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

East Mud Lake, New York

Executive Summary

This assessment characterizes the likelihood that a viable aquatic pathway exists at East Mud Lake in Forestville, New York, 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. The pathway is located at the headwaters of Silver Creek (Great Lakes Basin) and the North Branch of Conewango Creek (Mississippi River Basin), approximately five miles (eight km) southeast of Forestville, New York. Silver Creek flows directly into Lake Erie, while Conewango Creek enters the Allegheny River, which flows to the Ohio River. Habitat at this location includes East Mud Lake, small ponds, marshy/wetland areas, and streams.

The site was determined capable of conveying water across the basin divide for multiple days from a ten percent annual recurrence interval storm event. The existence of wetlands and ponds spanning the basin divide maintain a network of surface water features that likely become interconnected with streams on both sides of the basin divide starting at a ten percent annual recurrence interval storm. This led the pathway assessment team to determine that there is a medium probability for this location to develop hydrologic conditions that could potentially facilitate spread of ANS in either direction between the basins.

As a result of this medium rating for the probability of an aquatic pathway existing at East Mud Lake, the viability of this pathway for specific ANS of concern was then evaluated by looking at the biological requirements and capabilities of the five ANS listed to the right. A total of 12 ANS were originally identified for evaluation at this site. However, it was determined by the assessment team that the Silver Creek Reservoir Dam located immediately downstream from the East Mud Lake pathway provides a permanent barrier to any potential ANS attempting to reach the pathway location on their own from the Great Lakes Basin. Thus, only the five

Aquatic Nuisance Species of Concern	
Species	**Common Name**
Hypophthalmichthys molitrix	silver carp
Hypophthalmichthys nobilis	bighead carp
Mylopharyngodon piceus	black carp
Menidia beryllina	inland silverside
Alosa chrysochloris	skipjack herring

ANS listed in the table above which are currently found in the Mississippi River Basin were evaluated.

Four of these species are currently located more than 250 miles (402 km) away from the East Mud Lake aquatic pathway. The skipjack herring is the closest, but is still over 100 miles (161 km) away. There are numerous impediments to the upstream movement of these species within the Mississippi River Basin, including eight dams along the Allegheny River alone. The Allegheny River and connecting streams to the East Mud Lake pathway do not provide all of the necessary habitat requirements for all life stages of these ANS. Therefore, it was determined that there was a low probability that ANS from the Mississippi River Basin would be able to spread into the Great Lakes Basin through the East Mud Lake pathway. An overall pathway viability rating of "low" was therefore given to this location.

There were some areas of uncertainty in the rating of this pathway. For example, the "low" rating for the likelihood of ANS being able to transfer from the Great Lakes Basin to the Mississippi River Basin over the Silver Creek Reservoir spillway is based on published swimming capabilities of two species of ANS and calculations of water velocities and depths for only a one percent annual recurrence interval storm event. At lesser flows (more frequent) over the spillway, there may be a possibility that flows may enable an ANS to pass up its length. Lastly, further uncertainty includes the potential effects of increasing climate variability and how it might expedite or slow the spread of certain ANS, or change precipitation and runoff patterns.

An effort that would reduce some of this uncertainty would be a hydrological analysis of the full range of potential flows for the Silver Creek Reservoir spillway to further ensure that this is a permanent barrier to ANS upstream movement. In addition, a hydrology model could be developed to better understand the inflows and outflows from the appropriate area ponds. Such a model would also be useful in the event that any action is determined to be warranted to further limit the probability of ANS interbasin transfer through this location. Efforts such as educational programs for anyone potentially using waterways at the East Mud Lake site would seem to provide relatively small benefit given the site's relative remoteness, small size, and general lack of recreational opportunities. However, such efforts may have benefit in downstream watersheds to possibly limit the probability for ANS to be transported between basins by non-aquatic means.

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Acronyms

ANS . . . . . Aquatic Nuisance Species
ANSTF. . . . Aquatic Nuisance Species Task Force
CAWS . . . . Chicago Area Waterway System
CEQ. . . . . Council on Environmental Quality
CMP. . . . . Corrugated Metal Pipe
DEM. . . . . Digital Elevation Model
FEMA. . . . . Federal Emergency Management Agency
GIS . . . . . Geographic Information System
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
NCDC . . . . National Climatic Data Center
NEPA. . . . . National Environmental Policy Act
NOAA. . . . . National Oceanic and Atmospheric Administration
NRCS . . . . Natural Resources Conservation Service
NYSDEC . . New York State Department of Environmental Conservation
USACE . . . U.S. Army Corps of Engineers
USFWS . . . U.S. Fish and Wildlife Service
USGS . . . . U.S. Geological Survey
WRDA . . . . Water Resources Development Act

1 Introduction

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

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

This GLMRIS Focus Area 2 Aquatic Pathway Assessment report addresses the East Mud Lake location, in Chautauqua County, New York. 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 East Mud Lake location is shown as location number one in western New York State.

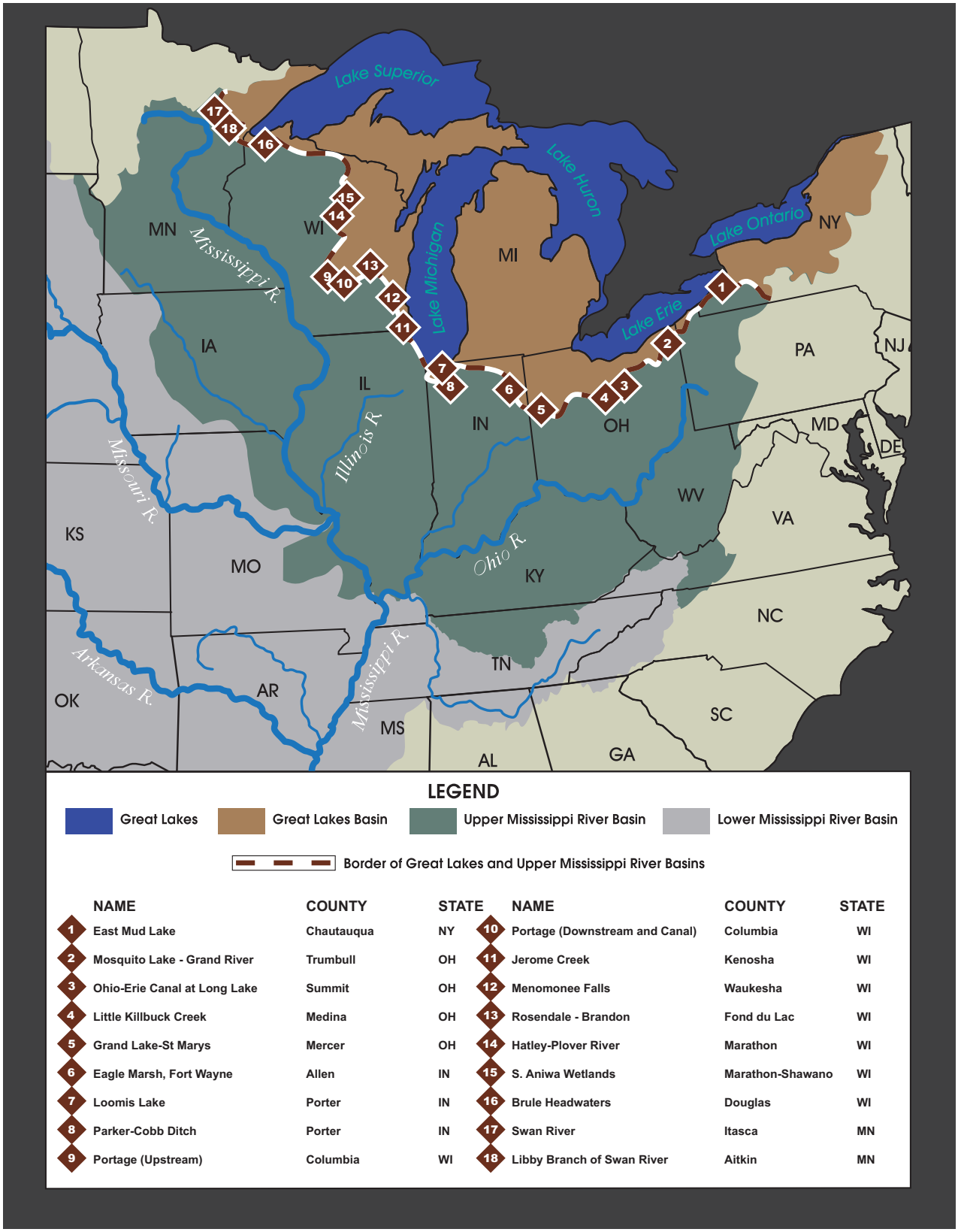
The GLMRIS is a very large and complicated task involving multiple USACE Districts and Divisions. Program Management of the study is conducted by the Great Lakes and Ohio River Division. The study considers several aquatic nuisance species (ANS) of concern, however, the proximity of Asian carp in the 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. Focus Area 2 is managed by the USACE, Buffalo District and evaluates all other potential aquatic pathways that exist or are likely to form across the basin divide separating runoff that flows into the Mississippi River and its tributaries from runoff that flows into the Great Lakes and its tributaries.

1.1 Study Purpose

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

This report is part of a tiered approach to assess the 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 East Mud 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 East Mud Lake location should be included in the inventory of locations where a viable surface water connection



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

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

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 and the probability that a viable aquatic pathway exists at the East Mud 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 East Mud 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 nongovernmental stakeholder organizations may best be coordinated and applied to prevent the interbasin spread of ANS through the East Mud Lake location.

1.2 Summary of 2010 Preliminary Risk Characterization for East Mud Lake, NY

The Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization was designed as the first step of a tiered approach to rapidly conduct a study intended to accomplish two objectives (USACE, 2010). The first and primary objective was to determine if there were any locations within the GLMRIS, aside from the CAWS, where a near term risk for the interbasin spread of ANS exists. Near term, in this case, indicates that implementation of some measure(s) might be warranted to reduce the potential for ANS transfer at that particular location in the short term versus setting that site aside for further analysis. Only one location, Eagle Marsh in Fort Wayne, Indiana, was determined to pose a near term risk for the potential spread of Asian carp into the Great Lakes Basin, and this led to the installation of a temporary barrier by Indiana Department of Natural Resources (INDNR) until a more complete assessment and remedy could be implemented. The 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 (i.e., that in excess of a one percent annual recurrence interval) 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).

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 an event of lower flood elevation that has a one in ten chance of being exceed during any given year, and a 0.2 percent annual recurrence interval storm (formerly referred to as a 500-year event) is a larger event that has a one in 500 chance of being exceeded in any given year.

The East Mud Lake location lies in a relatively narrow glacial valley in the glaciated Allegheny Plateau Region. The initial review of aerial photographs of this site in 2010 showed water flow south across the basin divide from East Mud Lake into the headwaters of the North Branch Conewango Creek. A local resident of the area interviewed during a site visit by a representative of the New York State Department of Environmental Conservation (NYSDEC) indicated that the actual drainage divide is located farther to the north than is indicated by the 12-digit hydrologic unit code (HUC-12) boundary at this location. This is the highest elevation of any of the Focus Area 2 locations evaluated within GLMRIS, and it was initially determined that it would likely be very difficult for ANS to get to this location from Lake Erie or the Ohio River solely via the surface water pathway. However, if ANS were able to reach this site by other non-aquatic means (e.g., human transport), then they could likely traverse the divide and enter the adjacent basin.

Although the preliminary risk characterization did not identify the East Mud 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 largely due to the lack of site specific hydrologic information about the wetlands and ponds at this location, as well as the exact role of downstream obstructions in preventing ANS from moving upstream to the pathway. The preliminary effort therefore recommended that a more detailed assessment be conducted at this location. This was subsequently done in collaboration with the NYSDEC, USFWS, USGS and other government agencies. The following actions were taken:

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

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

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

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, NOAA, and GLFC, was assembled to review and guide the work of these teams. Overall, extensive collaboration among partner agencies, the review team, and other subject matter experts has led to detailed Focus Area 2 pathway assessments.

2.2 Identification of Potential Pathways

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

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

2.3 Aquatic Nuisance Species of Concern

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

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

The list of ANS of concern for a particular location was developed by first consulting the USACE white paper titled, *Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study* released in September 2011 (USACE, 2011b). This technical paper, prepared by a multi-disciplinary USACE natural resources team, took a broad look at the potential range of species that could be of concern to the GLMRIS. The paper is Appendix C of the GLMRIS Focus Area 2 Study Plan and it is an integral component of the plan. This USACE white paper included a review of 254 aquatic species that are either non-indigenous to either basin or native species that occur in one basin or the other. The list of 254 aquatic species were iteratively Silver Creek Reservoireened 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 Silver Creek Reservoireening iteration, 119 of the 254 aquatic species reviewed were determined to pose a potential threat of infiltrating the other basin and were carried into the second iteration of the analysis. The other 135 species were rejected for further analysis for several reasons. Initially, 104 species were dropped from further consideration because they were determined to already be established in both basins. Another 31 species were removed from further analysis because they were not yet located in either basin, could bypass any aquatic control mechanism by terrestrial movement, or had no potential to cause adverse affects to the invaded ecosystem.

2.3.2 List of ANS of Concern for GLMRIS

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

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

2.3.3 List of ANS of Specific Concern at the East Mud Lake Location

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

Additionally, the East Mud 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 East Mud 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 East Mud Lake location. However, the NOAA Watchlist was utilized as a resource, at the recommendation of agency team members, to identify any additional potential future species that could be introduced into either basin and possibly spread from there to the other basin.

Each Focus Area 2 aquatic pathway team was granted flexibility in determining what ANS would be included in 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. Since the East Mud Lake site is positioned on the basin divide, upstream of any known ANS in the Mississippi River and Great Lakes Basins, each of the three subgroups in Tables 2 and 3 were evaluated based on the dispersal mechanisms and general mobility of the species within each group. As a result, 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. This eliminates organisms that rely on current for dispersal, such as plants and algae.

The aquatic pathway team initially selected 11 out of the 39 potential ANS from either basin as ANS of particular concern to the East Mud Lake location (Table 4). A twelfth ANS, viral hemorrhagic septicemia virus (VHSv), was also considered as a potential threat to the Mississippi River Basin as it can infect numerous fish species which could possibly transport the virus to new areas. In this table, proximity to the East Mud Lake site was determined by linear measurement from documented locations of ANS as depicted on the USGS Nonindigenous Aquatic Species website. This website is a central repository for spatially referenced biogeographic accounts of introduced aquatic species (USGS, 2011). Those species for which no proximity to the pathway is listed were those that were ultimately dropped from the species of concern list for East Mud Lake since there would be no way for them to get to the pathway from the Great Lakes Basin because of an impassible barrier at the Silver Creek Dam. This is discussed in the following paragraphs.

Following hydraulic and hydrologic analyses of the Silver Creek Reservoir Dam located just north of the East Mud Lake pathway and after consideration of the behavior and capabilities of ANS within the Great Lakes Basin, the aquatic pathway team determined that it is unlikely that any of the ANS currently established in the Great Lakes Basin are capable of passing the Silver Creek Reservoir spillway on their own from the Great Lakes Basin to the Mississippi River Basin. There are no ANS of concern threatening the Mississippi River Basin from the Great Lakes Basin via the East Mud Lake pathway.

According to information provided by the Chautauqua County Department of Public Works and analysis by the Aquatic Pathway Team, the Silver Creek Reservoir spillway is a stepped, relatively smooth, concrete channel over 320 feet (97 m) in length and 71 feet (22 m) width. The spillway steepens and narrows to a third of the width (L. Brumagin, P.E.- Chautauqua DPW, Personal Communication, December 1, 2011). The spillway design features make it in impassable barrier to the upstream movement of ANS. The spillway design increases water depth and velocity significantly on the downstream end for all but the lowest flow levels. For example, velocity estimates for a one percent annual

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

Table 4: Initial List of Potential ANS of Concern at the East Mud Lake Site					
Taxon	**Scientific Name**	**Common Name**	**Basin**	**Interbasin Dispersal Mechanism**	**Linear Proximity to Pathway (mi/km)**
fish	*Hypophthalmichthys nobilis*	bighead carp	MS	swimmer	> 250 /400
fish	*Hypophthalmichthys molitrix*	silver carp	MS	swimmer	> 500/800
fish	*Mylopharyngodon piceus*	black carp	MS	swimmer	> 800/1,200
fish	*Menidia beryllina*	inland silverside	MS	swimmer	> 700/1,100
fish	*Alosa chrysochloris*	skipjack herring	MS	swimmer	>100/160
fish	*Alosa aestivalis*	blueback herring	GL	swimmer	NA**
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer	NA**
fish	*Proterorhinus semilunaris*	tubenose goby	GL	swimmer	NA**
copepod	*Neoergasilus japonicus*	parasitic copepod	GL	fish parasite	NA**
virus	*Novirhabdovirus sp.*	viral hemorrhagic septicemia	GL	pathogen to fish & water column	NA**
mollusk	*Sphaerium corneum*	European fingernail clam	GL	floater	NA**
mollusk	*Valvata piscinalis*	European stream valvate (snail)	GL	floater	NA**

recurrence interval flow where the channel narrows to 24 feet (7.3 m) is 22.1 fps, increasing to 36.9 fps over the approximate 50 foot (15 m) channel length which has a 30.3 percent slope. This slope varies slightly over the remaining approximate 47 feet (14 m) of channel.

The blueback herring and alewife are the two species that likely possess the greatest swimming capabilities of all the ANS of concern to the Mississippi River Basin. In a study by Haro et al. (2004), flume experiments were conducted to quantify the swimming capabilities and endurance of several species of migratory fish, including the blueback herring and alewife. Upstream movement of blueback herring and alewife in this study averaged 59 feet (18 m) and 42 feet (13 m), respectively, at velocities of 4.9 fps. The ability of either species to move upstream decreased with increasing velocities. At a velocity of 8.2 fps, blueback herring were able to move upstream approximately 25 feet (7.6 m) while alewife managed only 16 feet (4.9 m). At a velocity of 11.5 fps , both species were only able to move upstream approximately 10 feet (3 m). These results suggest that even the strongest swimming ANS of concern currently within the Great Lakes Basin would have difficulty in passing up the Silver Creek Reservoir spillway at medium to high flows. The length of the steeper sections of the spillway are at the upper limits of these fishes swimming abilities based on a velocity of 4.9 fps. These steeper sections of the spillway experience much higher water velocities, with flows exceeding 36 fps at the one percent annual recurrence interval flood event. The smooth, laminar flow characteristics over the spillway provides minimal low flow velocity zones for any ANS needing to rest during their upstream movement. However, at lower flows ANS would likely still have trouble passing through these lower velocity sections of the Silver Creek Reservoir spillway, which are both over 100 feet (30 m) in length, in addition to the difficulty in navigating over the six foot (1.8 m) weir at the spillway crest. Lastly, the channel is open and affords no cover for protection, meaning that any ANS attempting to swim through this spillway at low flows would potentially be vulnerable to predation.

Considered, but not included in Table 4 as ANS of concern to the Great Lakes Basin were the northern snakehead and a scud (*Apocorophium lacustre*). Northern snakehead was not included given its distance from the East Mud Lake site (lower Mississippi River Basin) within the 50 year period of analysis for this study. Similarly, the scud was not included because it was also considered too far away and the primary dispersal mechanism is ballast water release (USACE, 2011b). There is little, if any, opportunity for such releases much beyond the end of navigation on the Allegheny River (69.6 river miles over 170 linear miles (273 km) from the head of navigation to East Mud Lake. Plant species were not included because their primary dispersal

Table 5: Species of Greatest Concern at East Mud Lake, NY					
Taxon	**Scientific Name**	**Common Name**	**Basin**	**Interbasin Dispersal Mechanism**	**Linear Proximity to Pathway (mi/km)**
fish	*Hypophthalmichthys nobilis*	bighead carp	MS	swimmer	> 250 /400
fish	*H. molitrix*	silver carp	MS	swimmer	> 500/800
fish	*Mylopharyngodon piceus*	black carp	MS	swimmer	> 800/1,200
fish	*Menidia beryllina*	inland silverside	MS	swimmer	> 700/1,100
fish	*Alosa chrysochloris*	skipjack herring	MS	swimmer	>100/160

mechanisms are recreational boats and trailers, downstream drift, and by attachment or consumption by animals. Opportunities for recreation related dispersal begin to decrease beyond the end of navigation on the Allegheny River (RM 69.6), likely ceasing altogether on Conewango Creek and beyond to East Mud Lake. Dispersal by downstream drifting is also unlikely since this pathway is located high upstream along the basin divide. Finally, dispersal by other non-aquatic vectors, such as hitchhiking on animals, was not included within the scope of this study. The final list of ANS of concern for East Mud Lake is provided in Table 5.

2.3.4 Key Attributes of Selected Organisms

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 and other relevant scientific literature (USACE, 2011b). Additional information was obtained from the USGS Non-indigenous Aquatic Species (NAS) website (USGS, 2011).

2.4 Pathway Assessment Process

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

Equation 1

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

Where:

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

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

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

Equation 2

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

Where:

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

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

Equation 3 [FA1 Model]

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

Where:

P_0 = P *Pathway exists*
P_1 = P *ANS has access to pathway*
P_2 = P *ANS transits pathway*
P_3 = P *ANS colonizes in new waterway*
P_4 = P *ANS spreads in new waterway*

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

Greater efficiency in analysis can be gained by modifying Equation 3 by eliminating evaluation of the last two elements because if a pathway does not exist there is no reason to collect data on colonization (P_3) and spread (P_4) in the new basin. In addition, the third element of Equation 3, ANS transits pathway (P_2), is broken down into its own sequence of necessary events to characterize in greater detail those variables being evaluated to determine whether or not a viable pathway exists. In setting aside the last two elements in Equation 3 (P_3 and P_4), no attempt is therefore made in this report to assess the probability that an ANS will colonize in or spread through the receiving waterway or basin. USACE or others may assess the last two elements of Equation 3 in the future when evaluating specific measures that could be taken to eliminate the probability of transfer at certain aquatic pathways.

