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

Ohio-Erie Canal, Ohio

US Army Corps of Engineers
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Executive Summary

This assessment characterizes the likelihood that a viable aquatic pathway exists at the Ohio-Erie Canal at Long Lake location, 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 conducting a species-specific assessment of the abilities of potential ANS to arrive at the pathway and cross into the adjacent basin. A couple of the key features of the Ohio-Erie Canal pathway are the Long Lake Feeder Gates and Long Lake Flood Gates that are adjacent to the Ohio-Erie Canal in Portage Lakes. These are the locations where water is either diverted from Long Lake (which sits in the Mississippi River Basin) into the Tuscarawas River through the Flood Gates or from Long Lake into the Ohio-Erie Canal through the Feeder Gates. Once in the Tuscarawas River, the water flows south into the Mississippi River Basin. However, much of the water that enters the Canal through the Feeder Gates flows north eventually reaching the Little Cuyahoga River (Great Lakes Basin).

There is a high probability of an aquatic pathway existing at this location, indicating that significant volumes of water are known to cross the basin divide continuously for days to weeks multiple times per year. Site visits confirmed that there is a constant hydrologic connection across the basin divide via the Ohio-Erie Canal in the vicinity of Akron, Ohio. Ultimately, Long Lake and the network of Portage Lakes sit perched near the basin divide and discharge water into both the Great Lakes and Mississippi River Basins.

A hydraulic analysis of the lock system located in the city of Akron determined that these structures will prevent the movement of ANS from the Great Lakes Basin to the Mississippi River Basin via the Ohio-Erie Canal. The Lock One gates are operated to maintain a constant elevation and flow rate in the canal. The Lock One gate north of Summit Lake in downtown Akron provides a 15 foot vertical barrier, preventing the movement of ANS from the Great Lakes Basin into the Mississippi River Basin through the Canal. This obstruction, along with several other locks and low head dams, would make ANS movement from the Great Lakes Basin into the Mississippi River Basin nearly impossible.

Aquatic Nuisance Species of Concern	
Species	**Common Name**
Hypophthalmichthys molitrix	silver carp
Hypophthalmichthys nobilis	bighead carp
Mylopharyngodon piceus	black carp
Channa argus	northern snakehead
Alosa chrysochloris	skipjack herring

As a result of this high rating for the probability of an aquatic pathway existing at Ohio-Erie Canal, the likelihood of ANS transfer at this location was evaluated. A total of five ANS were identified for a more focused evaluation based on the biological requirements and capabilities of each species. These species are listed in the table above.

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 occur in only one direction at the Ohio-Erie Canal pathway site. The biological evaluation concluded that this location provides suitable temporary habitat, and in some cases, permanent habitat for a diversity of aquatic life including the ANS of concern that have been identified for this pathway. Both the quality and the nature of the streams on either side of the interbasin divide allow for the potential support of ANS at the Ohio-Erie Canal at Long Lake site and it is possible that multiple ANS could utilize this pathway to transfer from the Mississippi River Basin to the Great Lakes Basin. Therefore, an overall pathway viability rating of “medium” was given to this pathway, which means in this case that while ANS transfer could occur it is estimated that none of the ANS would likely be able to reach the aquatic pathway within the next 20 years.

There is a high degree of recreational activity and fishing within the network of Portage Lakes. The potential also exists that these and possibly other ANS could transfer across the basin divide at this location by anthropogenic vectors. However, such non-aquatic vectors did not factor into the rating of this site

Some site specific opportunities to reduce the potential for ANS transfer at the Ohio-Erie Canal site may include implementing structural controls at a number of locations along the pathway, and discussions are on-going with the Ohio Department of Natural Resources (ODNR) to investigate such options. Additional and less site specific opportunities include further research on the biology of ANS so that the probability of their reaching the pathway location and getting through the aquatic pathway can be better understood, increased field sampling and monitoring for the presence of ANS to support better informed water resource management decisions within the state and region, and increased outreach and public education regarding ANS.

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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
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 (WRDA, 2007), and therein, it prescribes the following authority to the Secretary of the Army and the U.S. Army Corps of Engineers (USACE):

> *"(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 Ohio-Erie Canal at Long Lake location, in Summit County, Ohio. This location is one of 18 locations identified in the Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization as a potential aquatic pathway spanning the watershed divide between the Great Lakes and Mississippi River Basins outside of the Chicago Area Waterway System (CAWS) (USACE, 2010). This report is downloadable from the GLMRIS web site (glmris.anl.gov/).

The dashed line in Figure 1 depicts the nearly 1,500-mile (2,414-km) 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 Ohio-Erie Canal at Long Lake location is shown as location number 3, which lies in the cities of Akron and Portage Lakes, Summit County, Ohio.

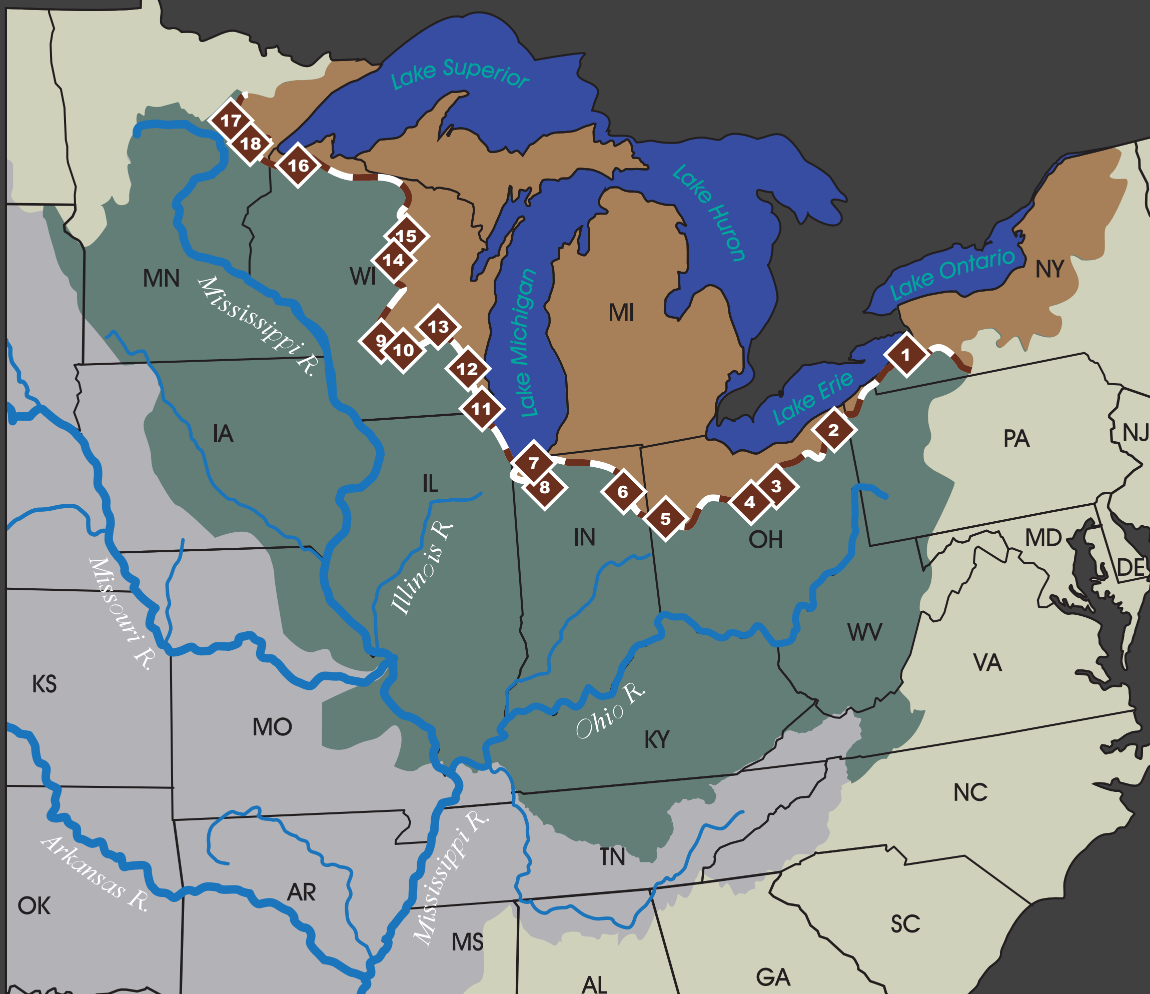
The GLMRIS is a very large and complicated task involving multiple USACE Districts and Divisions. Program Management of the study is conducted by the Great Lakes and Ohio River Division. The study considers several aquatic nuisance species (ANS) of concern, however, the proximity of Asian carp in the 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 in Chicago, Illinois and Eagle Marsh in Fort Wayne, Indiana. To help accelerate completion of the feasibility study, the Great Lakes and Ohio River Division split management of the GLMRIS into two separate focus areas. Focus Area 1 is managed by the USACE, Chicago District and addresses the CAWS 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 precipitation that flows into the Mississippi River and its tributaries from precipitation that flows into the Great Lakes and its tributaries.

1.1 Study Purpose

The preliminary report from 2010 and the subsequent analysis contained in this report have been produced for a broad audience ranging from the scientific community to the general public, and are specifically intended to identify any locations where an aquatic pathway exists or may form between the basins, and to evaluate the probability that specific ANS would be able 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.

This report is part of a tiered approach to assess the risk associated with the spread of ANS between the Great Lakes and Mississippi River Basins, 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 Ohio-Erie Canal at Long Lake 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 Ohio-Erie



LEGEND

Great Lakes | Great Lakes Basin | Upper Mississippi River Basin | Lower Mississippi River Basin

Border of Great Lakes and Upper Mississippi River Basins

	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).

Canal at Long Lake 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 comprehensive report that characterizes the probability of aquatic pathway formation, the probability that a viable aquatic pathway exists at the Ohio-Erie Canal at Long Lake location, and will enable the interbasin spread of ANS;

- Development of clear problem statements that frame the means, constraints, and likelihood of the interbasin spread of ANS via the potential aquatic pathway at the Ohio-Erie Canal at Long Lake 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 Ohio-Erie Canal at Long Lake location.

1.2 Summary of 2010 Preliminary Risk Characterization for Ohio-Erie Canal at Long Lake, 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. The second objective was to refine the scope of the other aquatic pathways portion of the GLMRIS by developing a list of potential aquatic pathways that could form anywhere along the divide separating the Great Lakes and Mississippi River Basins, and help provide a basis for prioritizing future feasibility study efforts based upon relative risk.

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

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

In 2010, it was determined on a preliminary basis that an aquatic pathway exists for flow toward the Great Lakes Basin at this location at up to a one percent annual recurrence interval flood event because of a set of two feeder gates that are maintained with a three inch (7.6 cm) opening to allow continual discharge from Long Lake into a canal connecting with the Cuyahoga River. In addition, an aquatic pathway was also believed to exist for flow toward the Mississippi River Basin because of a gated connection of Long Lake with the Tuscarawas River that leads to the Muskingum River and then the Ohio River. This connection of Long Lake with the Tuscarawas River was approximately a five foot (1.5 m) drop into the river, which under high water conditions the drop could be as little as one foot (30 cm) (ODNR, 2010). The mixed open water and wetland habitats at the basin divide at this location were also believed to be suitable habitat for multiple ANS. In addition to the gated connections at Long Lake, the preliminary characterization identified another possible surface connection that exists at this location because of the parallel alignment of the Tuscarawas River and the Ohio and Erie Canal for a length of approximately two miles (3.2 km). These two waterways are within 300 feet (91 m) of each other at their closest point, with only a five foot (1.5 m) high canal embankment separating them.

Although the preliminary risk characterization did not identify the Ohio-Erie Canal at Long Lake Pathway as a location where there is a near term risk for the interbasin spread of ANS, there was some uncertainty with this rating. This was due in part to the complex hydraulics and hydrology of the area and the need to better understand the connectivity between the Long Lake feeder gates, the canal, and the Tuscarawas River in an effort to discern the relative frequency and potential magnitude of any aquatic pathway at this location. The preliminary effort recommended that a more detailed assessment be conducted at this location. This was subsequently done in collaboration with the Ohio Department of Natural Resources (ODNR), USFWS, USGS, and USACE. The following actions were taken:

- Federal, State, and local stakeholders (i.e. USGS Water Science Center, Ohio DNR Division of Soil and Water Resources, County Surveyor, and/or local National Resource Conservation representatives) were briefed on the preliminary risk characterization results. Site visits to observe potential connection locations were made. The available topographic mapping and flood hazard information were compiled and reviewed.

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

- Conduct 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.

- Prepare a set of revised ANS transfer probability ratings for each location based upon a more detailed evaluation of ANS transfer probability via the aquatic pathway in both directions.

- Revise both the hydrologic and ANS probability ratings and characterization for each site based on the new information.

- Identify measures that could be implemented at the local or state level to mitigate the likelihood of ANS spreading across the Mississippi River and Great Lakes Basin divide

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 ODNR and USACE. The results also reflect the guidance, input, review comments, and concurrence of the multi-organization Agency Technical Review team of experts from NOAA, NRCS, USGS, USFWS, and USACE.

2 Study Methodology

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

2.1 Coordination

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

2.2 Identification of Potential Pathways

At 18 of the potential aquatic pathways identified during the 2010 Preliminary Risk Characterization, it was determined it would likely require an epic storm and flooding event (i.e., greater than a one percent annual recurrence interval storm event) for an aquatic pathway to ever form across the basin divide. These locations were not recommended for further investigation because areas that might require a flooding event in excess (greater magnitude, less frequency) of the one percent annual recurrence interval flood are less likely, and therefore present a low level of risk. This one percent threshold criteria 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 and 2012 in collaboration with USGS, NRCS, USFWS, state natural resource agencies, and county surveyors (where applicable), and the results for the Ohio-Erie Canal location are presented in this report.

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 (formerly referred to as a 500-year event) is a larger event that has a one in 500 chance of being exceeded in any given year.

Although the 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, 2011b). 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 Ohio-Erie Canal at Long Lake Location

The Ohio-Erie Canal at Long Lake aquatic pathway team then subdivided the set of species listed in Table 1 into two groups: ANS threatening the Great Lakes Basin, and ANS threatening the Mississippi River Basin. 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 Basin and and to the Great Lakes Basin, respectively (USACE, 2011b).

Additionally, the Ohio-Erie Canal at Long Lake 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 Ohio-Erie Canal at Long Lake 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 Ohio-Erie Canal at Long Lake location.

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 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, 2011b). It was therefore included as an ANS of concern threatening the Mississippi River Basin for the Ohio-Erie Canal at Long Lake aquatic pathway.

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 Ohio-Erie Canal at Long Lake 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.

Based on a hydraulic analysis of the lock systems located in the city of Akron and concurrence from ODNR, it has been determined that these structures will prevent the movement of ANS from the Great Lakes Basin to the Mississippi River Basin via the Ohio-Erie Canal at this

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

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

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

location. Only fish from the Mississippi River Basin were considered to have the requisite means of reaching the divide at the Ohio-Erie Canal at Long Lake site. To help facilitate determination of the probability of ANS spreading between the basins via this location, the team of biologists then selected a smaller group of species for more focused assessment. The species selected may be those most likely to arrive at the divide, pose the greatest possibility of ecological damage, and/or exhibit a broad range of biological characteristics that provides a more thorough evaluation of the probability that ANS could spread between the basins at this location. Five fish were ultimately identified as species of greatest concern for the Ohio-Erie Canal at Long Lake location. These were chosen based on their relative proximity to the site, history of invasiveness, and physical capabilities to potentially utilize this aquatic pathway (Table 4).

Proximity of the species of greatest concern to the Ohio-Erie Canal at Long Lake location was determined by documenting the locations of established populations of ANS depicted on the USGS Nonindigenous Aquatic Species (NAS) website (USGS, 2011b). The website has been established as a central repository for spatially referenced biogeographic accounts of introduced aquatic species. The program provides scientific reports, on-line and real-time queries, spatial data sets, regional contact lists, and general information. Review of these data determined that the range of ANS proximity to the pathway varies from less than 50 miles (80 km) to greater than 250 miles (402 km) from the potential pathway location.

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. Additional information was obtained from the USGS Nonindigenous Aquatic Species (NAS) website (USGS, 2011b).

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 at Ohio-Erie Canal at Long Lake

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	*Menidia beryllina*	inland silverside	MS	swimmer
fish	*Channa argus*	northern snakehead	MS	swimmer

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:

$P_1 = P_{\text{ANS associated with pathway}}$

$P_2 = P_{\text{ANS survives transit}}$

$P_3 = P_{\text{ANS colonizes in new environment}}$

$P_4 = P_{\text{ANS spreads beyond colonized area}}$

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:

$P_0 = P_{\text{Pathway exists}}$

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

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

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

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

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:

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

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

$P_{2b} = P_{\text{ANS establishing in proximity to the aquatic pathway}}$

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

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]

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

Where:

each Thursday = 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 (P_0) is not necessarily the same as there being no probability of a pathway existing. At those locations where the probability of a pathway existing (P_0) was determined to be medium or high which includes the Ohio-Erie Canal 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.

