870 feet above sea level, and the bottom of the spillway into Beaver Creek at an approximate elevation of 852 feet above sea level. This profile shows that the creek elevation at approximately 850 feet above sea level for the first 1,500 to 2,000 feet (457-610 m) downstream of the spillway, reflecting a very flat gradient in this stream. The two blips in the Beaver Creek profile line about 1,000 feet (305 m) downstream of the spillway reflect the elevation of road crossings and not the creek itself. An aerial photograph depicting the west end of Grand Lake, the U-shaped weir, and Beaver Creek is shown in Figure 8.

For this pathway, the elevations in Figure 7 and Figure 9 are based on the USGS 10m Digital Elevation Model (DEM) with a vertical accuracy of +/- 1 foot (30 cm). It should be pointed out that the absolute vertical accuracy (specific elevation) is not as important as the relative, or point-to-point, vertical accuracy (terrain) when evaluating terrain at this pathway to try and predict hydrology. Point-to-point accuracy is much more important to understanding local surface water hydrology than the absolute elevation. Accordingly, although the absolute elevation values may be slightly off from the true value (e.g., 600 feet (183 m) above sea level), they tend to be off a comparable amount at adjacent points so that the terrain of the area is actually depicted with relative accuracy. The grid size used to create the DEM can also affect the accuracy of the DEM. The larger the grid cell size (10 m cells vs. 30 m cells), the less detailed the terrain appears and therefore the less accurately the DEM depicts the actual terrain. The largest grid size used at any of the pathway locations is 10 m cells with some areas having more detailed information. Even though the 10 m cell size does not depict every hummock or hollow in the terrain, it does provide sufficient detail regarding general terrain and relative elevations.

The lake has a secondary outlet at the east end of the lake which supplies water to the remaining segment of the Miami and Erie Canal that discharges to the St. Marys River which is part of the Great Lakes Basin. Flow from the lake is controlled by two sluice gates, one 4 foot x 5 foot (1.2 m x 1.5 m) and the other 4 foot x 4 foot. Typically, only one gate is opened at a time with an opening height of approximately 1-2 inches (2.5-5 cm). During flood events, the sluice gates are closed (S. Dorsten-ODNR, personal communication, June 16, 2011). The flushing of debris is occasionally required from these gates during which a gate is then open 12-15 inches (30-38 cm) for approximately 10-15 minutes. There is also a fish hatchery on the east end of the lake that occasionally pulls water from the lake by way of two additional gates (size and type is unknown). The discharge from the hatchery is into the St. Marys River. It was stated that due to low water quality in the lake, the fish hatchery will start using groundwater as its primary water source in the very near future and will discontinue or reduce the use of water from Grand Lake St. Marys (S. Dorsten-ODNR, personal communication, June 16, 2011).

An aerial photograph of the headwaters of the Miami and Erie Canal at Grand Lake St. Mary, along with a profile and cross section of the canal, is presented in Figure 9. The profile shows the canal elevation at approximately 863 feet above sea level, approximately seven feet (2

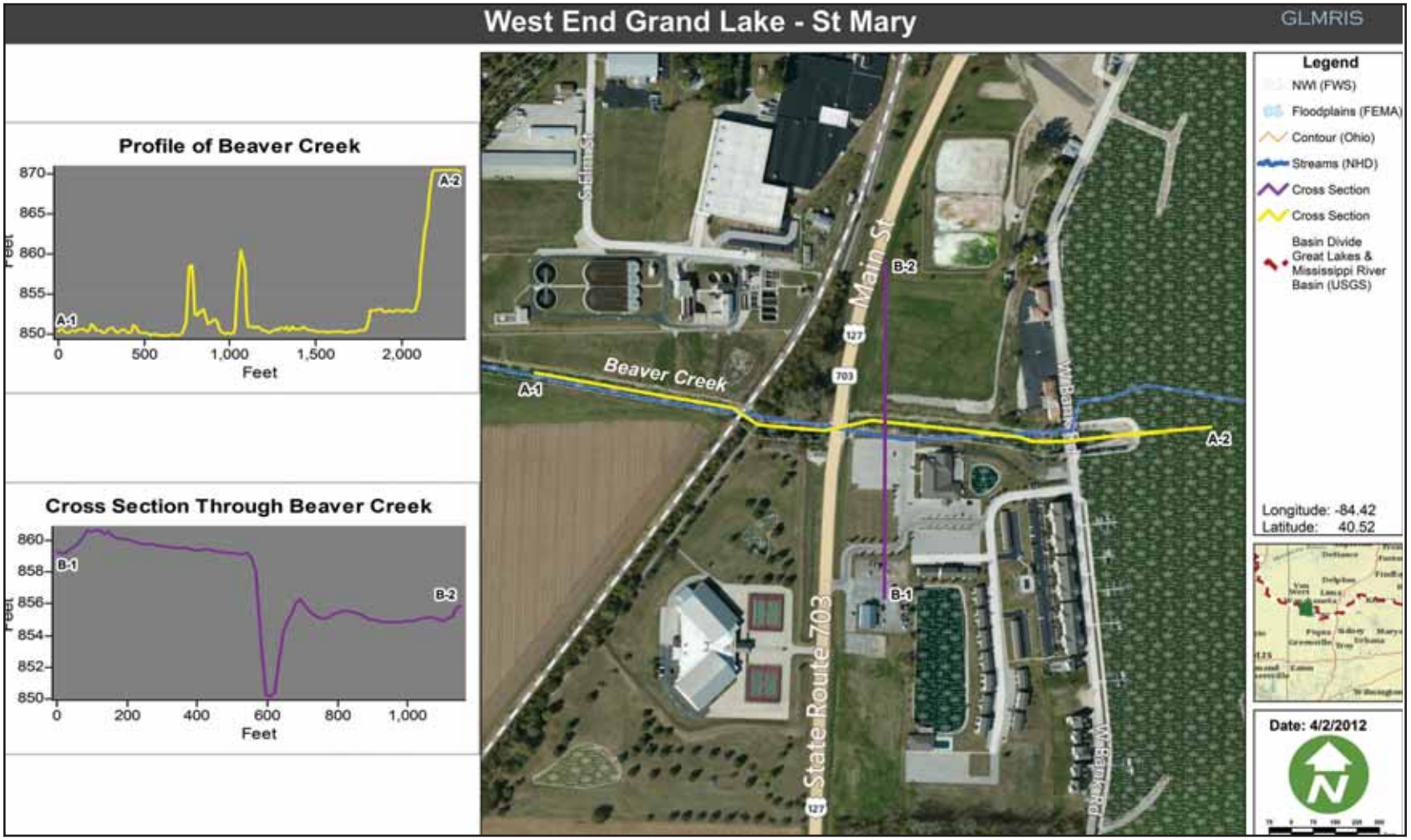


Figure 7. Plan view of west end of Grand Lake St. Marys showing U-shaped weir and outflow to Beaver Creek, based on two foot (61 cm) contours with a vertical accuracy of +/- 1 foot (30 cm). The yellow line and graph at the top left is the profile of the west end of the lake and Beaver Creek, and the purple line is a cross section through Beaver Creek showing stream channel and relative elevation of surrounding uplands. Note significant vertical elevation rise from the bed of Beaver Creek to the top of the weir. Background imagery courtesy of Bing Maps.

Figure 8. Aerial image of the west end of Grand Lake St. Marys showing horseshoe shaped outlet structure to Beaver Creek. The horseshoe weir was reconstructed in 1997 and since then the Lake Drain Outlet Structure shown on the figure is no longer used for normal regulation of lake levels. Background imagery courtesy of Bing Maps and inset photograph from USACE.