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

Equation 4 [Modification of Equation 3 – P2 Element]

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

Where:

P_2 = P *ANS transits pathway*
P_{2a} = P *ANS surviving transit to aquatic pathway*
P_{2b} = P *ANS establishing in proximity to the aquatic pathway*
P_{2c} = P *ANS spreading across aquatic pathway into new basin*

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

Equation 5 [FA2 Modified]

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

Where:

P_0 = P *Pathway exists*
$P_{1'}$ = P *ANS occurring within either basin*
P_{2a} = P *ANS surviving transit to aquatic pathway*
P_{2b} = P *ANS establishing in proximity to the aquatic pathway*
P_{2c} = P *ANS spreading across aquatic pathway into new basin*

Notice the overall probability is now the “probability a viable pathway exists” ($P_{Viable\ pathway}$) and is no longer the original “probability of establishment” 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 East Mud Lake pathway, the remaining four elements in Equation 5 were evaluated for each ANS of concern specific to that particular location for a 50 year period of analysis.

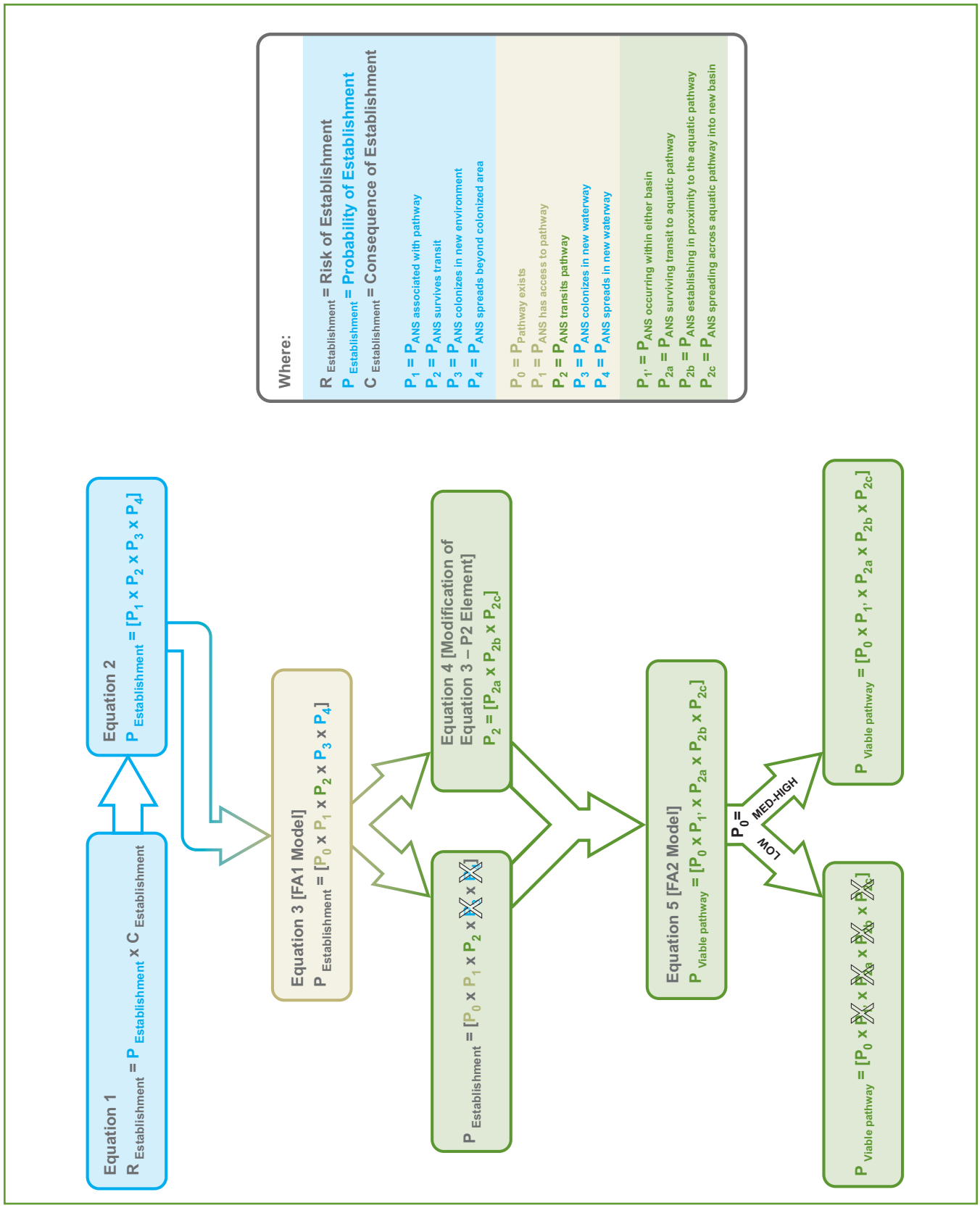


Figure 2. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

2.5 Example Calculation of Overall Aquatic Pathway Viability

As deSilver Creek Reservoiribed in Section 2.2, a list of ANS of concern for the East Mud 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 New York 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). 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 6 and Table 7). 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 6. In this example, all were rated low and 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

Table 6. 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 the Aquatic Pathway?**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway Viability Rating**
fish	Asian carp, silver carp, bighead carp, black carp	swimmer	M (RC)	M (RC)	L (RC)	L (MC)	M (RU)	L
fish	inland silverside	swimmer		M (VC)	L (MC)	L (RC)	L (RC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

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

Table 7. 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 the Aquatic Pathway?**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway Viability Rating**
fish	threespine stickleback	swimmer	M (RC)	M (VC)	L (RC)	L (MC)	L (MC)	L
pathogen	VHSv	fish pathogen / water column		H (VC)	H (MC)	H (RC)	H (RU)	M
Overall Pathway Viability for Spread of ANS from Great Lakes Basin to Mississippi River Basin								**M**

Basin to the Mississippi River Basin is calculated the same way and is shown in Table 7. 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 6 and 7. In Table 7, 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 6 and 7 were coordinated amongst the members of the pathway team until agreement was reached regarding the probability rating (H, M, or L) and the level of certainty (VC, RC, MC, RU, or VU).

3 Aquatic Pathway Characterization

This section describes and illustrates the topography and relevant 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 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. A site investigation was completed on May 25, 2011 to gather any relevant on-site information that would assist in determining the possibility of a continuous surface water connection existing or being able to form between the Mississippi River and Great Lakes Basins at the East Mud Lake location.

3.1 Location

East Mud Lake is located in the northeast portion of Chautauqua County, New York near the Cattaraugus County border and is in both the Townships of Hanover and Villenova, southeast of Forestville, New York (Figure 3). A general coordinate location is latitude N42° 25’ 37” and longitude W079° 01’ 02”. The site is located in a valley between two mountain ridges and not far from the low lying plains adjacent to Lake Erie. The ground elevation difference at the pathway location and the nearest adjacent ridge is approximately 340-350 feet (104-107 m) (Figure 4). East Mud Lake is located at the headwaters of Silver Creek (Great Lakes Basin) and the North Branch of Conewango Creek (Mississippi River Basin), approximately five miles (eight km) southeast of Forestville, New York. Silver Creek flows directly into Lake Erie, while Conewango Creek enters the Allegheny River, which flows to the Ohio River (Figure 5). Land use in the vicinity of East Mud Lake is composed of agricultural fields, woodlands and wetlands, and rural residential development. The hydraulic features at East Mud Lake consist of the lake itself, small ponds, wetland areas, and associated streams.

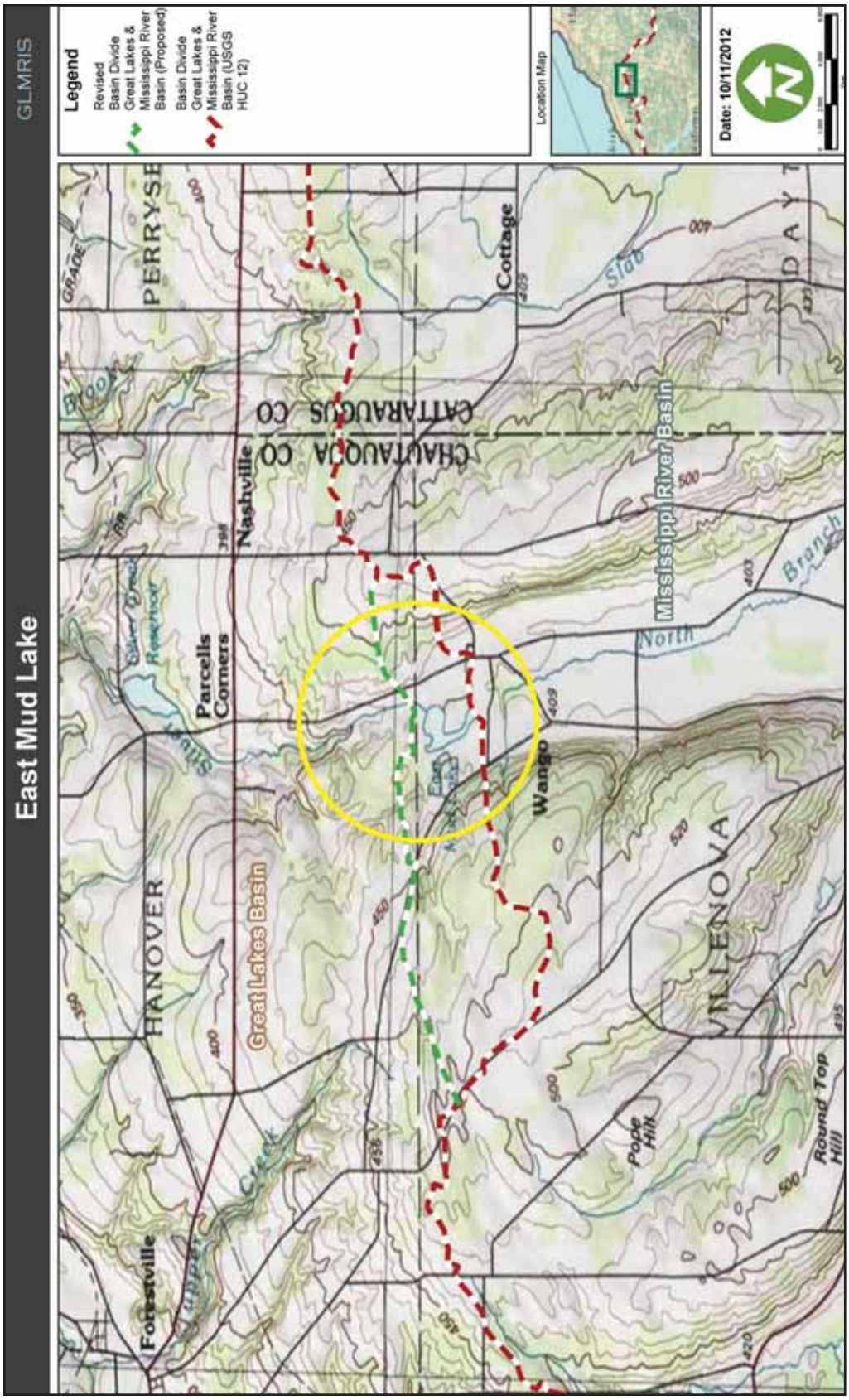


Figure 3. USGS topographic map showing location of the potential surface water connection at East Mud Lake, NY. The original HUC-12 basin divide between the Great Lakes and Mississippi River Basins is represented by the red-white line, with the green-white line showing the recommended revised basin divide location from on-site observations and further mapping evaluation.

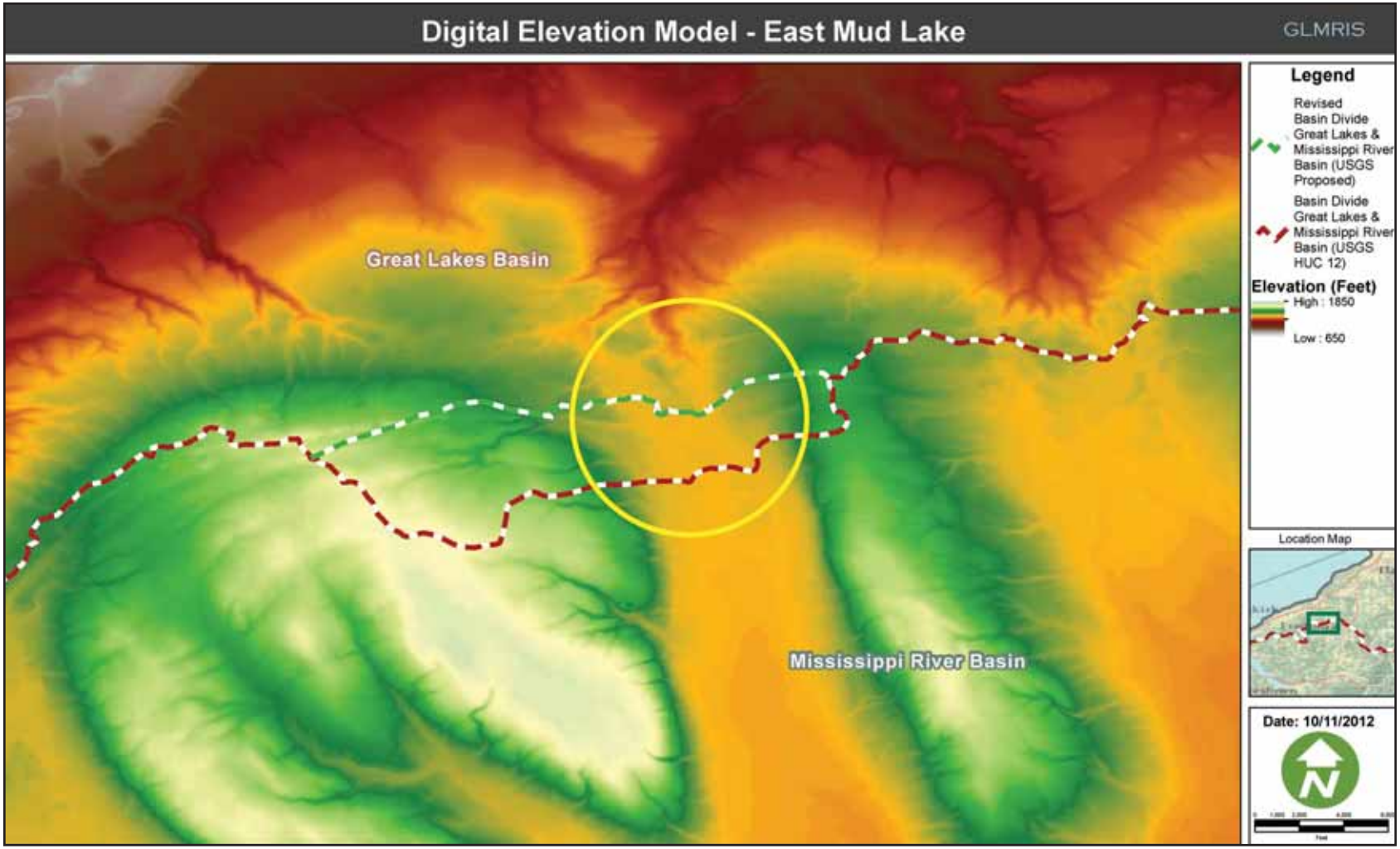


Figure 4. Digital elevation mapping of the East Mud Lake area showing the geographic location within a long narrow valley surrounded by higher ridges. Base imagery courtesy of Bing Maps.

Figure 5. Location of East Mud Lake aquatic pathway toward top of figure (yellow circle) and connecting streams to the Ohio River and Lake Erie. Base imagery courtesy of Bing Maps.

3.2 Climate

Climate is looked at in this section to identify any applicable elements of climate (e.g., temperature, rainfall) and how it may influence the likelihood of an aquatic connection forming at the subject pathway that could be utilized by ANS to spread between the basins. General climate data for the city of Silver Creek, which is located approximately eight miles (12.8 km) from the site, was obtained from City-Data.com (Figures 6-8). The City-Data website stated that the averages were based on data reported by over 4,000 weather stations. The climate of the Silver Creek area of New York State is influenced by its nearness to Lake Erie, while further away from the lake at higher elevations there are larger variances in temperatures.

The New York State Climate Office, located out of the Department of Earth and Atmospheric Sciences at Cornell University in Ithaca, New York, has additional information on snowfall normals on their webpage at http://www.nrcc.cornell.edu. For Chautauqua County and Cattaraugus County, they list the following monthly/ seasonal snowfall normals (1961-1990) (Table 8).

Franklinville is 33 miles (53 km) from East Mud Lake, Little Valley is 19 miles (31 km), Fredonia is 12 miles (19 km), and Westfield is 26 miles (42 km). Fredonia gets an average of almost 24.4 inches (62 cm) of snow in January and approximately seven feet (2.1 m) of snowfall during the winter season, with the other three sites typically getting higher amounts. Spring thaw is typically in March.

Studies of historical climate data indicate upward (positive) trends in annual temperature, precipitation, and runoff. Generally, the State of New York is already experiencing decreased winter snow cover, spring conditions are occurring a week or so earlier than just a few decades ago, and nighttime temperatures are measurably warmer. Summers have more superhot days and intense precipitation events are occurring more often throughout the Northeast (NYSDEC, 2011a; NYSWRI, 2012). Trends based on historical climate data and modeled future projections suggest that increases in the frequency of large rainfall events will continue, possibly more in the Northeast than other regions. Daily rainfall simulations suggest a 0.2 inch (5 mm) increase in the one percent annual recurrence interval storm by the end of the century (NYSWRI, 2012). The intensity of rainfall is particularly relevant. It is usually events that

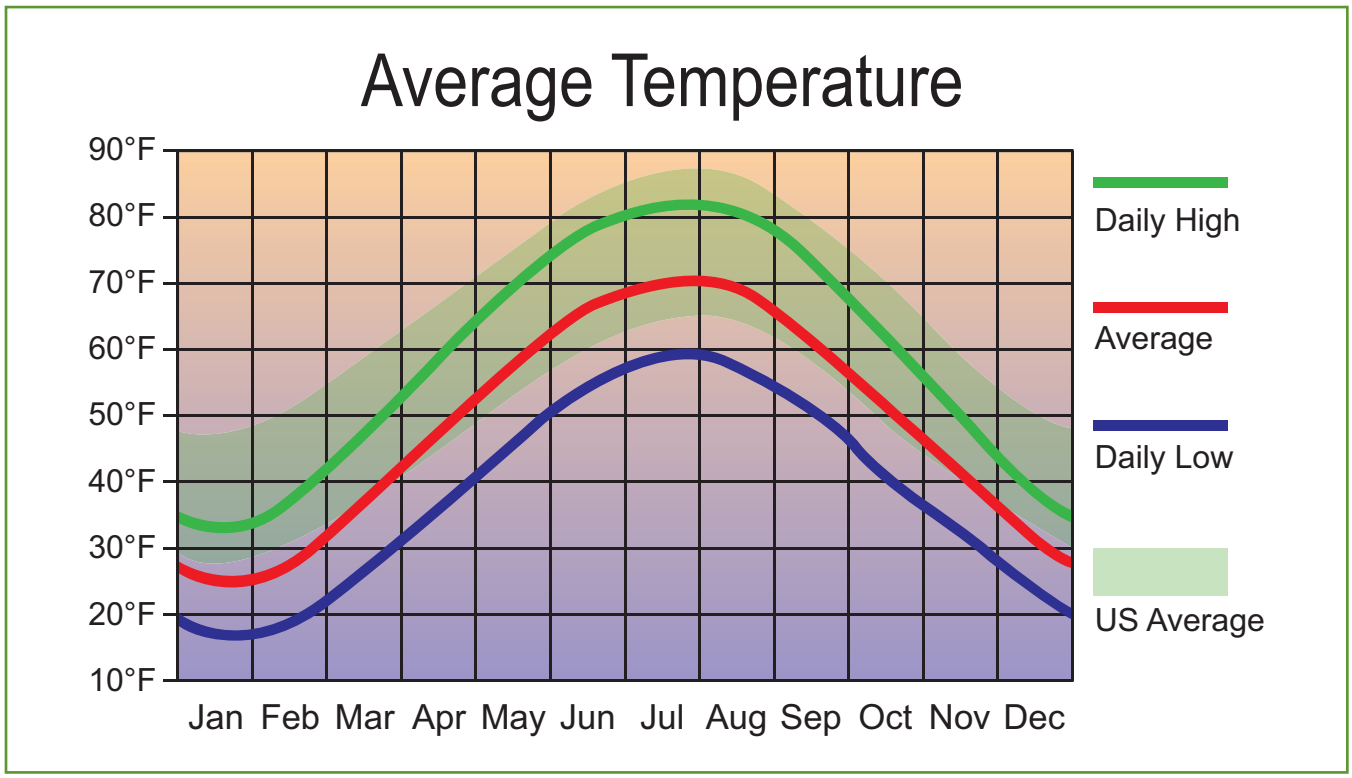


Figure 6. Average temperatures near East Mud Lake, NY (www.City-data.com). City-data.com does not guarantee the accuracy or timeliness of any information on this site.