2.5 Example Calculation of Overall Aquatic Pathway Viability

As described in Section 2.2, a list of ANS of concern for the Ohio-Erie Canal at Long Lake 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 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. 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

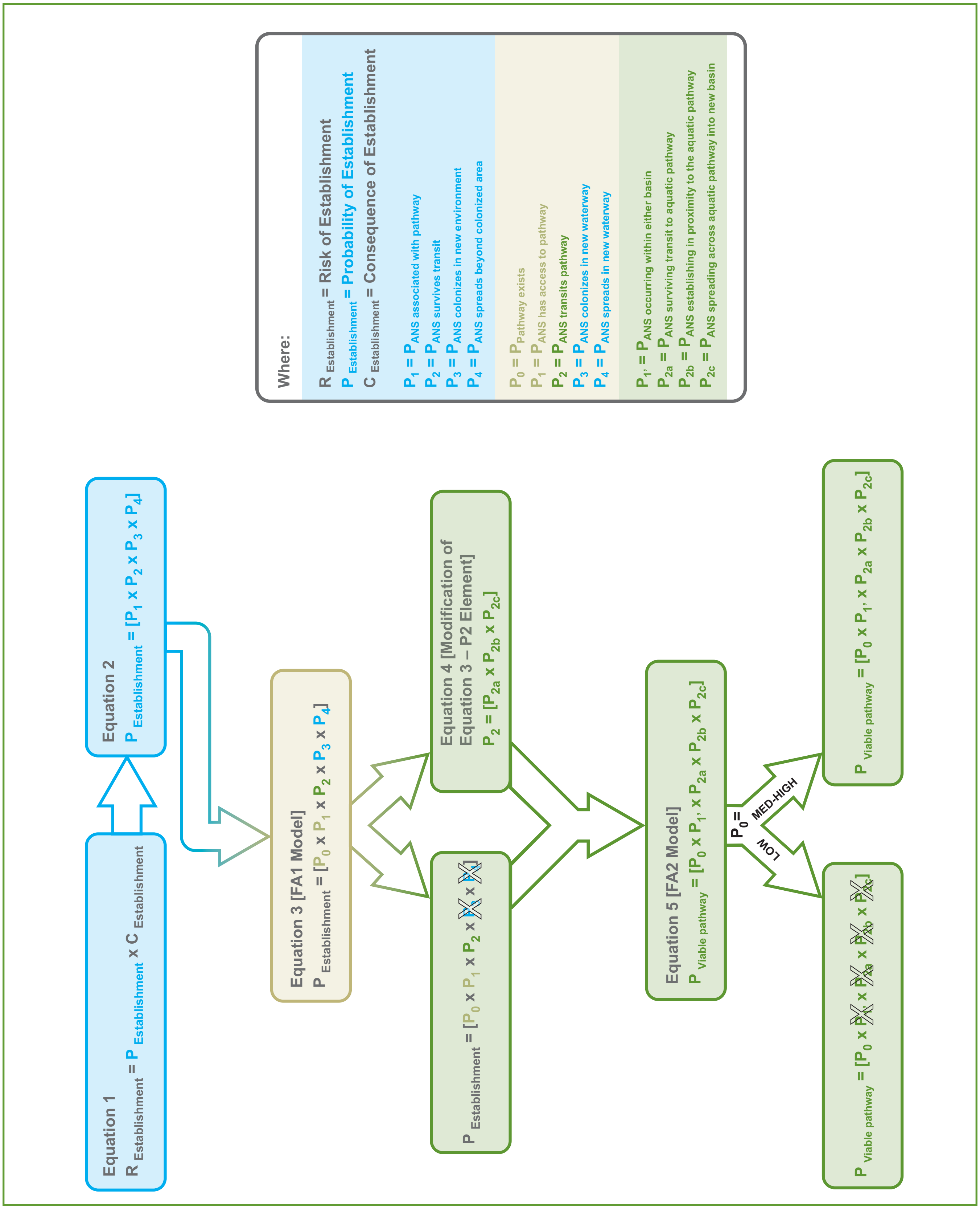


Figure 2. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

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

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 Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way Viability Rating**
fish	Asian carp, silver carp, bighead carp, black carp	swimmer	M (RC)	M (RC)	L (RC)	L (MC)	M (RU)	L
fish	inland silverside	swimmer		M (VC)	L (MC)	L (RC)	L (RC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

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

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

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

3.1 Location

The section of the Ohio-Erie Canal that is of concern for an ANS pathway is located between the cities of Akron and Portage Lakes, Summit County, Ohio. A couple of the key features of the Ohio-Erie Canal pathway are the Long Lake Feeder Gates and Long Lake Flood Gates that are adjacent to the Ohio-Erie Canal in Portage Lakes. These are the locations where water is either diverted from Long Lake (which sits in the Mississippi River Basin) into the Tuscarawas River through the Flood Gates or from Long Lake into the Ohio-Erie Canal through the Feeder Gates. Once in the Tuscarawas River, the water flows south into the Mississippi River Basin. However, much of the water that enters the Canal through the Feeder Gates flows north eventually reaching the Little Cuyahoga River (Great Lakes Basin). This site is located at latitude 41.022621 N and longitude 81.549736 W. The general location of the aquatic pathway as well as the surface water flow path to Lake Erie a

3.2 Climate

Climate is looked at in this section just to identify any applicable elements of climate (e.g., temperature, rainfall) and how they may influence the likelihood of an aquatic connection forming at the subject pathway that could be utilized by ANS to spread between the basins. The climate of the Tuscarawas River Basin is characterized by moderate extremes of heat, cold, wetness and dryness. Frequent and rapid changes in weather occur due to the passage of fronts associated with general low-pressure areas. Temperatures at this location can at times reach below freezing, mostly in December through March. Lowest precipitation amounts are during the winter with the highest amounts between April and November (Table 7).

The hydrologic connections between the basins at most locations in the pathway are perennial and not driven by rainfall. However, periodic flooding events from snowmelt and/or rainfall could increase flow velocities and the amount of interbasin flow at some locations, such as at the Nimisila spillway and backwater flooding of the Tuscarawas River. These potential interbasin pathway locations will be discussed in more detail later in this report. Although flooding is possible any time of the year, applicable stream gage data suggests that large floods occur most frequently in late winter and early spring (USGS, 2011a).

Table 7: Summary of Climate Variable for the City of Akron, OH (Source: Weather-Forecast, 2012).

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Mean Temperature°F	27.2	30.2	39.2	50.1	61.3	69.8	74.1	72.2	65.1	53.5	42.8	32.4	51.5
Mean Temperature °C	-2.7	-1.0	4.0	10.1	16.3	21.0	23.4	22.3	18.4	11.9	6.0	0.2	10.8
Normal Precip (in)	2.02	2	2.85	3.15	3.61	3.13	3.87	3.36	3.57	2.46	3.22	2.83	36.07
Normal Precip (cm)	5.13	5.08	7.24	8.00	8.03	7.95	9.83	8.53	9.07	6.25	8.18	7.19	91.62

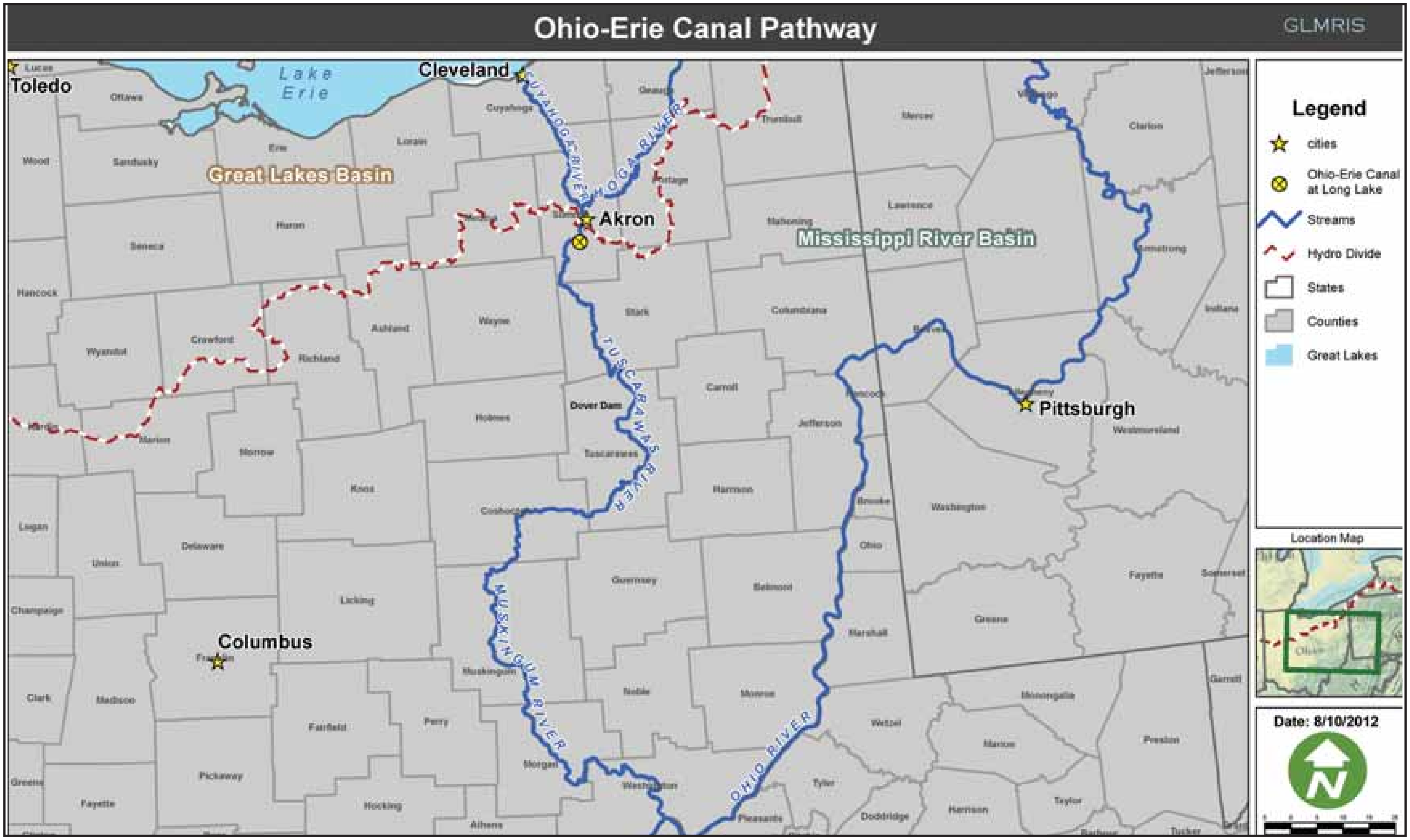


Figure 3. Location of Ohio-Erie Canal at Long Lake aquatic pathway and connecting streams to the Ohio River and Lake Erie. The Ohio River is also highlighted. Base imagery courtesy of Bing Maps.

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 in proximity to a remnant section of the Ohio-Erie Canal that remains between Barberton and Akron, Ohio. This section of the report is organized according to those critical features along the Ohio-Erie Canal that were considered during the evaluation of whether or not the canal is a viable aquatic pathway for interbasin spread of ANS between the Great Lakes and Mississippi River Basins. These features are highlighted in the following Sections 3.3.2 through 3.3.8.

A key component of the area is Portage Lakes State Park, which sits at one of the highest elevations in the state and is a location where water can flow either toward the Ohio River or Lake Erie (ODNR, 2012a). Although water can flow in either direction at the pathway via the Ohio-Erie Canal and the Tuscarawas River, the actual Great Lakes and Mississippi River Basin divide is located about four miles (6.4 km) to the north (Figure 4). The reason that this potential aquatic pathway is located so far from the actual basin divide is because of water management activities at the Portage Lakes which supply water to the Ohio-Erie Canal. A number of the Portage Lakes were constructed as reservoirs to feed the canals which at the time required a minimum depth of four feet (1.2 m). However, after 1913 the lakes were used for local industrial purposes, with some of them are still used today for recreational boating. The area was maintained for recreation by the Ohio Department of Public Works until 1949 when it was transferred to the ODNR Division of Parks and Recreation (ODNR, 2012a). The park has eight boat launches and eight lakes covering approximately 2,034 acres (823 ha) (ODNR, 2012a).

The area of greatest concern for interbasin surface water flow, and therefore the area of greatest concern for the potential spread of ANS between the two basins, is shown in Figure 5. Other potential aquatic pathways for flow from the Mississippi River Basin into the Ohio-Erie Canal are the Wolf Creek Outlet Gates, Tuscarawas Side Channel Diversion, and the Nimisila Reservoir. Flow leaves Long Lake via flood gates to the Tuscarawas River or by the feeder gates directly into the Ohio-Erie Canal (Figure 5). In the Tuscarawas River, flow is toward the Ohio River. However, in the Ohio-Erie Canal, flows can go either toward the Ohio River or the Great Lakes Basin. The light blue shading in Figure 5 shows that a majority of the area is within the one percent annual recurrence interval Federal Emergency Management Agency (FEMA) floodplain, meaning that overbank flooding from the Tuscarawas River directly north toward the Ohio-Erie Canal is a possibility and has occurred in the past in at least one location, although no surface water connection with the Canal is ever known to have established. See Section 3.3.8 for details previous flooding in this area.

The inputs and withdrawals of water from the Ohio-Erie Canal and Portage Lakes System is very complex. A diagram has therefore been provided by ODNR to help depict these inputs and withdrawals, and is illustrated in Figure 6. The actual canal pathway is depicted by the dark blue dashed line and extends between approximately Long Lake and Lock No. 1 to the north. The Portage Lakes (highlighted in blue) and the Tuscarawas River contribute water to Long Lake and discharge into the Ohio-Erie Canal through the feeder gates indicated on the figure.

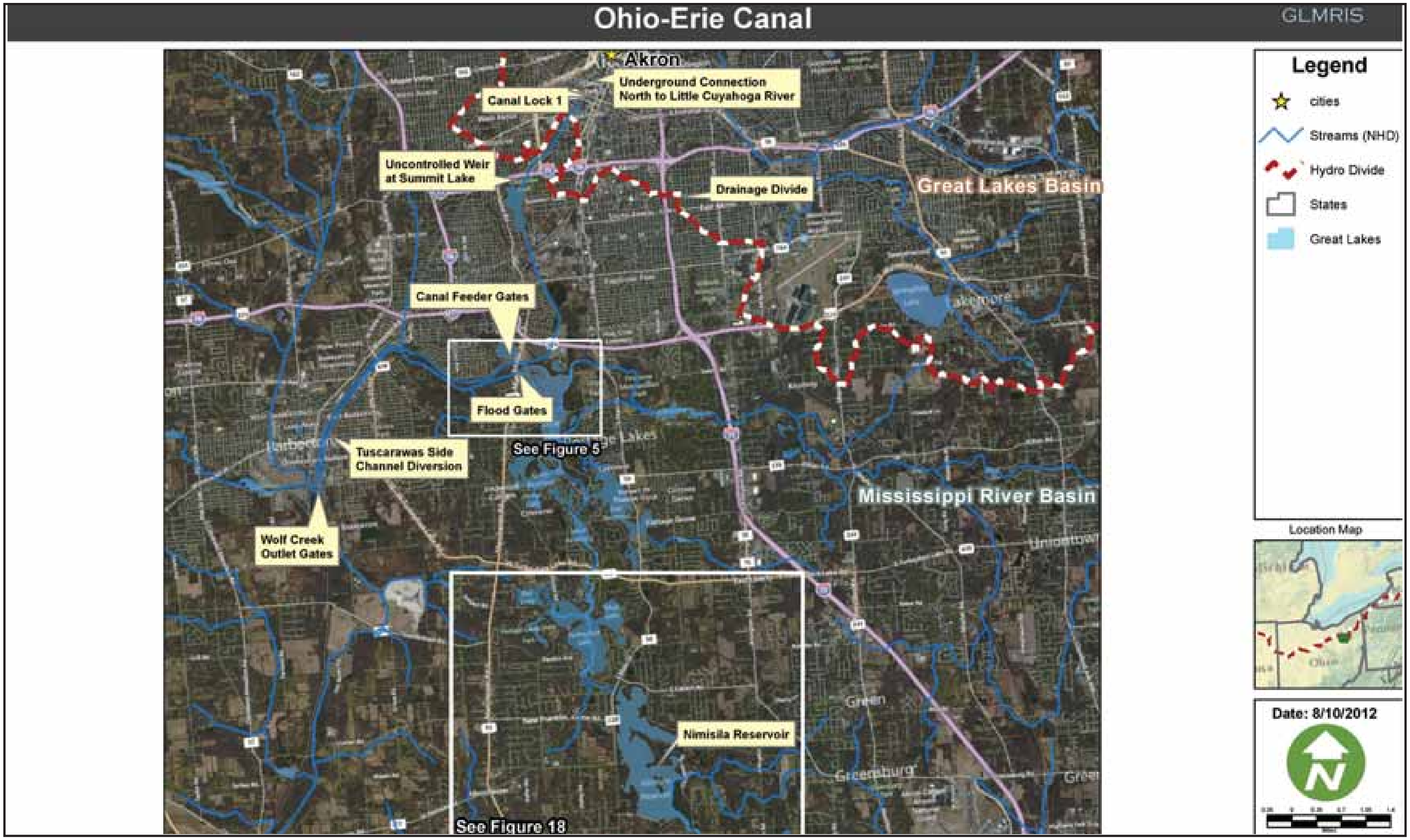


Figure 4. Location of aquatic pathway area and key study features relative to the Great Lakes and Mississippi River Basin divide about four miles to the north. Base imagery courtesy of Bing Maps.

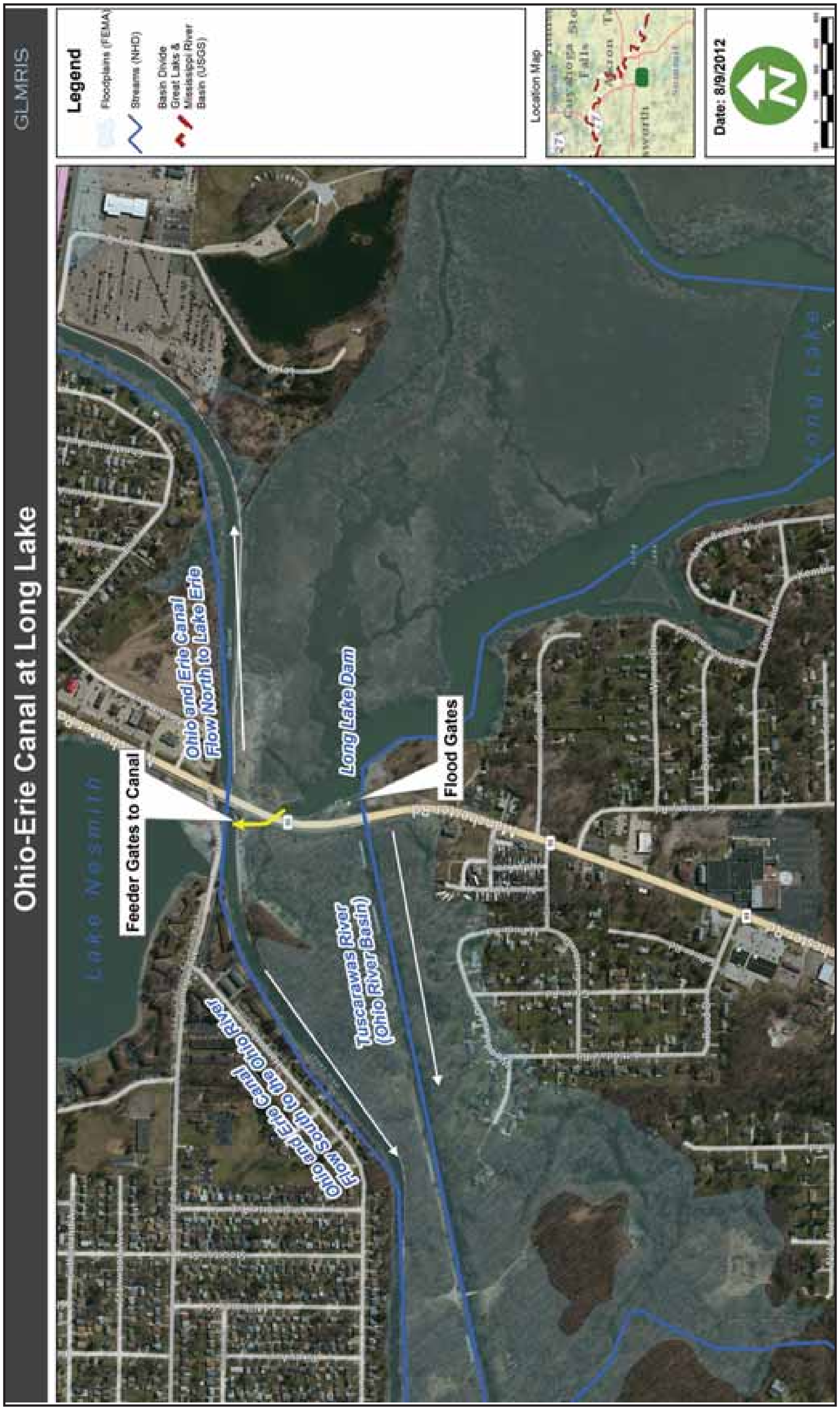


Figure 5. Detailed depiction of Ohio-Erie Canal at Long Lake aquatic pathway. Base imagery courtesy of Bing Maps.

3.3.1 Ohio-Erie Canal

The Ohio-Erie Canal, between approximately Long Lake and Lock No. 1, is the aquatic pathway that an ANS would need to utilize in order to move from the Tuscarawas River Basin into the Great Lakes Basin. The Ohio-Erie Canal is fed by the Portage Lakes along with local stormwater drainage from the surrounding urbanized area. The canal is also used for consumptive withdraws as illustrated by the red lines in Figure 6. Flow direction within this reach of the canal is generally toward the north into the Great Lakes Basin, but can at times become stagnant or flow in either direction.