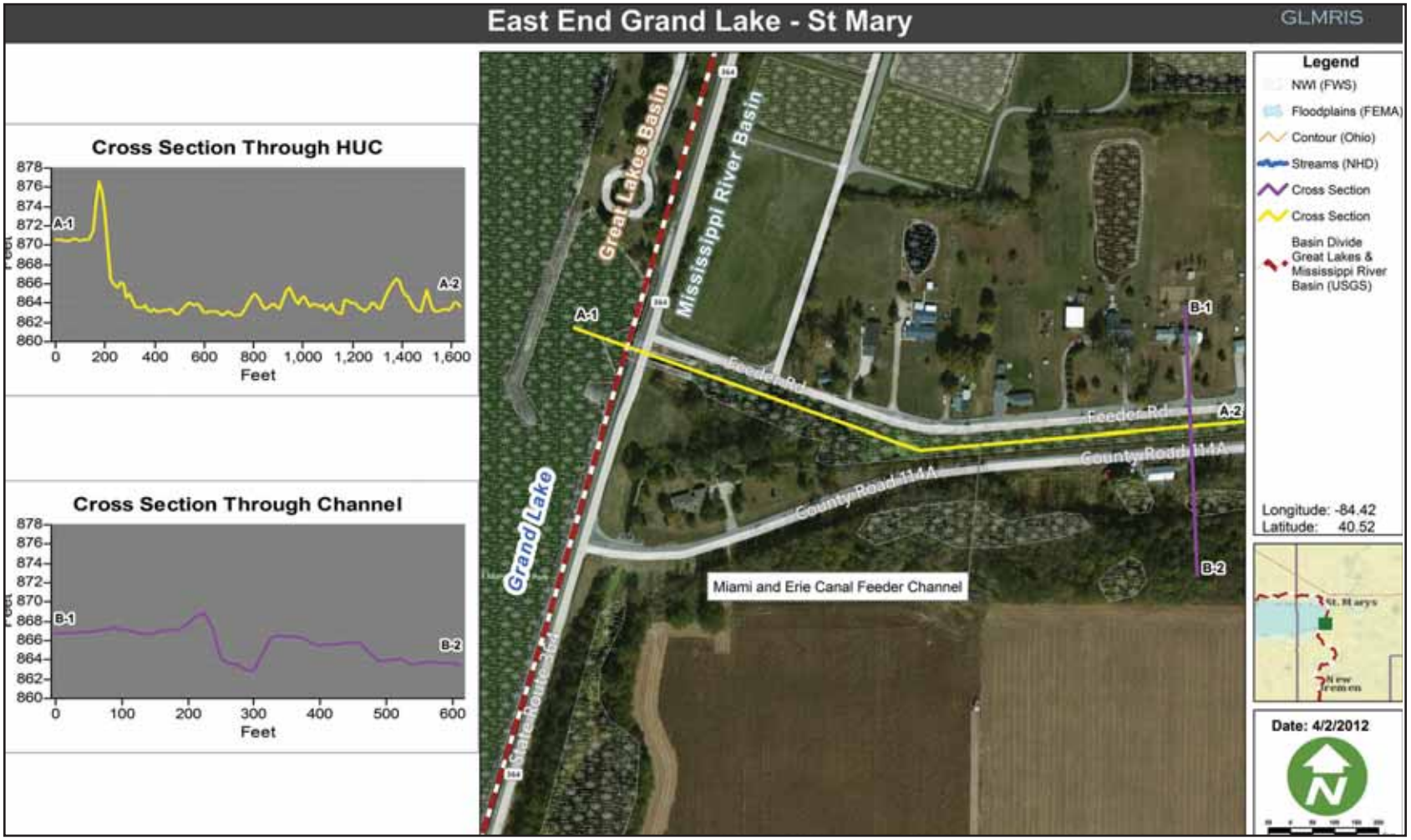


Figure 9. Plan view of east end of Grand Lake St. Marys showing secondary lake outlet and outflow to the Miami and Erie Canal Feeder Channel, based on two foot (61 cm) contours with a vertical accuracy of +/- 1 foot (30 cm). The yellow line and graph at the top left is the profile of the east end of the lake and of the feeder channel, and the purple line is a cross section through the feeder channel showing the channel dimensions and relative elevation of surrounding uplands. Background imagery courtesy of Bing Maps.

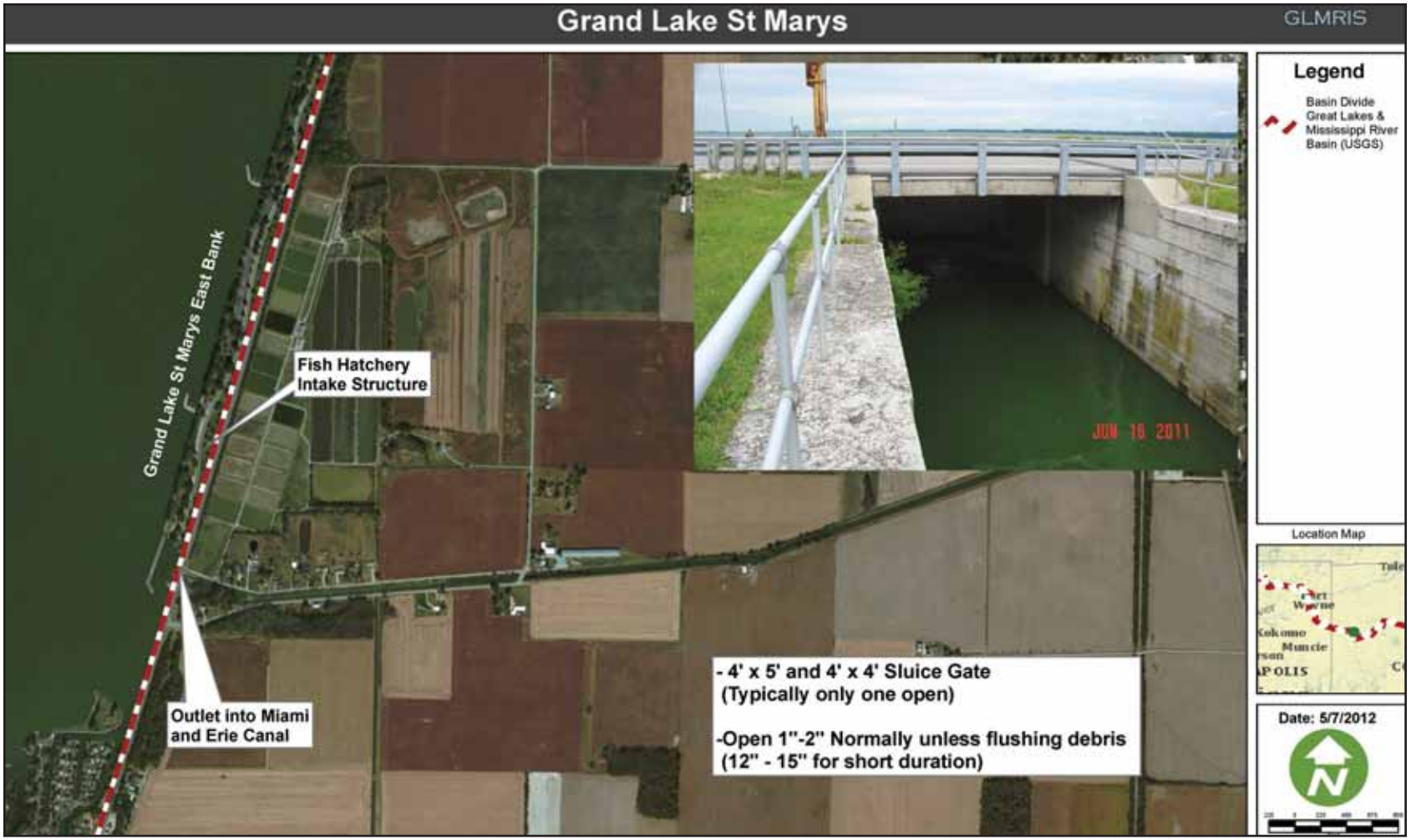


Figure 10. Aerial image of the east end of Grand Lake St. Marys showing outlet structure to Miami and Erie Canal Feeder Channel. Background imagery courtesy of Bing Maps and inset photograph from USACE.

meters) below lake level. According to ODNR personnel, normal water surface fluctuations in the canal can be up to 30 inches (76 cm) during extreme events (S. Dorsten-ODNR, personal communication, June 16, 2011 and July 27, 2012). An aerial photograph showing the east end of Grand Lake St. Marys and the receiving concrete sluice to the Miami and Erie Canal feeder channel is shown in Figure 10. The critical elements to understand about the hydrology of this lake as it relates to this study are as follows: (1) there are only two surface water outflows from the lake and no surface water inflows to the lake other than several small inlets originating from within the Grand Lake St. Marys watershed (south side of lake) and that are isolated from the Great Lakes and Mississippi River Basins, (2) there is a 15-20 foot (4-6 m) vertical elevation change over only a few hundred feet (90 m) out the western spillway, and (3) there is an approximately seven foot (two meter) vertical elevation change over about 75 feet (23 m) out of the eastern sluice gates.