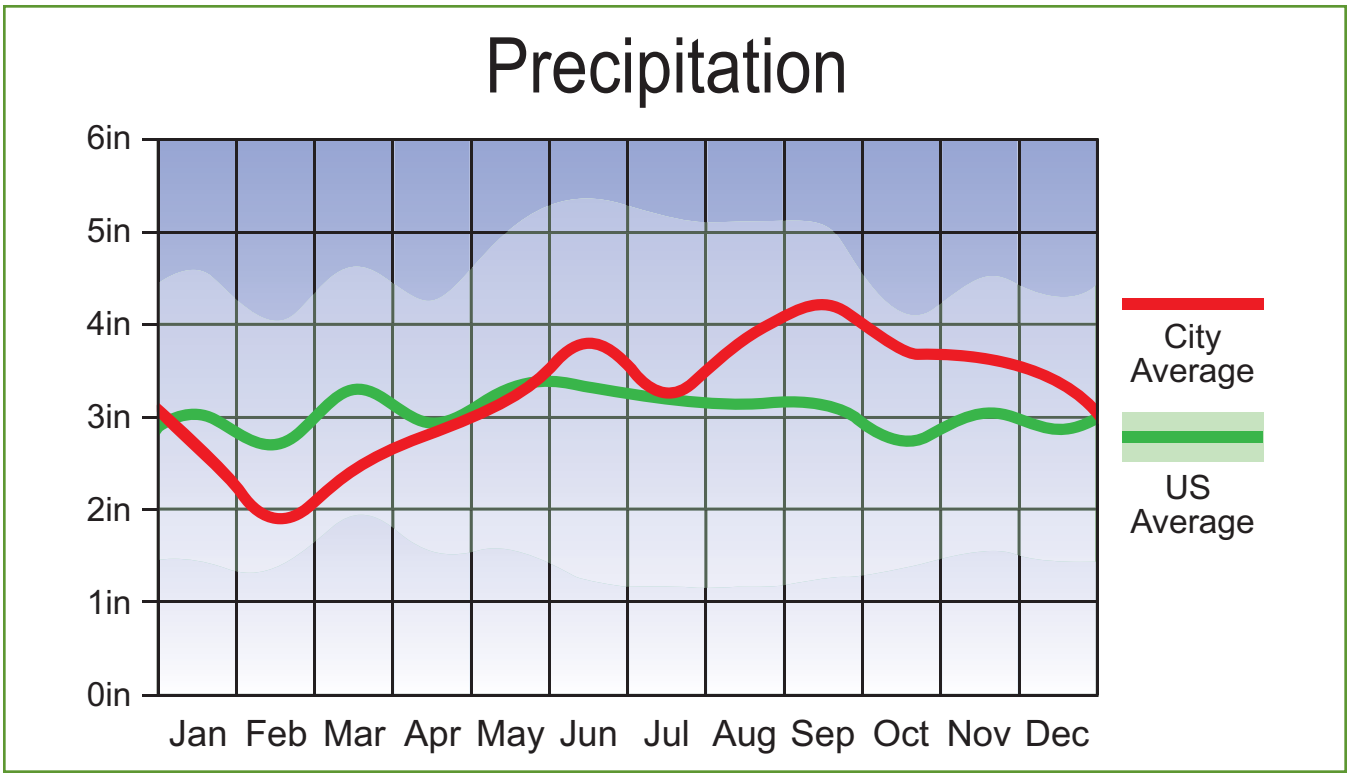


Figure 7. Average precipitation near East Mud Lake, NY (www.City-data.com). City-data.com does not guarantee the accuracy or timeliness of any information on this site.

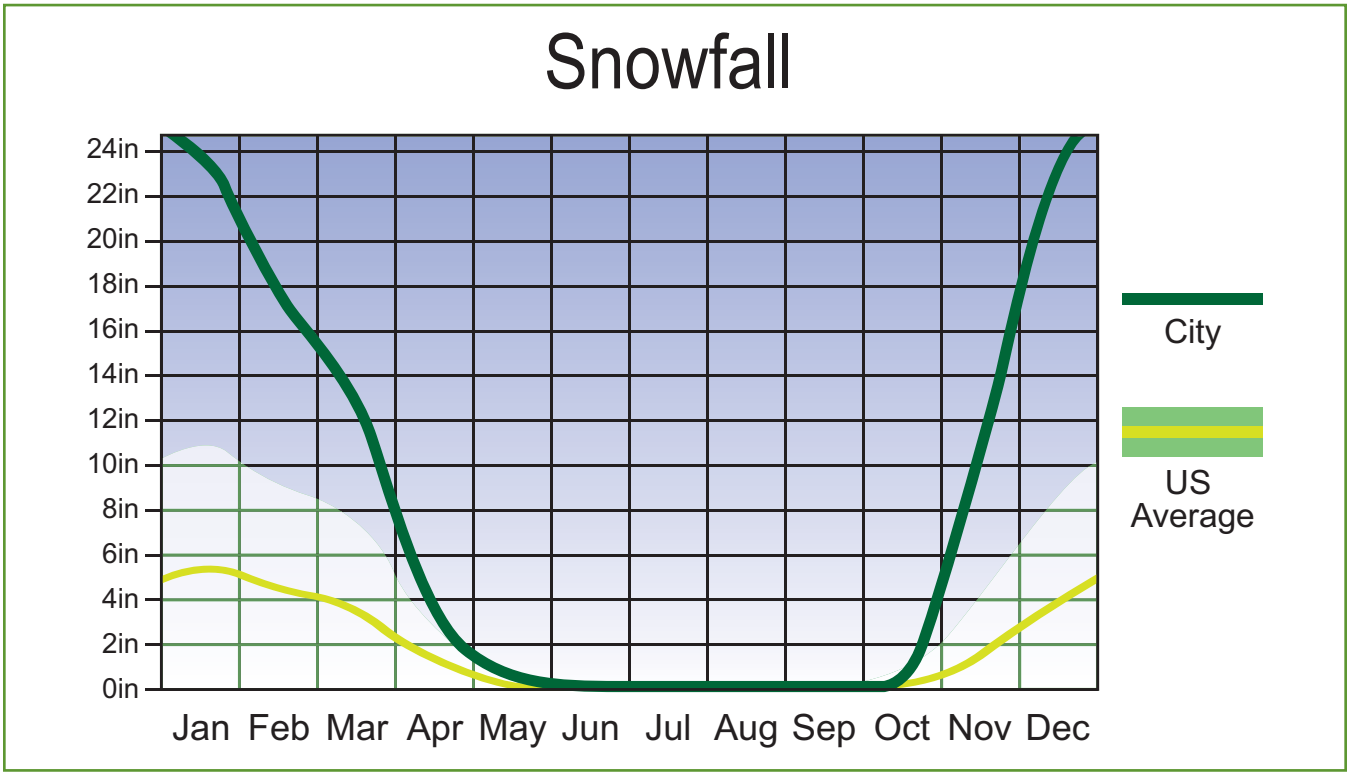


Figure 8. Average Snowfall near East Mud Lake, NY (www.City-data.com). City-data.com does not guarantee the accuracy or timeliness of any information on this site.

Table 8: Monthly/Seasonal Snowfall Normals 1961-1990

County	Station Name	Unit	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Cattaraugus	Franklinville	in	0	0	0	1	11.5	29	27.4	18.3	13.1	5.9	0.3	0	106.5
		cm	0	0	0	2.5	29.2	73.7	69.6	46.5	33.3	15.0	0.8	0	270.5
Cattaraugus	Little Valley	in	0	0	0	1.4	16.6	43.2	33.1	24	17.6	7.2	0.5	0	143.6
		cm	0	0	0	3.6	42.2	109.7	84.1	61.0	44.7	18.3	1.3	0	364.7
Chautauqua	Fredonia	in	0	0	0	0.2	7.2	22.7	24.4	16	9.2	2.7	0.3	0	82.7
		cm	0	0	0	0.5	18.3	57.7	62.0	40.6	23.4	6.9	0.8	0	210.1
Chautauqua	Westfield	in	0	0	0	0.5	8.5	25.4	22.3	16.2	11.6	3.1	0.4	0	88
		cm	0	0	0	1.3	21.6	64.5	56.6	41.1	29.5	7.9	1.0	0	223.5

exceed the soils ability to hold water, resulting in surface runoff which can cause flooding and possibly a surface water connection that could be used by ANS to move between the basins.

Currently observed trends and future projections suggest that changes in aquatic habitat are imminent (i.e., changes could be experienced within this study's 50 year framework). However, it is difficult to forecast how ANS may respond to potential increases in water temperature and associated changes in water quality brought about by periods of drought, followed by more frequent and intense flood events. It is certain that hydrologic and hydraulic estimates based on historical flow data will have to be reassessed, as hydroclimate continues to exceed the past envelope of natural variability (Milly et al., 2008).

3.3 Location Specific Surface Water Features

The information contained in this section is meant to present and interpret the readily available information for this location as it pertains to surface water conditions and any aspects within the area that may influence the behavior of surface water. The HUC-12 watershed divide line was initially laid out through the wetland area just south of East Mud Lake (red-white line, Figure 9). This line was the best approximation of the basin divide as initially developed by a coordinated effort between the USGS New York Water Science Center, USDA New York State NRCS, USEPA Regions 3 and 5, L-3 Titan Group, NYSDEC, and the State University of New York College of Environmental Science and Forestry. The initial assessment of this site in 2010 identified the potential for a surface water connection to exist at this location between the Great Lakes Basin and the Mississippi River Basin. During the site visit on May 25, 2011 it became evident to the pathway assessment team that the basin divide actually appeared to be farther to the north than where it is currently drawn as the HUC-12 (green-white line, Figure 9). The divide runs generally east to west between East Mud Lake and the two ponds to the north, and between New York Route 93 (South Dayton Silver Creek Road) on the east and Hulbert Road on the west. Placement of the actual basin divide (green-white line) at this location is based on observed relief in the field and stream flow directions, although contour information was not verified by new survey data. The exact location of the revised basin divide could therefore not be precisely determined within this glacially formed valley with current available data. Assuming the revised boundary better approximates the real divide location than the existing HUC-12 line, its exact location is not critical to understanding the aquatic pathway characteristics relative to determining the probability it could provide a viable aquatic pathway for ANS to transfer between the basins.

While in the field, the water in the pond to the northeast of East Mud Lake (Edwin Butcher Wildlife Pond) was observed to be flowing out of the pond to the north and to the south. The northwest pond (leftmost in Figure 9) had stream channels at both the north and the south end that flowed away from the pond, and water entered the northwest pond via a stream channel from the west. The largest pond in the center of the figure is East Mud Lake, which at the time of the site visit had water flowing in from the north and south ends. Water does not flow

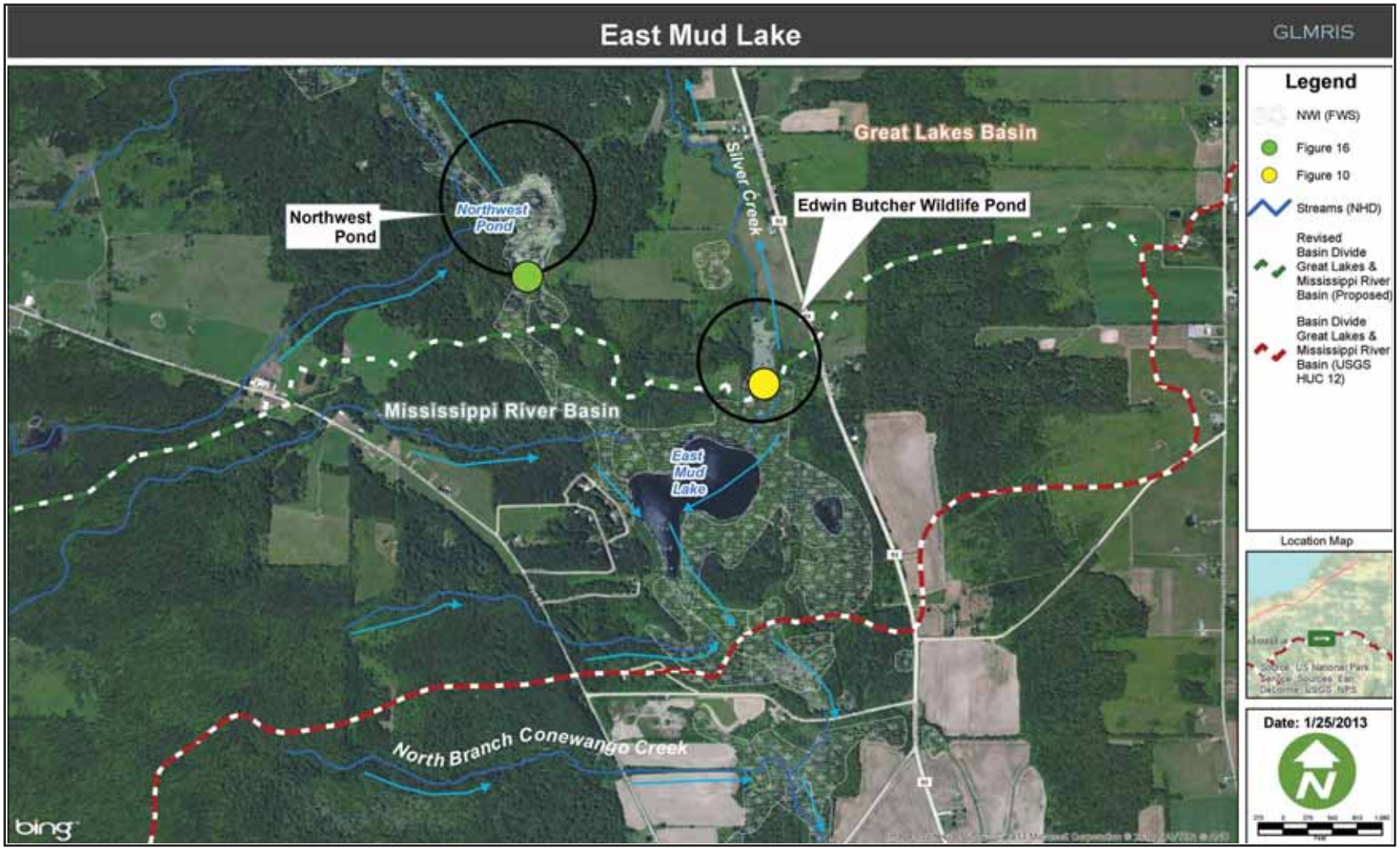


Figure 9. Original HUC-12 basin divide (red-white line) and new proposed basin divide line (green-white line) through the East Mud Lake location. Observed stream flow directions indicated by blue arrows. Base imagery courtesy of Bing Maps.

north out of East Mud Lake. On the northeastern side of the study area, flow through the Edwin Butcher Wildlife Pond is perennial. Examination of both the north and south end of this pond confirmed that there was flow out of the pond in both directions at the time of the site visit. At the pond's southern discharge point, there is a blocked culvert (Latitude N42° 26' 18", Longitude W079° 5' 38") and beaver dam (Figure 10 and Figure 11). The discharge from the pond was flowing through the beaver dam and continuing to East Mud Lake.

The outflow to the north from the Edwin Butcher Wildlife Pond is perennial and passes through a marshy area before passing under a built up field road crossing. The small stream is bridged by what appears to be a homemade permeable boulder/rock pile (Figure 12 and Figure 13).

The western flow path through the northwest pond did not appear to be perennial at the time of the site visit, and it appears to be blocked during low flow conditions by a beaver dam, and it ultimately flows north into Silver Creek (Figure 14 and Figure 15).

The southern exit from the northwest pond is slightly higher than the northern exit and was not flowing at the time of the site visit. Water from the southern exit flows south to East Mud Lake through marshy wetlands and small channels. Figure 16 shows the southern exit from the northwest pond and its general path to East Mud Lake through the marshy wetland area.

Profile and cross section drawings at the divide location at East Mud Lake are illustrated in Figure 17. The profile shows that the aquatic pathway is located at the low points along the basin divide (cross section intersect points), while the two cross sections have been placed along the most likely flow paths between the basins. The cross sections for the two flow paths show that there are pronounced high points (4-8 foot (1.2 - 2.4 m) elevation change) between the two ponds and East Mud Lake corresponding with the revised basin divide location. This supports the rationale for redrawing the interbasin divide line at this location instead of using the original HUC-12 basin divide line located farther to the south. There is, however, some uncertainty in the accuracy of the elevation differences between these two ponds and East Mud Lake since it is not known whether or not the

Figure 10. Flow from Edwin Butcher Wildlife Pond flowing south (right) to East Mud Lake. Shown is blocked culvert at south end of the Pond from beaver activity. Photo by USACE.

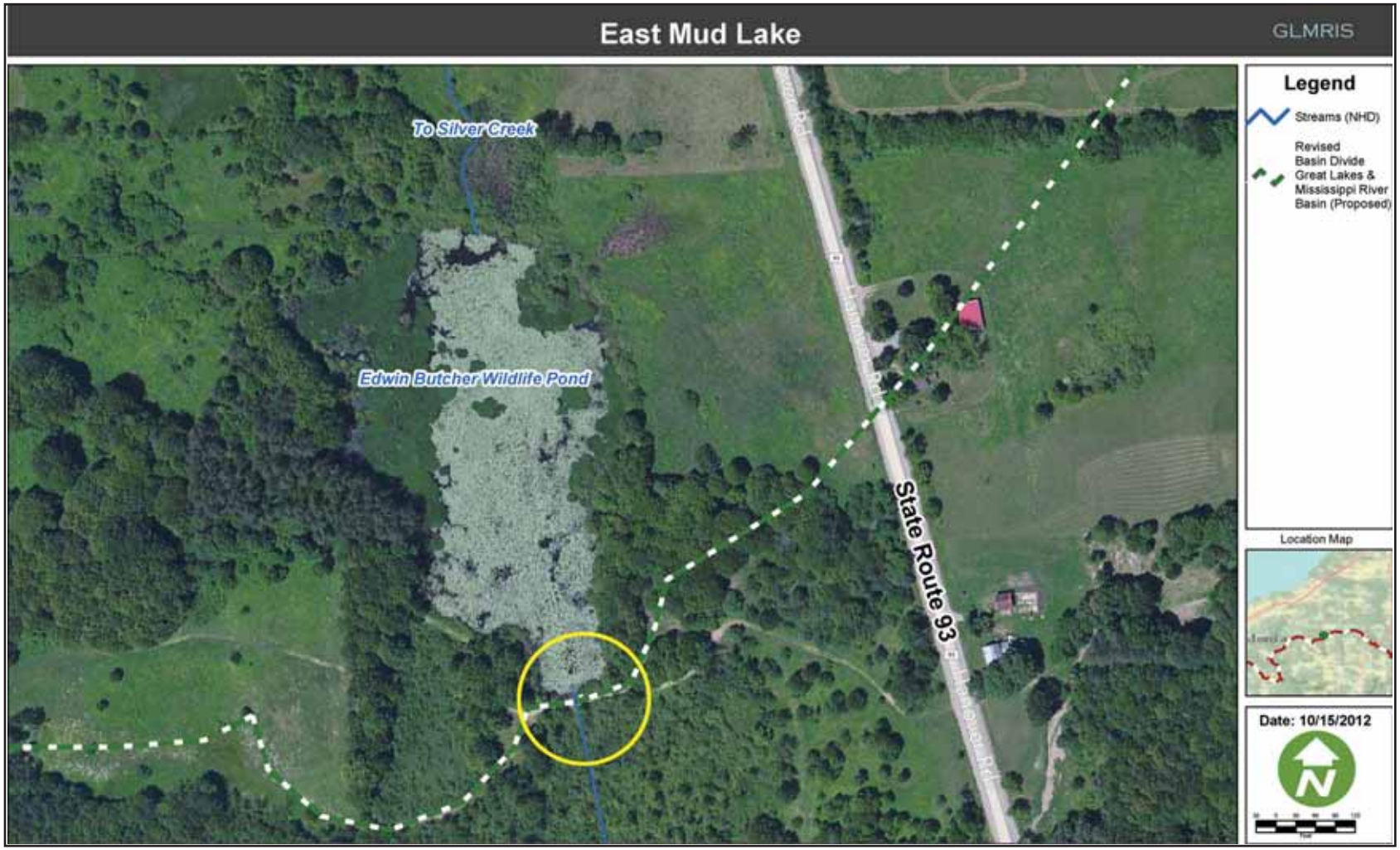


Figure 11. Location of southern discharge and blocked culvert at Edwin Butcher Wildlife Pond, north of East Mud Lake. Background imagery courtesy of Bing Maps.

Figure 12. Farm road bridge in tributary to Silver Creek, north of the Edwin Butcher Wildlife Pond. Photo by USACE. Reference also Figure 13.

water surface elevations of the ponds were influenced by beaver activity or other circumstances at the time the elevation data was collected.

For this pathway, the elevations in Figure 17 are based on the USGS 10-meter Digital Elevation Model (DEM) with a vertical accuracy of +/- 13.123 feet (4 m). This level of accuracy may lead one to conclude that there is a high degree of uncertainty regarding the potential for watershed connections being established during flood events at East Mud Lake. However, the absolute vertical accuracy (specific elevation) is not nearly as important as the relative, or point-to-point, vertical accuracy (terrain) when evaluating terrain at the divide location to try and predict hydrology. Point-to-point accuracy has been shown to be much greater than this margin of error regarding absolute elevation would indicate, although the topographic variability at the East Mud Lake location could be an additional source of elevation error.

Although the absolute elevation values vary from the true value (i.e., feet above sea level), they tend to vary a comparable amount at adjacent points so that the terrain of the area is actually depicted relatively well. The grid size used to create the DEM can also affect the accuracy of the DEM. The larger the grid cell size (10 m vs. 30 m), the less detailed the terrain appears and thus the less accurately the DEM depicts the actual terrain. The largest grid size used at any of the pathway locations is 10 m, with some areas having more detailed information. Even though the 10 m cell size does not depict every hummock or hollow in the terrain, it does provide sufficient detail regarding general terrain and relative elevations to provide useful data in evaluating the potential for a hydrologic connection forming across the basin divide.

New York State has mapped wetlands in the East Mud Lake area which cover a substantial area across the original and revised watershed divides, and include the ponds, East Mud Lake, and portions of the connecting streams (Figure 18). These are a mixture of forested, emergent, and Silver Creek Reservoirub-shrub wetlands that have saturated or inundated conditions for a significant portion of the year and that are dominated by vegetation that is tolerant or adapted to wet (hydric) conditions.