The reach of the Ohio-Erie Canal that was investigated is approximately 10 miles (16 km) in length and stretches from the Wolf Creek outlet gate near Barberton to Lock 1 in downtown Akron (Figure 4). The width of the canal varies but is approximately 50 feet (15 m) on average, with a varying depth that is a minimum of four feet (1.2 m). A typical reach of canal near the Long Lake Feeder Gates is shown in Figure 7 while another section is shown in Figure 8 within the downtown Akron area. The canal also flows through Summit Lake about two miles (3.2 km) to the north as it flows towards Lock 1 near the Little Cuyahoga River in Akron. There are no known hydraulic or structural characteristics within the Ohio-Erie Canal between Long Lake and approaching Lock 1 that would likely offer any kind of obstruction to the movement of most ANS.

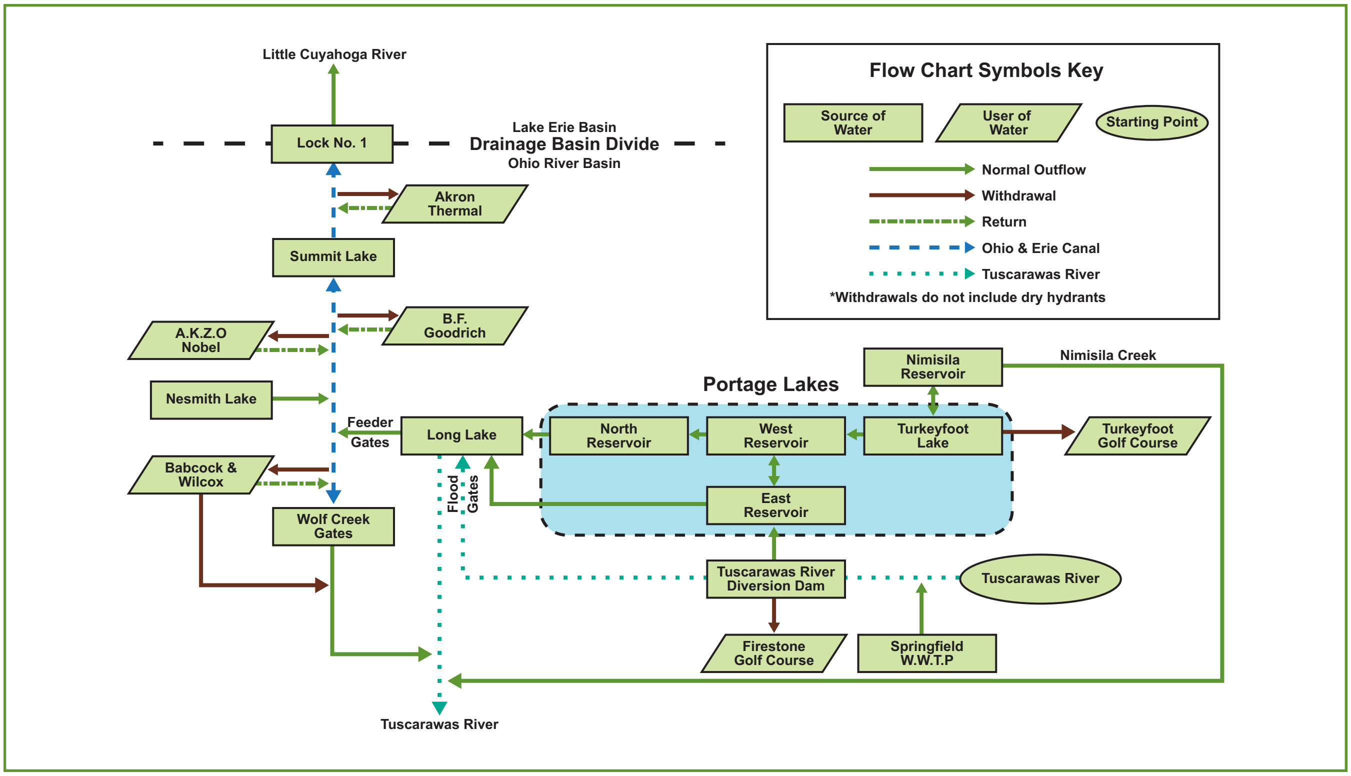


Figure 6. Ohio-Erie Canal Flow Chart (ODNR, 2012b).

Figure 7. View of Ohio-Erie Canal near Long Lake Feeder Gates. This location along the canal is shown in Figure 5, and the view is looking west with Lake Nesmith to the right (north). Photo by USACE.

Figure 8. Typical urbanized section of the canal in downtown Akron. Photo by USACE.

3.3.2 Long Lake Flood Gates

The most likely aquatic pathway for ANS moving toward the Great Lakes Basin is up the Tuscarawas River to just downstream of the Long Lake flood gates on the east side of State Route 93. During a moderate to high flow event on the Tuscarawas River it may be possible for ANS to navigate upstream through the gates into Long Lake where they would then have access to the Ohio-Erie Canal through the canal feeder gates (Figure 5). During lower flow conditions, it is likely not possible for ANS to move upstream from the Tuscarawas River through the flood gates due to a 2-3 foot (60-90 cm) vertical drop into rock rip rap from the base of the concrete apron which can be seen in Figure 9.

The Long Lake flood gates consist of five sluice gates that are approximately 16 feet wide and three feet high (4.6 m x 0.9 m) with a channel invert at 963.5 feet. During a site visit on May 27, 2011, there were moderately high flows and velocities through the gates (estimated at 10-20 feet per second [0.2-0.5 meters per second]), resulting from significant precipitation in the days just prior to the site visit. It was noted by ODNR staff that high velocities of the magnitude observed during the site visit might prevent ANS from moving through the gates, although it is unclear at what event the head drop through the flood gates would begin to allow passage of ANS. It was stated by ODNR representatives that there is normally very little flow through the gates, as evident in Figure 9. However, flow conditions during the site visit were much higher and are illustrated in Figure 10 and Figure 11.

Figure 9. Normal flow conditions at the Long Lake flood gates. Long Lake is to the left and the Tuscarawas River headwater is to the right. Photo by USACE.

Figure 10. Inflow to Long Lake flood gates from Long Lake during May 27, 2011 site visit. Long Lake to the left and Tuscarawas River to the right. Photo by USACE.


Figure 11. Outlet from Long Lake flood gates (to the left) during site visit on May 27, 2011. Photo by USACE.

3.3.3 Long Lake Canal Feeder Gates

Once in Long Lake, there is a potential for ANS to spread through the Long Lake feeder gates into the Ohio-Erie Canal (Figure 5 and Figure 12). Water is diverted from Long Lake to the canal via these feeder gates which are located approximately 560 feet (171 m) north of the flood gates. The canal feeder gates are two 36 x 36 inch sluice gates at an invert of 962.3. The gates are operated from on-site to provide approximately 11 million gallons per day (MGD) into the canal, of which approximately two MGD flow west and are diverted back into the Tuscarawas River and is controlled by the Wolf Creek gates described in the following section.There is also a weir located immediately upstream of the entrance to the feeder gates that assists in maintaining a relatively constant headwater. The operating machinery for the two sluice gates providing flow into the canal is shown in Figure 13.

Figure 12. Entrance to Ohio-Erie Canal feeder gates. The canal is located on the other side of these gates and to the right (north) of the photo. Long Lake is directly behind (east) the person taking this photo. The headwater to the Tuscarawas River is just off the photo to the top left. Photo by USACE.

Figure 13. Feeder gate machinery allowing for controlled flows from Long Lake into the Ohio-Erie Canal. Photo by USACE.

3.3.4 Wolf Creek Outlet

Approximately two MGD of the water diverted through the Long Lake feeder gates actually flows West back into the Tuscarawas River. This flow is controlled by two conduits; one is 30 inches (0.76 m) high and 30 inches (0.76 m) wide and the other conduit is 30 inches (0.76 m) in diameter. Both conduits have an invert elevation of 959.74 feet. The conduits are operated by two sluice type gate structures. There is also a five foot (1.5 m) overflow weir at the Wolf Creek outlet built in 1996 for water quality purposes which allows for the overflow of surface algae into Wolf Creek (Figure 14). The Wolf Creek outlet conduits are approximately 80 feet (24 m) long and flow into Wolf Creek. They are located at the southern end of the remaining segment of the Ohio-Erie Canal as shown in Figure 4. If backwater from the Tuscarawas River was high enough, a condition could develop that would allow for an aquatic pathway into the canal.

A detailed FEMA Flood Insurance Study (FIS) was recently completed for Wolf Creek in the vicinity of the Wolf Creek outlet (FEMA, 2009). The study profiles depict backwater from the Tuscarawas River as the primary source of water that would provide high water against the gates and that may have the potential for overtopping the gates. The flood elevations from this study are 959.7, 961.3, 961.8, and 963.5 feet for the 10 percent, 5 percent, 1 percent, 0.2 percent annual recurrence interval floods, respectively. Based on this information, there may be a potential for ANS to utilize such an aquatic pathway beginning at an approximately five percent annual recurrence interval event, although there is expected to be high velocity flow conditions through this gate from the canal toward the Tuscarawas River even during high backwater events from the Tuscarawas River. There is also an approximately one foot (30 cm) head drop through the gate that is maintained, even at a 0.2 percent annual recurrence interval event and backwater condition on the Tuscarawas River. These conditions greatly reduce the probability of this serving as a viable pathway for transfer of ANS.

Figure 14. Wolf Creek outlet gates, looking upstream at Ohio-Erie Canal with the gates in the foreground. Flow from the canal through gates to the Tuscarawas River would be toward the bottom of the figure and then to the right. The Tuscarawas River is on the opposite side of the berm. Photo by USACE.

3.3.5 Side Channel Diversion into the Tuscarawas River

There is a side channel weir that consists of three uncontrolled approximately six foot ogee weirs located roughly 0.3-miles (0.5 km) upstream of the Wolf Creek outlet works (Figure 4). These diversion structures are illustrated in Figure 15 and were originally constructed to divert flood waters from the canal into the Tuscarawas River, although they are no longer needed for this purpose. If submerged by flooding along the Tuscarawas River, it is likely that this weir could create an aquatic pathway from the Mississippi River Basin into the Great Lakes Basin through the canal, although there is no record of this ever having occurred (Mr. Hung Thai - ODNR, personal communication, January 9, 2013). Flood elevations published by FEMA for the Tuscarawas River indicate that the flood elevations at the location of the side channel weir are 960.9, 962.3, 962.6, 964.0 feet for the 10 percent, 5 percent, 1 percent, 0.2 percent annual recurrence interval floods, respectively (FEMA, 2009). The approximate elevation of the weir crest is believed to be slightly above the 964.5 foot elevation of the canal's normal water surface elevation, which would be approximately 0.5 feet (15 cm) above the 0.2 percent annual recurrence interval flood event on the Tuscarawas River.

Figure 15. Side channel weir diversion into the Tuscarawas River. Photo by USACE.

3.3.6 Canal Lock 1

For any aquatic species that are able to get into the canal through either the Long-Lake feeder gates, Tuscarawas River side channel diversion, or overland flooding between the Tuscarawas River and the Canal, an aquatic pathway would exist for them to move unobstructed through the canal north into Summit Lake, and then continue through Lock 1 toward the Little Cuyahoga River (Figure 4). Lock 1 is located north and east of Long Lake (Figure 4) and consists of two 6.6 foot (2 m) overflow weirs with a crest elevation of 964.2 feet, a five foot high by five foot wide (1.5x1.5 m) controlled sluice gate at invert of 950.45 feet, and a bypass weir with a crest elevation of 964.5 feet. The Lock 1 gates are operated to maintain a constant elevation and rate of flow in the canal. The gates also provide a 15 foot (4.6 m) barrier, preventing the movement of ANS from the Great Lakes Basin into the Mississippi River Basin through the canal. Since the only water feeding the canal is diversion water and storm water, it is the belief of the USACE hydrologic engineer and the representatives from ODNR on the pathway team that it would not be possible for the tailwater downstream from Lock 1 to ever get high enough during storm events to reduce this 15 foot (4.6 m) vertical barrier to a point where ANS could then move in an upstream direction from the Great Lakes Basin into the Ohio River Basin. A drawing of the location, type, size, and elevation of the control gates at Lock 1 is shown in Figure 16 and a photograph of the Lock 1 control weir is presented in Figure 17.

If an ANS could reach this point from the Ohio River Basin, it may then be able to move unobstructed through the remainder of the Ohio-Erie canal north into the Little Cuyahoga River and eventually to Lake Erie. However, Lock 1 along with several other locks and low head dams, would make ANS movement from the Great Lakes Basin into the Mississippi River Basin nearly impossible.

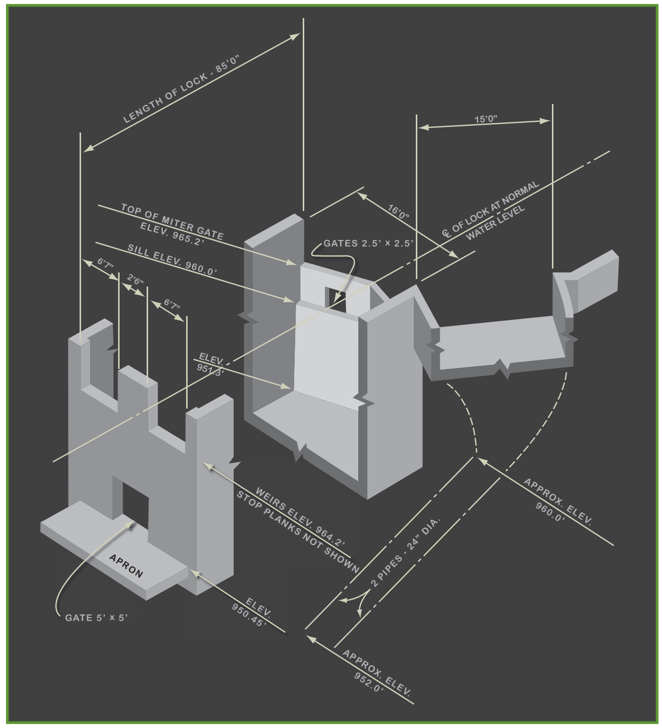


Figure 16. Lock 1 gate configuration provided by ODNR.


Figure 17. Lock 1 control weir. Photo by USACE.

3.3.7 Nimisila Reservoir

Nimisilia Reservoir is located about four miles (6.4 km) south of the Long Lake feeder gates and diverts water north into the Portage Lakes which then flow into Long Lake. The likelihood of an aquatic pathway existing from the Tuscarawas River into Nimisila Creek, and then upstream Nimisila Creek to the Nimisila Reservoir was investigated as part of this study. A substantial spillway structure exists at the south end of the reservoir that likely provides an obstruction between Nimisila Creek and the Nimisila Reservoir (Figure 18). Although the spillway does serve as an aquatic connection, the Nimisila Reservoir Dam is approximately 44 feet high, resulting in the spillway having a relatively steep slope over a concrete channel that likely experiences high flow velocities under higher flows.

Figure 18. Nimisila Reservoir and dam spillway. Long Lake is just to the north of the figure. Nimisila Creek flows away from the reservoir to the southwest and eventually enters the Tuscarawas River. Inset photo by USACE and background imagery courtesy of Bing Maps.

3.3.8 Tuscarawas River Flooding toward Ohio-Erie Canal

Backwater flooding from the Tuscarawas River toward the Ohio-Erie Canal was observed following a storm event during the summer of 2007 in the area just south of where the railroad bridge crosses the canal (Figure 19). It is not known what level (percent frequency) storm produced this flooding, but is estimated likely to be smaller (more frequent) than the one percent annual recurrence interval flood event (Mr. Hung Thai - ODNR, personal communication, January 9, 2013). The photograph inset on Figure 19 was taken from the south bank of the canal, which is about five feet (1.5 m) higher than the towpath that is flooded. This particular location near canal is flooded because it is a low point due to the railroad crossing. The purpose of the towpath is for vehicular traffic along the canal for inspection and/or routine maintenance activities. Although the flood waters came very close during the 2007 flood event, there was no direct surface water connection between the canal and the Tuscarawas River at this location. The canal is located approximately 10-20 feet (3-6 m) to the right (north) of from where the inset photograph was taken in Figure 19.

Figure 19. FEMA one percent floodplain and location of backwater flooding from the Tuscarawas River to near the Ohio-Erie Canal in July-August, 2007. View of inset photo is looking southwest toward the railroad bridge, and the edge of the towpath along the canal can be seen just along right side of the photo. The Tuscarawas River is to the left of the photo and the canal is 10-20 feet (3-6 m) to the right. Photo courtesy of ODNR.

3.4 Groundwater

The area of concern is characterized by sand and gravel formations of the Pleistocene Age, Sharon sandstone and shale formations, and Pottsville sandstone and shale formations that can have varying hydraulic conductivities. Production of groundwater wells in these formations ranges from three to 250 gallons per minute (Oelker et al., Not Dated). The affect of groundwater on the potential for an aquatic pathway existing of being able to form would seem negligible at this site due to the perennial nature of the Portage Lakes and Canal.

3.5 Aquatic Pathway Temporal Characteristics

Characterizing the temporal variability of the pathway hydrology is an important aspect of understanding the likelihood of an ANS being able to traverse the basin divide at this location as flood events may coincide with species movement and reproduction patterns and abilities to survive and establish populations in various areas.

The USGS, in cooperation with the city of Akron, maintains three gages along the canal system: the feeder gate, the outlet at Wolf Creek, and Lock 1 (USGS, 2011b). These gages give insight into the flow characteristics of the system. The flow exceedance probabilities for each of the three gages are presented in Figures 20-23. These figures are based on data collected between June 1998 and June 2011, and indicate about how frequently (percentage of time) a certain flow volume is exceeded. Complementary to this flow exceedence data is information regarding the flow record at the three gages from 1998 through 2011 (Figure 22). This figure indicates what the flows were at each of the three locations over this 12 year period and is also another way of expressing how frequently various flows are exceeded. In addition, the Summit County FEMA FIS for a section of the Ohio-Erie Canal located north of Summit Lake within the city of Akron depicts a flow depth of approximately six feet (1.8 m) and 10 feet (3 m) for the 10 and two percent annual recurrence interval events, respectively.

Multiple potential surface water connection points within this system were evaluated and the frequency of these connections forming varied from perennial to requiring a flood event somewhere in excess of the one percent annual recurrence interval event. There is a perennial connection between the Mississippi River and the Great Lakes Basins via the Long Lake Flood Gates (Section 3.3.2) and the Long Lake Canal Feeder Gate (Section 3.3.3) that empties into the Ohio-Erie Canal (Section 3.3.1). The Flood Gates and feeder gate are the main aquatic connection features of this pathway that an ANS would need to use to move from the Mississippi River Basin into the Great Lakes Basin.

An intermittent aquatic connection may form between the Tuscarawas River and the Ohio-Erie Canal during extreme flood conditions downstream of the Long Lake flood gates, although it is not known what level flood event might initiate this connection (Section 3.3.8). Based on the professional judgement of staff from the ODNR, this condition has not yet occurred but came fairly close during a flood event in 2007 which was believed to be a smaller (more frequent) flood event than the one percent annual recurrence interval flood. There is also perennial flow between the Ohio-Erie Canal and Little Cuyahoga River (Great Lakes Basin) via Lock 1 to the north of Long Lake, although this is only toward the Great Lakes Basin (Section 3.3.6). Similarly, a perennial surface water connection also exists between the basins via the Wolf Creek Outlet Gate from the canal to the Tuscarawas River (Section 3.3.4). Lastly, a surface water connection between the basins at the side channel diversion into the Tuscarawas River (Section 3.3.5) and the Nimisila Reservoir spillway (Section 3.3.7) could only potentially form during more extreme flood events somewhere in excess of the one percent annual recurrence interval flood, as suggested by the FEMA FIS and ODNR staff.