3.4 Groundwater

Although of minimal relevance for the Grand Lake St. Marys aquatic pathway, a groundwater section is included in this report to provide a more complete understanding of the area's hydrology, as groundwater can sometimes be a source of base flow for streams. Water levels in aquifers normally fluctuate seasonally in response to variations in groundwater recharge and discharge. Groundwater levels commonly rise in spring, when areal recharge is greatest due to 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, might result in higher volumes of surface water.

The state of Ohio has a network of observation wells for monitoring groundwater. In 2011, there were two active wells and two inactive wells in Auglaize County, and one active and one inactive well in Mercer County (ODNR, 2011e). The three wells closest to the potential aquatic pathway site are listed in Table 8.

Before readings were discontinued in 1972, gage AU-2 recorded ground water levels ranging from 10 feet (3 m) below the land surface to two feet (0.6 m) below ground level. This is the nearest gage to Grand Lake St. Marys, but no data has been recorded at this location for nearly 40 years. Gage AU-4's period of record (approximately five years) shows a range of groundwater levels spanning from 45 feet (14 m) to 56 feet (17 m) below the land surface. The largest draw-downs occur in summer and early fall, and the groundwater levels are replenished in the winter and spring. Over the course of the nearly 45 years of water level readings for gage MR-2, the groundwater levels have fluctuated from 60 feet (18 m) below ground surface to 81 feet (24.5 m) below the land surface. Over the last decade, readings have typically been between 70 and 75 feet (21-23 m) below the land surface (ODNR, 2011e). As a result of its depth, groundwater likely has a negligible influence on the formation of the aquatic pathway at Grand Lake St. Marys, which is primarily driven by lake levels and direct precipitation.

Table 8. Groundwater Wells near Grand Lake St. Marys, Ohio (ODNR, 2011e).

County/Well	Latitude & Longitude	Period of Record	Principal Drainage Basin
Auglaize (AU-2)	N 40° 33' 42" W 84° 23' 26"	6/24/1946 – 3/7/1972	St. Marys River
Auglaize (AU-4)	N 40° 24' 28" W 84° 22' 34"	6/26/2006 - present	Auglaize River
Mercer (MR-2)	N 40° 28' 33" W 84° 37' 52"	2/14/1967 - present	Wabash River

3.5 Aquatic Pathway Temporal Characteristics

Characterizing the temporal variability of the site's hydrology is an important aspect of understanding the likelihood of an ANS being able to traverse the basin divide as certain flood events may coincide with species movement, reproductive patterns, and abilities to survive and establish populations in various areas. The only temporal attribute of note for this site is that the area is periodically subjected to freezing temperatures on an annual basis.

According to ODNR representatives that operate the lake, the State Road 127 bridge over Beaver Creek downstream of the western spillway has been overtopped by one to two inches (2.5-5 cm) of water from extreme storm events. As can be seen by the profile line of Beaver Creek at this bridge in Figure 6, the lake level of Grand Lake St. Marys is still about ten feet (3 m) higher than the elevation of the bridge, indicating that there is little to no potential for backflow from the creek into the lake. This is further supported by the Mercer County Flood Insurance Study (FIS) which indicates that for the one percent annual recurrence interval event there is an 11-foot (3.3 m) water surface elevation difference across the fixed weir, with a flow depth of two feet (61 cm) across the top of the weir (FEMA, 2001). No data was available to correlate the frequency of flooding on the Miami and Erie Canal Feeder Channel side to the threat of backwater flooding into Grand Lake St. Marys, but this too appears unlikely due to the vertical elevation difference between the lake and canal. During flood events the sluice gates are completely shut, making it even more unlikely any type of aquatic pathway is formed during large storm events. Any potential threat of back flooding from the canal appears to rely completely on the closure of the sluice gates during flood events. Significant recent flooding has occurred in 2003, 2005, 2008, and 2011 (Table 7). Evidence of the February 2008 flooding at State Road 127 was captured in a video posted on the internet and a clip from that video is shown in Figure 11. The weir is visible in the background as significantly higher than the downstream water surface.

3.6 Probability Aquatic Pathway Exists

The rating discussed in this section is only for the likelihood of an aquatic connection existing at this potential pathway (P_0) at up to a one percent annual recurrence interval storm. A surface water connection does exist between the Great Lakes and Mississippi River Basins at the Grand Lake St. Marys location, based on the following:

- There are only two surface water outflows from the lake and minimal surface water inflows to the lake from several small inlets originating within the Grand Lake St. Marys Watershed and that are isolated from the Great Lakes Mississippi River Basins;
- Grand Lake St. Marys is a lake that is perched between the Great Lakes Basin and the Mississippi River Basin, with water flowing in both directions;
- There is perennial surface water outflow from the lake through the western spillway into the Mississippi River Basin (via Beaver Creek) and through the eastern sluice gates into the Great Lakes Basin (via the Miami and Erie Canal Feeder Channel);
- Flow from either Beaver Creek or the Miami and Erie Canal Feeder Channel into the lake is highly unlikely.

Due to the above evidence, the probability of a pathway existing between the Great Lakes and Mississippi River Basins at Grand Lake St. Marys is rated as high in both directions since it meets the criteria of a perennial or intermittent stream (in this case the lake via the two outflows) that is capable of conveying significant volumes of water across the basin divide continuously for days to weeks, multiple times per year (Appendix A).

The ratings for flow into both basins are considered very certain because of the following:

- There is perennial outflow from the lake into either basin;

Figure 11. Flooding in 2008 at State Road 127 on Beaver Creek, downstream of U-weir on Grand Lake St. Marys; accessed from internet on March 15, 2012.

- Due to vertical elevation differences between the receiving streams and the water level in the lake, there is minimal to no likelihood of backflow into Grand Lake St. Marys, although further study of the likelihood of backwater flooding from the Canal into the lake (east end) would further reduce the uncertainty with this rating;

- Only a partial record exists of how water levels change in the lake and receiving streams during flood events;

- Representatives from ODNR were available to provide reliable and relevant data and observations to reduce any uncertainties with this rating.

3.7 Aquatic Pathway Habitat

3.7.1 Terrestrial and Riparian Plants and Land Use

The combined Grand Lake St. Marys and Beaver Creek watershed drains 171 square miles (443 square kilometers). An estimated 25,000 citizens reside in the Grand Lake St. Marys and Beaver Creek Watershed year round, with nearly 11,500 people living in the city of Celina, which draws drinking water from the lake. The population expands in the summer months with vacationers at the state park and various religious and youth camps in the area (OEPA, 2007).

The land use in the Beaver Creek and Grand Lake St. Marys Watershed is 80.5 percent row crop and pasture land, 12 percent wetlands or open water, four percent forested, and three percent urban/residential. According to agricultural statistics, there are 295,400 “animal units” of hogs, poultry, and cows in the watershed (OEPA, 2007). Recreational opportunities abound in the watershed with camping, fishing, boating, and hunting on or in the vicinity of Grand Lake St. Marys. There are two bike paths and several religious historical sites on the south side of the lake.

Two endangered terrestrial species have been known to occur near Grand Lake St. Marys: the Indiana bat (*Myotis sodalis*), a Federally-listed endangered species, and the eastern massasauga rattlesnake (*Sistrurus catenatus*). The snake is currently also listed as endangered by the state of Ohio.

3.7.2 Aquatic Resources

Comprehensive biological, chemical, and physical data were collected from Grand Lake St. Marys and Beaver Creek Watersheds by the Ohio Environmental Protection Agency (OEPA) in 1999. Additional water chemistry data were collected in 2005-2006 at select locations and at varying steam flows during the winter and spring to support load reduction models (OEPA, 2007). The OEPA study of 22 sites on 11 small streams in the watershed showed that it ranks in the ten most impaired watersheds in Ohio. None of the streams met the goals associated with healthy warm water habitat streams. Many small streams that drain to the lake, as well as Beaver Creek downstream of the lake, are impaired because of physical changes to the land.