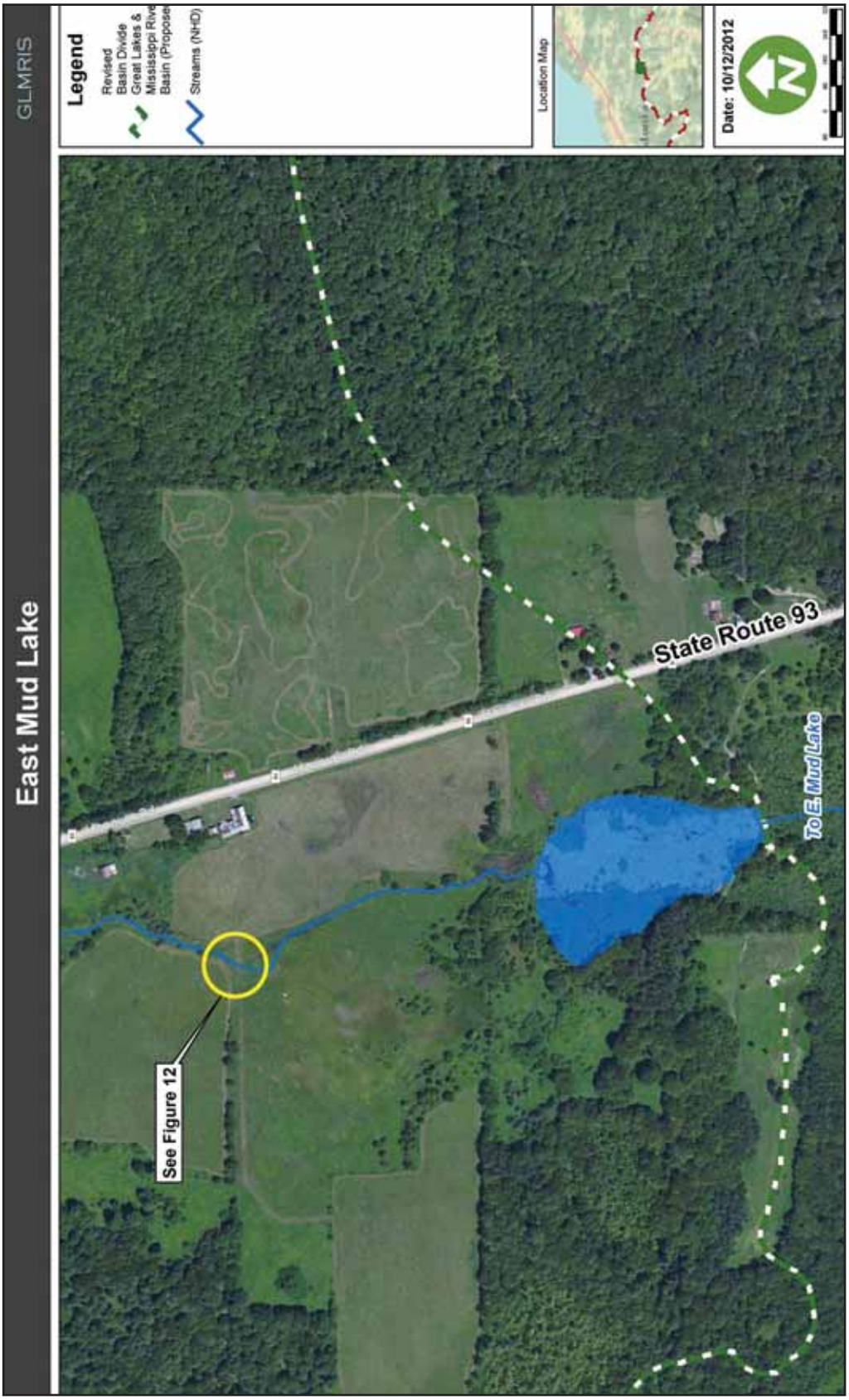


Figure 13. Location of farm road bridge on tributary to Silver Creek, north of the Edwin Butcher Wildlife Pond. Reference also Figure 12. Background imagery courtesy of Bing Maps.

Figure 14. Flow path through northwest pond. Photo by USACE.

New York State has also compiled Federal Emergency Management Agency (FEMA) Q3 Flood Zone Data sets for this area (Figure 19). The FEMA study that was completed on this specific site was not a detailed study, but was an approximate study with the area shown as Flood Zone A. The FEMA mapping shows that the water elevation from a one percent annual recurrence interval storm event does cross the basin divide and inundates East Mud Lake as well as the surrounding ponds and wetlands (red shading in Figure 19). The one percent flood footprint does not match up perfectly with the contours and appears to be shifted slightly to the west. However, the general extent of the flood zone is very evident and supports the determination that an interbasin aquatic connection exists between the Great Lakes Basin and the Mississippi River Basin at a one percent annual recurrence interval flood event.

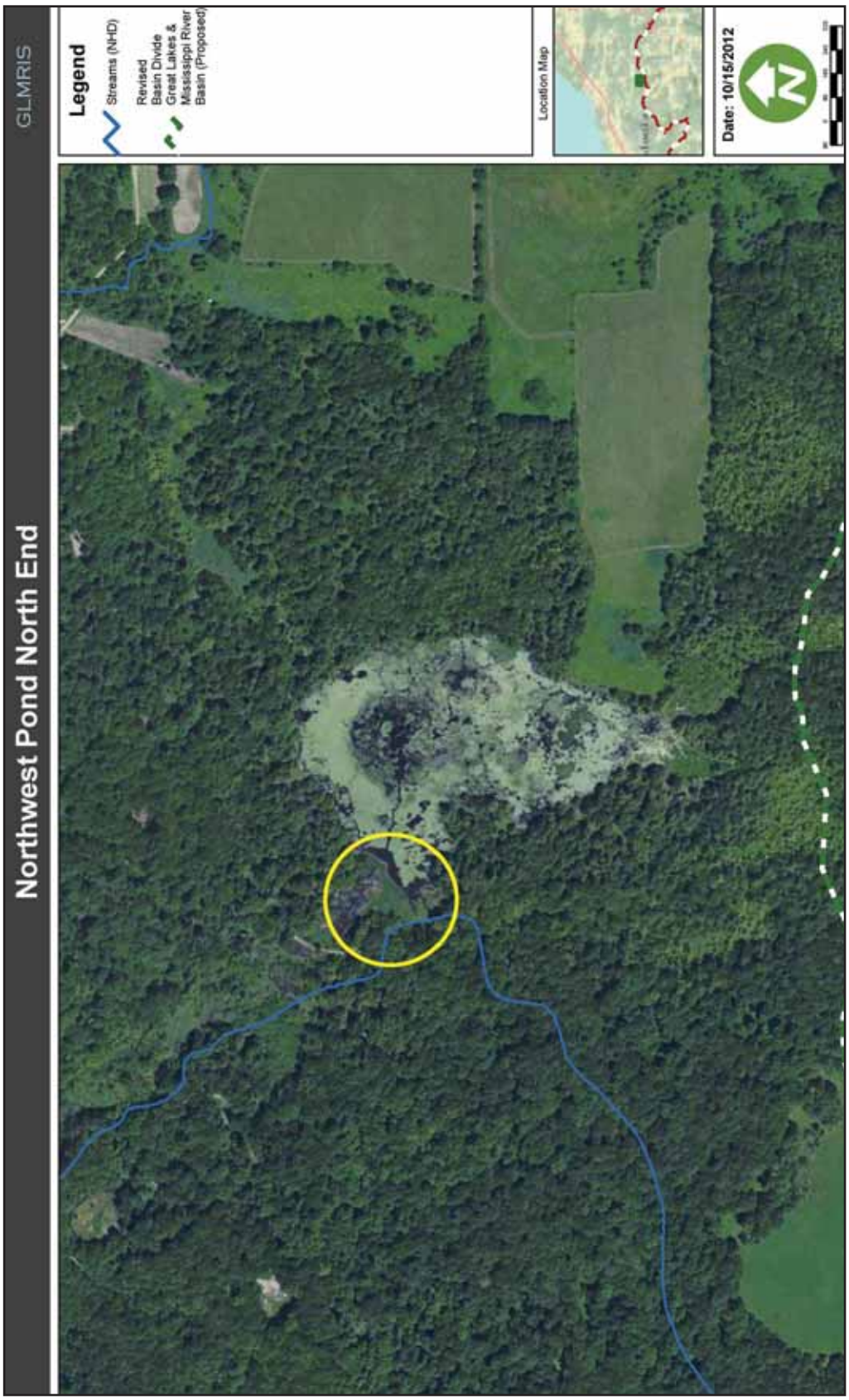


Figure 15. Location of northern discharge from northwest pond and beaver dam. Background imagery courtesy of Bing Maps.

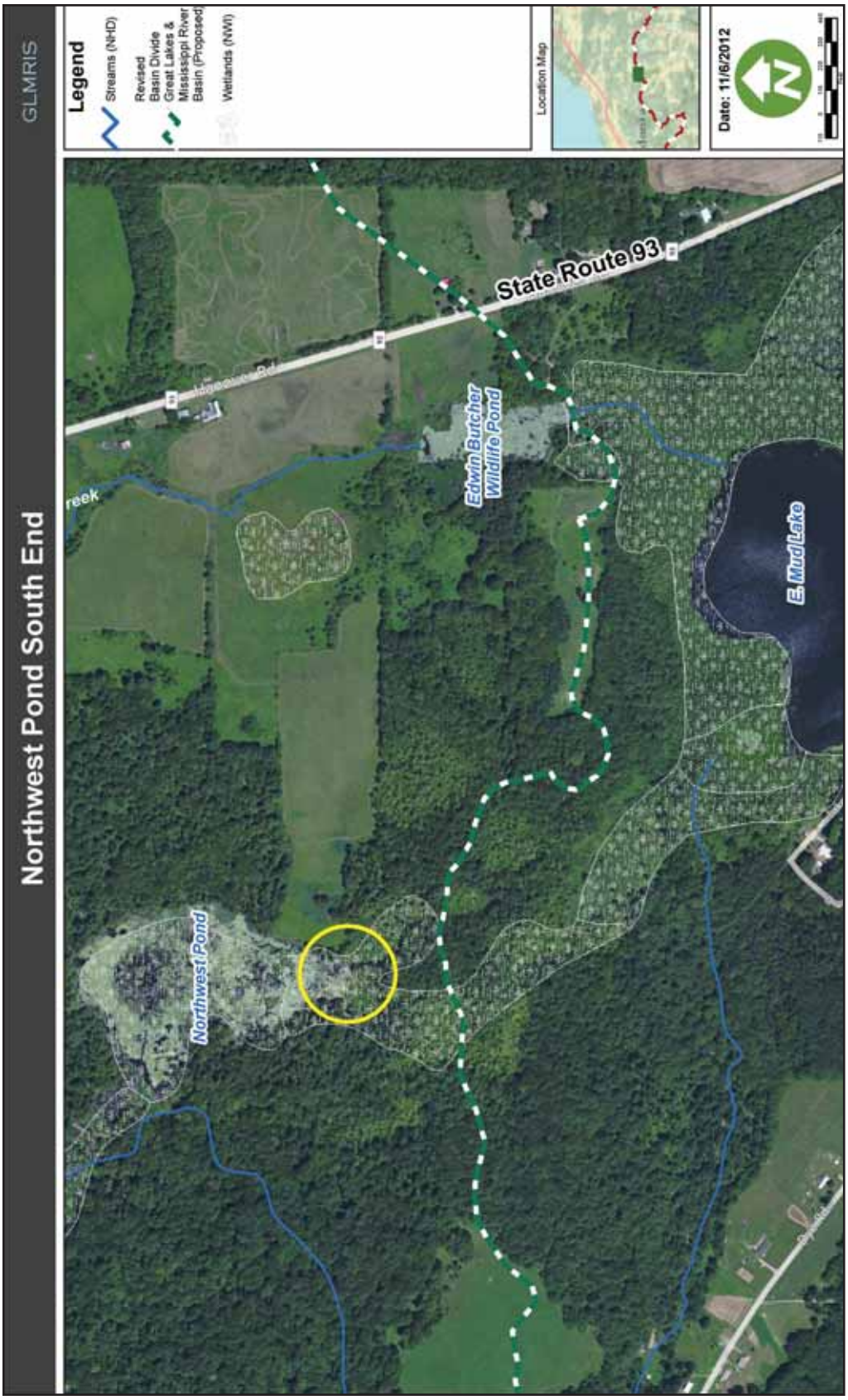


Figure 16. Location of southern discharge from northwest pond and flow path (wetland area) to East Mud Lake. Background imagery courtesy of Bing Maps.

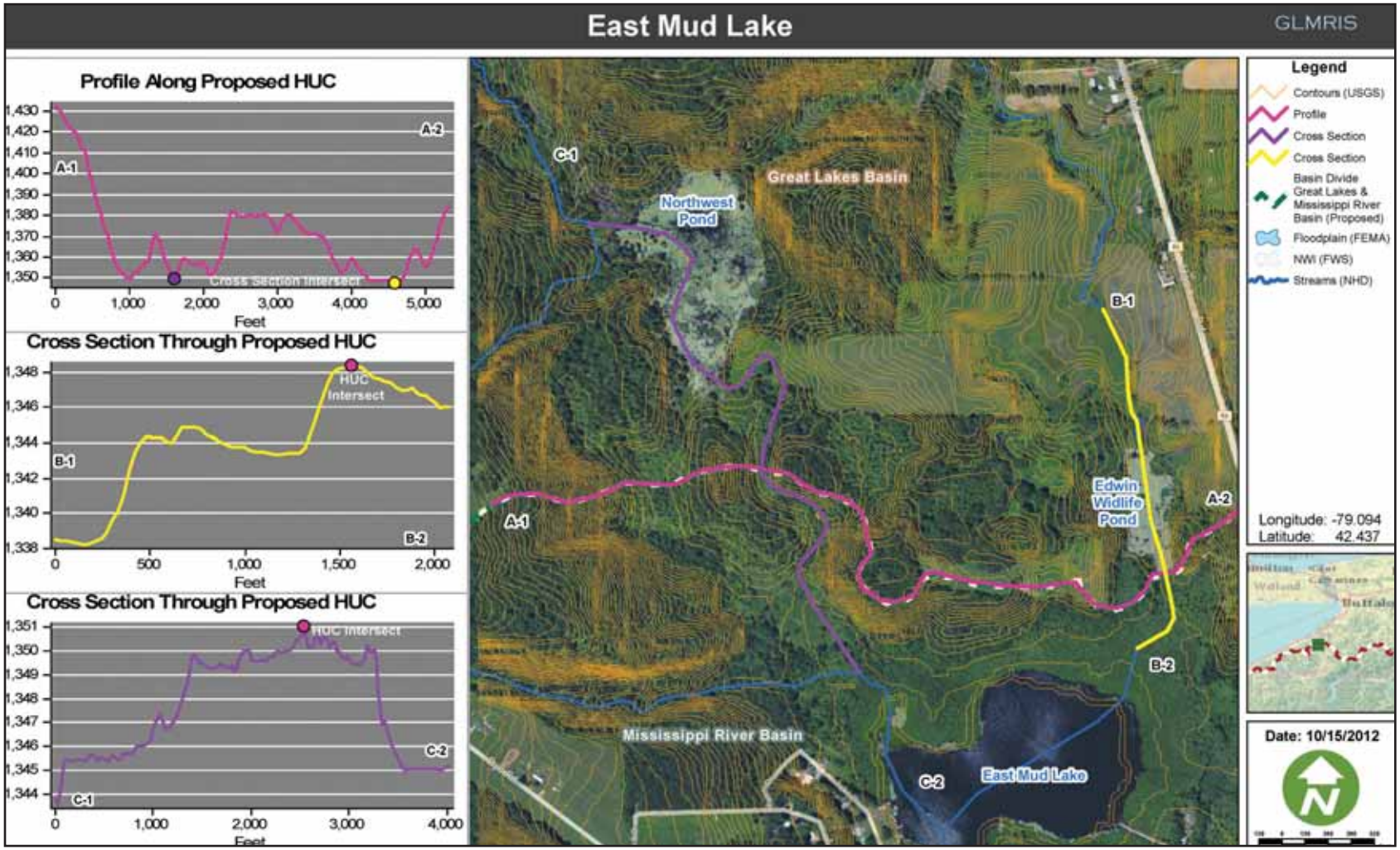


Figure 17. Typical profile and cross-sections at East Mud Lake, based on 10m DEM, with a vertical accuracy of +/-13 feet (4 m). The green/white line with pink overlay is the proposed revised basin divide. Yellow line in the figure and the graph on the middle left is the cross section between East Mud Lake and the Edwin Butcher Wildlife Pond. The purple line in the figure and the bottom left is the cross section between East Mud Lake and the Northwest Pond. Note based on graphs on left side that the two cross sections are drawn through the low points along the basin divide, and the cross sections themselves indicate a pronounced elevation difference between the basin divide and the ponds on either side. Background imagery courtesy of Bing Maps.

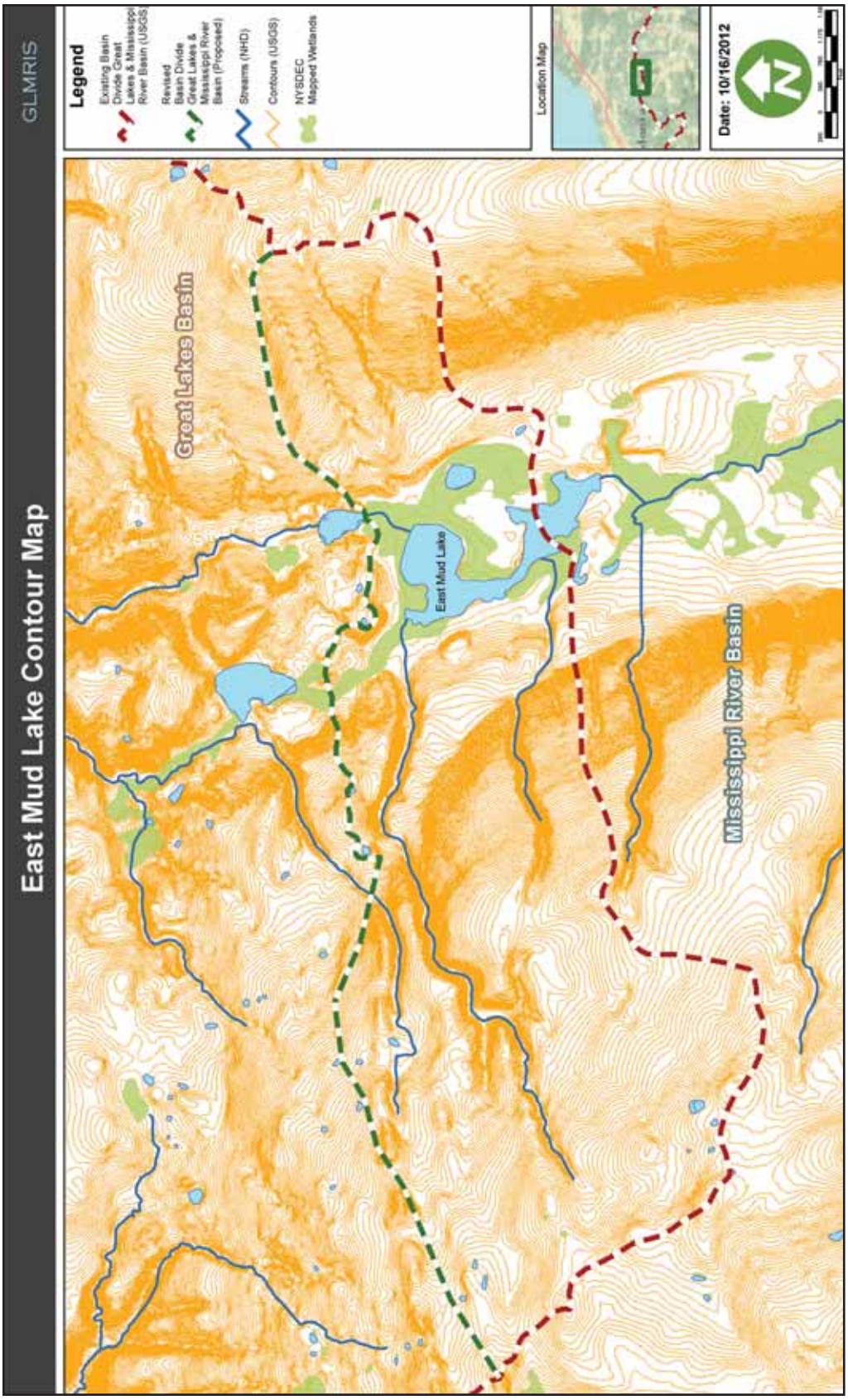


Figure 18. Mapped wetlands at East Mud Lake location and connecting streams. Base imagery courtesy of Bing Maps, and wetland mapping is from the New York State Department of Environmental Conservation.