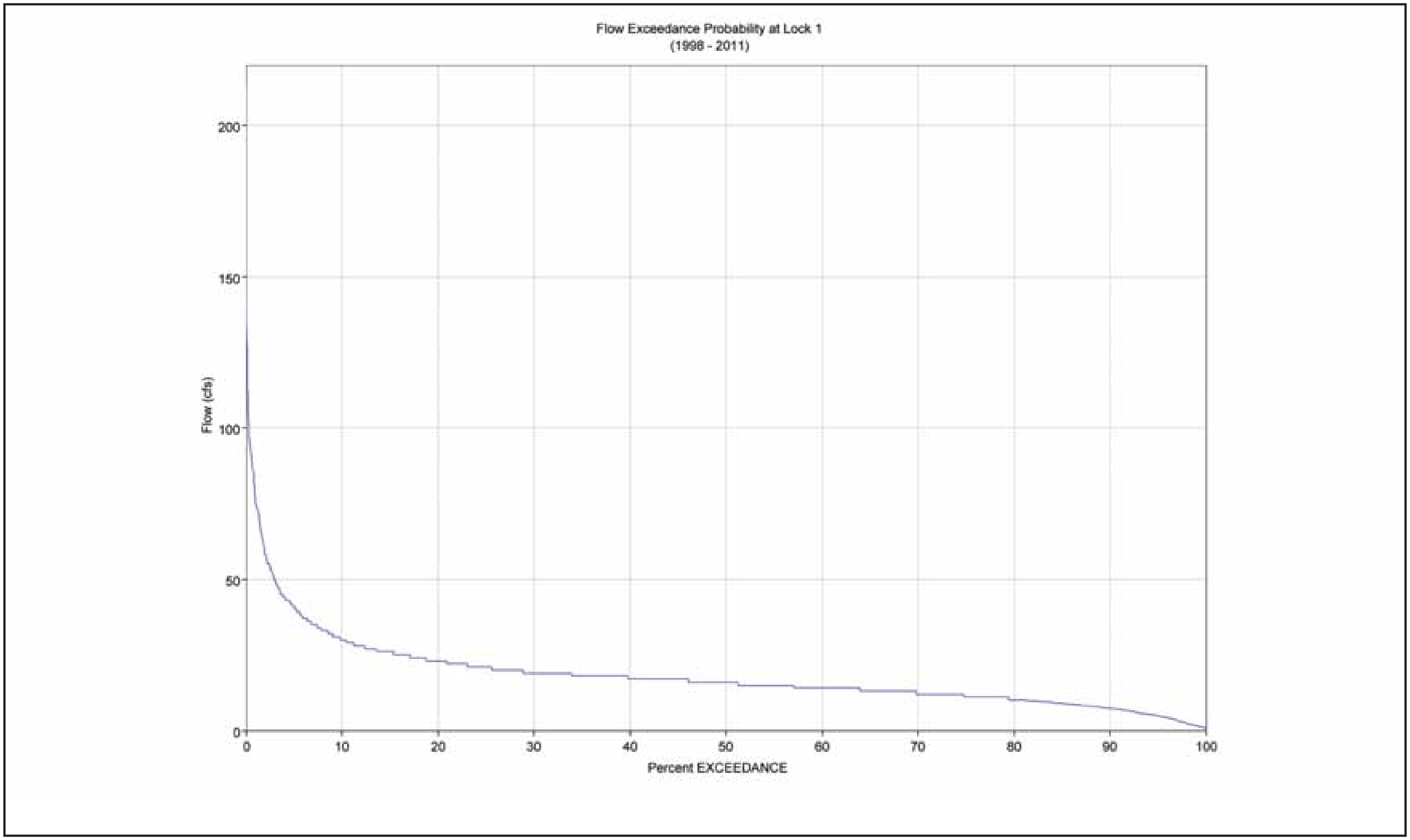


Figure 20. Lock 1 gage flow exceedance plot. For example, a flow of 30 cfs would be exceeded approximately ten percent of the time. Graph created by USACE based on USGS gage data (USGS, 2011a).

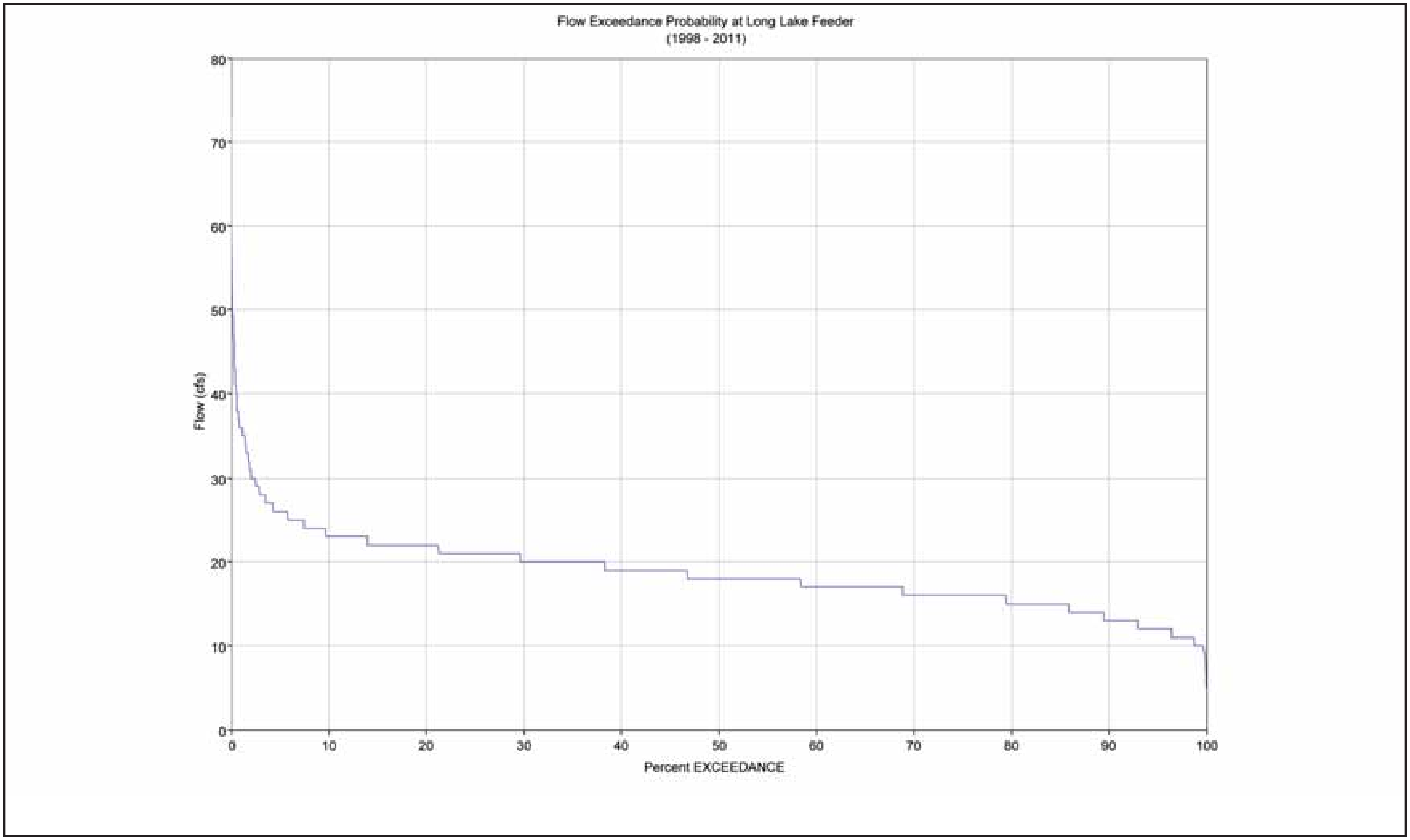


Figure 21. Long Lake feeder gage flow exceedance plot. For example, a flow of 30 cfs would be exceeded approximately three percent of the time. Graph created by USACE based on USGS gage data (USGS, 2011a).

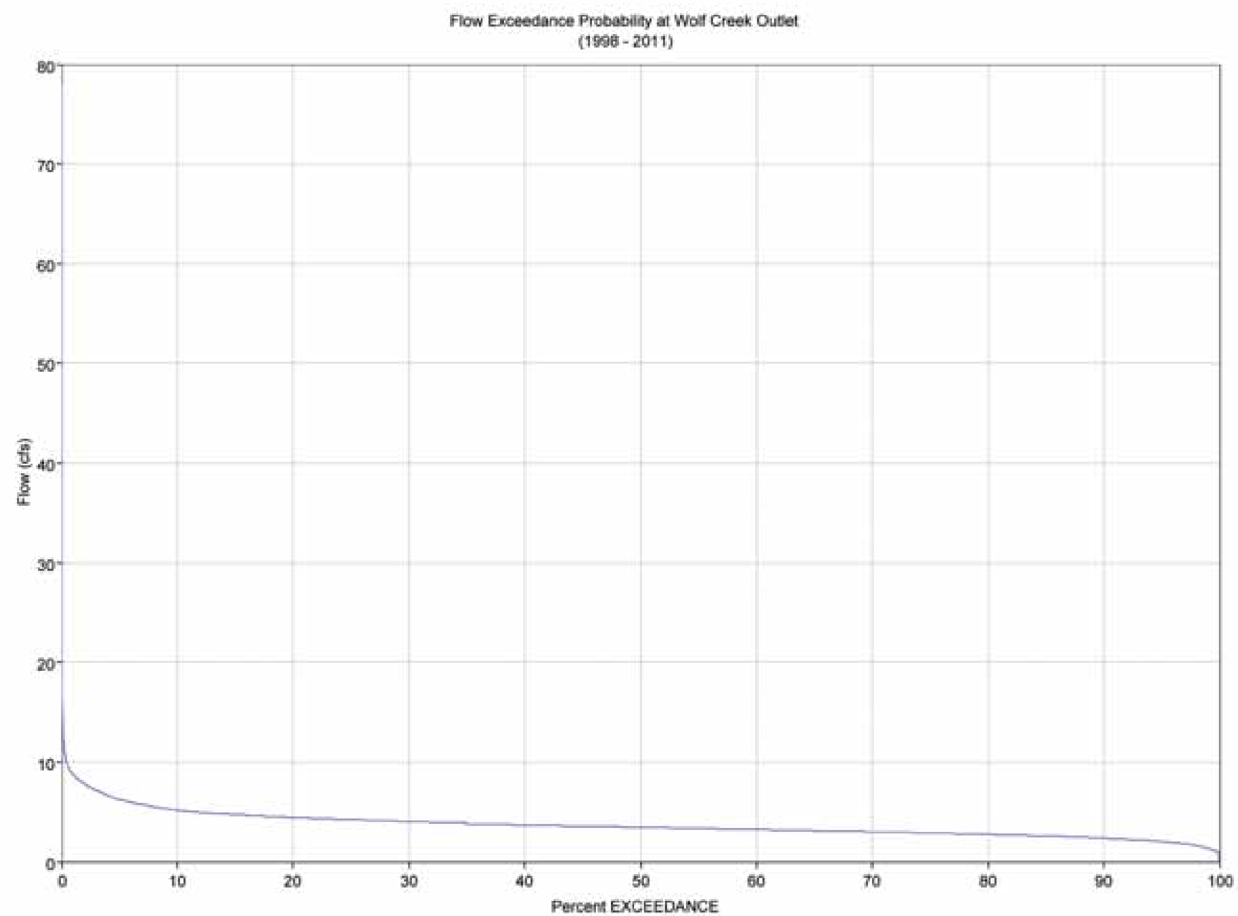


Figure 22: Wolf Creek gage flow exceedance plot. For example, a flow of five cfs would be exceeded approximately ten percent of the time. Graph created by USACE based on USGS gage data (USGS, 2011a).

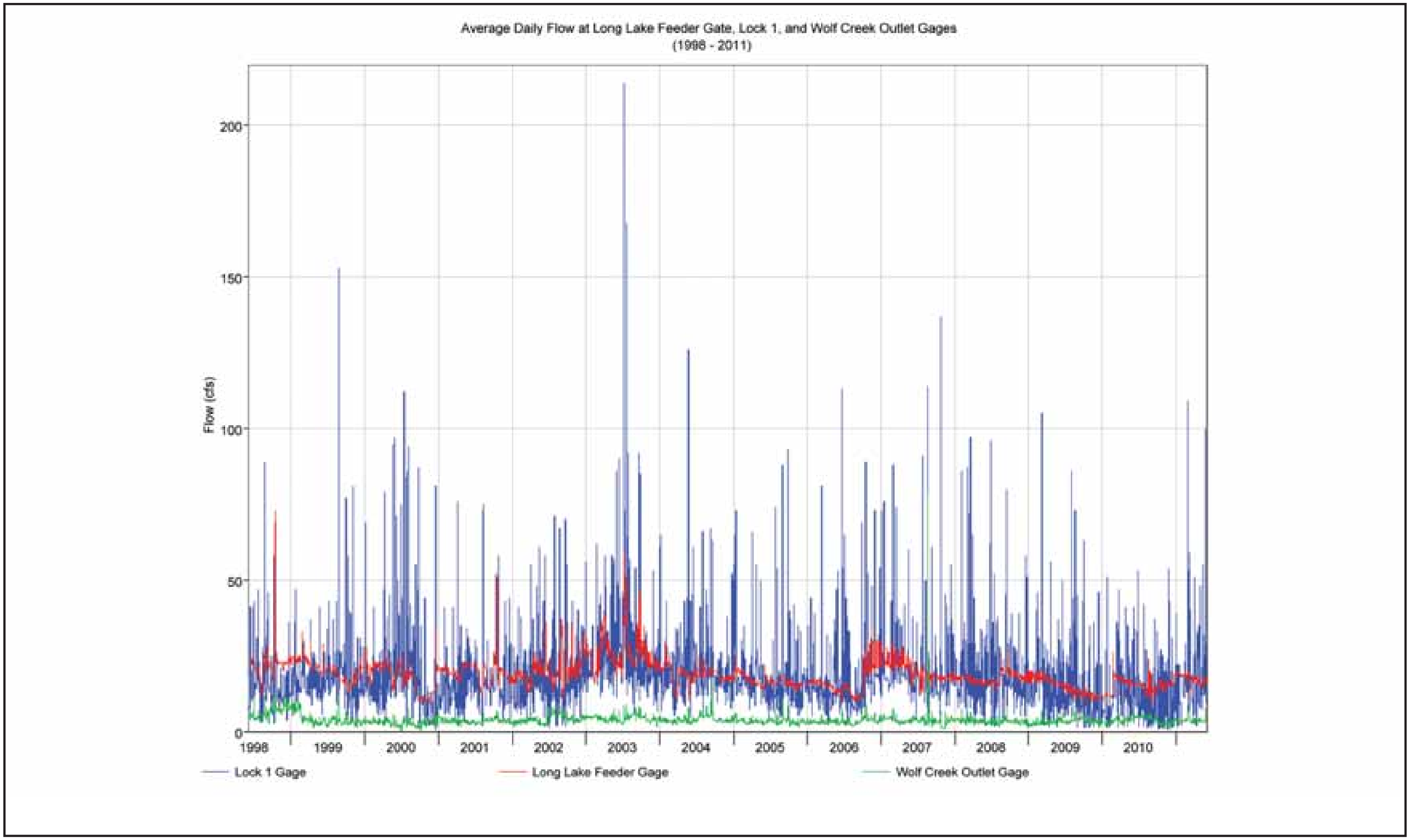


Figure 23. Flow at Long Lake feeder gage, Lock 1, and Wolf Creek outlet from 1998 to 2011. The most substantial flows are experienced through the Long Lake feeder gage location and the gage with the smallest amount of flows is the Wolf Creek outlet. Graph created by USACE based on USGS gage data (USGS, 2011a).

3.6 Probability Aquatic Pathway Exists

The rating discussed in this section is only for the likelihood of an aquatic connection existing at the Ohio-Erie Canal at Long Lake location (P_0) at up to a one percent annual recurrence interval storm and is not necessarily a reflection of the potential for any ANS to utilize such a connection to traverse between the basins. A surface water connection does exist between the Great Lakes and Mississippi River Basins at several of the locations considered during this investigation (i.e., Long Lake feeder gates, Long Lake flood gates, Nimisila Reservoir spillway, and Wolf Creek outlet) based on the following summary points:

- Flooding has been observed from backwater flow on the Tuscarawas River north toward the Ohio-Erie Canal downstream from the Long Lake flood gates, which is also an area within the mapped FEMA one percent annual recurrence interval floodplain;

- There is intermittent to perennial surface water flow from the Nimisila Reservoir through the Nimisila Dam spillway into Nimisila Creek (tributary to Tuscarawas River);

- There is perennial flow through Lock 1 on the Ohio-Erie Canal north of Summit Lake into the Great Lakes Basin, although with a significant elevation difference above and below the lock;

- Although more likely from an event less frequent than the one percent recurrence interval, flooding on the Tuscarawas River could submerge the three ogee weirs just upstream of the Wolf Creek outlet works, which could create an aquatic pathway between the Tuscarawas River and the Ohio-Erie Canal;

- A perennial aquatic pathway exists between Long Lake and the Ohio-Erie Canal via the Long Lake flood gates and the Long Lake feeder gates.

Although an aquatic connection exists between the Ohio-Erie Canal at Long Lake in the Portage area and the Little Cuyahoga River in Akron, the flow is only toward the Great Lakes Basin because of the 15 foot (4.6 m) vertical elevation difference above and below Lock 1. Because of the mixture of intermittent and perennial surface water connections at the Ohio-Erie Canal at Long Lake pathway which convey significant volumes of water continuously for days to weeks multiple times each year, a rating of high was assigned for the probability that an aquatic pathway exists on the Ohio-Erie Canal.

This rating is considered “very certain” based on the following:

- Flow data was available from ODNR who manages the water in the area regarding frequency and amount of flow at many of the locations evaluated;

- Available FEMA floodplain mapping covered much of the area between the Tuscarawas River and the Ohio-Erie Canal;

- Most of the uncertainty regarding pathway existence has to do with determining the exact interaction between the Ohio-Erie Canal itself with backwater flooding on the Tuscarawas River and Wolf Creek.

The team rating form for the probability of an aquatic pathway existing for the Ohio-Erie Canal at Long Lake aquatic pathway, along with associated definitions of the criteria that were used, can be found in Attachment A of this report.