In the Beaver Creek-Grand Lake St. Marys Watershed, degraded stream habitat is primarily the result of channelization and ongoing maintenance activities carried out to improve water conveyance. Nearly all stream channels have been modified and an extensive subsurface tile drainage network has been installed for agriculture. Stream banks are often engineered and channel dredging is routinely performed (OEPA, 2007). In agricultural areas, practices specifically designed to increase drainage efficiency, such as subsurface drainage and channelization, increase peak flows during storm events. Efficient drainage also results in low flow conditions that are more extreme and occur more frequently, which can also adversely affect water quality. Such hydrologic alterations diminish the capacity of the system to assimilate pollutants and support diverse aquatic communities. Most channelization is found on the small to medium-sized Grand Lake St. Marys tributaries, but also along some parts of the main stem of Beaver Creek. Natural stream habitats are essentially absent in the watershed (OEPA, 2007). Loss of floodplains and streamside vegetation has also degraded the creeks and lake. When trees along the stream banks are removed, the lack of shade allows the

water temperature to increase substantially, which then decreases the amount of dissolved oxygen available for aquatic organisms. This is worsened by inputs of manure and untreated sewage flowing from failing home septic systems and small communities without any wastewater collection or treatment (OEPA, 2007).

Grand Lake St. Marys is heavily used for recreational boating, with eight state-operated boat launches and several private boat launches (ODNR, 2011). It has a mean depth of three to five feet (1-1.5 m) and is subjected to a strong prevailing wind. These factors produce a great amount of wave action that contributes to shoreline erosion. This erosion results in a loss of riparian vegetation, which could otherwise act as a filter to water draining into the lake. Wave action is also responsible for stirring up nutrient rich sediments and keeping them suspended in the water column, and encouraging more algal growth (OEPA, 2007).

The following describes the aquatic resources within the connecting waterways between Grand Lake St. Marys and Lake Erie:

Miami and Erie Canal Feeder Channel ► Miami and Erie Canal ► St. Marys River ► Maumee River ► Lake Erie.

Miami and Erie Canal

The man-made Miami and Erie Canal was completed in 1845. The “Deep Cut” part of the Miami and Erie Canal is 6,600 feet (2,011 m) in length, and ranged from five to 52 feet (2-16 m) deep (Benington, 2009). Aquatic habitat within the canal is poor, but it does support some fish species and could aid in ANS spread.

Auglaize River

The primary causes of water quality impairment in the Upper Auglaize River watershed are habitat degradation (including flow alteration and sedimentation), organic enrichment, excessive nutrients, and elevated bacteria levels. The Upper Auglaize River watershed is intensely agricultural, with approximately 89 percent of the land used for cropland and pasture. The remaining land use is about eight percent forest, 2.2 percent urban (residential and commercial/industrial), and less than one percent wetlands and open water (OEPA, 2004).

St. Marys River

The St. Marys river also suffers from many of the same problems seen in the Auglaize River watershed. Increased sediment and nutrient loading due to intensely agricultural land use has degraded overall water quality and decreased the abundances of sensitive aquatic organisms.

Maumee River

The Maumee River is connected with the St. Josephs River which has good water quality, and the St. Marys River which has degraded water quality (INDNR, 1996). The Maumee River flows through several major cities including Toledo Ohio, Defiance Ohio, and Fort Wayne, Indiana. Typical river habitat types are present throughout the course of the Maumee River. Habitats present vary from deep pools to backwater eddies and shallow riffles. Water quality within the Maumee tends to become more degraded as it approaches Lake Erie. The OEPA has issued fish consumption advisories from the Indiana state line downstream to Waterville, Ohio and from Waterville to the mouth of the Maumee River at Lake Erie. Both advisories include warnings on common carp (*Cyprinus carpio*) consumption (OEPA, 2011). The stretch of the Maumee River from the Ohio state line to Defiance, Ohio is considered a state scenic river (ODNR, 2011a). Despite water pollution, this stretch of the river generally provides quality habitat for a variety of fish species. The Maumee River also supports a diverse fishery. It is known mostly for the exceptional numbers of walleye that run up the river to spawn around early spring each year (ODNR, 2011b). White bass also demonstrate a large spawning run up the river. In addition, smallmouth bass, multiple sunfish species, channel catfish, and flathead catfish are among the most abundant predatory species. The Maumee River also has a diverse freshwater mussel population.

Lake Erie

Lake Erie is one of the largest lakes in the world by surface area. Despite its large size, it is shallower than the other Great Lakes and is also the warmest, most biologically productive of the Great Lakes. Due to the high productivity of Lake Erie, it supports a healthy

fishery (ODNR, 2011c). The Maumee River empties into the western basin of Lake Erie at Toledo. This western basin has an average depth of only 24 feet (7.3 meters) (ODNR, 2011c). Lake St. Clair is located to the north and upstream of the western basin of Lake Erie, connected by the Detroit River. Lake St. Clair is also highly productive biologically.

The following describes the aquatic resources of the connecting waterways between Grand Lake St. Marys and the Mississippi River:

Beaver Creek ► Wabash River ► Ohio River ► Mississippi River

Beaver Creek

Beaver Creek was ranked as one of the ten most impaired streams in Ohio (OEPA, 2007). Physical changes to the land within the Grand Lake St. Marys and Beaver Creek Watersheds have greatly diminished aquatic habitat quality. Increased run-off and channelization have also limited the diversity and quality of the natural flora and fauna of the creek.

Wabash River

The Wabash River supports a diverse fishery. Fish species range from small darters to large paddlefish. Sport species present include blue catfish (*Ictalurus furcatus*), channel catfish (*Pylodictus olivaris*), flathead catfish (*Ictalurus punctatus*), white bass (*Morone chrysops*), striped bass (*Morone saxatilis*), hybrid striped bass (*Morone saxatilis* x *M. chrysops*), smallmouth bass (*Micropterus dolomeiu*), spotted bass (*Micropterus punctatus*), largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), freshwater drum (*Aplodinotus grunniens*), and sauger (*Sander canadensis*). Fish species that typically make up the forage base include spotfin shiner (*Cyprinella spiloptera*), emerald shiner (*Notropis atherinoides*), gizzard shad (*Dorosoma cepedianum*), bullhead minnow (*Pimephales vigilax*) (Pyron and Lauer 2004). Common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), bighead carp (*Hypophthalmichthys nobilis*), and silver carp (*Hypophthalmichthys molitrix*) are also present. Historically, the Wabash River has supported 27 state threatened or state endangered mussel species, including eight which are Federally endangered. Mussel populations are greatly reduced in numbers of individuals and species in the Wabash River. Cummings, et al. (1992) reported 62 species of mussels in the Wabash River, but of those 25 were represented by dead specimens only. Water quality within the Wabash River is often impacted by increased levels of nitrates and total dissolved solid loads (McFall et al., 2000).

Ohio and Mississippi Rivers

The Mississippi River and its major eastern tributary, the Ohio River, contain similar large-river habitat types. These include, but are not limited to, large open water, deep pools, long reaches, slow-moving impounded areas, channels, backwaters, and vast floodplains. Both rivers offer abundant habitat for a myriad of aquatic organisms.

3.7.3 Water Quality

There is no data regarding the volume or velocity of water exiting the lake from either the west or east outlet structures. The elevation between the west outlet structure and the channel of Beaver Creek is 15-20 feet (4-6 m), while the elevation difference between the east outlet gates and the feeder canal is approximately seven feet (2 m). By the time the water exits the lake it has been exposed to agriculture chemicals and livestock operations within the watershed that are responsible for heavy nutrient loading (OEPA, 2007). These excessive nutrient inputs to the lake have promoted the growth of algae that contributes to a high level of organic material and a resultant high biological oxygen demand. This condition can be further exacerbated under high temperature and low flow conditions that can occur in the watershed during the summer months. In addition, the city of Celina is currently under orders to reduce total trihalomethane levels in their finished water. Total trihalomethanes are chemical by-products created when chlorine is added for disinfection when it reacts with organic material (OEPA, 2007).

Ohio EPA has identified three known toxins in Grand Lake St. Marys: microsystin, cylindrospermopsin,

and saxitoxin. Each of these is a result of biological processes in blue-green algae, a cyanobacteria that forms as algal blooms occur in water conditions like those occurring in Grand Lake St. Marys. These are caused in part by a combination of elevated phosphorus levels from nutrient runoff (OEPA, 2007).