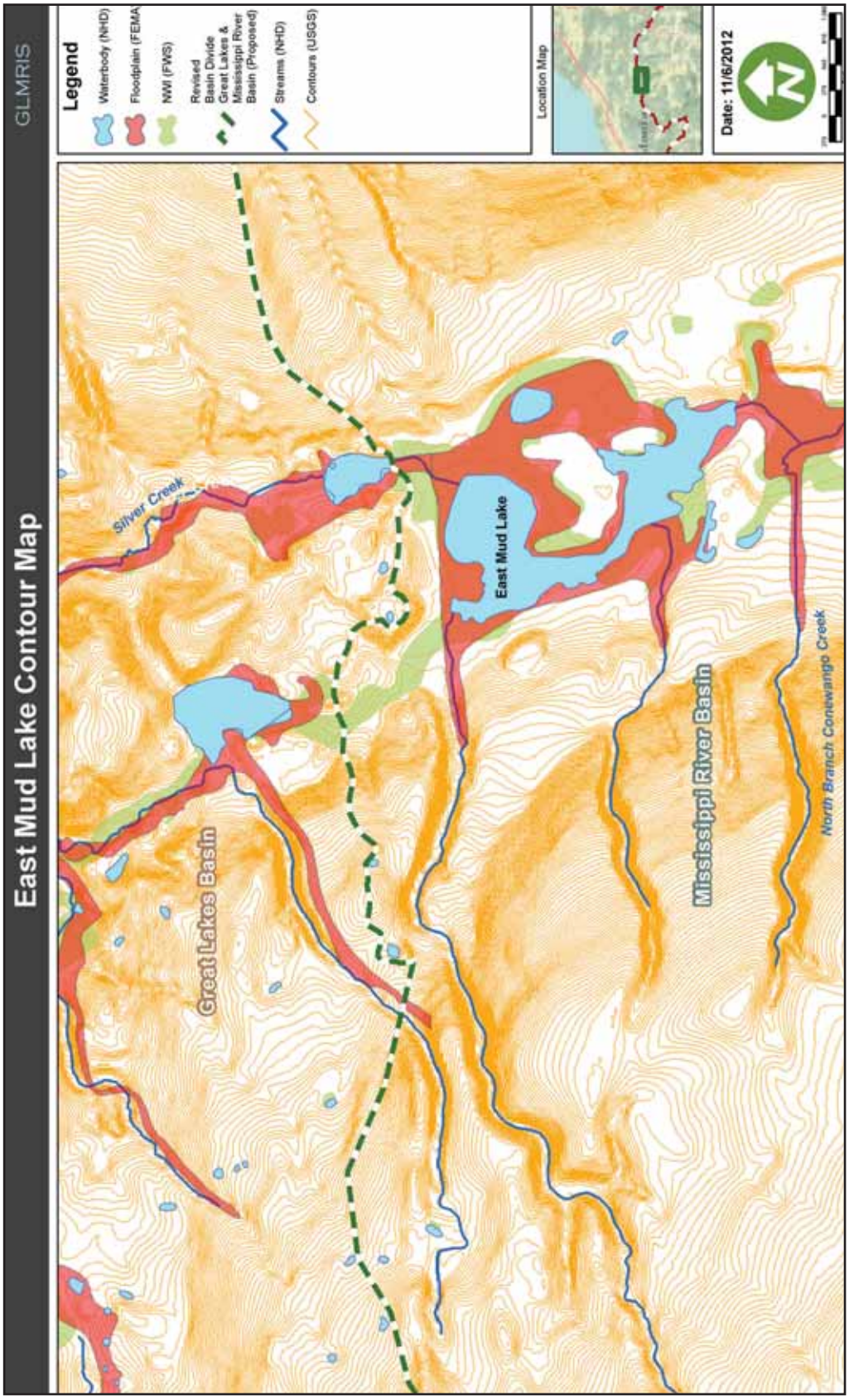


Figure 19. FEMA floodplain mapping for East Mud Lake site showing one percent annual recurrence interval flood outline, waterbodies, and wetland areas (FIPS 36013, FIRM Panel 3610820001C). Base imagery courtesy of Bing Maps.

3.4 Groundwater

Groundwater was taken into consideration as a part of determining the likelihood of a pathway existing due to the fact that groundwater can be a source of headwater to streams in upper portions of the basin divide or the source of baseflow in wetland areas. New York State has mapped aquifers statewide based on the NYS Geological Survey surficial and bedrock maps. These aquifers often consist of sand and gravel, and yield large supplies of water to wells. These maps show that there is an unconsolidated aquifer under the entire East Mud Lake site, divided into two parts (Figure 20). The northern part (dividing lines goes east - west through East Mud Lake) is listed as Type–Moraine and has unknown yield. The southern part is listed as *Type–Unconfined, High Yield*, with a yield of 100 gallons per minute.

The USGS does not have any groundwater monitoring wells closer than 0.8 mile (1.3 km) from East Mud Lake (Table 9, Figure 21). However, during the May 25, 2011 site visit, USGS personnel noted that there are several natural springs near the northeast pond (Edwin Butcher Wildlife Pond), especially on the western flank of the moraine hills surrounding the ponds. The material in this area is mapped as a till moraine (Muller, 1977), which by definition is more permeable than a normal till plain in western New York State. The discharge of springs on the flanks of the Edwin Butcher Wildlife Pond may be supplemented by additional springs issuing through the bottom of the pond. No spring measurements were made, but visual inspection of one spring indicated a discharge of about 0.5-1.0 gallons per minute (0.0014-0.002 cubic feet per second; per USGS estimate). It is likely that the combination of precipitation and groundwater are the primary sources of hydrology for the surface water features in this area.

Based on the geographic information system (GIS) project mapping used for this site, the water surface elevation of East Mud Lake is around elevation 1345 feet. Six of the 15 wells listed in Table 9 have water surface elevations higher than the water surface elevation of East Mud Lake. This further supports the belief that groundwater is one of the primary sources of surface water for this area.

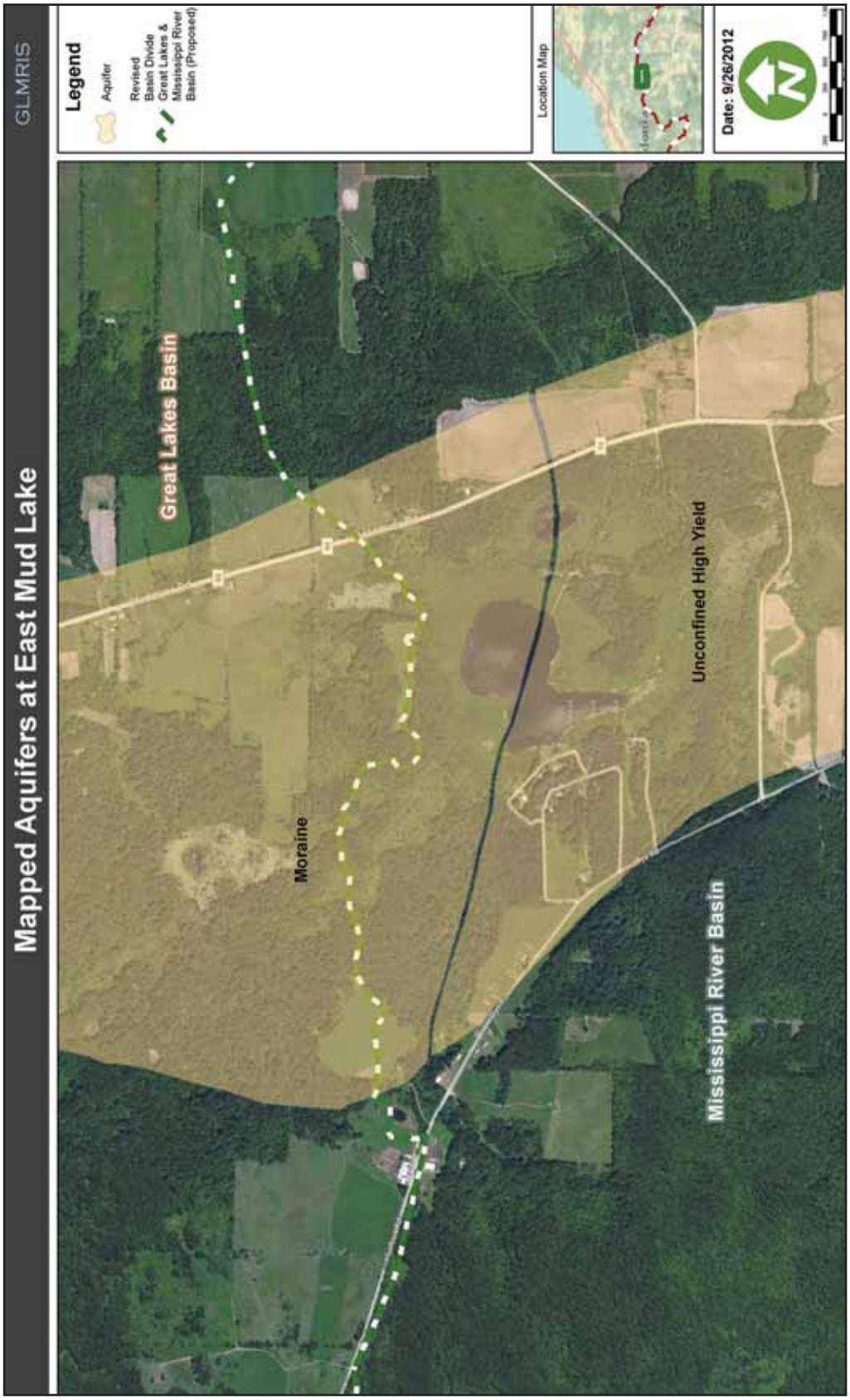


Figure 20. Two groundwater aquifers at East Mud Lake site (NYS Geological Survey). Background imagery courtesy of Bing Maps.

Table 9: Water Wells

DEC Well Num.	Distance from East Mud Lake	Latitude	Longitude	Ground water depth	Ground elevation	Ground water elevation	Bottom of Well - depth elevation
CU1036	0.8	42.4325	-79.1125	65	1529	1464	1452
CU1037	0.8	42.437222	-79.111667	60	1472	1412	1393
CU1216	1.0	42.420944	-79.086806	42	1343	1301	1299
CU1253	1.1	42.41825	-79.0955	2	1339	1337	1106
CU1025	1.2	42.451194	-79.097694	25	1299	1274	1246
CU1006	1.4	42.453444	-79.096472	0	1267	1267	1209
CU2215	1.4	42.420361	-79.115722	10	1638	1628	1603
CU1669	2.2	42.426083	-79.137167	4	1667	1663	1637
CT852	2.6	42.435444	-79.045444	19	1340	1321	1304
CU2208	2.9	42.475139	-79.103306	2	1218	1216	1168
CT804	3.4	42.423167	-79.030778	13	1330	1317	1291
CU1120	3.4	42.434167	-79.163889	29	1533	1504	1475
CT890	3.6	42.3995	-79.0445	30	1444	1414	1376
CU1670	3.9	42.377333	-79.087333	14	1313	1299	1333
CU1654	4.2	42.433167	-79.1775	17	1352	1335	1300

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. A hydrologic connection between the basins at this location is most likely to establish during periods of spring snowmelt and after periods of heavy rainfall. The East Mud Lake Pathway consists of two ponds along the basin divide and associated wetlands that connect with streams that drain into both the Great Lakes and Mississippi River Basins. The Edwin Butcher Wildlife Pond (northeast pond) has perennial flow leading to either basin and the northwest pond has intermittent flow to either basin. The northwest pond is connected to East Mud Lake by a contiguous wetland area. The northwestern pond has several inflowing streams which raise the surface elevation during heavier rainfall events and likely result in a continuous flow path developing toward East Mud Lake (south of the northwest pond).

3.6 Probability Aquatic Pathway Exists

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

- Shallow groundwater depths and agricultural drainage likely contribute to sustained base flows in the ponds and wetlands during parts of the year.
- The Edwin Butcher Wildlife Pond (northeast pond) has perennial flow leading to either basin and the northwest pond has intermittent flow to either basin, with the area between the NW pond and East Mud Lake being mostly wetland.
- Extensive wetlands dominate the areas between the ponds.

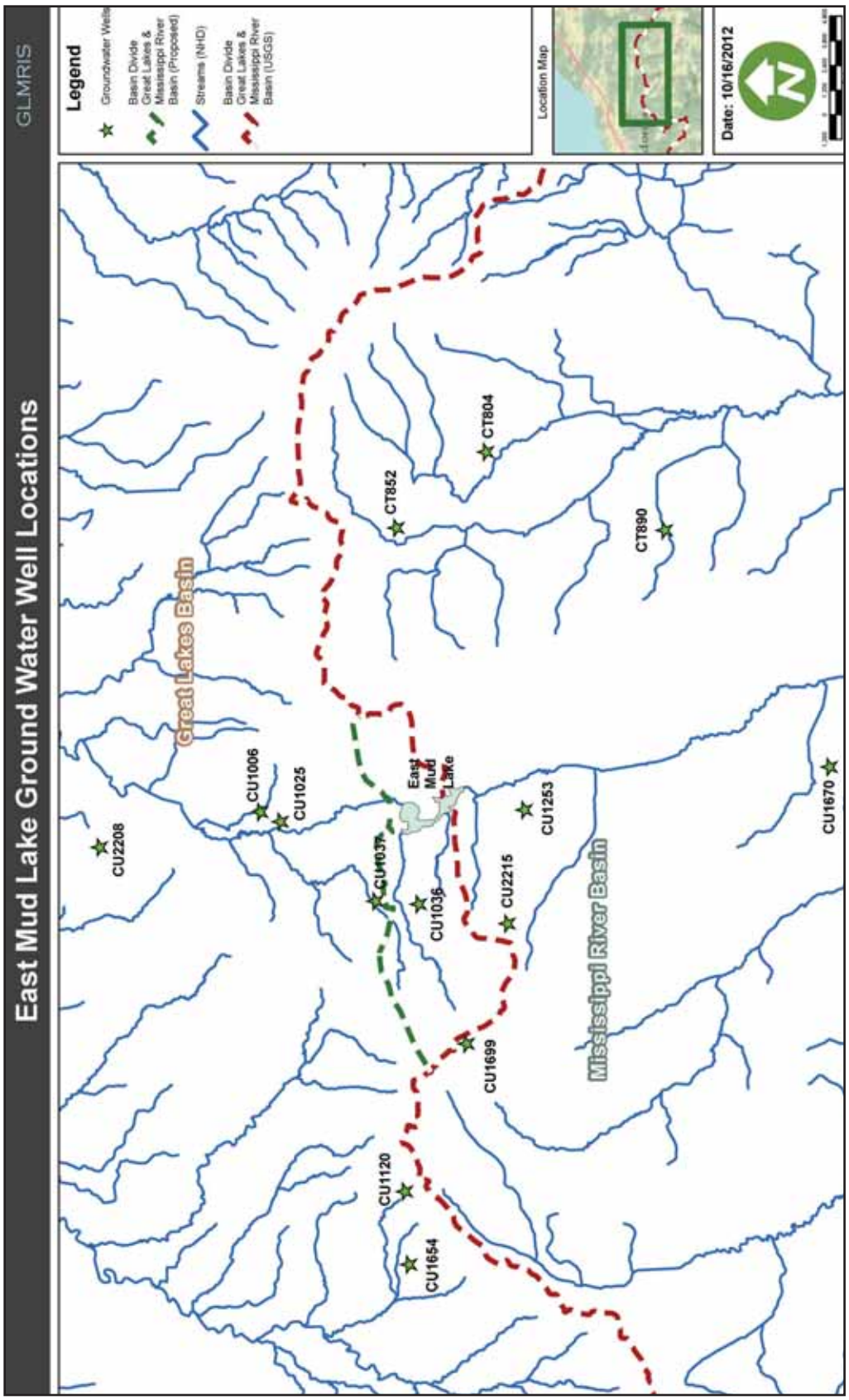


Figure 21. Water wells within four miles (6.4 km) of East Mud Lake (USGS). Background imagery courtesy of Bing Maps.

- Based on analysis of topographic data and field observations, the actual basin divide should be located through the NW pond and the Edwin Butcher Wildlife Pond rather than south of East Mud Lake.

- The aquatic pathway is located at the low points along the basin divide through the NW and NE ponds.

- The FEMA one percent annual recurrence interval floodplain is contiguous across the basin divide through the Edwin Butcher Wildlife Pond, and is nearly contiguous through the NW pond. Where the floodplain is broken along the NW flow path, NWI wetland areas have been mapped.

- Water quality in the streams leading away from the pathway in either direction is generally high enough to support fish populations, and in some cases is suitable for drinking water.

Due to the above evidence, the probability of a pathway existing between the Great Lakes and the Mississippi River Basin at East Mud Lake is rated medium since it meets the criteria of intermittent streams (or interconnected wetlands) capable of maintaining a surface water connection with both basins continuously for multiple days from a ten percent annual recurrence interval storm. In the case of East Mud Lake, there is a network of several ponds and associated wetland areas through which an aquatic pathway may form.

This rating for aquatic pathway existence is considered reasonably certain because of the following:

- There is some uncertainty related with the ground elevations as shown in Figure 17, which has a vertical accuracy of +/- 13 feet (4 m). However, general point-to-point elevations are believed to be fairly accurate; and

- There are no USGS groundwater monitoring wells closer than 0.8 mile from the pathway. However, springs were observed on the flanks of the Edwin Butcher Wildlife Pond that may be supplemented by additional springs issuing through the bottom of the pond.

- Beaver activity in the area may be influencing surface water behavior (e.g., dam on Edwin Butcher Wildlife Pond), and may have affected topographic data depending on whether or not beaver activity raised or lowered water levels at the time the data was gatherered.

- On-site observations confirmed the presence of flows entering East Mud Lake from the north and south, as well as flows leaving to the north and south (via wetlands or streams) from both the NW pond and Edwin Butcher Wildlife Pond.

- The rating for the probability of an aquatic pathway existing at East Mud Lake did not take into account any potential future climate change and how it might affect the likelihood of aquatic pathway formation at East Mud Lake.

3.7 Aquatic Pathway Habitat

3.7.1 Land Use and Aquatic Resources

Land use near the East Mud Lake site consists mainly of agricultural areas and woodlands. Around the ponds at the pathway are open water areas (ponds), and a mixture of scrub-shrub, emergent, and forested wetlands, and rural residential development. Drainage to the north (Great Lakes Basin) is through the Silver Creek Watershed and while drainage to the south (Mississippi River Basin) is through the Conewango Creek Watershed.

3.7.2 Water quality

Stream, lake, and pond classifications in New York State are based on water quality. All water bodies in the state are provided a water quality classification based

on existing, or an expected, best usage of each water body or water body segment. The classification AA or A is assigned to waters that are used as a source of drinking water. Classification B indicates a water used for swimming and other contact recreation, but not for drinking water. Classification C is for waters supporting fisheries and that are suitable for noncontact activities. The lowest classification and standard is Class D. Waters with classifications A, B, and C may also have a subclassification, or standard of (T), indicating that it may support a trout population, or (TS), indicating that it may support trout spawning (TS). Under New York State environmental conservation law (ECL) (Title 5 of Article 15), certain waters of the state are protected on the basis of their classification. Streams and small water bodies that are designated as Class C (T) or higher (i.e., C (TS), B, or A) are collectively referred to as "protected streams." Within the East Mud Lake pathway vicinity, there are three stream quality classifications (Figure 22). The North Branch of Conewango Creek is designated as a Standard C (T) protected stream meaning that is can support a trout population. This indicates that the connecting streams at least in close proximity to the pathway have water quality suitable to support fish, although some of the intermittent areas or shallow areas in the wetlands may experience warmer temperatures or lower dissolved oxygen levels during late summer months. Class A streams are assigned to waters used as a source of drinking water (NYSDEC, 2012b).

Most of the river and stream miles that have been assessed in the Allegheny River Watershed fully support designated uses, but there are still some impacts mainly from nonpoint agriculture and streambank erosion. Approximately 23 percent of the river miles in this watershed are listed as either not supporting designated uses or having minor impacts or threats to water quality, and only three percent are impaired (NYSDEC, 2007). Water quality in the lower Conewango Creek Watershed is impacted by nutrient enrichment, primarily from agriculture and urban runoff in the form of polycyclic aromatic hydrocarbons (PAHs) with aquatic life and recreational use being impacted (NYSDEC, 2007). The North Branch of Conewango Creek nearest to the pathway location does not have any use impairments, although the 11.1 mile (17.8 km) reach is Class C stream, likely due to nonpoint source nutrient enrichment (NYSDEC, 2007).

Water quality in the lower 22 miles (35 km) of the Silver Creek Watershed is categorized as stressed for recreation, aquatic life, and habitat due to turbidity, dissolved oxygen demand, sediment, and nutrients from municipal wastewater treatment, nonpoint sources, and possibly streambank erosion. In contrast, the upper 33 miles (53 km) of the Silver Creek Watershed have no use impairments and are deSilver Creek Reservoiribed as being "similar to a natural community with minimal human impacts" (NYSDEC, 2010).

3.7.3 Aquatic Organisms

East Mud Lake and the surrounding ponds and wetlands are located on private lands and have not had any formal biological surveys performed on them. It is assumed that the fish community is a warmwater community made up of common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), possibly northern pike (*Esox lucius*), Pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis machrochirus*), and assorted minnow species (D. Einhouse-NYSDEC, personal communication, April 6, 2012). The stream areas directly downstream on either side of the basin divide likely have a similar compliment of species with the most abundant species being minnows and dace. These species would include white sucker, hog sucker, creek chub, blacknose dace, etc. The lower portions of Conewango Creek are stocked by NYSDEC with brown trout (West Branch), paddlefish, and Muskellunge and Silver Creek is stocked with steelhead trout (NYSDEC, 2011c).