3.7 Aquatic Pathway Habitat

3.7.1 Aquatic Resources

The Ohio-Erie Canal at Long Lake location consists of a variety of aquatic habitats. The network of Portage Lakes is a system of reservoirs and associated wetlands south of Akron, Ohio. The Portage Lakes are at three topographical levels. Long Lake is the lowest lake, and was formed by flooding a swamp area which had a small pothole lake at its south end. North reservoir, at the middle elevation, was formed by a dike flooding a flat area of land and a small pothole lake known as Hower Lake. At the highest elevation and impounding the largest acreage of water (1,192 acres or 482 ha) are three separate reservoirs: East, West, and Turkeyfoot Lake. Turkeyfoot Lake is connected to West Reservoir by a channel. West Reservoir overflows into North Reservoir and is connected to East Reservoir by a channel. East Reservoir has a control structure from which water is released into a channel which then flows into Long Lake. The surface acreages and average lake depths are as follows:

Turkeyfoot Lake:
483 surface acres (195 ha)
12.6 feet average depth (3.8 m)

West Reservoir:
105 surface acres (42 ha)
11.3 feet average depth (3.4 m)

East Reservoir:
208 surface acres (84 ha)
14.8 feet average depth (4.5 m)

North Reservoir:
165 surface acres (67 ha)
10.0 feet average depth (3 m)

Long Lake:
231 surface acres (93 ha)
16.3 feet average depth (5 m)

A significant portion of the Portage Lake system supports a variety of wetland habitats, including the six acre (2.4 ha) Portage Lakes Wetland State Nature Preserve between Long Lake and the East Reservoir, which is a remnant of a larger tamarack swamp and is now primarily a tall shrub sphagnum bog community dominated by speckled alder and arrow wood. Some rare species found growing there include swamp birch, tamarack, alder-leaved buckthorn and smooth gooseberry. These wetland ecosystems play an important role in the life history of the species that utilize its resources. The USFWS National Wetlands Inventory Map (NWI) displays the approximate locations of wetland habitat in this region (Figure 24). An typical image of this wetland habitat is provided in Figure 25.

3.7.2 Water Quantity and Quality

In general, water quality within the Ohio-Erie Canal at Long Lake pathway site is adequate for the support of most aquatic organisms. The water quality within Long Lake itself supports a diverse recreational fishery (ODNR, 2012c). Adjacent to the lake is a large wetland complex that separates the lake from two other connected lakes and provides a buffer to much of the residential development surrounding the area. The lake and its outflows would provide a consistent source of water and habitat for most aquatic organisms.

From the south side of the city of Akron, the Tuscarawas River drains a 2,589 square mile (6,705 square kilometer) watershed and flows through both urban and rural environments. Estimates of land cover in the upper portion of the Tuscarawas Watershed are 17 percent urban, 36 percent pastureland, 20 percent row crop, 22 percent forest, and five percent surface water (OEPA, 2009). Due to the land use mixture, water quality within the upper Tuscarawas River Watershed is fairly low and most of the municipal and industrial discharges to the river are within Summit and Stark Counties. The primary impairments within the watershed are nutrient enrichment, habitat alteration, sediment, organic enrichment/dissolved oxygen, and pathogens (OEPA, 2009). However, it is believed to be adequate to meet the habitat and forage needs of most ANS.

The Ohio-Erie Canal functions as a series of ponds with very little flow through the system. Sufficient water is provided to the canal by the outflow from Long Lake which helps to mobilize the downstream flow of floating vegetation (e.g., algae) and ensure that the canal does not turn anoxic. The canal also gets aerated downstream of each of the locks that lead to its confluence with the Little Cuyahoga River north of Summit Lake. Both the canal and the Little Cuyahoga River are surrounded by industrial and residential land uses. Water quality is impacted by industrial and municipal discharges leading to eutrophication, low dissolved oxygen, and adverse habitat alterations (OEPA, 2003). Despite low water quality, this system is capable of supporting ANS.

Water diverted from Long Lake into the Ohio-Erie Canal

Figure 24. National Wetland Inventory mapping in area of interest (USFWS, 2012a). Background imagery courtesy of Bing Maps.


Figure 25. Long Lake and associated wetland habitat. Photo by USACE.

flows freely through the canal and eventually into either the Tuscarawas River or the Little Cuyahoga River. The Ohio-Erie Canal and Little Cuyahoga River sub-watershed drains the Akron metropolitan area and is among the most urbanized and densely populated in the state. Housing density within the sub-basin is most dense in areas along the course of the river, and tends to increase from upstream to downstream. Urban runoff is a well documented source of nonpoint pollution to surface waters, the effects of which on aquatic life are usually exacerbated where sanitary and storm water sewers are combined and discharge into receiving streams (OEPA, 2003).

Aquatic habitat quality becomes substantially better downstream of the confluence of the Little Cuyahoga and Cuyahoga Rivers at the southern end of the Cuyahoga Valley National Park. High quality physical habitat attributes are found in this reach of the Cuyahoga River and typically include natural stream channels, coarse substrates, and wooded riparian corridors. Further downstream towards Lake Erie, the aquatic habitat conditions within the Cuyahoga River deteriorate as the landscape becomes increasingly urbanized is it approaches Cleveland and Lake Erie (OEPA, 1999). The Lower Cuyahoga River was designated as a Great Lakes Area of Concern (AOC) in 1985 by the Water Quality Board of the International Joint Commission. Some of the beneficial use impairments for this AOC include degradation of fish and wildlife populations, degradation of benthos, eutrophication, and loss of fish and wildlife habitat (OEPA, 2008).

3.7.3 Aquatic Organisms

The Portage Lakes support popular sport fish such as largemouth bass, black and white crappie, bluegill, redear sunfish, pumpkinseed, warmouth sunfish, yellow perch, channel catfish, bullhead, white sucker, and carp. Long Lake is one of the few inland lakes in Ohio where OEPA has conducted a detailed electro-fishing survey of the entire fish community (OEPA, 1998). The overall fish community was dominated by bluegill sunfish (40 to 60 percent of all fish collected), warmouth sunfish (nine to 20 percent), and bluntnose minnow (one to 18 percent). Other game fish collected included white and black crappie, largemouth bass, yellow perch, and pumpkinseed sunfish. During this survey, OEPA documented the presence of two rare species of fish, the Iowa darter which is listed as state "Special Interest", and the pugnose minnow, listed as state "Endangered" (ODNR, 2012c). The potential for rare aquatic plants also exists. However, no survey of aquatic plants has been conducted. Federally listed threatened and endangered species within Summit County, Ohio include the Indiana bat (*Myotis sodalis*) and northern monkshood (*Aconitum noveboracense*) (USFWS, 2012b).

3.8 Connecting Streams to Great Lakes and Mississippi or Ohio River

The flow path from the Ohio River to the aquatic pathway location at the Ohio-Erie Canal at Long Lake is 112 miles (180 km) upstream through the Muskingum River to the Tuscarawas River, and from there another 115 miles (185 km) upstream to the Long Lake flood gates in Portage, Ohio. The flow path from this point into the Great Lakes Basin is through the Long Lake feeder gates into the Ohio-Erie Canal and then three miles (4.8 km) north to Summit Lake. From Summit Lake, the flow path continues about 4.7 miles (7.6 km) through the canal to Lock 1, and finally another 1.3 miles (2.1 km) north into the Little Cuyahoga River. The Little Cuyahoga River then enters the Cuyahoga River downstream and eventually enters Lake Erie at Cleveland, Ohio (Figure 26). The flow path depicted in Figure 24 also indicates the location of the potential instream obstacles from the Ohio River to the pathway location. Although there are several low head dams, small waterfalls, and lakes between the pathway and Lake Erie, the only real barrier to upstream movement of ANS from the Great Lakes to the pathway location is at Lock 1, which provides for a 15 foot (4.6 m) elevation difference between upstream and downstream of the lock.

There are many potential obstructions along the flow path from the Ohio River to the pathway, including 13 navigation lock and dams along the Ohio River, 10 low head dams (relic navigation dams), and three dams along the Tuscarawas River. Pancake Lake Dam and Lake Lucern Dam are located on tributaries to the Tuscarawas River and therefore would not impede potential upstream ANS movement on the main stem of the Tuscarawas River. The presence of navigation dams on the Ohio River does not seem to provide a reliable obstacle to prevent the upstream passage of ANS based on the movement of Asian carp to date through the Mississippi and Illinois Rivers. A schematic drawing of the Ohio River Lock and Dam system is presented in Figure 27.

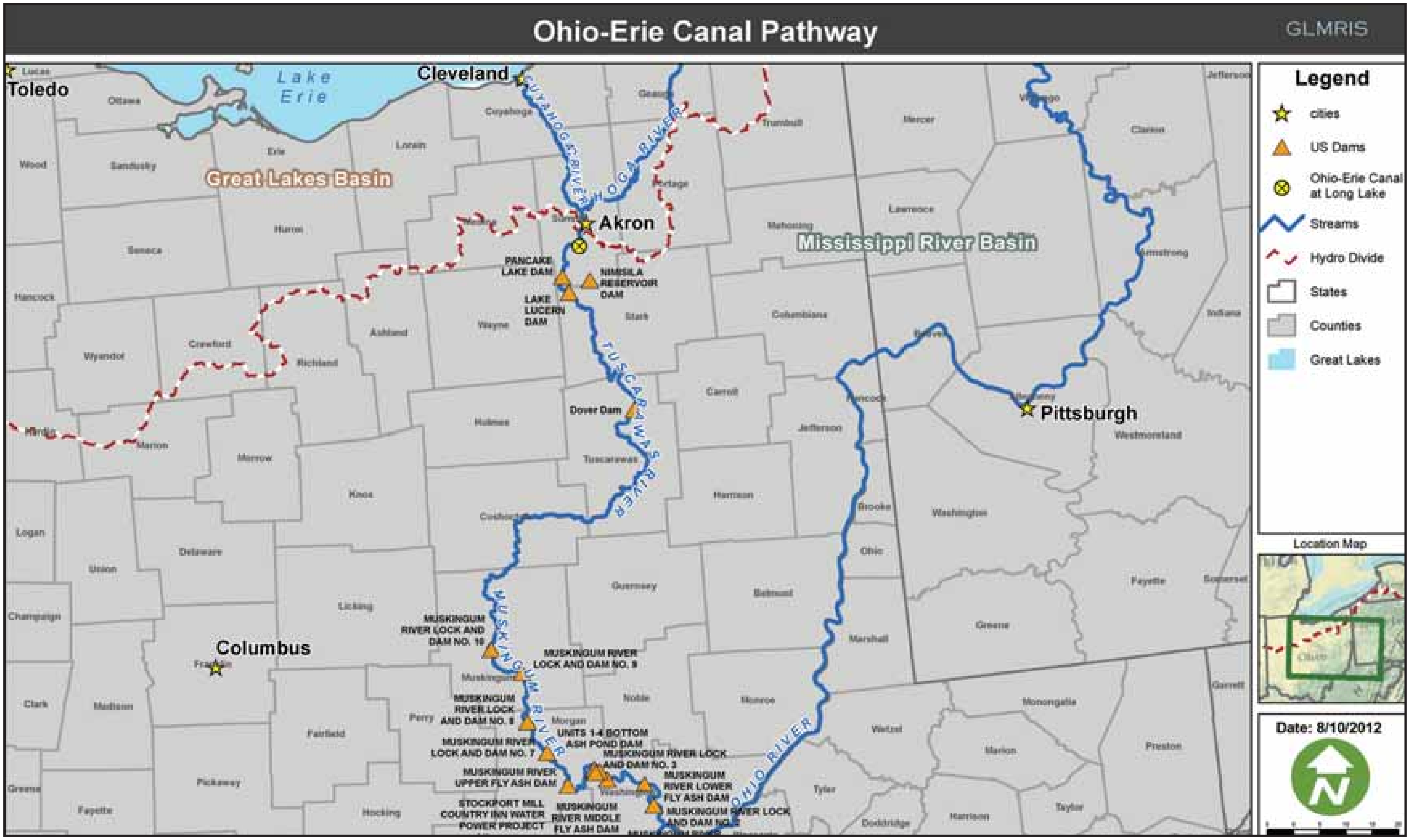


Figure 26. Flow path from the Ohio-Erie Canal at Long Lake to both the Ohio River and Lake Erie, along with location of potential instream obstructions to the upstream movement of ANS (NID, 2010). Background imagery courtesy of Bing Maps.

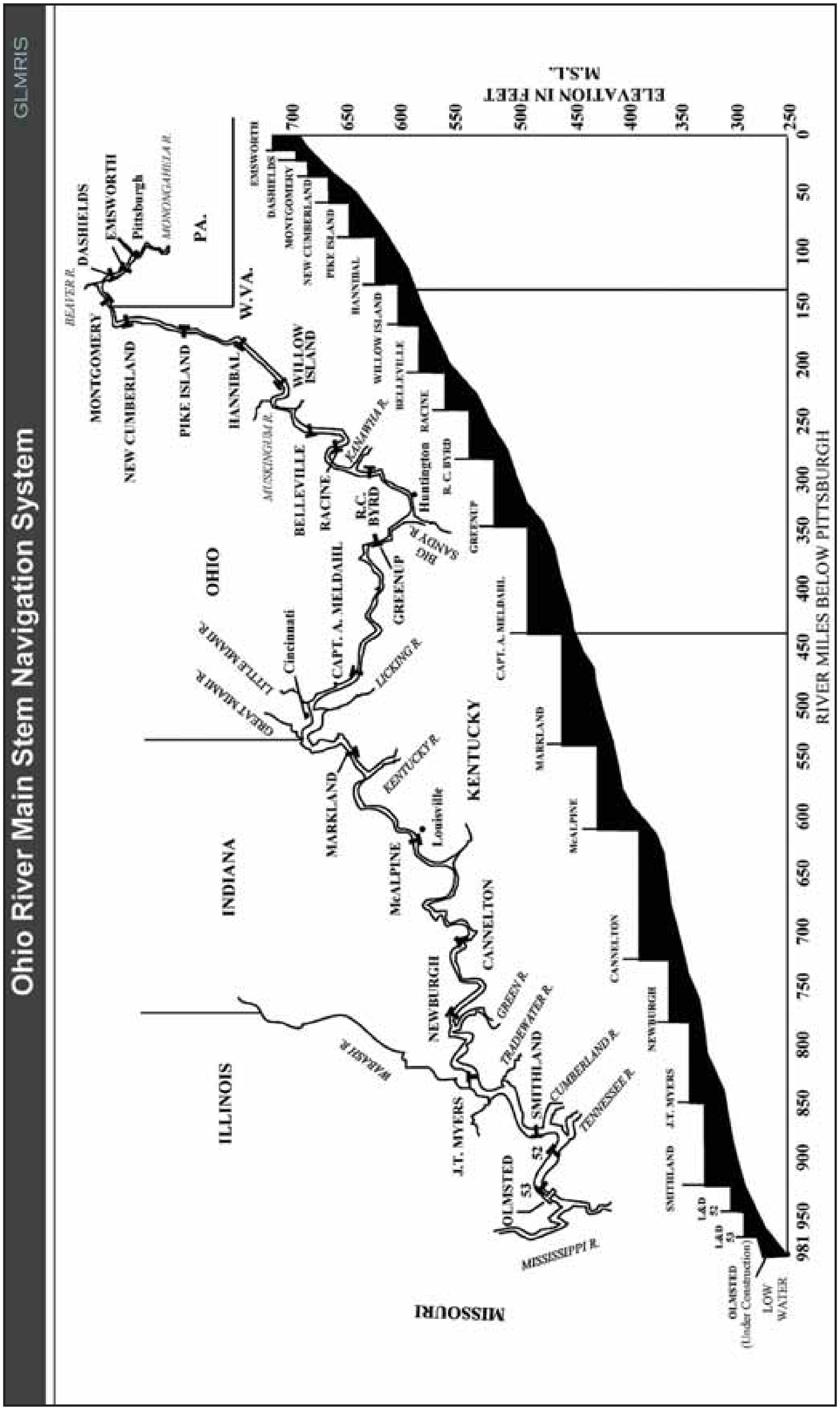


Figure 27. Ohio River Navigation System illustrating the relative distance and magnitude of the navigation structures and normal pools. Figure by USACE.

3.8.1 Muskingum and Tuscarawas River Structures

The ten non-operational locks and dams along the Muskingum River and two unnamed low head dams on the Tuscarawas River (Dover Dam will be discussed in the next section) may prevent the upstream movement of an ANS during most flow conditions (Table 8). The dams on the Muskingum River range in hydraulic height from 11.6 to 20.1 feet (3.5-6.1 m) during normal flow conditions. Flood profiles were developed by the USACE for the Muskingum Watershed Conservancy District for the Muskingum River in 1936, which incorporates the proposed (now built) reservoirs in the basin (USACE, 1936). The study evaluated the effect of these non-operational navigation structures on water surface profiles given discrete flow frequencies. Given that the study was performed in 1936, it may not be consistent with current hydrologic and hydraulic conditions and/or computational procedures, but may offer good planning level insight to the relative frequency of submergence of these structures.

Based on the 1936 study, all of the locks and dams on the Muskingum River are overtopped by various amounts of floodwater on an annual basis (99 percent annual recurrence interval). The information presented in Table 2 compares the top (obstacle) elevation of each dam on the river against the approximate water elevation of different flow events. For example, at Lock and Dam No. 3 the one year storm would result in approximately 2.7 feet (82 cm) of flow over the top of the dam and the 100-year (one percent annual recurrence interval) event would result in approximately 20.6 feet (6.3 m) over the top of the dam. However, it is important to keep in mind that these are just estimates and not based on current hydrologic analysis and computational procedure. In addition, the amount of water flowing over the dam at a particular hydrologic event is not necessarily directly related to the ability of an ANS to pass through that flow. For example, at some undetermined flood event (which varies for each structure), there is likely to be enough flow over the dam such that there is not a large head difference between the upstream flow and the downstream tailwater, making it easier for a potential ANS to pass upstream of the structure. Very little information is available regarding the two unnamed low head dams on the Tuscarawas River, but it is assumed because they are low head dams that they would be inundated during flood events.

The USACE Huntington District has identified great river fish passage as a project opportunity on the Muskingum River. Removal of dams and/or construction of fish passage ladders on the Muskingum River have been described as potential ecosystem restoration projects. These projects would allow for better movement and spawning opportunities for great river fish which have seen population declines since the lock and dam systems were constructed. Conversely, this may also aid the spread of ANS upstream towards the divide by decreasing the effectiveness of current obstacles in the river.

3.8.2 Dover Dam

Dover Dam is located on the Tuscarawas River in Tuscarawas County, about 3.5 miles (5.6 km) northeast of Dover, Ohio. The dam is one of a series of 16 USACE flood control dams in the Muskingum Watershed. It is a concrete gravity structure constructed with a maximum height of 83 feet (25 m) above the riverbed (Figure 28). Dover Dam is a “dry dam”, meaning that it does not maintain a normal pool during low flow conditions. An uncontrolled ogee spillway is located at the center of the structure. There are 18 gated conduits that provide flow through the dam below the flood control pool. Looking downstream, the right group of sluices is the lowest (inverts at elevation 862 feet) and are controlled by five foot by 10 foot (1.5x3 m) gates. The left group is the next lowest (invert elevations at 867 feet) and are controlled by seven foot by seven foot (2.1x2.1 m) gates. The center group of sluices is the highest (invert elevations at 872 feet) and are also controlled by seven foot by seven foot (2.1x2.1 m) gates (Figure 29). During normal flows, the lower bay gates are fully open and a run of river condition exists.

From a flow standpoint, the most likely means for ANS to move upstream past this dam is at low or normal flow conditions through the lowest elevation sluice gates. At higher flows, the pressure of the water through the conduits would produce extreme velocities that would

Table 8: Potential Obstacles for ANS Movement through the Muskingum and Tuscarawas Rivers (USACE, 1936; NID, 2010).