3.7.4 Aquatic Organisms

Popular game fish in Grand Lake St. Marys include channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), white crappie (*Poxomis annularis*), and several sunfish (*Lepomis* spp.). The ODNR reports a fair number of catfish, crappie, and sunfish, and poor numbers (but large size) of largemouth bass (ODNR, 2011d).

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 Grand Lake St. Marys location in accordance with the procedures outlined in the Methodology Section of this report. The following subsections present the results of the biological evaluation of the likelihood of an viable aquatic pathway existing at Grand Lake St. Marys that would enable ANS spreading between the Great Lakes and Mississippi River Basins. This potential was characterized as high, medium or low for the following categories:

- Probability that pathway exists (Section 3)
- Probability of the target ANS occurring within either basin
- Probability target ANS survive transit to reach aquatic pathway
- Probability of ANS establishment in proximity to 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.

Just as important as the subjective estimates of probability are the remarks that summarize the key data that supports the estimates, which were made by an interagency team of biologists for each ANS of concern to the Grand Lake St. Marys location. The completed forms, which include the probability and certainty ratings and the remarks from all agency professionals participating in this assessment, are included in 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. Both silver carp and bighead carp have been recorded in significant numbers in the Illinois River (USGS, 2011). Black carp may be established in portions of the lower Mississippi River Basin. The known distribution of black carp is not as extensive as that of the silver and bighead carp (USGS, 2011).

Team Rating: **Medium**
Certainty rating: Very Certain

Northern Snakehead

The northern snakehead was found in 2008 in Arkansas, and has since established a reproducing population in the area. This population is within the Mississippi River Basin and represents a population that could spread throughout the basin. Although in a different basin, this species is also established in the Potomac River in Maryland and Virginia (USGS, 2011). While this species is within the Mississippi River Watershed, its population here does not seem to be spreading at a high rate at this time and it is unlikely that it would reach the Grand Lake St. Marys divide location within the next 20 years without the assistance of some non-aquatic vector.

Team Rating: **Medium**
Certainty rating: Moderately Certain

Parasitic Copepod

The parasitic copepod has a life cycle in which the female adopts a parasitic phase on several fish species, including members of the minnow family, sunfish family, catfish family, and potentially other fish species. The common carp is a frequent host of the parasite (Hudson and Bowen, 2002). The females can detach and re-attach to host species. The invasive copepod has been detected in Lake Huron and Lake Erie, and is likely found throughout the Great Lakes. The common carp is established in Lake Michigan, as well as the rivers and streams leading to Grand Lake St. Marys from the Great Lakes. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp, and the likelihood the common carp would use and survive in the pathway habitats. The invasive copepod species and a necessary host species are in the Great Lakes Basin. The males are free living but do not have the capability of moving upstream. The literature indicates that the copepod is small and relatively easy to miss in field surveys, even by trained biologists. Therefore, the parasitic copepod may be much more prevalent than the distribution maps depict.

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

Viral Hemorrhagic Septicemia Virus

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. 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 (USGS, 2011). Viral hemorrhagic septicemia virus has been found in many species of fish including common carp. The common carp is established in the Great Lakes, as well as the rivers and streams leading to Grand Lake St. Marys from the Great Lakes. While other host fish species are known to exist in connecting streams, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp and the likelihood the common carp would use and survive in the pathway habitats. The virus and a necessary host species are in the pathway. It should also be noted that VHSv has been found in 28 different host fish species in the Great Lakes Basin and that it can survive without a host in the water column (WDNR, 2012).

Team Rating: **Medium**
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. The 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 ruffe has extended its range rapidly and modeling predicts it will find suitable habitat in all five Great Lakes (USGS, 2012). Literature reviews and actual fish survey data have not documented the collection of the ruffe in smaller upstream tributaries.

The tubenose goby's introduced range includes Lake St. Clair, Erie, Huron, Superior, and Ontario and is a benthic species that consumes a wide variety of invertebrates (USGS, 2011). They are found in the open waters and estuaries of slow flowing rivers and are often quite abundant in backwaters and lakes, and seem to prefer dense vegetation. It has been collected in the lower reaches of larger Great Lakes rivers and estuaries, 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 now located within both the Great Lakes Basin and the Mississippi River Basin. The tubenose goby's nearest locations are in Lake Superior and Lake Huron (USGS, 2011).

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

Threespine Stickleback

The threespine stickleback is found in each of the Great Lakes except Lake Ontario (Lake Ontario HUC 8 records are within native range) and has been collected in some inland river systems (USGS, 2011). This species prefers to live in smaller streams but may occur in a variety of habitat including lakes and large rivers. The threespine stickleback was first encountered in lower Green Bay about 25 years ago, but has never been seen upstream from this area. Great Lakes populations of this species tend to be potamodromous (truly migratory but within fresh water only) and only enter the lower reaches of streams briefly during spring spawning.

Team Rating: **Medium**
Certainty rating: Moderately Certain

4.2 Probability ANS surviving transit to aquatic pathway

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

High - Target ANS are established in relatively close proximity to 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 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.

Asian Carp

Spawning and the subsequent movement of silver and bighead carp is initiated by rising water levels following heavy rains (Jennings, 1988; Verigin, 1978). Both species are strong swimmers and silver carp are capable of jumping considerable distances out of the water [up to 12 feet (3.6 m)]. Despite such capabilities, it is unlikely that Asian carp will be able to progress any further upstream in the Mississippi River Basin than the Roush Dam located on the Wabash River near Huntington, Indiana, and downstream of where Beaver Creek enters the Wabash River. The distance from Roush Dam, to Grand lake St. Marys is approximately 100 stream miles (161 km). Roush Dam is a 90-foot (27 m) tall flood control dam with no fish passage structure making it a complete barrier to fish passage (ODNR, personal communication, July 26, 2010). While both species are highly opportunistic, bighead carp are primarily zooplanktivorous, whereas silver carp primarily consume smaller phytoplankton and fine particulate organic matter (Jirasek et al., 1981; Dong and Li, 1994; Williamson and Garvey, 2005). Sufficient forage is available throughout the Wabash River for both silver and bighead carp.

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).

Juvenile, sexually immature Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers (e.g., dams) to continue their upstream movement (D. Chapman-USGS, personal communication, September 12, 2011; N. Caswell-USFWS, personal communication, September 12, 2011). 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-USGS, 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.

The Indiana Department of Natural Resources is monitoring Asian carp in the Wabash River, downstream of the Beaver Creek, and the Miami and Erie Canal. An Asian carp spawn in the Wabash River was reported in late May 2011. Very few eggs were found in Peru, Indiana, which is approximately 40 miles (64 km) downstream of the J. Edward Roush Dam, located near Huntington, Indiana. The eggs were also very young (few embryonic cell divisions had taken place). Substantial numbers of eggs were found in Logansport and Lafayette, Indiana (Doug Keller, INDNR, personal communication, August 16, 2011). The species identity of the eggs were DNA verified. Contrary to previous observations of conditions that may initiate spawning, spawning events have been documented on the Wabash River without any accompanying rise and fall in the hydrograph (Dr. Reuben Goforth, Purdue University, personal communication, June 18, 2012). The INDNR has also funded Purdue University to conduct a two year ultrasonic telemetry study on Asian carp movement. One hundred silver carp were collected, tagged, and re-released in the Wabash River, and attempts were made to collect fish for tagging as far upstream as possible. Only a few individuals were collected in or above Peru, Indiana due to low densities. Monitoring stations are in place along the Wabash River and Little River to monitor the carp movements. To date, no tagged fish have been detected in the Little River in Indiana, and only one tagged fish has been detected in the Wabash River near the mouth of Little River (Doug Keller, INDNR, personal communication, August 16, 2011).

In summary, there are many uncertainties one must take into account when attempting to predict the temporal and spatial movements of Asian carp. While

on-going research by INDNR and Purdue University may suggest that tagged Asian carp have no interest in spreading into small ditches and streams from more suitable areas, more long term studies are needed, and even these may not help explain the seemingly random movements of young Asian carp that have been witnessed in Midwestern rivers and their tributaries (D. Chapman-USGS, personal communication, September 12, 2011; D. Keller-INDNR, personal communication, August 16, 2011).

In summary, there are many uncertainties one must take into account when attempting to predict the temporal and spatial movements of Asian carp. While on-going research by INDNR and Purdue University may suggest tagged Asian carp have no interest in spreading into small ditches and streams from more suitable areas, more long term studies are needed, and even these may not help explain the seemingly random movements of young Asian carp that have been witnessed in midwestern rivers and their tributaries (Coulter and Goforth, 2012; D. Chapman-USGS, personal communication, September 12, 2011; D. Keller-INDNR, personal communication, August 16, 2011).