3.8 Connecting streams to Great Lakes and Mississippi or Ohio River

The surface water flow path from the study area at East Mud Lake to both Lake Erie and the Ohio River is shown in Figure 23. Also illustrated in this figure is the location of each of the known potential obstructions to the upstream movement of ANS from their current known locations within either basin to the aquatic pathway site. The Allegheny River Watershed consists of 204,000 square miles (528,357 square kilometers) and is part of

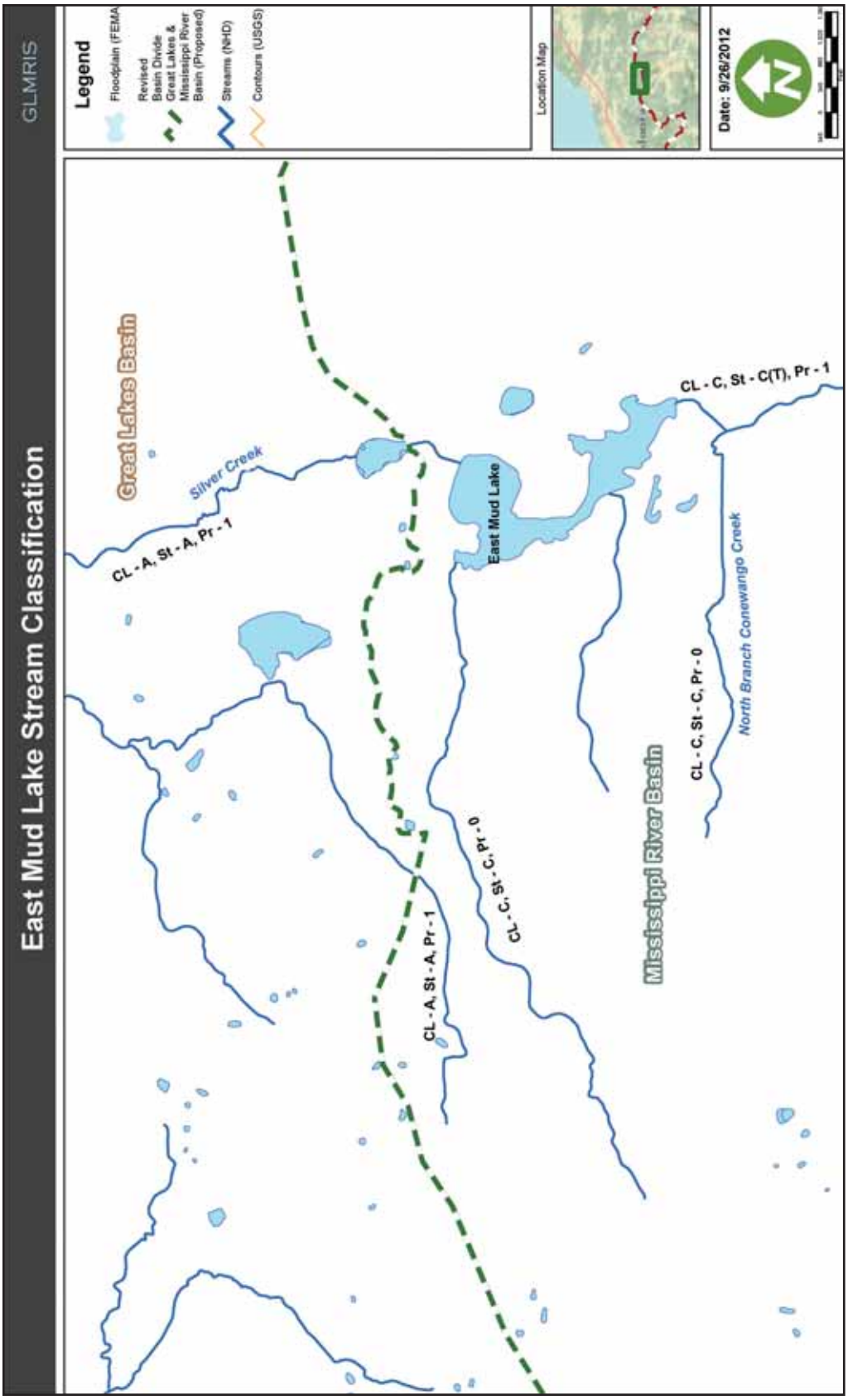


Figure 22. Water quality stream classifications near East Mud Lake from NYSDEC. "Cl" refers to Classification, "St" refers to Standard, and "Pr" refers to Protected (NYSDEC). Background imagery courtesy of Bing Maps.

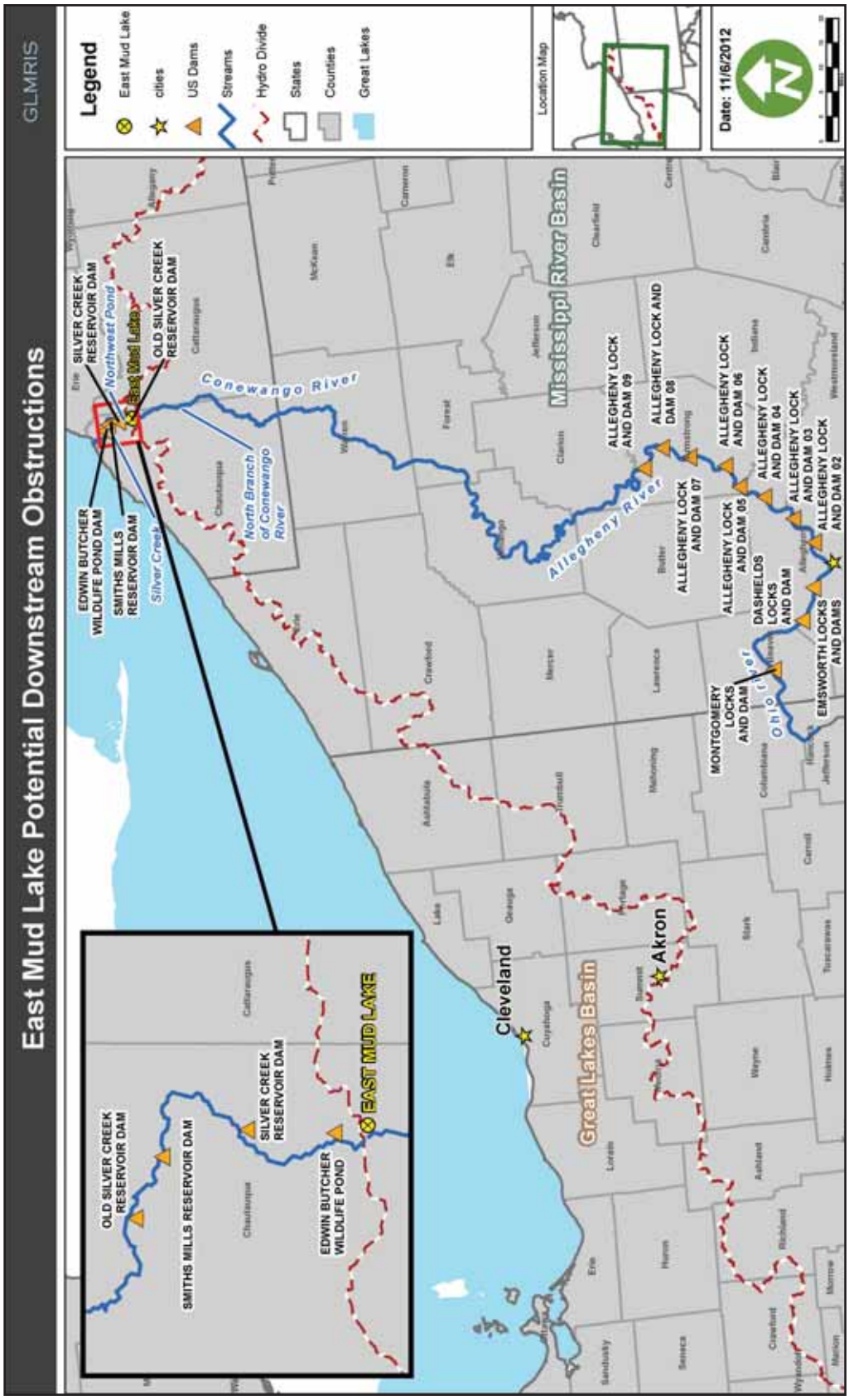


Figure 23. Flow path from East Mud Lake aquatic pathway to both Lake Erie and the Ohio River, along with potential in-stream obstacles to upstream movement of aquatic nuisance species (NID, 2010).

the Ohio River Basin (NYSDEC, 2012a). The multiple navigation locks and dams on the Allegheny and Ohio Rivers likely do not provide a reliable and complete obstacle to prevent the upstream passage of ANS due to the presence of function lock systems and based on the movement of Asian carp to date through the Mississippi and Illinois Rivers. In addition, the amount of service at all of the Allegheny River locks has recently been reduced by the USACE for the foreseeable future, with Locks 8 and 9 only being operated by appointment, Lock 5 only operated during daylight hours, and Locks 2, 3 and 4 closed between midnight and 8:00am. A schematic drawing of the Ohio River Lock and Dam system is presented in Figure 24 and an aerial image of Lock and Dam Number 9 on the Allegheny River is presented in Figure 25.

Between East Mud Lake and Lake Erie there are four dams on Silver Creek (inset on Figure 23). The first dam is near the pathway on the north side of the Edwin Butcher Wildlife Pond. This dam is an earthen dam that was built in 1952 (N42.439167, W079.094444). During typical weather conditions the water discharges from the north side of the pond through a drop inlet and from the south side through a culvert. During high water conditions it overflows the earthen dam. The FEMA floodplain mapping indicates that this small pond is inundated during a one percent annual recurrence interval storm event. This dam is not considered to be an obstruction to ANS in either direction.

The second dam is an earthen dam with a concrete spillway that was built in 1925 and is located at the Silver Creek Reservoir (Figures 26 and 27). The discharge from this dam is uncontrolled, with water flowing from the spillway down a stepped, relatively smooth concrete channel, where it then enters a natural stream channel. The concrete channel is 320 feet (97 m) long and has an average slope of 0.05 foot per linear foot (Figure 27). Calculations by the USACE estimate that for a one percent annual recurrence interval flow of 1,790 cfs there would be 4.1 feet (1.25 m) of water passing the crest of the weir and flowing at approximately 6.16 feet per second (fps). Normal depth and flow velocity near the 71 foot (22 m) wide top section (6.2 percent slope) would be 1.62 feet and 15.5 fps, which increases to 3.4 feet and 22.1 fps as the spillway narrows to its 24 foot (7.3 m) width. The normal depth and flow velocity on the section of the spillway with a 30.3 percent slope would be 2.0 feet (0.6 m) deep and 36.9 fps and normal depth and velocity on the one percent slope would be 6.2 feet (1.8 m) and 12.0 fps. Lastly, normal depth and flow velocity on the 29 percent slope would be 2.1 feet (0.64 m) and 36.4 fps. This dam is not considered to be a likely obstruction for ANS attempting to move from the reservoir into the Great Lakes Basin. However, given the velocities through the spillway, it is considered to be an obstruction for any ANS attempting to move up the spillway into the reservoir and eventually to East Mud Lake. It should be noted that flows less than (smaller) the one percent annual recurrence interval flow have not been computed by USACE. It may be possible that some lower flows could provide sufficient amounts of slower water for some ANS to ascend this spillway.

The third dam between East Mud Lake and Lake Erie is located at the Smiths Mills Reservoir (Figure 28). It is a concrete gravity dam that was built in 1906. This reservoir has two flow paths into it from Silver Creek as shown by the yellow circles in Figure 28.

One flow path crosses under Kings Road and feeds the main area of the reservoir. The second flow path, also crossing under Kings Road, is just to the west and feeds the smaller section of the reservoir. The two sections of the reservoir are separated by an earthen dike. Due to potential stability issues with the concrete gravity dam, the low conduit in the concrete dam is open and has drained the main reservoir. This conduit allows water to pass through the dam at ground level and would likely allow the passage of ANS. The second section of the reservoir still retains water, but its spillway is much higher and would provide an obstruction for ANS attempting to pass in the upstream direction. However, during the site visit on May 25, 2011 a local resident deSilver Creek Reservoiribed a previous storm event that resulted in very high water passing over the dam and even through the windows of the control building at the dam (structure shown in Figure 29).

The fourth dam is a concrete gravity dam built in 1911 and is located at the Old Silver Creek Reservoir. This is a low dam (three feet (0.9 m) in height) which is likely submerged during most storm events and is not believed to be an obstruction to the potential upstream or downstream movement of ANS.

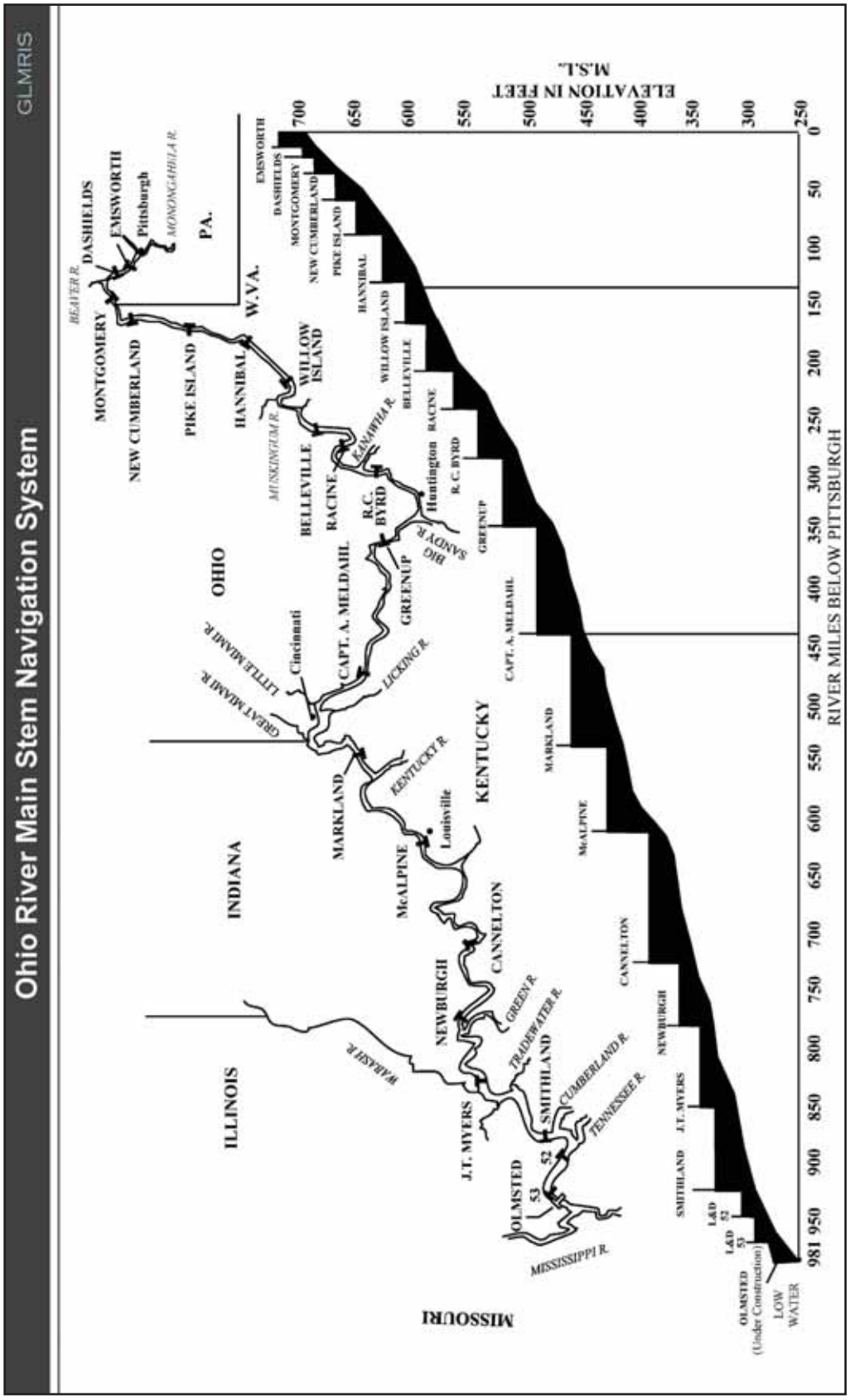


Figure 24. Ohio River lock and dam system illustrating the relative distance and magnitude of the multiple navigation structures and normal pools. Figure from USACE.

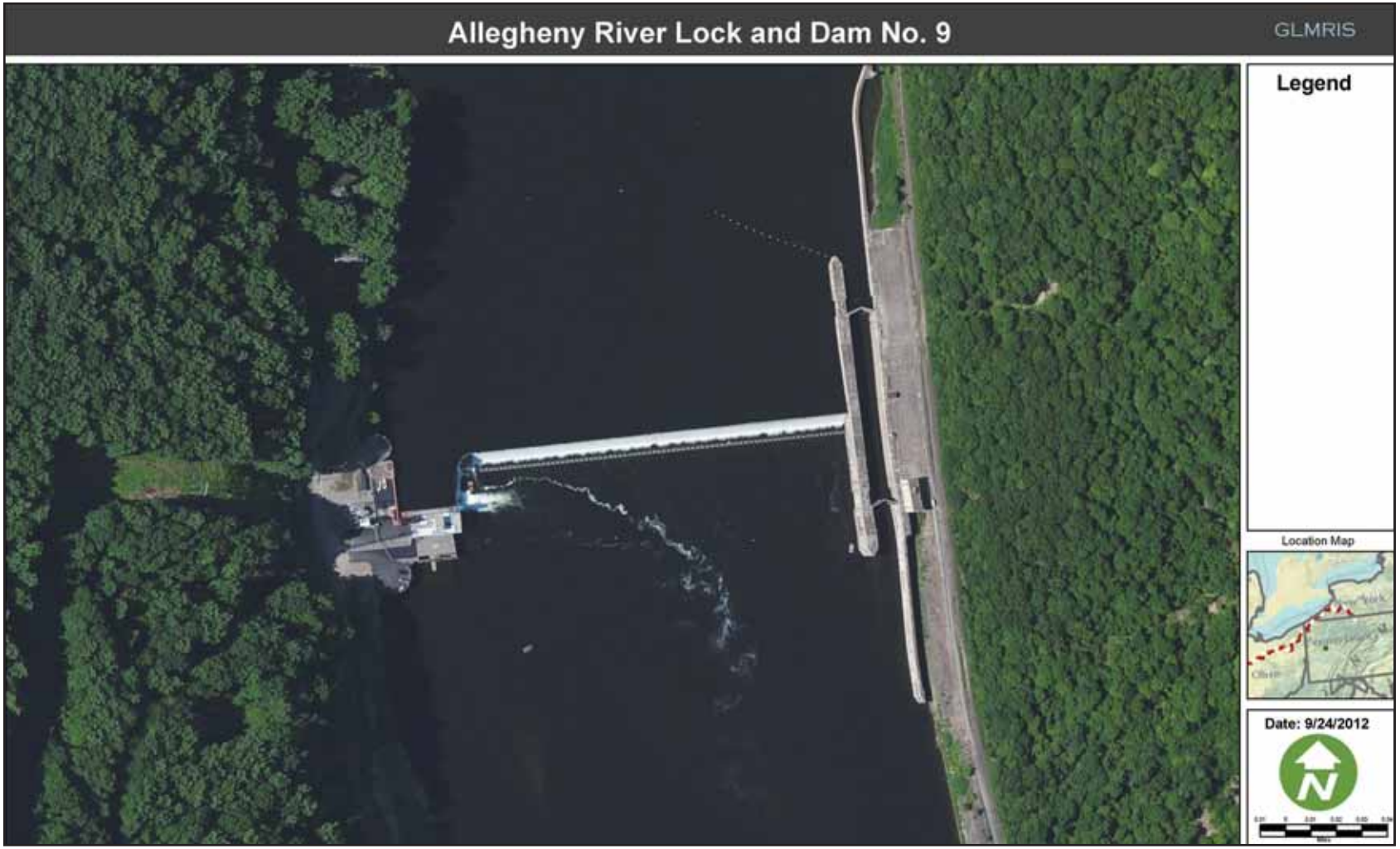


Figure 25. Lock and Dam No. 9 on the Allegheny River, typical Allegheny River navigation dam (aerial imagery courtesy of Bing Maps).

Figure 26. Silver Creek Reservoir Dam and Spillway, Parcells Corners, NY. See Figure 27 for further imagery and details of the spillway. Image courtesy of Bing Maps.

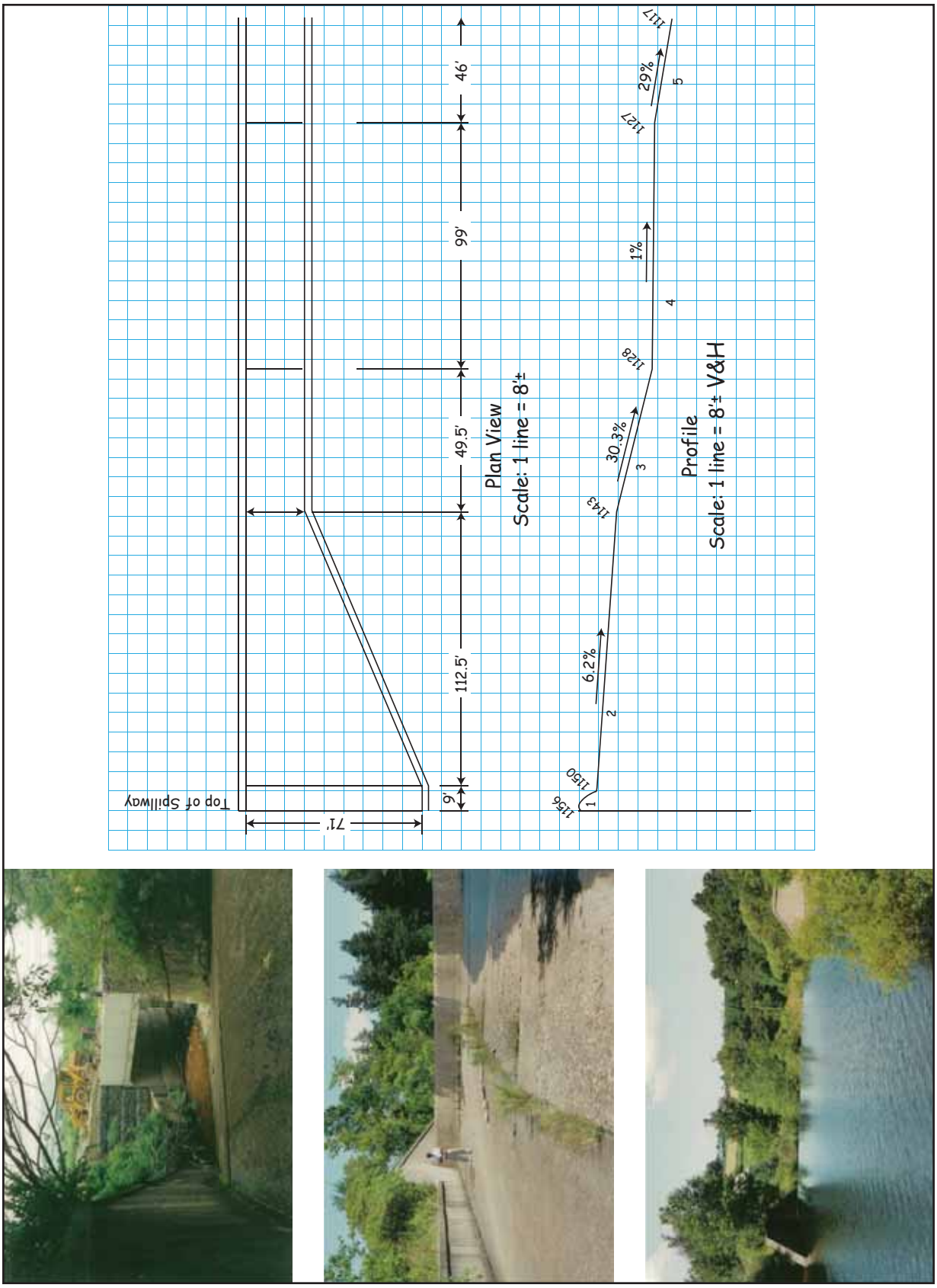


Figure 27. Silver Creek Reservoir Spillway, Parcells Corners, NY. Base of spillway shown in upper left image and spillway weir [6 feet (1.8 m) in height] shown in lower left image, with scaled profiles to the right. Pictures and profiles provided courtesy of Chautauqua County Department of Public Works. .