River	Name	RM	Obstacle Elev. (feet-NAVD88)	NIDHyd. Height(feet)	1 yr	2 yr	5yr	10yr	15yr	25yr	50yr	100yr
Muskingum River	Lock and Dam No 2	5.7	593.5	17.5	603.1	606.7	611.9	614.5	616.8	619.5	623.5	627
	Lock and Dam No 3	14	607.6	17.6	610.3	613.7	617.9	619	621.2	622.5	625.9	628.2
	Lock and Dam No 4	25	617.0	17	623.9	626	629	630.8	632.4	634	637.1	640.1
	Luke Chute lock and Dam (Dam No 5)	34	627.7	19.7	633.7	636	639.5	642	643.5	645.9	648.5	652.5
	Stockport Lock and Dam (Dam No 6)	40	640.1	20	642	643	646	648.8	650.4	652.5	655.5	659.7
	Malt Lock and Dam (Dam No 7)	49	650.2	15.2	656	658	661.1	663.8	665.8	667.7	670.5	674.5
	Rokeby Lock and Dam (Dam No 8)	57	661.1	20.1	666	667	669.1	671.2	672.4	673.8	676.9	679.8
	Lock and Dam No 9	68	672.1	18.5	679.8	680.5	682	684.2	685.9	687.2	690	692.2
	Dam No 10	77	687.6	11.6	692	693.5	696.4	697.5	698	698.2	700.7	702
	Lock and Dam No 11	85.5	699.3	15.3	704.8	705	705.9	706.8	707.7	709	710.2	714
Tuscarawas River	Unnamed Dam 1	57.5	N/A	N/A	N/A	N/A	N/A	866	N/A	N/A	867	868
	Dover Dam	63	N/A	56	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Unnamed Dam 2	68.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

likely prohibit the movement of ANS upstream past the dam. This is supported by operation staff at the dam who believe it to be likely that fish could easily pass upstream of the dam during low flow conditions. The probability of exceedance of a particular pool elevation and reservoir outflow is shown in Figure 30. This figure suggests that a hydrologic condition that might allow for an ANS to move upstream through Dover Dam would occur approximately 86 percent of the time.

Figure 28. Dover Dam during higher flow conditions. Downstream is toward the bottom of the photo. The sluices at the lowest elevation and that have run of the river flow at normal, lower flow conditions are on the left side of the picture. Photo courtesy of USACE, Huntington District.

Figure 29. View of the upstream side of Dover Dam looking at the openings to most of the 18 gated conduits through the dam. From left to right are the intermediate, high flow, and low flow conduits, respectively. Photo courtesy of USACE-Huntington District.

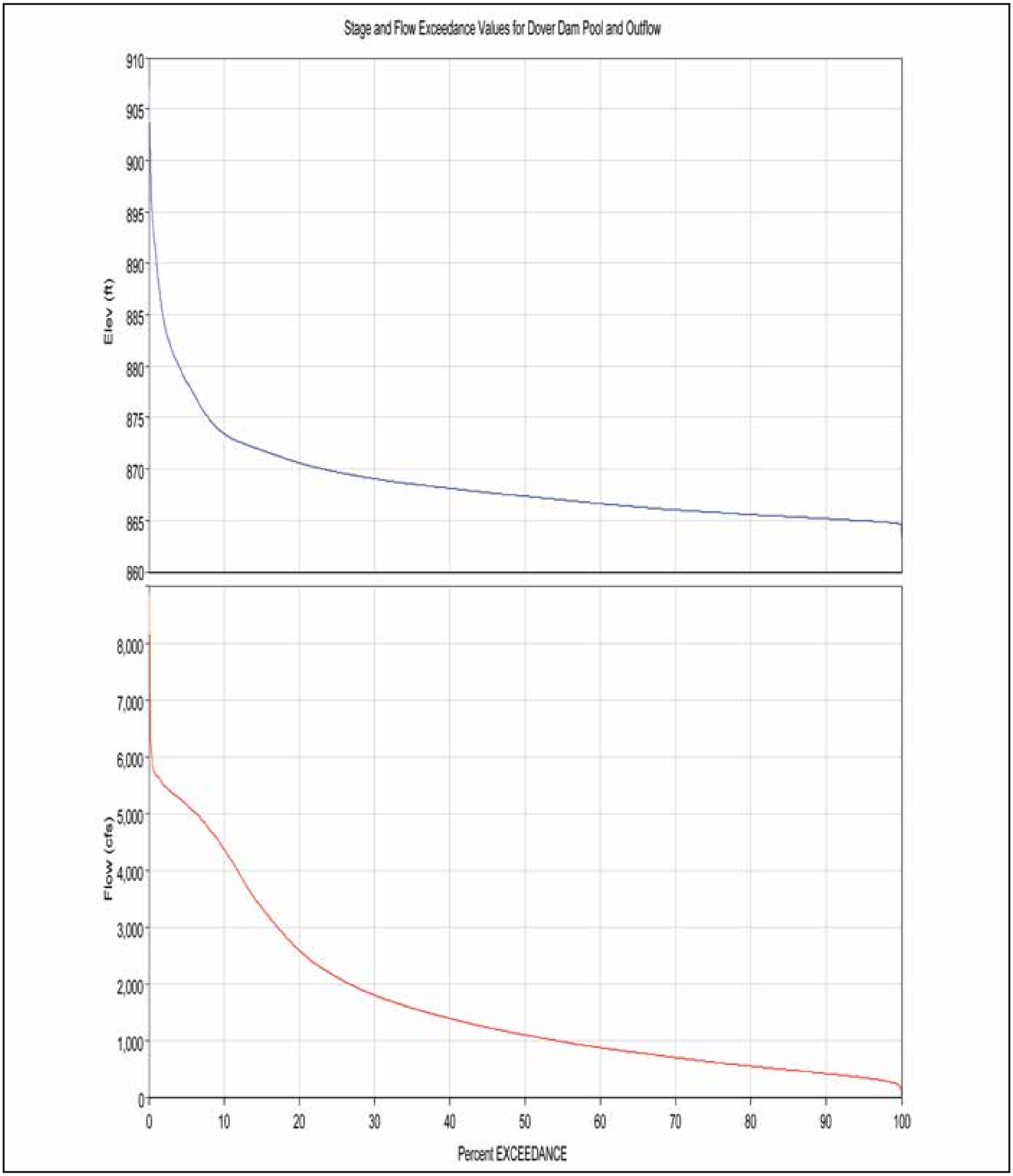


Figure 30. Pool elevation and outflow exceedance probabilities (USACE-Huntington District).

4 Aquatic Pathway Viability for ANS of Concern

The viability of the aquatic pathway was assessed by the project team for the ANS of concern for Ohio-Erie Canal at Long Lake location in accordance with the procedures outlined in the Methodology Section of this report. This potential was characterized as high, medium, or low for the following categories:

- Probability that pathway exists (Section 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

These characterizations were completed by a team of agency biologists for each species under consideration. A team probability and certainty rating also is provided. The rating represents the most conservative probability assessment for each category considered. The forms describing the probability and certainty ratings from all agency professionals participating in this assessment is included at Attachment A.

4.1 Probability of the ANS being within either basin

General Considerations for Assigning Probability Ratings:

High - Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.

Medium - Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.

Low - Target ANS is not known to exist on a connected waterway.

Certainty ratings were applied as outlined above.

Asian Carp

Silver carp and bighead carp are established in the middle and lower Mississippi River Basin. Successful breeding populations seem to stop near Louisville, Kentucky. Occurrences of the bighead carp have been noted in the Upper Ohio River Basin including Moundsville, West Virginia and the Mahoning River in Ohio. Black carp may be established in portions of the lower Mississippi River Basin and they have also been reported in the Mississippi River upstream of the mouth of the Ohio River. The known distribution of black carp is not as extensive as the silver and bighead carp. Asian carp species are established in the Ohio River Basin.

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

Northern Snakehead

The northern snakehead was found in 2008 in Monroe, Arkansas (> 250 miles (402 km) from the Ohio-Erie Canal at Long Lake site, and further by stream mile), and has since established a reproducing population in that area. Although in a different basin, this species is also established in the Potomac River in Maryland and Virginia (USGS, 2011b).

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

Skipjack Herring

The native range of skipjack herring includes the Mississippi River Basin from central Minnesota south to the Gulf of Mexico, and from southwestern Pennsylvania west to eastern South Dakota, Nebraska, Kansas, Oklahoma, and Texas (USGS, 2011b). Skipjack herring have been collected in Lake Michigan, but it has not yet been determined if the species is established in the basin. From the years 1989-1993, three separate collections were made by Wisconsin commercial fisherman. Since they are a migratory species, dams often impede their reproduction. Records indicate that this species was much more abundant in the Upper Mississippi River Basin before it was impounded. Current range distribution maps suggest that the species is established within the main stem of the Muskigum River approximately 50-100 miles (80-161 km) away from the aquatic pathway (NatureServe, 2012).

Team Rating: **High**
Team Certainty Rating: Very 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 the location and have ample opportunity, capability, and motivation to successfully navigate through the connecting streams to arrive at the subject pathway within 10 to 20 years.

Medium - Target ANS are established at locations in close enough proximity to the location and have limited capability to survive passage through the connecting streams to arrive at the subject pathway within 20 to 50 years.

Low - Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations through the connectin streams to arrive at the subject pathway within next 50 years.

Asian Carp

Spawning of silver and bighead carp is initiated by rising water levels following the heavy rains (Jennings 1988; Verigin et al. 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)). There are no obstacles in the Tuscarawas or Muskingum Rivers that would permanently prevent the upstream movement of silver carp or bighead carp to the pathway location. Habitat present within most of these rivers is not ideal for silver and bighead carp, which are native to and thrive in larger river systems, but it is not known to what extent the smaller size of these rivers may prevent the upstream movement of Asian carp to the pathway. Bighead carp are zooplanktivorous, while silver carp consume smaller phytoplankton and fine particulate organic matter

(Williamson and Garvey 2005; Dong and Li, 1994). However, sufficient forage is believed to be available for both species throughout the river systems downstream of the pathway, including the Muskingum and Tusacarawas Rivers. Forage abundance and diversity likely decreases moving upstream towards the pathway as flow volume decreases.

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). 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, such as dams, to continue their upstream movement (D. Chapman-USGS, personal communication, September 12, 2011 and N. Caswell-USFWS, personal communication September 12, 2011). The gradient needed to prevent juvenile fish from moving up streams is unknown. Thus it is unclear if the gradients of the Muskingum or Tuscarawas Rivers are sufficient to prevent potential future upstream movement of young carp. 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) through 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 ability for Asian carp to survive transit upstream to the Ohio-Erie Canal is supported by the moderate levels of habitat and forage that would likely be provided by the Muskingum and Tuscarawas Rivers. However, it is believed that this group of fish has yet to establish any breeding populations above the McAlpine Pool on the Ohio River which is greater than 500 river miles (805 km) away. The nature of the Upper Ohio River is vastly different from the Lower Ohio River where successful populations have established. The lower river provides many backwater areas that Asian carp prefer. In general, the upper river is characterized by narrower valleys, smaller floodplains, and less backwater areas. This lack of preferred habitat on the Upper Ohio River may be the obstacle that cannot be overcome by Asian carp (D. Chapman-–USGS, and J. Thomas-ORSANCO, and J. Stark-The Nature Conservancy, personal Communication, June 2011).

Bighead carp do not show the athletic jumping ability of the silver carp, but it is still a strong swimmer. The hydraulic nature (e.g., head, flow, and current) of the pathway should prevent the bighead carp from moving into Long Lake through the outlet structure. However, the silver carp, with its jumping ability, could possibly make a lateral jump from the Tuscarawas River to the Ohio-Erie Canal at the ogee weir and the area of backwater flooding of the Tuscarawas River near the railroad bridge. However, this would likely only be during a storm event at or in excess of the one percent annual recurrence interval.

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

Northern Snakehead

The northern snakehead is an incredibly resilient species that can survive out of the water for short periods of time and the young can even move overland short distances between bodies of water. 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 back-waters and marshes (Courtenay, Jr. and Williams 2004). The northern snakehead likely possesses the ability to move through the aquatic pathway to the Ohio-Erie Canal at Long Lake. For example, it could possibly enter the canal at areas inundated by backwater flooding from the Tuscarawas River, where flooding abuts close to the south bank of the canal at the railroad crossing and where it may be able to move the short distance over the canal berm (Figure 19). However, its preferred habit is not flowing waters, which will likely slow its spread up the Mississippi River and its tributaries. The lack of backwater and marsh areas in the Upper Ohio River, Muskingum, and Tuscarawas Rivers may impede the movement of the snakehead to the pathway. Unlike the Asian carps, northern snakeheads do not make long upstream spawning runs and, as a result, are not likely to spread quickly through the Mississippi River Basin without the aid of anthropogenic means. Despite its preference for stagnant, oxygen-depleted back waters and marshes, the northern snakehead has been consistently caught by anglers in the Potomac River near Great Falls, Virginia during spring high flow events (J. Newhard-USFWS, personal communication, December 22, 2011). Based on data from external tags recaptured by anglers, in rare instances, northern snakehead have been found to move as far as 50 river miles (80 km) upstream at a rate of approximately one mile (1.6 km) per day. This extensive movement typically occurs in the spring with the fish returning back downstream to slower moving water in the summer (J. Newhard-USFWS, personal communication, December 22, 2011). The lack of backwater and marsh areas in the Upper Ohio and Muskingum Rivers may impede the movement of the snakehead to the pathway.

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

Skipjack Herring

Skipjack herring are a migratory species found in larger rivers, often in areas of swift current. In Ohio this species is only found in the Ohio River and its larger tributaries, particularly the Scioto River and Muskingum (ODNR, 2011). Skipjack herring are strongly migratory within rivers and prefer fast flowing water where they are renowned for leaping. They are found in clear to moderately turbid waters in large rivers and reservoirs usually within the current over sand or gravel (Page and Burr, 1991). Skipjack herring feed in large schools with adults feeding on other herring species such as the threadfin shad, gizzard shad, and young of the year herring species, while the juveniles feed on dipterans and other aquatic insects. Since skipjack herring tend to prefer large fast flowing rivers, it is unlikely that they would move upstream of their current range in the mainstem Muskingum River into the smaller, more turbid, tributaries leading the Ohio-Erie Canal pathway. Despite the connectivity of the Tuscarawas River to its native range further down the Ohio River Basin, the skipjack herring has never been recorded in that drainage. This is likely due to the affinity of the fish to large river habitat. The Tuscarawas River likely does not contain suitable habitat to allow for a successfully breeding population. As noted by Trautman (1981), "it is absurd to expect this deep and swift-water inhabiting species to migrate across Ohio through the sluggish canals when it does not penetrate far inland in the largest unobstructed streams in the Ohio drainage."

Team Rating: **Low**
Team Certainty Rating: Moderately Certain

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

Long Lake is part of a larger system of lakes known as the Portage Lakes (Figure 31). In 1825, the Ohio Legislature appropriated funds for the construction of a large network of canals and reservoirs to supply water for the Ohio-Erie Canal System. The Portage Lakes, a series of lakes south of Akron, were created as water supply reservoirs to satisfy this need. They were formed by the construction of dikes and dams to raise water levels within swamps and existing small lakes in this area. The area is used largely for recreational purposes today.

Popular sport fish of interest to anglers in these lakes consist of largemouth bass, black and white crappie, bluegill, redear sunfish, pumpkinseed, warmouth sunfish, yellow perch, channel catfish, bullhead, white sucker, and carp. The abundance of fishing at Long Lake and within the Portage Lakes as a whole may present a threat for the transfer of ANS via water craft, associated equipment, and fishing gear. From April to July, 2010, the ODNR-Wildlife District Office conducted a survey of anglers (167) on Long Lake. The results of this survey indicate that anglers at Long Lake travel from the Great Lakes

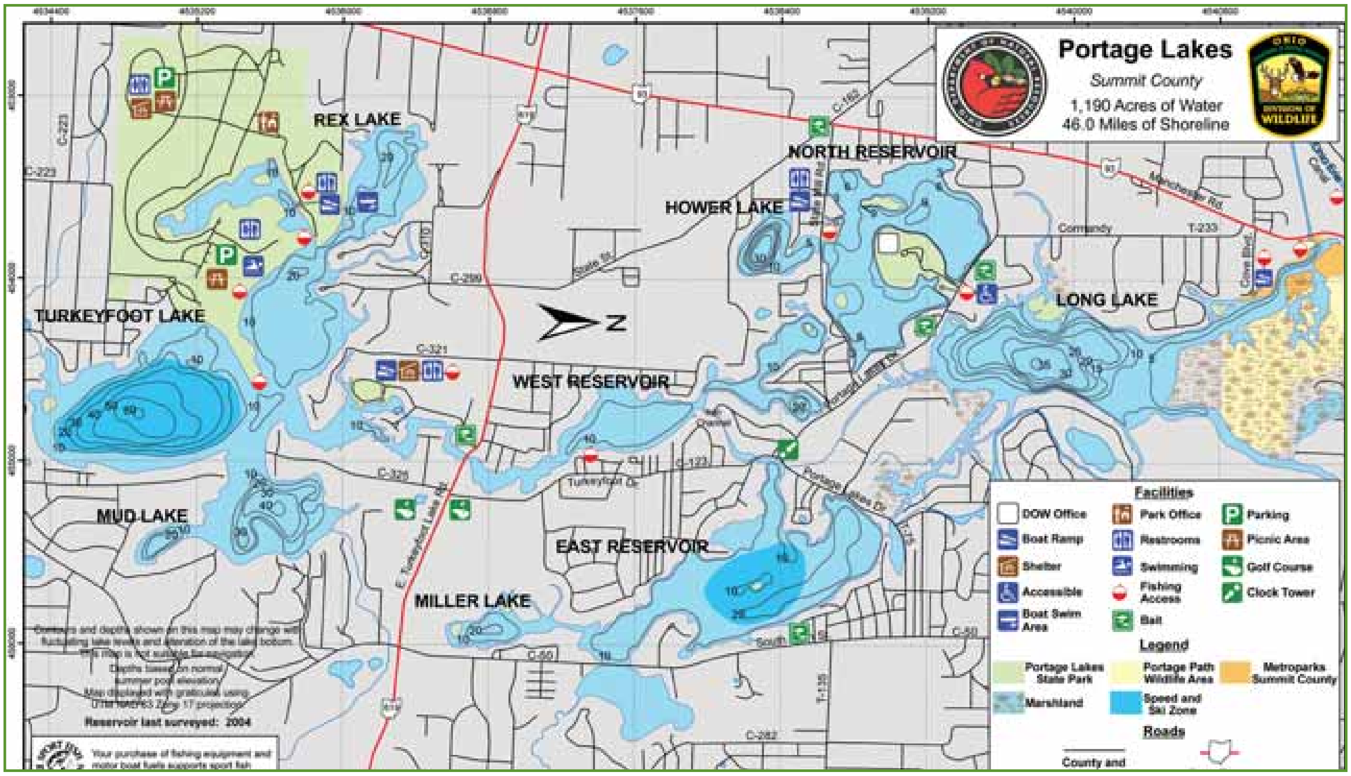


Figure 31 . Portage Lakes vicinity and recreational map (ODNR, 2012d).

Basin, the Mississippi River Basin, and the Chesapeake Bay Basin in order to fish on Long Lake (Figure 32).

Considering the widespread distribution of anglers and the level of recreational activity within the Portage Lakes, it is reasonable to conclude that the potential for transfer of ANS between the Great Lakes and Mississippi River Basins by non-aquatic, anthropogenic vectors is a possibility.

However, the ratings associated with such non-aquatic vectors in this section do not influence the overall pathway rating outlined in this report and are only included to point out other potential pathways (e.g., anthropogenic) that may be important to different audiences. Any further analysis of these non-aquatic pathways and vectors outside of this study should develop a separate list of ANS, which will likely differ from those which might exploit the aquatic pathway on their own.

General considerations for assigning probability ratings:

High - 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 - ANS are established at locations in close enough proximity to the location and have limited capability to survive movement through a non-aquatic pathway to arrive at the subject pathway within 20 to 50 years.