There is a definite hydrologic connection that occurs at Grand Lake St. Marys between the Great Lakes and Mississippi River Basins. However, the ability of Asian carp to arrive at Grand Lake St. Marys was given a rating of low for two main reasons: (1) the obstruction presented by Roush Dam on the Wabash River, and (2) the U-shaped weir control structure at Grand Lake St. Marys would prevent Asian carp from entering the lake via Beaver Creek.

Team Rating: **Low**
Certainty rating: Very Certain

Northern Snakehead

The northern snakehead utilizes specialized structures (suprabranchial organ and a bifurcate ventral aorta) that permits aquatic and aerial respiration (Ishimatsu and Itazaw 1981, Graham 1997). This species thrives in stagnant, oxygen depleted backwaters and marshes (Courtenay, Jr. and Williams, 2004). Beaver Creek connects the Wabash River to Grand Lake St. Marys and is located upstream of Roush Dam near Huntington, Indiana. The Roush Dam is a 90-foot (27 m) tall flood control dam that has no fish passage structure making it a complete barrier to fish passage (ODNR, personal communication, July 26, 2010). In addition, the obstruction of a U-shaped weir control structure at Grand Lake St. Marys would also prevent northern snakehead from entering the lake. Therefore, there is a low probability that northern snakehead would be able to find their way into Grand Lake St. Marys solely through the aquatic pathway.

Team Rating: **Low**
Certainty rating: Very Certain

Parasitic Copepod

The parasitic copepod has been found on the common carp, Therefore, common carp was used as a surrogate potential host species to estimate the probability of the parasitic copepod moving from its current location in the Great Lakes Basin to the Grand Lake St. Marys pathway location. During spring runoff events typically in April and May, common carp move into the shallow waters of bays and river systems to spawn. Within the rivers, common carp move upstream to spawn in suitable habitat such as marshes and sometimes drainage ditches with as little as a one foot or less (<30 cm) of water depth. Common carp are strong swimmers and are capable of moving upstream during moderate flow events. The parasitic copepod has been found to infect common carp (USGS, 2011). The only obstructions for a host fish to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Great Lakes Basin. Since there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of approximately seven feet (2.1 m), and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Therefore, a rating of “low” was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

Viral Hemorrhagic Septicemia Virus

In addition to the parasitic copepod, common carp is also a potential host for VHSv (USGS, 2011). The common carp was therefore used as a surrogate potential host to

estimate the probability of VHSv moving from its current location in the Great Lakes Basin to the Grand Lake St. Marys pathway location (USGS, 2011). During spring run-off events in April and May, common carp move into the shallow waters of bays and river systems to spawn. Within the rivers, common carp move upstream to spawn in suitable habitat such as marshes and sometimes drainage ditches with as little as one foot or less (<30 cm) of water depth. Common carp are strong swimmers and are capable of upstream movement during moderate flow events.

The only obstructions for a host fish to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Great Lakes Basin. Since there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of about seven feet (2.1 m), and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Therefore, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

Ruffe and Tubenose Goby

The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel, 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). The ruffe has a high reproductive rate and spawns in clean water. The ruffe's ability to swim upstream during high flow events and move over dams is questionable, especially since it prefers still or slow moving water (Fishbase, 2011). 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 tubenose goby is found in the open waters and estuaries of slow flowing rivers. The tubenose goby appears to be more capable of living in more diverse types of riverine habitat than the ruffe (Dopazo et al. 2008; Jude and DeBoe, 1996). Sufficient forage ranging from zooplankton to fish may be available throughout the Great Lakes side of the connection. However, suitable habitat for the ruffe and tubenose goby in the Auglaize River, Miami and Erie Canal, and the St. Marys River may be limited or even nonexistent.

The only obstruction (other than habitat suitability) for these species to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Great Lakes Basin. Since there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of about seven feet (2.1 m), and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Therefore, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

Threespine Stickleback

The threespine stickleback has been found in the Great Lakes and in smaller river systems (USGS, 2011). There is a definite hydrologic connection that occurs between basins at Grand Lake St. Marys. The only obstruction for this fish to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Miami and Erie Canal Feeder Channel. Since there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of about seven feet (2.1 m), and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Therefore, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

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

This section does not influence the overall pathway rating outlined in this report and is only included to point out other potential pathways (e.g., anthropogenic) that may be important to different audiences. Any further analysis of 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 passage 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.

It is likely that most of the ANS of concern could become established in, and spread from, Grand Lake St. Marys if they were introduced from anthropogenic sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. One reason most invasive species are successful is the fact that they are able to survive and reproduce in a wide range of environmental conditions. The motivation for anthropogenic introductions range from accidental to intentional and malicious. Public education regarding the detrimental impacts of ANS and how to prevent their spread are likely the best tools to prevent anthropogenic transfer from occurring.

The aquatic pathway that exists at Grand Lake St. Marys is perched and periodically drains to both the Mississippi River Basin and the Great Lakes Basin. The natural spread of ANS through this aquatic pathway is prohibited by the Roush Dam on the Wabash River, and the two outlet structures from Grand Lake St. Marys into Beaver Creek or the Miami and Erie Canal Feeder Channel. However, if any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. It is outside the scope of this study to evaluate the probability associated with anthropogenic and non-aquatic vectors and pathways for ANS transfer between the two basins. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches (ODNR, 2011). It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

4.3 Probability of ANS Establishment in Proximity to 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 the target 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.

Team Rating: Species-specific ratings for this section were not completed because the ratings for the likelihood that any of the ANS of concern for Grand Lake St. Marys would be able to survive transit from their current known locations in either basin to the pathway were all low.

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.

Team Rating: Species-specific ratings for this section were not completed because the ratings for the likelihood that any of the ANS of concern for Grand Lake St. Marys would be able to survive transit from their current locations in either basin to the pathway were all low. In addition, it is not possible for any of the ANS to enter Grand Lake St. Marys by the aquatic pathway because of the two outlet structures from the lake.

Table 9. Summary of individual probability elements and overall pathway viability rating (Mississippi River Basin to Great Lakes Basin). Certainty ratings for each element are in parentheses.

			Form 1 (P_0)	Form 2 (P_1)	Form 3a (P_{2a})	Form 4 (P_{2b})	Form 5 (P_{2c})	$P_{Viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists? (Sect. 2.6)**	**ANS Occurring Within Either Basin? (Sect. 4.1)**	**ANS Surviving Transit to Pathway? (Sect. 4.2.1)**	**ANS Establishing in Proximity to Pathway? (Sect. 4.3)**	**ANS Spreading Across Aquatic Pathway into New Basin? (Sect. 4.4)**	**Aquatic Pathway Viability Rating**
fish	*Asian Carp, silver carp, bighead carp, black carp*	swimmer	H (VC)	M (VC)	L (VC)	*	*	L
fish	*northern snakehead*	swimmer		M (MC)	L (VC)	*	*	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 rating (Great Lakes Basin to Mississippi River Basin). Certainty ratings for each element are in parentheses.

			Form 1 (P_0)	Form 2 (P_1)	Form 3a (P_{2a})	Form 4 (P_{2b})	Form 5 (P_{2c})	$P_{Viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists? (Sect. 2.6)**	**ANS Occurring Within Either Basin? (Sect. 4.1)**	**ANS Surviving Transit to Pathway? (Sect. 4.2.1)**	**ANS Establishing in Proximity to Pathway? (Sect. 4.3)**	**ANS Spreading Across Aquatic Pathway into New Basin? (Sect. 4.4)**	**Aquatic Pathway Viability Rating**
fish	*threespine stickleback*	swimmer	H (VC)	M (MC)	L (VC)	*	*	L
fish	*Benthic fish* *ruffe and tubenose goby*	swimmer		M (RC)	L (VC)	*	*	L
crustacean	*parasitic copepod*	parasite		M (RC)	L (VC)	*	*	L
virus	*VHSv*	fish pathogen/ water column		M (RC)	L (VC)	*	*	L
Overall Pathway Viability for Spread of ANS from Great Lakes Basin to Mississippi River Basin:								**L**

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 Grand Lake St. Marys 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 Grand Lake St. Marys location, 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 Grand Lake St. Marys location, the overall pathway viability for transferring species from the Great Lakes Basin to the Mississippi River Basin is "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 Grand Lake St. Marys Pathway is "low".