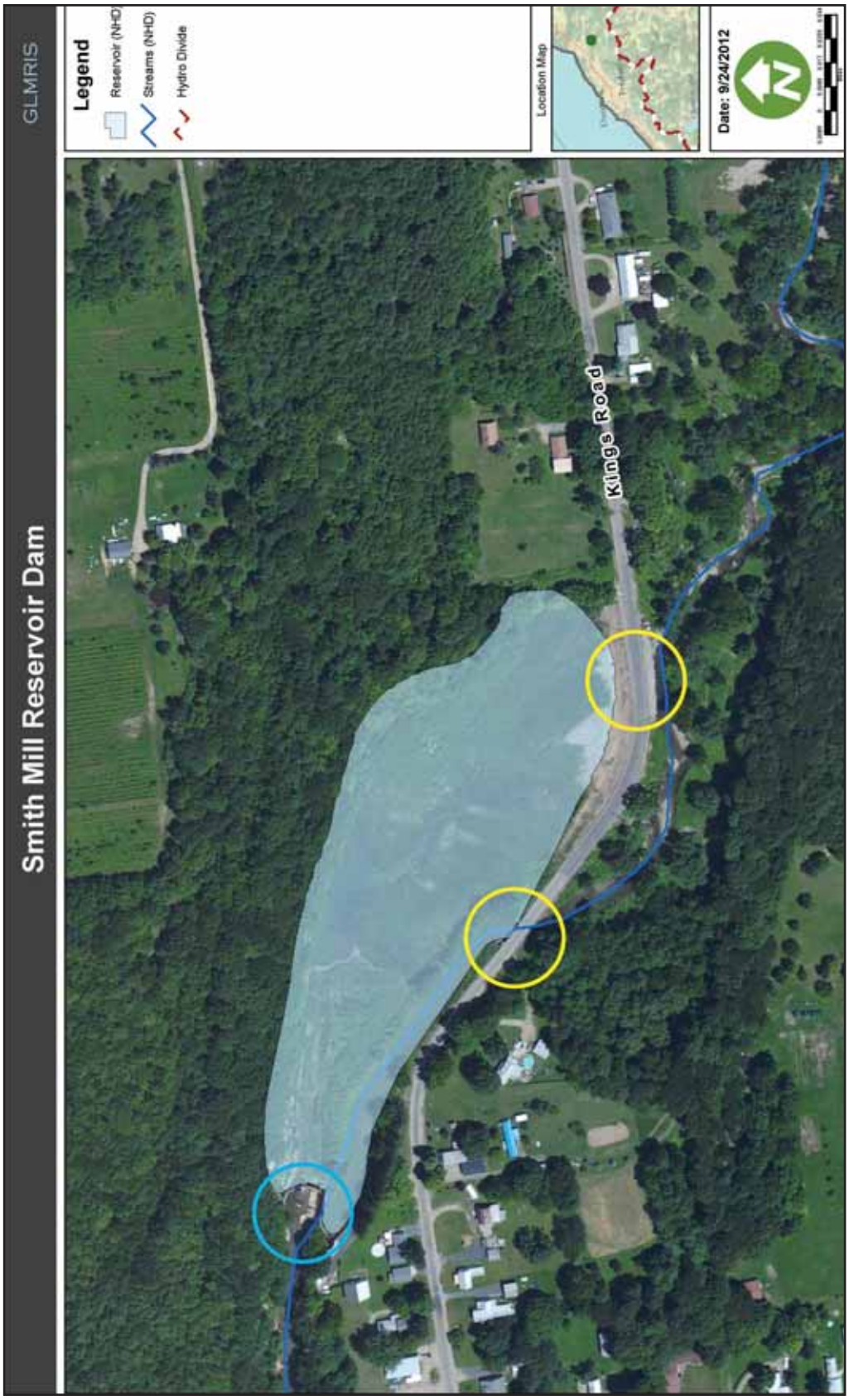


Figure 28. Smith Mills Reservoir shown in blue shading. The two locations where water enters are at the yellow circles and the blue circle is the location where water exits the reservoir. A closeup of the exit point is presented in Figure 29. Background imagery courtesy of Bing Maps.

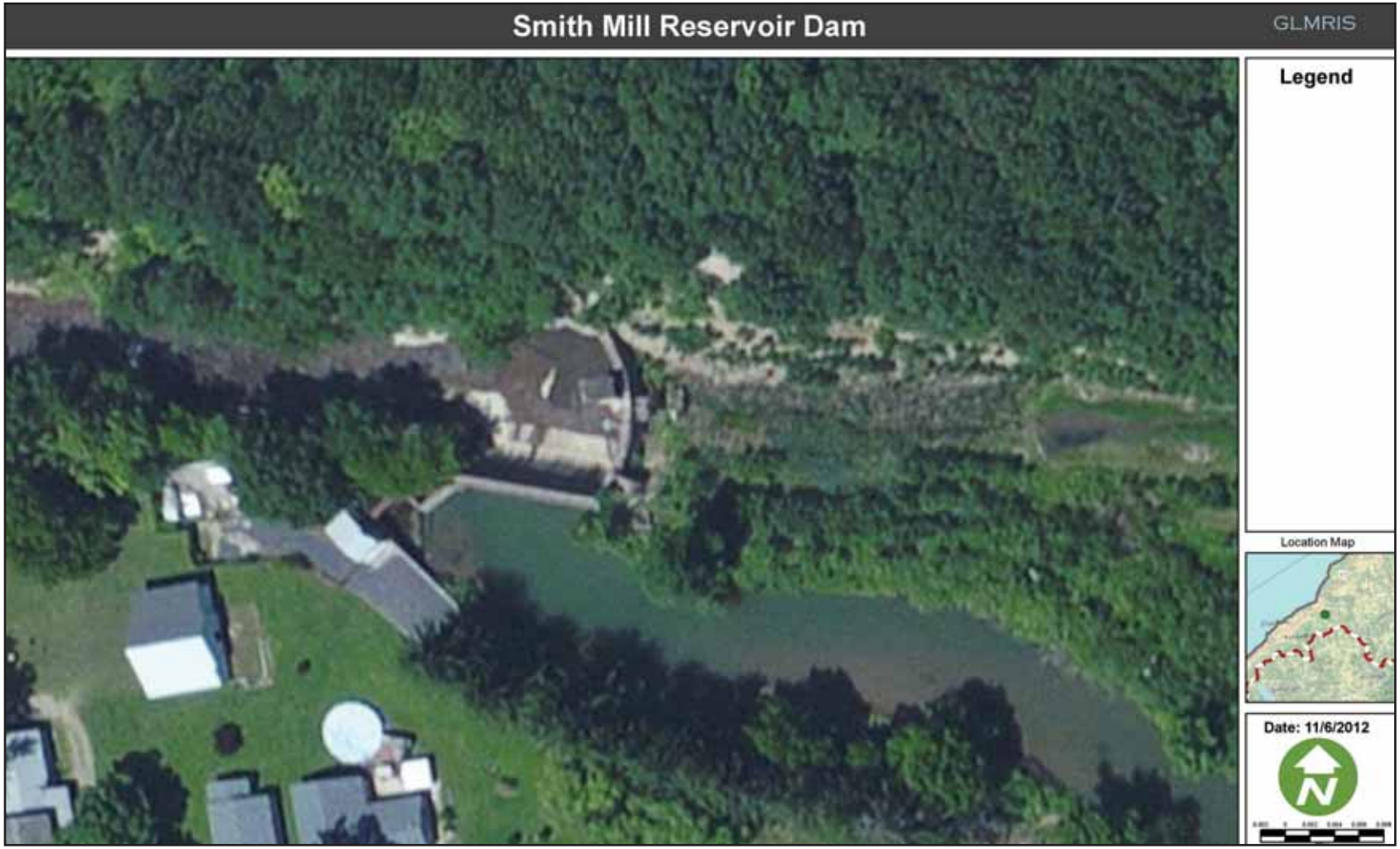


Figure 29. Smith Mills Reservoir Dam, Smiths Mills, NY. This is a close-up view of the area indicated by the blue circle in Figure 27. Image courtesy of Bing Maps.

4 Aquatic Pathway Viability for ANS of Concern

The following subsections present the results of the biological evaluation of the likelihood of the specified ANS of concern spreading from the Mississippi River Basin to the Great Lakes Basin via the East Mud Lake aquatic pathway. The potential for species movement across the basin divide was assessed by the project team in accordance with the procedures outlined in the Methodology Section of this report. The potential for species transfer was characterized as high, medium, or low for the following categories:

- Probability that Aquatic Pathway Exists (Section 3)
- Probability of ANS Being Within Either Basin
- Probability of ANS Surviving Transit to Aquatic Pathway
- Probability of ANS Establishing 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. An overall team probability and certainty rating is also provided. The overall rating represents the most conservative probability assessment for each category considered. The forms deSilver Creek Reservoiribing 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 spreading 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 spreading 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 (Nico and Fuller, 2011). In 1995 and 2000, individuals of bighead carp were recorded from Lake Erie at Sandusky, Ohio, although there is no evidence

that these are from establish populations (i.e., breeding population) and may just be from single captures (Kolar, et al., 2005). 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 that of the silver and bighead carp. Asian carp species are established in the Ohio River Basin.

Team rating: **Medium**
Team certainty rating: Moderately Certain

Inland Silverside

The inland silverside's native range is eastern North America, including the Atlantic and Gulf Slopes (mostly near the coast) from Massachusetts to the Rio Grande drainage in Texas and southeastern New Mexico; north from the Mississippi River and major tributaries (mainly Arkansas and Red Rivers) to southern Illinois and eastern Oklahoma (Page & Burr, 1991). It is a marine species that ascends rivers and prefers estuaries, lagoons, brackish seas, and rivers (Fishbase, 2011). It is believed that the presence of the species in the Mississippi River in southern Illinois and in the lower Ohio River in Illinois and Kentucky are a result of natural dispersal (Fuller & Nico, 2012). Past fish surveys using extensive fine meshed trawling within the uppermost reaches of the Ohio River (e.g., River Mile 55) have not encountered this species (G. Seegert – EA Engineering, Science & Tech, personal communication, December 8, 2011).

Team rating: **Medium**
Team certainty rating: Moderately 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, 2011). Records indicate that this species was much more abundant in the Upper Mississippi River Basin before it was impounded. Skipjack herring are found in southwest Pennsylvania (USGS, 2011). However, skipjack herring are not found in the upper reaches of the Ohio and Allegheny Watersheds primarily because of it being a migratory species and the relatively high number of dams per river mile on these rivers (USACE, 2011b).

Team rating: **Medium**
Team certainty rating: Reasonably Certain

4.2 Probability Target ANS Survives Transit to Aquatic Pathway

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

General considerations for assigning probability ratings:

High - Target ANS are established in relatively close proximity to the location and have ample opportunity, capability, and motivation to successfully navigate through the connecting streams to arrive at the subject pathway within 10 to 20 years.

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

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

The same certainty ratings identified above also apply here.

Asian Carp

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 (3.6 m)) (Hill and Pegg, 2008). Despite multiple USACE dams on the upper Ohio and Allegheny Rivers, and the recent reductions in navigation lock operation along the Allegheny River, there appear to be no permanent obstacles between where these carp are currently established and the East Mud Lake pathway. However, aquatic habitat between the uppermost reaches of the Allegheny River and East Mud Lake does not appear to be ideal for either bighead or silver carp which are native to large rivers and associated their floodplain backwater areas. However, it is not known to what extent this may prevent their upstream movement, especially during spawning. Bighead carp are zooplanktivorous, while silver carp consume smaller phytoplankton and fine particulate organic matter (Williamson and Garvey, 2005; Dong and Li, 1994). Sufficient forage is believed to be available for both species throughout the Allegheny River and possibly even Conewango Creek. Forage abundance and diversity likely decreases moving upstream towards the pathway as flow volume decreases. However, a pair of large common carp (estimated at five to eight pounds) was found within the Conewango Creek Basin immediately below East Mud Lake near East Lake Road during the May 25, 2011 site visit. While potentially indicative of fish this size being able to move this far upstream, common carp were introduced in many places throughout North America and so their existence immediately below East Mud Lake is not proof of their passage from further down the Allegheny and Ohio Rivers. In addition, common carp are omnivorous, capable of feeding throughout the water column and are considerably more flexible in their feeding strategies than *Hypophthalmichthys* spp., which are generally planktivores that feed higher in the water column (K. Baerwaldt-USACE, personal communication, March 1, 2012). Common carp have exhibited a capability to survive and even thrive in habitats that may not support Asian carp.

Adult black carp are primarily molluscivores. However, they will opportunistically consume a wide variety of food items (USFWS, 2002). Juvenile black carp have a diet more similar to silver and bighead carp, consisting primarily of zooplankton (USACE, 2011b). The diet of juvenile black carp may allow them to survive in areas unsuitable for adults. The habitat of black carp is very similar to the grass carp (Nico and Jelks, 2005). It is believed that black carp should be able to colonize the same areas of the United States where the grass carp have established (USFWS, 2002).

Juvenile, sexually immature Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers, 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. It is unclear if the gradients of the Allegheny River or Conewango Creek 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) though tributaries of the lower Missouri River. These tributaries were located laterally to the Missouri river segment in which these fish hatched (D. Chapman-USGS, personal communication, September 12, 2011). Adult, sexually mature Asian carp have occasionally been found in very small streams, which appear scarcely large enough to support the fishes at low water (D. Chapman, personal communication, September 12, 2011). The age of these fish when they arrived at these locations is unknown.

Asian carp have yet to establish any breeding populations above the McAlpine Pool on the Ohio River which is greater than 500 river miles (805 km) away from the East Mud Lake pathway. The nature of the Upper Ohio River is vastly different from the Lower Ohio River where successful populations of Asian carp have established. The lower river provides many backwater areas that Asian carp prefer for habitat. 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. Duane-USGS, J. Thomas-ORSANCO, and J. Stark-The Nature Conservancy, pers. Communication, June 2011). In consideration of all of this information, the aquatic pathway team is moderately certain that there is a low probability for the successful movement of Asian carp from the Ohio River to the East Mud Lake area within the next 50 years.

Team rating: **Low**
Team certainty rating: Moderately Certain

Inland Silverside

The inland silverside moves in large schools that can number in the thousands and they can travel far up streams and rivers, especially in southern part of their range (NatureServe, 2012). The species' natural spread rate through the Mississippi River Basin is not known because it has been actively stocked in lakes. The average lifespan of the inland silverside is about 16 months, with few surviving their second winter (NatureServe, 2012). Inland silverside has a high population doubling time under suitable conditions and is capable of producing 30,000 eggs per month (FishBase, 2011; Stoeckel, 1988). As a relatively small fish (approximately five inches (13 cm) in total length at maturity), it is likely that this species would seek refuge from high water velocities during flood events, instead of attempting to move upstream. The available habitat data suggests the inland silverside will colonize within rivers and streams but are usually found in clear, quiet water over sand or gravel. Given the long distance from where inland silverside are currently documented in the lower Ohio River and the East Mud Lake pathway and the numerous impediments along the way, there is only a low probability of inland silverside being able to reach the East Mud Lake site within the next 50 years.

Team rating: **Low**
Team certainty rating: Moderately 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, as well as southwest Pennsylvania (USGS, 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. Since skipjack herring tend to prefer large fast flowing rivers, it is unlikely that they would move upstream of their current range. As noted by Trautman (1981) regarding the likely behavior of this species in Ohio waters, "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." Given the relatively long distance from where skipjack herring are currently documented in southwestern Pennsylvania and the East Mud Lake pathway and the numerous impediments along the way, there is only a low probability of skipjack herring being able to reach the East Mud Lake site within the next 50 years.

Team rating: **Low**
Team certainty rating: Moderately Certain

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

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

differ from those which may exploit the aquatic pathway.

General considerations for assigning probability ratings:

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

The same certainty ratings identified above also apply here.

Asian Carp, Inland Silverside, and Skipjack Herring

Since the East Mud Lake site is in private ownership, it is not likely that fishing or boating would occur at or near this location. Fishing and other recreational traffic would likely be the primary means by which these species might be relocated from the Mississippi River Basin to the Great Lakes Basin, but there was little to no evidence of any recreational activities or fishing at the pathway during the May 25, 2011 site visit (e.g., discarded fishing line, bait containers, bobbers in trees, or boat ramps). In addition to limited accessibility, the evident lack of fishing is likely due to the small and likely shallow nature of the ponds and heavy vegetation found along most shorelines. In addition, the NYSDEC (2009) closely regulates what fishing baits may be used and where, and pursues an active public advertising campaign to stop the spread of aquatic invasive species and diseases (NYSDEC, 2011b). One other vector for non-aquatic ANS transfer between the basins is through intentional relocation by humans favoring certain ANS as food. Of the seven ANS originating in the Great Lakes Basin, only blueback herring would seem large enough to serve as food (max length 16 inches). While historically used fresh or salted for human consumption, or as fish meal and oil (Pardue, 1983), there does not appear to be great demand for blueback herring in the area. Movement of ANS through hitchhiking on other animals or avifauna is another potential vector for some ANS to transit the basin divide. However, it is not limited to the aquatic pathway at East Mud Lake and could potentially occur at multiple locations along the basin divide (e.g., waterfowl and wading birds are capable of transporting dotted duckweed (*Landoltia punctata*)). Given the low level of recreational fishing and public access at East Mud Lake and along Conewango Creek, the pathway team assigned a rating of low to the probability of these species (including those ANS from the Great Lakes Basin) being introduced to the aquatic pathway through non-aquatic means (e.g., bait buckets) within the next 50 years.

Team rating: **Low**
Team certainty rating (Asian carp): Reasonably Certain
Team certainty rating (Inland silverside & Skipjack Herring): Moderately Certain

4.3 Probability of ANS Establishing 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 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, 2005). 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, 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). Neither of these habitat requisites for population establishment appears to be adequately met in the vicinity of the East Mud Lake location, which is dominated by shallow streams and ponds and wetland areas. However, these species would seem to have a greater probability of establishing themselves in the upper Ohio River and maybe the lower Allegheny River, which are still a considerable distance from the East Mud Lake area. As such, the pathway team rated the likelihood of Asian carp establishment at the East Mud Lake pathway as low.

Team rating: **Low**
Team certainty rating: Reasonably Certain

Inland Silversides

As a size-selective, planktivore, the inland silverside relies primarily on sight for feeding, which could be limited within and around the wetlands and drainage ditches at the divide (Elston and Bachen, 1976). Spawning occurs in shallow water in areas with abundant vegetation, and includes all forms of plants, including dead leaves, tree roots, algal mats, or rooted aquatic plants of marshes (Hildebrand, 1922; Weinstein, 1986). Food habits of the inland silverside include: planktivore; particulate feeder; size-selective picker, and the main food item is zooplankton (Saunders, 1959; Goldstein and Simon, 1999). Stomachs of adults in west Tennessee contained food items including midge larvae, mayfly larvae (*Hexagenia*), and fallen terrestrial insects, including Homoptera, Hymenoptera (Etnier and Starnes, 1993). Morris (1982) reported that inland silversides collected from Lake Conroe, Texas, fed mostly on zooplankton at all sizes, and major food organisms in the diet were from the following groups: Sididae, Chydoridae, Ceriodaphnia, *Bosmina*, Cyclopoida, and Ostracoda. Species fed predominately upon cladocerans (60 percent of total number of food organisms, with largest category, Sididae, representing 32 percent). Bettoli et al. (1991) reported consumption of fish eggs, in Lake Conroe, Texas.

Hubbs et al. (1971) inferred that the native inland range for the inland silverside does not extend beyond the confluence of the Ohio and Mississippi Rivers because it cannot withstand winters farther north. Richards (1977) however showed that the inland silverside can survive for at least two weeks at 34.7º F (1.5ºC). Stoeckel and Heidinger (1988) demonstrated that inland silversides can be maintained over winter in aquaculture systems at temperatures above 59ºF (15ºC), when they were fed a prepared diet. They also demonstrated that inland silversides have a high mortality during extended periods of cold during the winter in unheated ponds and reservoirs. Overwintering mortality in the 80-90 percent range has been reported for the inland silverside in Rhode Island waters (Bengtson, 1982). Based only on the dietary variability of this species, it is reasonable to conclude that a population could be established in close proximity to the pathway. However, it is likely that prolonged freezing temperatures (Section 3.2) at the pathway would prevent the establishment of this species.

Team rating: **Low**
Team certainty rating: Moderately Certain

Skipjack Herring

Skipjack herring are a schooling migratory species that prefer fast flowing water instead of slower and more stagnant systems. This species has a greater probability of gradually establishing itself in the Allegheny River, which would still be far from the East Mud Lake area. As such, the team rating for the likelihood of skipjack herring establishing a sustainable population at the pathway near East Mud Lake is low.

Team rating: **Low**
Team certainty rating: Reasonably Certain

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

General Considerations for Assigning Probability Ratings:

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

Asian Carp

Asian carp have demonstrated exceptional capabilities of spreading through large river systems and will likely continue to do so. If Asian carp reach the basin divide at East Mud Lake and establish a population, it is likely they would be able to spread through the pathway into the Great Lakes Basin when surface water conditions permit.

Team rating: **High**
Team certainty rating: Moderately Certain

Inland silversides

Although the habitat at the pathway location is not optimal for establishment, if inland silversides were able to establish a population at the East Mud Lake pathway location, there is a high probability that this species would then be able cross through the pathway into the Great Lakes Basin during suitable surface water conditions, although not likely in high numbers. As a result, the team rating for the probability that inland silverside could spread into the Great Lakes Basin through the East Mud Lake aquatic pathway is high.