Low - 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.

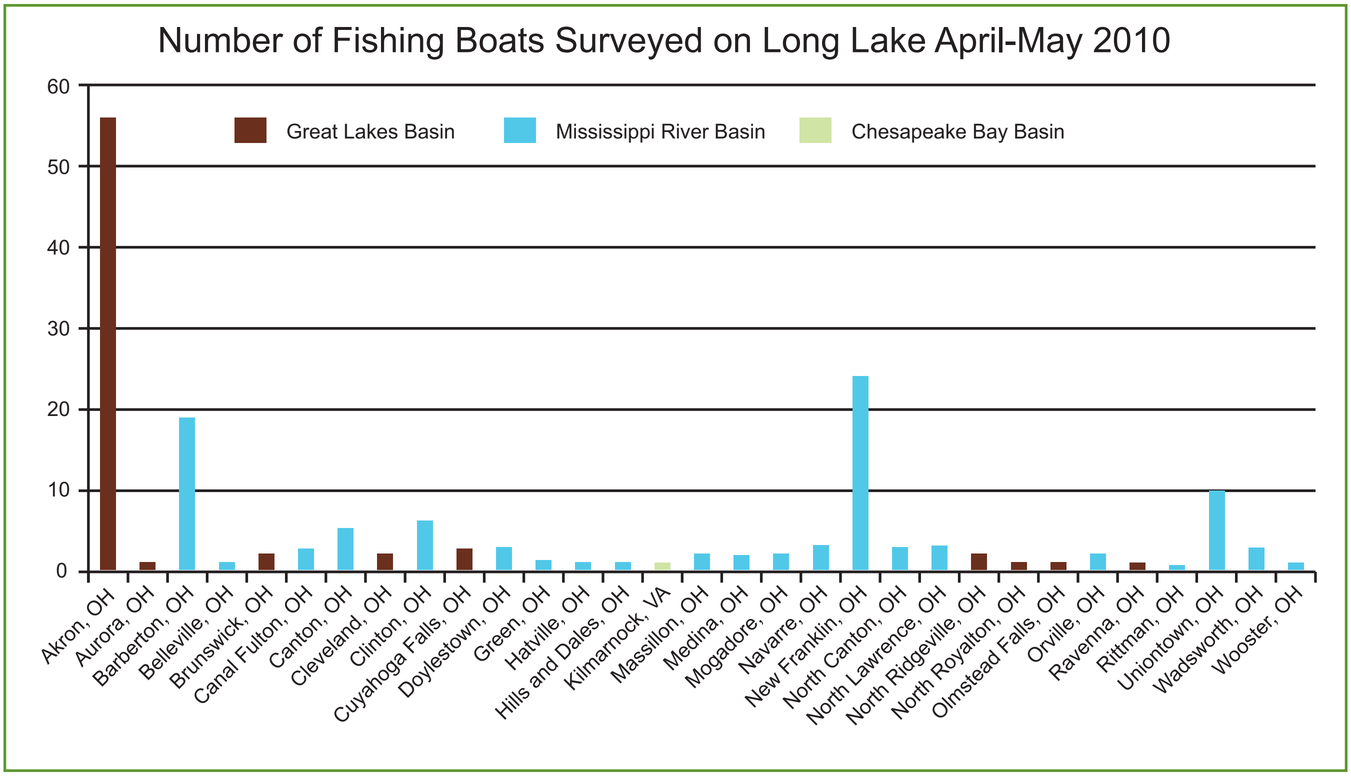


Figure 32 . Creel survey results for Long Lake, Ohio. Figure created by USACE based on 2010 survey data provided by ODNR.

Asian Carp

Transport by anthropogenic vectors such as bait buckets is possible since this area supports many fishing related recreation opportunities. However, adult Asian carp are easily distinguished from other native species, limiting the likelihood that an informed angler could unknowingly transport this species between water bodies in this area. In addition, since established breeding populations of Asian carp are not known to be in close proximity to the Portage Lakes, accidental transport of young fry or juvenile fish is also unlikely. The use of Long Lake by anglers from such a diverse area within the Mississippi River Basin could result in the accidental transport of young Asian carp to the pathway from more distant watersheds.

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

Northern Snakehead

Many species of snakehead, including the northern snakehead, have been popular aquarium fish. However, in 2002 the import and interstate transport of northern snakehead was banned without a permit from the USFWS (www.anstaskforce.gov). Considering this limitation, it is highly unlikely that the northern snakehead will arrive at the divide by anthropogenic means, such as aquarium releases. However, if the northern snakehead were released in the immediate vicinity of the divide, on either side, it is likely the fish would survive and establish a viable population in the area.

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

Skipjack Herring

Transport of this species by anthropogenic vectors is possible since this area supports many recreational fishing opportunities.

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

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 available habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

Asian Carp

Silver and bighead carp are fast growing species that are capable of surviving in a wide range of water temperatures and reproducing quickly, provided suitable habitat is available. Life history habitat requirements generally include diverse needs for current areas, backwater habitats, deep overwintering holes, and other habitat types needed for survival (Nico and Jelks, 2011). Successful spawning and recruitment is unlikely and would prevent establishment of actual populations at the divide, as all species of Asian carp require lowland rivers to complete their life cycles (Nico and Jelks, 2011). Bighead and silver carp need 35-40 miles (56-64 km) of open river to successfully spawn (Jennings, 1988; Verigin et al. 1978; Nico and Jelks, 2011). Furthermore, it is believed that silver and bighead carp require sufficient flow to keep fertilized eggs suspended for successful reproduction (Gorbach and Krykhtin, 1980). Although it is unlikely that spawning would occur within the upper Tuscarawas River near the pathway because Asian carp prefer to spawn in large flood swollen rivers, a population of non-reproducing fish could still establish themselves in the vicinity of the pathway. If individuals were able to spread upstream into Long Lake, there is likely suitable habitat and forage to sustain a number of Asian carp. In addition, there is uncertainty about the ability of juvenile Asian carp to reach the pathway and survive since they have been observed in the uppermost reaches of small tributaries to large rivers attempting to pass over barriers, such as dams, to continue their upstream movement, and adult Asian carp have been found in very small streams with very low water (D. Chapman-USGS, personal communication, September 12, 2011). As a result of this, and despite the lack of apparent suitable spawning habitat at the pathway, a rating of medium was assigned for probability of Asian carps to establish themselves at the pathway location.

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

Northern Snakehead

The northern snakehead's native range (latitude 24-53º N) and temperature tolerance 32 º F – 86º F (0-30 ºC) indicates a species that, if introduced, could establish populations throughout most of the contiguous United States (Courtenay, Jr. and Williams 2004). Northern snakeheads are naturally aggressive predators that could easily acclimate to the conditions in and around the Ohio-Erie Canal at Long Lake site as long as there is an ample food supply, which appears to be the case. The snakehead's preference for shallow aquatic and wetland habitats, coupled with its ability to breathe air, make it more possible for this species to colonize the wetlands, streams, and the canal at the divide location. It still may succumb to winter freeze-out, but it does have the ability to survive under the ice. They can be very opportunistic in their feeding habits, preying on everything from insect larvae to fish, frogs, and crustaceans. Northern snakeheads prefer shallow ponds and marshes with aquatic vegetation (USGS, 2011b). This is similar to a lot of the aquatic habitat adjacent to Ohio-Erie Canal at Long Lake. Additionally, northern snakeheads aggressively defend their nest and young fry, reducing predation on young snakehead by other fish.

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

Skipjack Herring

It is unclear whether skipjack herring could establish a viable population in the vicinity of the pathway. Although skipjack herring prefer areas of swift current in larger rivers, they have been found to exist in lentic habitats such as reservoirs and impoundments. However, the lower quality of the upper Tuscarawas River Watershed and Ohio-Erie Canal, and higher water temperatures during the summer months may limit their ability to persist in this area (USGS, 2011b; Smiley et al., 2008).

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

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

General Considerations for Assigning Probability Ratings:

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

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

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

Asian Carp

If Asian carp reach the Ohio-Erie Canal at Long Lake pathway and surface water connections permit, it is highly likely that they would be able to spread through the aquatic pathway into the Great Lakes Basin. Asian carp have demonstrated exceptional capabilities of spreading through large river systems, and will likely continue to do so.

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

Northern Snakehead

The habitat of the pathway consists of a series of inter-connected lakes, streams, and wetlands which link the Mississippi River Basin with the Great Lakes Basin. It is likely that the northern snakehead could survive in this system and transfer into the Great Lakes Basin via the Ohio-Erie Canal. As an air breather that has even been known to move short distances over land, that can survive in areas with poor water quality, and that can forage on a wide variety of aquatic organisims, it is likely this species has a strong potential to move through the Ohio-Erie Canal and Portage Lakes System and eventually into the Great Lakes Basin via the Little Cuyahoga River at Akron.

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

Skipjack Herring

If the skipjack herring was able to establish a population in Long Lake it would likely be able to flow freely from Long Lake into the Great Lakes Basin through the Ohio-Erie Canal. Alewife and blueback herring share similar habitat preferences and life histories as the skipjack herring, and both of these species have established a viable population within the Great Lakes. Furthermore, as noted by Tautman (1931), “had the skipjack succeeded in invading Lake Erie it presumably should have established itself in these large waters.”

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

5 Overall Aquatic Pathway Viability

As discussed in Sections 2.4 and 2.5, the determination of the likelihood of a viable aquatic pathway occurring at the Ohio-Erie Canal at Long Lake 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). 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 Ohio-Erie Canal location, one species group (Asian carp) and northern snakehead were rated "medium" and one species (skipjack herring) was rated "low". Therefore, the overall pathway viability for transferring species from the Mississippi River Basin to the Great Lakes Basin is "medium". Since no ANS were found to be able to arrive at the pathway location from the Great Lakes Basin because of Lock Number 1 in Akron, individual species evaluations of ANS from the Great Lakes did not factor into the overall pathway viability rating for the Ohio-Erie Canal at Long Lake.

6 Conclusions

The hydrologic assessment determined that an aquatic pathway does exist between the basins through the Ohio-Erie Canal at Long Lake, and an overall aquatic pathway viability rating of "medium" was given because Asian carps and northern snakehead could utilize this pathway to transfer from the Mississippi River Basin into the Great Lakes Basin. In this case, a rating of medium in this case means that while these species could transfer to the Great Lakes Basin through this location, they are not likely to reach the pathway from their current known locations within the Mississippi River Basin within the next 20 years. Some of the potential ANS transfer points within this pathway include the Tuscarawas River to the Long Lake flood gates, the feeder gates at Long Lake to the Ohio-Erie Canal, overland flooding between the Tuscarawas River and the canal, and the Wolf Creek outlet works. Transfer from the Great Lakes Basin to the Mississippi Basin is not possible due to the system of locks separating the Little Cuyahoga River from the Ohio-Erie Canal in the city of Akron. There is a possibility that athletic or strong swimming fish could use the Ohio-Erie Canal as a pathway into the Great Lakes due to its interconnectedness with the Tuscarawas River, Long Lake, and the Portage Lakes. It was also noted during the assessment that there is a distinct potential for anthropogenic vectors (e.g., bait bucket, bilge water) to

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	Form 2	Form 3a	Form 4	Form 5	
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists? (Sect. 3.6)**	**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)	H (RC)	M (RC)	M (RC)	H (RC)	M
fish	*northern snakehead*	swimmer		M (RC)	M (RC)	H (RC)	H (RC)	M
fish	*skipjack herring*	swimmer		H (VC)	L (MC)	M (MC)	H (RC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin:								**M**

move or introduce ANS at or near the Ohio-Erie Canal and Long Lake sites, although such vectors were not evaluated as part of this assessment.

7 Problems and Opportunities

This section uses the results of the pathway assessment to develop a list of statements that define and frame the nature and extent of the problems associated with the potential interbasin transfer of ANS at this site. Following these problem statements is a list of corresponding opportunity statements that were developed in the course of the pathway assessment to help initiate and guide any further study of this location.

7.1 Ohio Erie Canal at Long Lake Problem Statements

This section uses the results of the assessment to develop a list of statements that briefly define and frame the nature and extent of the problems associated with the potential for movement of ANS through the Ohio-Erie Canal at Long Lake aquatic pathway into the Great Lakes Basin.

- The interagency team evaluating the hydrology of the Ohio-Erie Canal at Long Lake rated it as having a high probability for the occurrence of an aquatic pathway between the basins. Implementing structural controls to prevent transfer of ANS at this location may be quite challenging and impose flood related issues during significant storm events.

- The primary ANS of concern for interbasin transfer from the Mississippi River Basin through the Ohio-Erie Canal at Long Lake into the Great Lakes Basin are fish. An interagency team that evaluated the hydrology and conducted the biological evaluation of the ANS rated the likelihood (overall pathway viability) of ANS transfer from the Mississippi River Basin to the Great Lakes as medium. The rating was reached through collaboration among the interagency team which assigned a medium rating to two types of fish, the Asian carps (silver, bighead and black), and the northern snakehead. The three species of Asian carp represent prolific swimmers of greatest concern. The northern snakehead is not as prolific a swimmer and is not established within as close a proximity to the site as some of the Asian carp species. However, its affinity for ditch and wetland types of habitats and its amphibious traits make it a species with a high likelihood of being able to establish a population and spread across the basin divide if it reaches the pathway.

- There was significant uncertainty associated with biological characterization due to a variety of unknowns regarding the location and distribution of the large array of ANS that have been introduced to the waters of the U. S., as well as the life history requirements of each of these ANS and the suitability of the habitat within the waterways between the current nearest locations of the ANS and the pathway.

- There are other ways that human beings or other vectors (e.g., avifauna) could facilitate ANS bypassing the aquatic pathway and transferring between the basins through some non-aquatic pathway, including but not limited to: collection of bait in one basin and 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, etc. The high level of recreational boating and fishing within the network of Portage Lakes make this of particular concern.

7.2 Ohio Erie Canal at Long Lake 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 spread into the Great Lakes Basin through the Ohio-Erie Canal at Long Lake aquatic pathway. The following list of opportunities is not specific to the USACE, but incorporates a wide range of possible applicable authorities, capabilities, and jurisdictions at the Federal, state, and local levels. These are as follows:

- Evaluate structural opportunities for preventing transfer of ANS at Ohio-Erie Canal Pathway:
    - Modification of the Long Lake flood gates;
    - Modification of the Long Lake feeder gate into the canal;
    - Installation of some structure to prevent ANS movement in the Canal between Summit Lake and Lock 1 North;
    - Increase height of the south berm of the Ohio-Erie Canal near the railroad bridge to reduce potential for species moving over the berm during backwater flooding of the Tuscarawas River;
    - Modification or removal of the ogee weir just north of the Wolf Creek outlet;
    - Retrofit of the Nimisila Reservoir spillway to prevent ANS from moving up the spillway into the reservoir during higher flows;
- Evaluate non-structural opportunities for preventing transfer of ANS at the Ohio-Erie Canal Pathway:
    - New or modified regulations or ordinances prohibiting the establishment of drainage ways that connect the Mississippi River tributaries with Great Lakes tributaries;
    - Improve and increase field sampling and monitoring for the presence of ANS in connecting streams to support better informed water resource management decisions within the state and region:
        - Develop an integrated ANS sampling and analysis plan utilizing eDNA and conventional biological sampling techniques
        - 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 ODNR and report to the state and USGS-NAS
        - Use of boater check-in stations to verify the boat location history, inspect bait holds, and ballast water would greatly reduce the probability of accidental transport of ANS;
- Prevent introductions of additional ANS:
    - Improve regulations for bilge release
    - Improve regulations on the pet industry
    - Improve regulations on the live bait industry
    - Improve regulations on the aquaculture industry
- Public education to:
    - Prevent anthropogenic transfer (e.g., bait bucket)
    - Prevent transfer due to cultural reasons
    - Identify and report the observation and collection of ANS to ODNR and USGS;
- Stream restoration efforts, such as for fish passage of native species, should take into consideration any potential effect they might have on the factors that contributed to this rating. For example, a proposal to remove or modify an existing dam that is relied upon in this assessment for blockage of ANS might alter the rating for one or more species of ANS;

- Explore 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 chemical controls where appropriate, and/or biological controls such as species-specific diseases specific to particular ANS;
- Support research on the biology of ANS so that risk of ANS transfer can be better understood;
    - Life history requirements
    - Habitat requirements and tolerances
    - History of invasiveness

None of the opportunities identified above are exclusive of the others. In fact, any single structural measure to prevent ANS transfer through the Ohio-Erie Canal pathway would likely benefit from corresponding development and implementation of one or more of the other types of opportunities identified. The results of this assessment should be considered during the next update to the Ohio Aquatic Nuisance Species Management Plan.

8 References

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

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

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

FEMA. (2009). Detailed Flood Insurance Study: Summit County, Ohio and Incorporated Areas, July 20, 2009. Federal Emergency Management Agency.

Gorbach, E.I., and M.L. Krykhtin. (1980). Maturation rate of the white amur *Ctenopharyngodon idella* and silver carp *Hypophthalmichthys molitrix* in the Amur River. Journal of Ichthyology 21 (4):835–843

Graham, J.B. (1997). Air-breathing fishes: evolution, diversity, and adaptation. Academic Press. San Diego, California. xi +. 299 pp.

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

Ishimatsu, A. and Y. Itazaw. (1981). Ventilation of the air-breathing organ in the snakehead *Channa argus*. Japanese Journal of Ichthyology 28(3): 276–282

Jennings, D.P. (1988). Bighead carp (*Hypophthalmichthys nobilis*): a biological synopsis. Biological Report. U.S. Fish and Wildlife Service. 88(2): 1-35

NatureServe. (2012). NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Accessed: July 18, 2011. http://www.natureserve.org/explorer.

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

NID. (2010). National Inventory of Dams [Data files]. U.S. Army Corps of Engineers. Retrieved from http://geo.usace.army.mil/pgis/f?p=397:758033484717107.

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

ODNR. (2010). Potential of Asian Carp migration from the Ohio River into the Lake Erie Basin within Ohio. Ohio Department of Natural Resources. pp. 4

ODNR. (2011). A to Z Species Guide – Skipjack Herring website. Retrieved from http://www.dnr.state.oh.us

ODNR. (2012a). Ohio Department of Natural Resources: Portage Lakes State Park. Website accessed July 27, 2012: http://www.dnr.state.oh.us/parks/tabid/779/Default.aspx

ODNR. (2012b). Ohio Department of Natural Resources, Division of Parks-Canals. Canal Lands Website, from Fact Sheet Number 97-41. Ohio and Erie Canal/Hydraulic Operations: http://www.dnr.state.oh.us/portals/7/pubs/fs_gifs/flowblrg.gif

ODNR. (2012c). State Listed Species. Ohio Department of Natural Resources, Division of Wildlife. Website accessed July 27, 2012: http://www.dnr.state.oh.us/Home/ExperienceWildlifeSubHomePage/Endangeredthreatenedspeciesplaceholder/resourcesmgtplansspecieslist/tabid/5664/Default.aspx

ODNR. (2012d). Ohio Department of Natural Resources, Division of Parks-Canals. Portage Lakes Fishing Map. Website: http://www.dnr.state.oh.us/Portals/9/pdf/lakemaps/PortageLakes.pdf

Oelker, E.F., J.M. Raab, L.C. Brown, and K.M. Boone. (Not Dated). Summit County Ground-Water Resources: Factsheet. Ohio State University Extension: Food, Agricultural and Biological Engineering (AEX-490.77, Columbus, OH).