6 Conclusions

Grand Lake St. Marys is a shallow lake perched at the divide between the Great Lakes and Mississippi River Basins. There are only two outflows from the lake and no inflows other than from direct precipitation and from a number of small tributary streams on the south side of the lake. The western outflow presents an impassible barrier for any ANS that might attempt to enter Grand Lake St. Marys from the Mississippi River Basin through Beaver Creek. There is an approximately 17 foot (5.1 m) vertical drop from the lake into Beaver Creek, a tributary to the Wabash River. Any ANS moving upstream in the Mississippi Basin would also encounter the Roush Dam on the Wabash River near Huntington, Indiana which also presents an impassible fish barrier. The eastern outflow also presents an impassible barrier for any ANS that might attempt to enter the lake from the Great Lakes Basin through the Miami and Erie Canal Feeder Channel. There is an approximately seven foot (2.1 m)

vertical drop from the lake into the Miami and Erie Canal Feeder Channel which is ultimately connected with the Maumee River and Lake Erie. Therefore, the overall pathway viability rating for Grand Lake St. Marys is low.

It is likely that many of the ANS of concern could become established in, and spread from Grand Lake St. Marys into either basin if they were introduced into the lake from sources such as exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. If any ANS were artificially introduced into the lake from such vectors they would then only have a downstream swim or float to arrive within the adjacent basin. However, these non-aquatic vectors did not influence the overall aquatic pathway viability rating for Grand Lake St. Marys in this report, so it should therefore be noted that the unique geographic positioning and recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

6.1 Grand Lake St. Marys 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 this location, some opportunities were still identified that, if implemented, could prevent or reduce the probability of ANS spreading between the basins at Grand Lake St. Marys. The opportunities listed below are not necessarily specific to the Grand Lake St. Marys location and they are also not specific to the USACE authorities, but incorporate a wide range of possible applicable authorities, capabilities, and jurisdictions at the Federal, state, and local levels and include some more regional opportunities. These are as follows:

- New or improved regulations or ordinances prohibiting the establishment of drainage ways that would connect the Mississippi River tributaries with Great Lakes tributaries.
- Take ANS transfer potential into account for proposed water resource projects (e.g., ecosystem restoration, dam removal, stream restoration, water management).
- Explore and support measures to reduce the potential source populations of ANS:
  - Increase commercial and recreational harvest, specifically bighead and silver carp
  - Implement measures to interfere with successful reproduction of ANS
  - Introduce biological controls such as diseases specific to particular ANS
- Public education to:
  - Prevent bait bucket transfers of ANS
  - Prevent transfer via boating and recreational equipment
  - Prevent transfer due to religious or cultural ceremonies
  - Improve identification and reporting of ANS to the appropriate authorities
- Support research on the biology of ANS so transfer potential can be better understood:
  - Life history
  - Habitat requirements and tolerances
  - History of invasiveness
- Improve and increase field sampling and monitoring for the presence of ANS to support better informed water resource management decisions within the state and region:
  - Develop integrated ANS sampling and analysis plans utilizing eDNA and conventional biological sampling events at times when ANS would be expected to be

present in any connecting streams, such as during flood events.

- Target, encourage, and train recreational fishermen, boaters and other direct users of the surface waters of the state of Ohio to identify, report, collect, and deliver ANS to the appropriate agencies.

- Prevent introductions of additional ANS:
  - Improve regulations for bilge releases
  - Improve regulations on the pet industry
  - Impose regulations on the live bait industry
  - Improve regulations on the aquaculture industry

None of the opportunities identified above are exclusive of the others. In fact, any single measure to prevent ANS transfer through the Grand Lake St. Marys location 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 aid in management and operations of Grand Lake St. Marys as well as in the implementation future updates to the Ohio Aquatic Nuisance Species Management Plan.

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Appendix A

Evaluation Forms for Each Species of Concern for the Grand Lake St. Marys Location

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	ODNR - Hydraulic Engineer	High	VC	High	VC
	USGS - Hydraulic Engineer	High	VC	High	VC
	Team Ratings	**High**	**VC**	**High**	**VC**

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: Flow is regularly connected to both watersheds, but flow is believed possible in downstream direction only. The probability of backwater inundation to permit transfer of species into Grand Lake St Marys appears highly unlikely due to the operation of the sluice gate at the east end of the lake, as well as the significant water surface differential that is maintained across the U-weir at the west end of the lake even during extreme events.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Asian Carp

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	VC		
	Ohio DNR - Biologist	Medium	VC		
	Ohio DNR - Biologist	Medium	VC		
	Team Rating	**Medium**	**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 and bighead carp are established throughout the Mississippi River Basin. Both silver carp and bighead carp have been recorded in significant numbers in the Illinois River. Black carp may be established in portions of the lower Mississippi River Basin. The known distribution of black carp is not as extensive as that of the silver and bighead carp.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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, Louisville - Biologist	Low	VC	Medium	RC
	USACE, Louisville - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Team Ratings	**Low**	**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.

Spawning and the subsequent migration of silver and bighead carp is initiated by rising water levels following heavy rains. Both species are strong swimmers and silver carp are capable of jumping considerable distances out of the water. Despite such capabilities, it is unlikely that Asian carp will be able to progress any further upstream in the Mississippi River Basin than the Roush Dam located on the Wabash River near Huntington, Indiana, and downstream of where Beaver Creek enters the Wabash River. The distance from Roush Dam, the upstream extent of Asian carp in the Wabash River, to Grand lake St. Marys is approximately 100 stream miles. Roush Dam is a 90-foot (27 m) tall flood control dam that has no fish passage structure making it a complete barrier to fish passage (ODNR, personal communication, July 26, 2010). The habitat of black carp is very similar to the grass carp. 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).

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

It is likely that most of the ANS of concern could become established in, and spread from Grand Lake St. Marys if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. If any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	ODNR - Hydraulic Engineer	High	VC	High	VC
	USGS - Hydraulic Engineer	High	VC	High	VC
	Team Ratings	**High**	**VC**	**High**	**VC**

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: Flow is regularly connected to both watersheds, but flow is believed possible in downstream direction only. The probability of backwater inundation to permit transfer of species into Grand Lake St Marys appears highly unlikely due to the operation of the sluice gate at the east end of the lake, as well as the significant water surface differential that is maintained across the U-weir at the west end of the lake even during extreme events.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Northern Snakehead (*Channa argus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Louisville - Biologist	Medium	MC		
	Ohio DNR - Biologist	Medium	MC		
	Ohio DNR - Biologist	Medium	MC		
	Team Rating	**Medium**	**MC**		

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 northern snakehead was found in 2008 in Arkansas and has since established a reproducing population in the area. While this species is within the Mississippi River Watershed, its population does not seem to be spreading at a high rate at this time and it is unlikely that it would reach the Grand Lake St. Marys divide location within the next 20 years without the assistance of some non-aquatic vector.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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, Louisville - Biologist	Low	VC	Medium	RC
	USACE, Louisville - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Team Ratings	**Low**	**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.

As obligate air breathers, northern snakeheads obtain required oxygen directly from the atmosphere. This species thrives in stagnant, oxygen depleted backwaters and marshes. Beaver Creek connects the Wabash River to Grand Lake St. Marys and is located upstream of Roush Dam near Huntington, Indiana. The Roush Dam is a 90-foot (27 m) tall flood control dam that has no fish passage structure making it a complete barrier to fish passage. In addition, the obstruction of a U-shaped weir control structure at Grand Lake St. Marys would also prevent northern snakehead from entering the lake. Therefore, there is a low probability that northern snakehead would be able to find their way into Grand Lake St. Marys solely through the aquatic pathway.

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

It is likely that most of the ANS of concern could become established in, and spread from Grand Lake St. Marys if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. If any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Parasitic Copepod (*Neoergasilus japonicus*)

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	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	ODNR - Hydraulic Engineer	High	VC	High	VC
	USGS - Hydraulic Engineer	High	VC	High	VC
	Team Ratings	**High**	**VC**	**High**	**VC**

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: Flow is regularly connected to both watersheds, but flow is believed possible in downstream direction only. The probability of backwater inundation to permit transfer of species into Grand Lake St Marys appears highly unlikely due to the operation of the sluice gate at the east end of the lake, as well as the significant water surface differential that is maintained across the U-weir at the west end of the lake even during extreme events.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Parasitic Copepod (*Neoergasilus japonicus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	RC		
	USACE, Louisville - Biologist	Medium	MC		
	Ohio DNR - Biologist	Medium	RC		
	Ohio DNR - Biologist	Medium	RC		
	Team Rating	**Medium**	**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 copepod has a life cycle in which the female adopts a parasitic phase on several fish species, including members of the minnow family, sunfish family, catfish family, and potentially other fish species. The common carp is a frequent host of the parasite. The females can detach and re-attach to host species. The invasive copepod has been detected in Lake Huron and Lake Erie, and is likely found throughout the Great Lakes. The common carp is established in Lake Michigan, as well as the rivers and streams leading to Grand Lake St. Marys from the Great Lakes. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp and the likelihood the common carp would use and survive in the pathway habitats. The invasive copepod species and a necessary host species are in the Great Lakes Basin.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Parasitic Copepod (*Neoergasilus japonicus*)

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, Louisville - Biologist	Low	VC	Medium	RC
	USACE, Louisville - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Team Ratings	**Low**	**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 copepod has been found on the common carp and the common carp was therefore used as a surrogate potential fish host to estimate the probability of the parasitic copepod moving from its current location in the Great Lakes Basin to the Grand Lake St. Marys pathway location. During spring runoff events typically in April and 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 sometimes drainage ditches with as little as a one foot or less of water depth. Common carp are strong swimmers and are capable of upstream migration during moderate flow events. The copepod has been found to infect common carp. The only obstructions for a host fish to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Great Lakes Basin. As there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of approximately seven feet (2.1 m) and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Accordingly, a rating of “low” was assigned.

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

It is likely that most of the ANS of concern could become established in, and spread from Grand Lake St. Marys if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. If any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Viral Hemorrhagic Septicemia (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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	ODNR - Hydraulic Engineer	High	VC	High	VC
	USGS - Hydraulic Engineer	High	VC	High	VC
	Team Ratings	**High**	**VC**	**High**	**VC**

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: Flow is regularly connected to both watersheds, but flow is believed possible in downstream direction only. The probability of backwater inundation to permit transfer of species into Grand Lake St Marys appears highly unlikely due to the operation of the sluice gate at the east end of the lake, as well as the significant water surface differential that is maintained across the U-weir at the west end of the lake even during extreme events.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Viral Hemorrhagic Septicemia (VHSv)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	RC		
	USACE, Louisville - Biologist	Medium	VC		
	Ohio DNR - Biologist	Medium	RC		
	Ohio DNR - Biologist	Medium	RC		
	Team Rating	**Medium**	**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: This virus has been reported from throughout the Great Lakes Basin. VHSv has been found in many species of fish including common carp. The common carp is established in the Great Lakes, as well as the rivers and streams leading to Grand Lake St. Marys from the Great Lakes. While other host fish species are known to exist in connecting streams, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp and the likelihood the common carp would use and survive in the pathway habitats. VHSv and a necessary host species are in the pathway.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Viral Hemorrhagic Septicemia (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, Louisville - Biologist	Low	VC	Medium	RC
	USACE, Louisville - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Team Ratings	**Low**	**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.

In addition to the parasitic copepod, common carp is also a potential host for VHSv. The common carp was therefore used as a surrogate potential fish host to estimate the probability of VHSv moving from its current location in the Great Lakes Basin to the Grand Lake St. Marys pathway location. During spring run-off events in April and 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 sometimes drainage ditches with as little as one foot or less of water depth. Common carp are strong swimmers and are capable of upstream migration during moderate flow events.

The only obstructions for a host fish to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Great Lakes Basin. As there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of about seven feet (2.1 m) and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Accordingly, a rating of low was assigned.

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

It is likely that most of the ANS of concern could become established in, and spread from Grand Lake St. Marys if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. If any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	ODNR - Hydraulic Engineer	High	VC	High	VC
	USGS - Hydraulic Engineer	High	VC	High	VC
	Team Ratings	**High**	**VC**	**High**	**VC**

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: Flow is regularly connected to both watersheds, but flow is believed possible in downstream direction only. The probability of backwater inundation to permit transfer of species into Grand Lake St Marys appears highly unlikely due to the operation of the sluice gate at the east end of the lake, as well as the significant water surface differential that is maintained across the U-weir at the west end of the lake even during extreme events.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	VC		
	Ohio DNR - Biologist	Medium	RC		
	Ohio DNR - Biologist	Medium	RC		
	Team Rating	**Medium**	**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 associated with river mouths and estuaries of large river systems entering the Great Lakes, and the ruffe has been identified in Lake Superior, the Green Bay portion of Lake Michigan and Lake Huron. Literature reviews and actual fish survey data have not documented the collection of the ruffe in smaller upstream tributaries. The tubenose goby's introduced range includes Lake St. Clair, Erie, Huron, Superior, and Ontario. It has been collected in the lower reaches of larger Great Lakes rivers and estuaries.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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, Louisville - Biologist	Low	VC	Medium	RC
	USACE, Louisville - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Team Ratings	**Low**	**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 ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel, but has a tolerance for different habitats and environmental conditions. The ruffe has a high fecundity rate and spawns in clean water. The ruffe's ability to swim upstream during high flow events and migrate over dams is questionable. The tubenose goby is found in the open waters and estuaries of slow flowing rivers. The tubenose goby appears to be more capable of living in more diverse types of riverine habitat than the ruffe. Sufficient forage ranging from zooplankton to fish may be available throughout the Great Lakes side of the connection. However, suitable habitat for the ruffe and tubenose goby in the Auglaize River, Miami and Erie Canal, and the St. Marys River may be limited or even nonexistent.

The only obstruction (other than habitat suitability) for these species to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Great Lakes Basin. As there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of about seven feet (2.1 m) and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Accordingly, a rating of low was assigned.

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

It is likely that most of the ANS of concern could become established in, and spread from Grand Lake St. Marys if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. If any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	ODNR - Hydraulic Engineer	High	VC	High	VC
	USGS - Hydraulic Engineer	High	VC	High	VC
	Team Ratings	**High**	**VC**	**High**	**VC**

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: Flow is regularly connected to both watersheds, but flow is believed possible in downstream direction only. The probability of backwater inundation to permit transfer of species into Grand Lake St Marys appears highly unlikely due to the operation of the sluice gate at the east end of the lake, as well as the significant water surface differential that is maintained across the U-weir at the west end of the lake even during extreme events.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - Threespine Stickleback (*Gasterosteus aculeatus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	VC		
	Ohio DNR - Biologist	Medium	MC		
	Ohio DNR - Biologist	Medium	MC		
	Team Rating	**Medium**	**MC**		

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 three spine stickleback is found in each of the Great Lakes except Lake Ontario and has been collected in some inland river systems. Literature indicates this species prefers to live in smaller streams but may occur in a variety of habitat including lakes and large rivers.

Grand Lake St. Marys, Mercer & Auglaize Counties, OH - 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, Louisville - Biologist	Low	VC	Medium	RC
	USACE, Louisville - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Ohio DNR - Biologist	Low	VC		
	Team Ratings	**Low**	**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 three Spine stickleback has been found in the Great Lakes and in smaller river systems. The only obstruction for this fish to reach Grand Lake St. Marys are the sluice gates that connect Grand Lake St. Marys to the Miami and Erie Canal Feeder Channel. As there is an elevation difference between the sluice gates and the Miami and Erie Canal Feeder Channel of about seven feet (2.1 m) and the sluice gates are closed during flood events, back flooding into Grand Lake St. Marys would be highly unlikely. Accordingly, a rating of low was assigned.

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

It is likely that most of the ANS of concern could become established in, and spread from Grand Lake St. Marys if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, eco-terrorism, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic sources. The lake provides a variety of habitat types that are suitable for most of the ANS considered in this report. If any ANS were artificially introduced into the lake they would then only have a downstream swim or float to arrive within the adjacent basin. Grand Lake St. Marys is used for recreational boating, with eight state-operated boat launches and several private boat launches. It should therefore be noted that the recreational use of Grand Lake St. Marys does pose some residual probability for the interbasin transfer of ANS.