OEPA. (1998). Biological and water quality study of the Little Cuyahoga River and tributaries. Ohio Environmental Protection Agency. Volume 1. pp. 164

OEPA. (1999). Biological and water quality study of the Cuyahoga River and selected tributaries. Ohio Environmental Protection Agency. Volume 1. pp. 141

OEPA. (2003). Total maximum daily loads for the Lower Cuyahoga River. Ohio Environmental Protection Agency, Division of Surface Water. Final Report, September 26, 2003. pp. 110

OEPA. (2008). Delisting Targets for Ohio Areas of Concern – Ashtabula River, Black River, Cuyahoga River, Maumee River. Ohio Environmental Protection Agency. p. 85

OEPA. (2009). Total Maximum Daily Loads for the Tuscarawas River Watershed. Ohio Environmental Protection Agency, Division of Surface Water. Final Report, July 27, 2009.

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

Smiley, P.C., R.B. Gillespie, K.W. King, and C. Huang. (2008). Contribution of habitat and water quality to the integrity of fish communities in agricultural drainage ditches. Journal of Soil and Water Conservation 63(6):218A-219A

Trautman, M.B. (1981). The Fishes of Ohio. Ohio State University Press, 1981.

USACE. (1936). Modified Frequency Profiles, Muskingum River. State of Ohio Muskingum Watershed Conservancy District.

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

USACE. (2011a). Great Lakes and Mississippi River Inter-basin Study Focus Area 2 Risk Characterization Plan. United States Army Corps of Engineers, Great Lakes and Ohio River Division.

USACE. (2011b). Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Inter-basin Study. United States Army Corps of Engineers, Great Lakes and Ohio River Division, Interim Report.

USFWS. (2002). Black Carp Invasive Species Program Fact sheet. Accessed March 23, 2012: http://www.fws.gov/southeast/hotissues/Black_Carp_FS.pdf

USFWS. (2012a). National Wetland Inventory. U.S. Fish and Wildlife Service on-line mapper: http://www.fws.gov/wetlands/Data/Mapper.html

USFWS. (2012b). County Distribution of Federally-Listed Threatened, Endangered, Proposed, and Candidate Species. U.S. Fish and Wildlife Service. Website accessed July 27, 2012: http://www.fws.gov/midwest/endangered/lists/ohio-cty.html

USGS. (2011a). Long Lake Feeder O&E Canal, USGS Gage 410121081330300; Wolf Creek, USGS Gate 410014081362600; and Lock 1 Outlet O&E Canal, USGS Gage 410433081312500. Dover Gage data from USACE-Huntington District.

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

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

Weather-Forecast. (2012). Website accessed February 14, 2012 for city of Akron: http://www.weather-forecast.com/locations/Akron/forecasts/latest

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

Williamson, C. J. and J. E. Garvey. (2005). Growth, fecundity, and diets of newly established silver carp in the middle Mississippi River. Trans. Amer. Fish. Soc. 134: 1423–1430

Appendix A

Ohio-Erie Canal Evaluation Forms

Ohio - Erie Canal at Long Lake, Summit County, 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 LRB-H&H Hydraulic Engineer	High	VC	High	VC
	USACE LRH - Wildlife Biologist	High	VC	High	VC
	USACE LRB - Soil Scientist	High	VC	High	VC
	USACE LRB - Biologist	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: The hydrologic risk rating is purely based on the permanence of water flowing from Long Lake into both GL and MR Basins.

Ohio - Erie Canal at Long Lake, Summit County, OH - Asian Carp

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRH - Wildlife Biologist	High	RC
	USACE LRB - Soil Scientist	High	RC
	USACE LRB - Biologist	High	RC
	USACE LRB - Biologist	High	RC
	Division of Wildlife, D3 Fish Mgmt. Sup.	High	RC
	Team Rating	**High**	**RC**

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

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

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

Remarks: Silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*) are established throughout the Lower Ohio River basin. Successful breeding populations seem to stop near Louisville, KY. Occurences of the bighead carp have been noted in the Upper Ohio River basin including Moundsville, WV and the Mahoning River in Ohio. In 1995 and 2000, bighead were recorded from Lake Erie at Sandusky, Ohio. Although, it is uncertain whether these fish were caught from established breeding populations or random introductions (Kolar, Chapman, and others, 2005). It is reasonable to expect that bighead carp could make there way up the Tuscarawas River to the pathway. The reproductive success of those individuals is questionable.

Ohio - Erie Canal at Long Lake, Summit County, 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 LRH - Wildlife Biologist	Medium	RC	Medium	RC
	USACE LRB - Soil Scientist	Medium	RC	Low	MC
	USACE LRB - Biologist	Medium	RC	Medium	MC
	USACE LRB - Biologist	Medium	RC	Medium	MC
	Division of Wildlife, D3 Fish Mgmt. Sup.	Low	RC	Medium	RC
	Team Ratings	**Medium**	**RC**	**Medium**	**MC**

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

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

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

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

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

3A. Spawning of silver and bighead carp is initiated by rising water levels following the 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). There are no obstacles in the Tuscarawas or Muskingum Rivers that would permanently prevent upstream migration of silver carp or bighead carp. Habitat present within most of these rivers is not ideal habitat for silver and bighead carp, which are native to and thrive in large rivers, but it is not known to what extent this may prevent migration or passage. Bighead carp are zooplanktivorous, while silver carp consume smaller phytoplankton and fine particulate organic matter (Williamson and Garvey 2005). Sufficient forage is available for both species throughout the larger rivers downstream of the pathway including the Muskingum and Tusacarawas Rivers. Forage abundance and diversity decreases moving upstream towards the pathway as volume decreases.

Adult black carp are primarily molluscivores. However, they will opportunistically consume a wide variety of food items. Juvenile black carp have a diet more similar to silver and bighead carp, consisting primarily of zooplankton. 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). It is believed that black carp should be able to colonize the same areas of the United States where the grass carp have established.

Juvenile, sexually immature Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers, such as dams, to continue their upstream movement (Chapman, Duane. USGS, personal communication, September 12, 2011 and Caswell, Nate. USFWS, personal communication September 12, 2011 with Eagle Marsh team). 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 (Chapman, Duane. USGS, personal communication, September 12, 2011 with Eagle Marsh team). Newly hatched fry are not known to move significant distances upstream; however, they may move long distances up small tributaries and side channels in the vicinities of where they hatch. It has also been noted that 12-18 inch Asian carp have been known to travel long distances, throughout river systems, for no apparent reason (Chapman, Duane. USGS, personal communication, September 12, 2011 with Eagle Marsh team). Adult, sexually mature Asian carp have also been found in very small streams, which appear scarcely large enough to support the fishes at low water (Chapman, Duane. USGS, personal communication, September 12, 2011 with Eagle Marsh team). The age these fishes arrived at these locations is unknown.

Survivability of Asian carp to the pathway is supported by the moderate levels of habitat and forage that would be provided by the Muskingum and Tuscarawas Rivers. However, it is believed that this group of fish has yet to establish any breeding populations above the McAlpine Pool on the Ohio River which is greater than 500 river miles away. The nature of the Upper Ohio River is vastly different from the Lower Ohio River where successful populations have established. The lower river provides many backwater areas that Asian carp prefer. In general, the upper river is characterized by narrower valleys, smaller floodplains, and less backwater areas. This lack of preferred habitat on the Upper Ohio may be the obstacle that cannot be overcome by Asian carp (Chapman, Duane -USGS and Jeff Thomas - ORSANCO, pers. communication). For these reasons, the Asian carp received a Medium rating for transit survivability.

It is more likely that the bighead would reach the pathway first. This fish does not show the athletic jumping ability of the silver carp, yet it is still a strong swimmer. The hydraulic nature (head, flow, and current) of the pathway should prevent the bighead from migrating into Long Lake through the outlet structure. The silver carp, with its jumping ability, could make a lateral jump from the Tuscarawas River to the Erie Canal during a 100+ year storm event at the ogee weir. For this to occur, a single fish would be incredibly lucky or the Tuscarawas would have to support a large population of carp attempting to migrate and jump. It is unlikely that any carp could navigate through the outlet structure at Long Lake.

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

3B. Transport by other means is possible as this area supports many recreational opportunities including boating and fishing.

Ohio - Erie Canal at Long Lake, Summit County, OH - Asian Carp

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRH - Wildlife Biologist	Medium	RC
	USACE LRB - Soil Scientist	Medium	RC
	USACE LRB - Biologist	Medium	RC
	USACE LRB - Biologist	Medium	RC
	Division of Wildlife, D3 Fish Mgmt. Sup.	High	RC
	Team Ratings	**Medium**	**RC**

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

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

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

Remarks: Silver and bighead carp are fast growing species that are capable of surviving in a wide range of water temperatures and reproducing quickly, providing suitable habitat is available. It's believed that silver and bighead carp require sufficient flow to keep fertilized eggs suspended for successful reproduction (Gorbach and Krykhtin 1980). It is unlikely that spawning would occur within the upper Tuscarawas proximal to the pathway because the fish prefer to spawn in large flood swollen rivers.

Ohio - Erie Canal at Long Lake, Summit County, OH - Asian Carp

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRH - Wildlife Biologist	High	VC
	USACE LRB - Soil Scientist	High	VC
	USACE LRB - Biologist	High	RC
	USACE LRB - Biologist	High	RC
	Division of Wildlife, D3 Fish Mgmt. Sup.	High	RC
	Team Ratings	**High**	**RC**

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

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

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

Remarks: Asian carp have demonstrated exceptional capabilities of spreading through large river systems, and will likely continue to do so. It is still uncertain whether they will colonize the Upper Ohio River and its tributaries.

Ohio - Erie Canal at Long Lake, Summit County, 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 LRB-H&H Hydraulic Engineer	High	VC	High	VC
	USACE LRH - Wildlife Biologist	High	VC	High	VC
	USACE LRB - Soil Scientist	High	VC	High	VC
	USACE LRB - Biologist	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: The hydrologic risk rating is purely based on the permanence of water flowing from Long Lake into both GL and MR Basins.

Ohio - Erie Canal at Long Lake, Summit County, 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 LRB - Soil Scientist	Medium	RC
	USACE LRH - Wildlife Biologist	Medium	RC
	USACE LRB - Biologist	Medium	RC
	USACE LRB - Biologist	Medium	RC
	Division of Wildlife, D3 Fish Mgmt. Sup.	Low	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 northern snakehead was found in 2008 in Monroe, Arkansas (> 250 miles from the Ohio Erie Canal at Long Lake site), and has since established a reproducing population in the area. Although in a different basin, this species is also established in the Potomac River in Maryland and Virginia (USGS 2009a).

Ohio - Erie Canal at Long Lake, Summit County, 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 LRB - Soil Scientist	Medium	RC	Low	RC
	USACE LRH - Wildlife Biologist	Medium	RC	Low	RC
	USACE LRB - Biologist	Medium	RC	Low	RC
	USACE LRB - Biologist	Medium	RC	Low	RC
	Division of Wildlife, D3 Fish Mgmt. Sup.	Low	RC	Medium	RC
	Team Ratings	**Medium**	**RC**	**Low**	**RC**

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

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

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

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

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

The northern snakehead is an incredibly resilient species. As obligate air breathers, northern snakeheads obtain required oxygen directly from the atmosphere. This species thrives in stagnant, oxygen depleted back-waters and marshes (Courtenay, Jr. and Williams 2004). The northern snakehead likely possesses the ability to migrate through the aquatic pathway to the Ohio Erie Canal at Long Lake site, however, its preferred habit is not flowing waters, which will likely slow its spread up the Mississippi River and it tributaries. Unlike the Asian carps, northern snakeheads do not make long upstream spawning runs and, as a result, are not likely to spread quickly through the Mississippi River Basin without the aid of anthropogenic means. Andy J. - The lack of backwater and marsh areas in the Upper Ohio River, Muskingum, and Tuscarawas Rivers may impede the migration of the snakehead to the pathway.

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

3B. Many species of snakehead, including the northern snakehead, have been popular aquarium fish. However, in 2002 the import and interstate transport of northern snakehead was banned without a permit from the U.S. Fish and Wildlife service (www.anstaskforce.gov). Considering this limitation it is highly unlikely that the northern snakehead will arrive at the divide by anthropogenic means, such as aquarium releases. However, if the northern snakehead were released in the immediate vicinity of the divide, on either side, it is likely the fish would survive and establish a viable population. Although Long Lake is a very popular fishing lake with significant boat traffic, it is impossible to quantify the possiblility of transfer of this species via recreational boating.

Ohio - Erie Canal at Long Lake, Summit County, OH - Northern Snakehead (*Channa argus*)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRH - Wildlife Biologist	High	RC
	USACE LRB - Soil Scientist	Medium	RC
	USACE LRB - Biologist	High	RC
	USACE LRB - Biologist	High	RC
	Division of Wildlife, D3 Fish Mgmt. Sup.	High	RC
	Team Ratings	**High**	**RC**

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

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

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

Remarks: The northern snakehead's native range (24-53 oN) and temperature tolerance (0-30 oC) indicates a species that, if introduced, could establish populations throughout most of the contiguous United States (Courtenay, Jr. and Williams 2004). Northern snakeheads are naturally aggressive predators that could easily acclimate to the conditions in and around the Ohio Erie Canal at Long Lake site as long as there is an ample food supply, which appears to be the case. They can be very opportunistic in their feeding habits, preying on everything from insect larvae to fish, frogs, and crustaceans. Northern snakeheads prefer shallow ponds and marshes with aquatic vegetation, which is similar to the aquatic habitat adjacent to Ohio Erie Canal at Long Lake. Additionally, northern snakeheads aggressively defend their nest and young fry, reducing predation on young snakehead by other fish. Andy J. - There are some connected wetlands in the area, but I do not believe they are expansive enough to support a sustainable population.

Ohio - Erie Canal at Long Lake, Summit County, OH - Northern Snakehead (*Channa argus*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRB - Soil Scientist	High	RC
	USACE LRH - Wildlife Biologist	High	RC
	USACE LRB - Biologist	High	RC
	USACE LRB - Biologist	High	RC
	Division of Wildlife, D3, Fish Mgmt Sup.	High	RC
	Team Ratings	**High**	**RC**

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

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

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

Remarks: The northern snakehead's native range (24-53 ^{o}N) and temperature tolerance (0-30 ^{o}C) indicates a species that, if introduced, could establish populations throughout most of the contiguous United States (Courtenay, Jr. and Williams 2004). Northern snakeheads are naturally aggressive predators that could easily acclimate to the conditions in and around the Ohio Erie Canal at Long Lake site as long as there is an ample food supply, which appears to be the case. They can be very opportunistic in their feeding habits, preying on everything from insect larvae to fish, frogs, and crustaceans. Northern snakeheads prefer shallow ponds and marshes with aquatic vegetation, which is similar to the aquatic habitat adjacent to Ohio Erie Canal at Long Lake. As an air breather that has even been known to move short distances over land, it is likely this species has the potential to move into and out of this environment.

Ohio - Erie Canal at Long Lake, Summit County, OH - Skipjack herring (*Alosa chrysochloris*)

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 LRB-H&H Hydraulic Engineer	High	VC	High	VC
	USACE LRH - Wildlife Biologist	High	VC	High	VC
	USACE LRB - Soil Scientist	High	VC	High	VC
	USACE LRB - Biologist	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: The hydrologic risk rating is purely based on the permanence of water flowing from Long Lake into both GL and MR Basins.

Ohio - Erie Canal at Long Lake, Summit County, OH - Skipjack herring (*Alosa chrysochloris*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRB - Biologist	High	VC
	USACE LRH - Biologist	High	VC
	Division of Wildlife-District 3 Fish Mgt. Sup.	High	VC
	USACE LRB - Soil Scientist	High	VC
	Team Rating	**High**	**VC**

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

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

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

Remarks: The native range of skipjack herring (*Alosa chrysochloris*) includes the Mississppi River basin from central Minnesota south to the Gulf of Mexico, and from southwestern Pennsylvania west to eastern South Dakota, Nebraska, Kansas, Oklahoma, and Texas (USGS, 2011). Skipjack herring have been collected in Lake Michigan, but it has not yet been determined if the species is established in the basin. From the years 1989-1993, three separate collections were made by Wisconsin commercial fisherman. Because they are a migratory species, dams often impede their reproduction. Records suggest that this species was much more abundant in the Upper Mississippi River basin before it was impounded. Current range distribution maps suggest that the species is established within the main stem of the Muskigum River approximately 50 - 100 miles away from the aquatic pathway.

Ohio - Erie Canal at Long Lake, Summit County, OH - Skipjack herring (*Alosa chrysochloris*)

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 LRB - Biologist	Low	MC	Medium	MC
	USACE LRH - Biologist	Low	MC	Medium	MC
	Division of Wildlife-District 3 Fish Mgt. Sup.	Medium	RC	Medium	RC
	USACE LRB - Soil Scientist	Low	MC	Medium	MC
	Team Ratings	**Low**	**MC**	**Medium**	**MC**

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

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

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

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

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

3A. Skipjack herring are a migratory species found in larger rivers often in areas of swift current. In Ohio this species is only found in the Ohio River and its larger tributaries, particularly the Scioto River and Muskigum (ODNR, 2011). Skipjack herring are strongly migratory within rivers and prefer fast flowing water where they are renowned for leaping. They are found in clear to moderately turbid waters in large rivers and reservoirs usually within the current over sand or gravel (Page and Burr 1991). Skipjack herring feed in large schools with adults feeding on other herring species such as the threadfin shad, the gizzard shad and young of the year herring species, while the juveniles feed on dipterans and other aquatic insects. Because skipjack herring tend to prefer large fast flowing rivers, is unlikely that they would migrate upstream of their current range in the mainstem Muskingum River into the smaller, more turbid, tributaries leading the Ohio-Erie Canal pathway. Despite the connectivity of the Tuscarawas River to its native range, the skipjack herring has never been recorded in that drainage. This is likely due to the affinity of the fish to large river habitat. The Tuscarawas likely does not contain suitable habitat to allow for a successfully breeding population. As noted in "The Fishes of Ohio" (Tautman, 1981), "it is absurd to expect this deep- and swift-water inhabiting species to migrate across Ohio through the sluggish canals when it does not penetrate far inland in the largest unubstructed streams in the Ohio drainage."

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

3B. Transport by other means is possible as this area supports many recreational opportunities including boating and fishing.

Ohio - Erie Canal at Long Lake, Summit County, OH - Skipjack herring (*Alosa chrysochloris*)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRB - Biologist	Medium	MC
	USACE LRH - Biologist	Medium	MC
	Division of Wildlife	Medium	RC
	USACE LRB - Soil Scientist	Medium	MC
	Team Ratings	**Medium**	**MC**

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

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

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Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: It is unclear whether skipjack herring could establish a viable population in the vicinity of the pathway. Although skipjack herring prefer areas of swift current in larger rivers, they have been found to exist in lentic habitats such as resevoirs and impoundments. However, as a visual predator, the turbid waters of the Tuscarawas River, Long Lake and the Ohio Erie Canal are likely unsuitable for skipjack herring population establishment.

Ohio - Erie Canal at Long Lake, Summit County, OH - Skipjack herring (*Alosa chrysochloris*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty
	USACE LRB - Biologist	High	RC
	USACE LRH - Biologist	Medium	RC
	Division of Wildlife-District 3 Fish Mgt. Sup.	High	RC
	USACE LRB - Soil Scientist	High	RC
	Team Ratings	**High**	**RC**

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

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

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Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: If skipjack herring did establish a population in Long Lake they would likely flow freely from from Long Lake into the Great Lakes Basin through the Ohio-Erie Canal.