Team rating: **High**
Team certainty rating: Moderately Certain

Skipjack herring

If this species were able to establish near the East Mud Lake pathway, they would likely be able to move into the Great Lakes Basin through the ponds, steams, and wetlands at the pathway during suitable flooding conditions.

Team rating: **High**
Team certainty rating: Moderately 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 East Mud Lake location for each ANS of concern is the product of five probability elements (Equation 5). 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 10). The overall pathway viability for transferring ANS of concern from the Mississippi River Basin to the Great Lakes Basin was then equal to the highest probability of a viable pathway for each ANS of concern in Table 10. For the East Mud Lake location, all five ANS were rated “low”, and thus the overall pathway viability for transferring species from the Mississippi River Basin to the Great Lakes Basin is also “low”. As was discussed earlier, the pathway viability for transferring ANS from the Great Lakes Basin to the Mississippi River Basin was not calculated due to their inability to arrive at the pathway because of the downstream barrier at the Silver Creek Dam and spillway. The only threat posed by the East Mud Lake aquatic pathway is toward the Great Lakes Basin, and the probability of ANS moving through the pathway on their own toward the Great Lakes Basin is “low”.

6 Conclusions

The hydrologic assessment of the East Mud Lake aquatic pathway determined that an aquatic pathway exists across the basin divide at this location since there are intermittent streams and interconnected wetlands at the location capable of maintaining a surface water connection with streams in both basins continuously for multiple days from a ten percent annual recurrence interval flood event. A total of 12 ANS from both basins were evaluated for their potential to arrive at the pathway location from within their existing basin, and then be able to use this pathway to cross into the adjacent basin. However, this list of ANS was soon reduced to only those species that are currently located within the Mississippi River Basin since it was found that any ANS within the Great Lakes Basin would not be able to move upstream of the Silver Creek Reservoir Dam and spillway. Only five ANS were considered for a more focused evaluation in this report. The probability of all five ANS being able to use this pathway to cross into the Great Lakes Basin was determined to be low, largely due to the low probability that any of them could reach the pathway location on their own and then establish a population in the vicinity, all within the next 50 years. The overall aquatic pathway viability of the East Mud Lake location was therefore determined to be low. Although introduction of ANS to the pathway location is possible by anthropogenic

Table 10: Summary of individual probability elements and overall pathway viability rating (Mississippi River Basin to Great Lakes Basin). Certainty ratings for each element are in parentheses.

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists? (Sect. 3.6)**	**ANS Occurring Within Either Basin? (Sect. 4.1)**	**ANS Survivng 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	M (RC)	M (MC)	L (MC)	L (RC)	H (MC)	L
fish	inland silverside	swimmer		M (MC)	L (MC)	L (MC)	H (MC)	L
fish	skipjack herring	swimmer		M (RC)	L (MC)	L (RC)	H (MC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

means, it was determined to be highly unlikely due to existing land use and private ownership, and was not a consideration in the overall rating of the East Mud Lake pathway location.

7 Problems and Opportunities

This section uses the results of the aquatic 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 East Mud Lake Problem Statement

- In assessing the Silver Creek Reservoir spillway, water velocities and depths were only computed for a one percent annual recurrence interval storm. As a result, it is uncertain whether or not lesser flows could provide sufficient amounts of lower velocity water for some ANS attempting to move up the Silver Creek Reservoir spillway from the Great Lakes Basin.

- There has been no hydrologic or hydraulic modeling of the East Mud Lake site. Therefore, there was uncertainty associated with the pathway team's understanding of the pathways surface water behavior and how it responds to different storm events. Contributing to this uncertainty is the on-going effect of beaver at the pathway which likely serves to modify any flow amounts and directions.

- Given the studies 50 year period of analysis, there is additional uncertainty regarding the potential effects of climate change on surface water hydrology at the pathway and how it may affect aquatic habitat.

- Although not believed to influence the certainty of the ratings in this report, the existing basin divide represented by the HUC-12 watershed divide appears to be inaccurate based in resource review and field investigation.

- The diverse open water and wetland habitats of the East Mud Lake vicinity are likely highly suitable for allowing some ANS of concern to transfer into the Great Lakes Basin in the event they were somehow introduced into the pathway.

- There was uncertainty associated with the biological ratings, including:

  - The current location and distribution of the large array of ANS that have been introduced to the waters of the U.S.

  - The exact capabilities and ecological tolerances of some ANS (e.g., Asian carps, skipjack herring) as relates to their ability to establish within and move through smaller tributaries such as those leading to the East Mud Lake pathway.

  - The suitability of the habitat between the current nearest locations of ANS and the pathway location.

  - Scarcity of stream gages and real data on water levels at the pathway.

Detailed survey information on the exact elevations at this location was not available.

7.2 East Mud 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 between the basins at the East Mud 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 and apply at the local and/or regional scales. These are as follows:

- New or modified regulations or ordinances prohibiting the establishment of drainage ways that connect tributaries between the Mississippi River and Great Lakes Basins.
- Stream restoration efforts in either watershed, 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 (Silver Creek Spillway) for blockage of ANS might alter the rating for one or more species of ANS.
- Further analyses of flows through the Silver Creek Spillway, especially at flows more frequent than the one percent annual recurrence interval flow, would reduce the level of uncertainty regarding any ANS ability to pass upstream in the spillway during lower flow events.
- 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 biological controls such as species-specific diseases specific to particular ANS.
- Public education to:
    - Prevent anthropogenic (e.g., bait bucket) transfer.
    - Identify and report the observation and collection of ANS to the ODNR and the USGS-NAS.
    - Support research on the biology of ANS so that risk of ANS transfer can be better understood.
- Life history:
    - Habitat requirements and tolerances.
    - History of invasiveness.
- Improve and increase field sampling and monitoring in connecting streams for the presence of ANS 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.
- Prevent introductions of additional ANS.

None of the opportunities identified above are exclusive of the others. In fact, any single structural measure to prevent ANS transfer through the East Mud Lake 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 may also aid in the implementation of, and future updates to, the New York State Aquatic Nuisance Species Management Plan.

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Appendix A

Evaluation Forms for each ANS of Concern Selected for the East Mud Lake Pathway

East Mud Lake Report

May, 2013

East Mud Lake, Chautauqua County, NY - 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 LRP - H&H Hydraulic Engineer	Medium	RC	Medium	RC
	USACE LRB - H&H Hydraulic Engineer	Medium	RC	Medium	RC
	USACE LRB - Biologist	Medium	RC	Medium	RC
	USACE LRP - Biologist / Site Lead	Medium	RC	Medium	RC
	USGS - Hydrologist	Medium	RC	Medium	RC
	NYSDEC - Biologists	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**RC**	**Medium**	**RC**

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

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

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

Remarks: There is a connection between the Great Lakes and Mississippi River Basins through a small permanent pond located NNE of East Mud Lake, within easy sight of Hanover Road (Route 93). From the south end of this pond water was observed to flow south into East Mud Lake (over a beaver dam, plugging a small road culvert). Water with small fish (2"-3" in length) was observed to flow north into the Silver Creek drainage from this pond, from a field road crossing (the small stream bridged by a home made permeable boulder/rock pile) immediately north of the pond. A second pathway may exist NNW of East Mud Lake. (NOTE: this assessment applies ONLY to the waterways in the immediate area of the divide. There's at least one spillway north of the divide that may block passage from GLB into MRB.)

East Mud Lake, Chautauqua County, NY - Asian Carp

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE LRP - Biologist	Medium	MC		
	USACE LRB - Biologist	Medium	MC		
	NYSDEC - Great Lakes Fish Biologists	Medium	MC		
	Team Rating	**Medium**	**MC**		

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

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

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

Remarks: Bighead carp (Hypophthalmichthys nobilis) and, to a lesser degree, silver carp (H. molitrix) are established throughout the Lower Ohio River basin (NOTE: black carp, Mylopharyngodon piceas, while not as advanced in their expansion as the other two carp species, are included here based on their similarities to the widely-distributed grass carp {Ctenopharyngodon idell; NOTE: a 10.2 kg, 0.95 m grass carp was collected from Pool 8 of the Allegheny River, Nov 2011--Ventorini, R., PA F&BC, personal comm.} and M. piceas great threat to native snails, mussels, and clams.) Successful breeding populations of both Hypophthalmichthysseem to stop near Louisville, KY, for the time being; however, occurences of bighead have been noted in the Upper Ohio River basin as far up the total pathway as Moundsville, WV, and the Mahoning River in Ohio. In 1995 and 2000, bighead were also recorded from Lake Erie at Sandusky, Ohio; yet, it's unknown if these fish represented successful breeding populations or were random introductions (Kolar et al. 2005). While some degree of uncertainty remains, it would seem unlikely that individual bighead and silver carp could reach the East Mud Lake area within 20 years, and the reproductive success of those individuals of even greater question. While these carp are robust, strong swimmers and certainly capable of passing through navigation locks, the remaining distance to East Mud Lake, combined with: 2) the recently-imposed reduction in Allegheny River navigation lock operation by the Corps' Pittsburgh District (i.e., eliminating night lockages and possibly total lockages, thereby reducing the probability of transfer), 3) the other impediments further up the aquatic pathway, and 4) the relatively poor foodbase provided by the Allegheny River and waters further up the pathway (due, in part, to relatively low levels of TSD, in part due to large aggregations of filter feeders along sections) suggest Asian carp will not reach East Mud Lake within 20 years.

East Mud Lake, Chautauqua County, NY - 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 LRP - Biologist	Low	MC	Low	MC
	USACE LRB - Biologist	Low	MC	Low	RC
	NYSDEC - Great Lakes Fish Biologists	Low	RC	Low	RC
	Team Ratings	**Low**	**MC**	**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.

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, although this behavior appears triggered by threat, rather than an urge to clear rapids or other obstructions to travel, as demonstrated by salmonids). Despite: 1) the remaining distance to East Mud Lake, 2) multiple dams, 3) recently-imposed reduction in lock operation along the Allegheny River by the Corps' Pittsburgh District, and 4) other impediments further up the upper aquatic pathway, there would appear to be no permanent obstacles between where these carp currently are in the Ohio River and East Mud Lake, NY. Aquatic habitat in the East Mud Lake area is not ideal for either bighead or silver carp, which are native to and thrive in large rivers, but it is not known to what extent this may prevent passage. Bighead carp are zooplanktivorous (but will switch to phytoplankton when zooplankton levels are low; Kolar et al. 2007), 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, including the entire Ohio and lower Allgheny rivers. Forage abundance and diversity decreases moving upstream towards the drainage divide pathway as water quality increases (less TSDs) and water 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 bighead and silver carp, consisting primarily of zooplankton, enabling them to survive in areas unsuitable for adults. While juvenile Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers to continue their upstream movement, they tend to move laterally away from the river in which they were spawned and not back upstream (Chapman, D., and N. Casewell, USGS, personal comm. with Eagle Marsh team, 12 September 2011). Additionally, 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 vicinity of where they hatch. It has also been observed that 12-18 inch Asian carp travel long distances throughout river systems for no apparent reason, and that adult, sexually mature Asian carp have been found in very small streams, which appear scarcely large enough to support fish at low water levels (Chapman, D., USGS, personal comm. with E. Marsh team, 12 September 2011); however, the age of these large fish when they first arrived at these confined locations is unknown. Nonetheless, survivability of Asian carp on their way to the East Mud Lake area remains questionable, given the current lack of preferred habitat along the uppermost pathway. The nature of the Upper Ohio River (and Allegheny River) is very different than the Lower Ohio River, where successful Asian carp populations have become established (e.g., the lower river provides many backwater areas that Asian carp prefer).

In general, the upper aquatic pathway is characterized by narrower valleys, smaller floodplains, and less backwater areas. This current lack of preferred habitat on the Upper Ohio may be an obstacle that cannot be overcome by successful Asian carp populations (Chapman, D., USGS; J. Thomas, ORSANCO; J. Stark, TNC; personal comm.), and close to a 1% flood event would likely be required for successful transfer through the pathway. Considering everything above, a "Low" transfer (3A) rating would seem the most appropriate.

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

Likewise, the probability of transfer via other means (3B), either natural or anthropogenic (e.g., bait buckets, intentional introduction) within the next 20-50 years would seem to merit a "Low" rating, given the apparent low level of recreational fishing (this due to predominantly privately-ownd lands in the area, i.e. inaccessability) and the species lack of status as a favored food fish in current regional cuisines. Caveat: all of this could change with any dramatic change in habitat and/or foodbase during the next few decades.

East Mud Lake, Chautauqua County, NY - 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 LRP - Biologist	Low	RC		
	USACE LRB - Biologist	Low	MC		
	NYSDEC - Great Lakes Fish Biologists	Low	RC		
	Team Ratings	**Low**	**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: Bighead and silver 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 some time for successful reproduction (Gorbach and Krykhtin 1980). It is somewhat unlikely that spawning would occur within the East Mud Lake area (East Mud Lake is small, as are the several area ponds, marshy/wetland areas, and streams along the pathway) or smaller water bodies and waterways between East Mud Lake and the Allegheny River. If Asian carp reach the pathway at the drainage divide during a flood or series of flood events, they may survive long enough to transfer into the Great Lakes basin; although it is unlikely that adults would survive long periods of time within the East Mud Lake area. As such, these species likelihood of colonizing and establishing a sustainable population in close proximity to the pathway near East Mud Lake can be rated as "Low." These species have a greater probability of establishing themselves lower in the aquatic pathway (i.e., Ohio River and lower Allegheny River), still at some considerable distance from the East Mud Lake area.

East Mud Lake, Chautauqua County, NY - 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 LRP - Biologist	High	MC		
	USACE LRB - Biologist	High	MC		
	NYSDEC - Great Lakes Fish Biologists	High	MC		
	Team Ratings	**High**	**MC**		

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, however, whether they will colonize the upper Ohio River and its tributaries. If these species succeed in reaching the basin divide at East Mud Lake and surface water connections permit, it is likely that they would spread beyond the aquatic pathway at the divide into the waters of the Great Lakes basin. Climate change or other factors, both unrelated and related, such as increased TDS levels, could expedite this expansion.

East Mud Lake, Chautauqua County, NY - Inland silverside (*Menidia beryllina*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE LRP - H&H Hydraulic Engineer	Medium	RC	Medium	RC
	USACE LRB - H&H Hydraulic Engineer	Medium	RC	Medium	RC
	USACE LRB - Biologist	Medium	RC	Medium	RC
	USACE LRP - Biologist / Site Lead	Medium	RC	Medium	RC
	USGS - Hydrologist	Medium	RC	Medium	RC
	NYSDEC - Biologists	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**RC**	**Medium**	**RC**

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

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

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

Remarks: There is a connection between the Great Lakes and Mississippi River Basins through a small permanent pond located NNE of East Mud Lake, within easy sight of Hanover Road (Route 93). From the south end of this pond water was observed to flow south into East Mud Lake (over a beaver dam, plugging a small road culvert). Water with small fish (2"-3" in length) was observed to flow north into the Silver Creek drainage from this pond, from a field road crossing (the small stream bridged by a home made permeable boulder/rock pile) immediately north of the pond. A second pathway may exist NNW of East Mud Lake. (NOTE: this assessment applies ONLY to the waterways in the immediate area of the divide. There's at least one spillway north of the divide that may block passage from GLB into MRB.)

East Mud Lake, Chautauqua County, NY - Inland silverside (*Menidia beryllina*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE LRP - Biologist	Medium	RC		
	USACE LRB - Biologist	Medium	MC		
	NYSDEC - Great Lakes Fish Biologists	Medium	MC		
	Team Rating	**Medium**	**MC**		

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

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

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

Remarks: This fish is currently documented in the lower Ohio River, at great distance from East Mud Lake (NOTE: recent and past fish surveys, including extensive fine-meshed trawling efforts, within the uppermost reaches of the Ohio River have never yielded this species--Seegert, G. {EA Engineering, Science & Tech, providing impingment abundance monitoring at power plants, as part of the Ohio River Ecological Research Program}, personal comm.). Further, the numerous navigational locks/dams, along with a recent decrease in lock operation by the Corps' Pittsburgh District along the Allegheny River (eliminating night lockages and possibly total lockages, thereby reducing the probability of transfer) and other impediments along the way within the MRB suggest inland silversides will not reach East Mud Lake within 20 years. A marine species that ascends rivers, inland silversides are usually found at the surface of clear, quiet water over sand or gravel; with expansion (via natural dispersal) thought to be associated with increases in TSDs (favorable to zooplanktivores). That said, relatively little else is known about this species, aside from the fact they have a high, minimum population doubling time under suitable conditions (FishBase 2011); as such, certainty regarding the speed of this species expansion would appear only moderate.

East Mud Lake, Chautauqua County, NY - Inland silverside (*Menidia beryllina*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE LRP - Biologist	Low	MC	Low	MC
	USACE LRB - Biologist	Low	MC	Low	MC
	NYSDEC - Great Lakes Fish Biologists	Low	MC	Low	MC
	Team Ratings	**Low**	**MC**	**Low**	**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.

The long distance from where currently documented in the lower Ohio River to the East Mud Lake area and the numerous impediments along the way, suggests a "Low" qualitative rating for inland silversides through their movement in the aquatic pathway (refer to 3A) within 50 years.

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

Likewise, the probability of transfer via other means (3B), either natural or anthropogenic (e.g., bait buckets, intentional introduction), seems low within the next 50 years, given the apparent low level of recreational fishing (this due to predominantly privately-ownd lands in the area, i.e. inaccessability) and the species lack of status as a favored food fish in regional cuisines.

East Mud Lake, Chautauqua County, NY - Inland silverside (*Menidia beryllina*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE LRP - Biologist	Low	MC		
	USACE LRB - Biologist	Low	MC		
	NYSDEC - Great Lakes Fish Biologists	Low	MC		
	Team Ratings	**Low**	**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.

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

Remarks: This species likelihood of colonizing and establishing a sustainable population in close proximity to the pathway near East Mud Lake could be rated as "Medium" at best, but should probably be rated as "Low." Inland silversides move in large schools, congregating in shallows (preferring sand or gravel bottoms) with overhead cover if possible, but then move out to open water to feed. As such, the scope and scale of such preferred habitat features in the East Mud Lake area would seem insufficient for this species, given the small size of the lake, the other small ponds, marshy/wetland areas, and streams in the area (albeit sections are over-grown by forest vegetation along certain reaches, providing cover from predators). Moreover, most of the Allegheny River currently doesn't provide elevated levels of TSDs, untimately providing a foodbase, thereby encouraging zooplanktivore expansion. (Caveat: increased shale gas extraction activities along the Allegheny River have appeared to elevate TSDs along certain reaches recently; however, the ultimate impacts are hard to assess at this time.) This species would seem to have a greater probability of gradually establishing itself lower in the aquatic pathway (i.e., throughout the entire Ohio River), still at some distance from the East Mud Lake area.

East Mud Lake, Chautauqua County, NY - Inland silverside (*Menidia beryllina*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE LRP - Biologist	High	MC		
	USACE LRB - Biologist	High	MC		
	NYSDEC - Great Lakes Fish Biologists	High	MC		
	Team Ratings	**High**	**MC**		

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: Inland silversides may expand from their current locations in the lower Ohio River, through similar habitat upriver (i.e., throughout the Ohio River) and beyond, if water quality declines (in regard to TSD's). Climate change could lead to this species expansion in regard to both rising temperatures and more severe rain events, which would likely lead to periodic increased turbidity, encouraging the growth of this species zooplankton foodbase.

East Mud Lake, Chautauqua County, NY - 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 LRP - H&H Hydraulic Engineer	Medium	RC	Medium	RC
	USACE LRB - H&H Hydraulic Engineer	Medium	RC	Medium	RC
	USACE LRB - Biologist	Medium	RC	Medium	RC
	USACE LRP - Biologist / Site Lead	Medium	RC	Medium	RC
	USGS - Hydrologist	Medium	RC	Medium	RC
	NYSDEC - Biologists	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**RC**	**Medium**	**RC**

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

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

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

Remarks: There is a connection between the Great Lakes and Mississippi River Basins through a small permanent pond located NNE of East Mud Lake, within easy sight of Hanover Road (Route 93). From the south end of this pond water was observed to flow south into East Mud Lake (over a beaver dam, plugging a small road culvert). Water with small fish (2"-3" in length) was observed to flow north into the Silver Creek drainage from this pond, from a field road crossing (the small stream bridged by a home made permeable boulder/rock pile) immediately north of the pond. A second pathway may exist NNW of East Mud Lake. (NOTE: this assessment applies ONLY to the waterways in the immediate area of the divide. There's at least one spillway north of the divide that may block passage from GLB into MRB.)

East Mud Lake, Chautauqua County, NY - Skipjack herring (*Alosa chrysochloris*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE LRP - Biologist	Medium	RC		
	USACE LRB - Biologist	Medium	RC		
	NYSDEC - Great Lakes Fish Biologists	Medium	RC		
	Team Rating	**Medium**	**RC**		

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

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

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

Remarks: While this fish is already documented in SW Pennsylvania (PA), the substantial remaining distance to East Mud Lake and the numerous navigational locks/dams, along with a recent decrease in lock operation by the Corps' Pittsburgh District (eliminating night lockages and possibly total lockages, thereby reducing the probability of transfer) and other impediments along the way within the MRB strongly suggest skipjack herring will not reach East Mud Lake within 20 years. This migratory species extirpation from the Upper Mississippi River is credited to the construction of dams; therefore, it is reasonable to expect the numerous similar structures along the pathway to impede this species advance.

East Mud Lake, Chautauqua County, NY - 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 LRP - Biologist	Low	MC	Low	MC
	USACE LRB - Biologist	Low	RC	Low	RC
	NYSDEC - Great Lakes Fish Biologists	Low	RC	Low	RC
	Team Ratings	**Low**	**MC**	**Low**	**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.

The relatively long distance from where currently documented in SW PA to the East Mud Lake area and the numerous impediments along the way (with "surviving" defined as the minimum viable population able to survive and continue on), suggests a low qualitative rating for skipjack herring through their movement within the aquatic pathway (refer to 3A) within 20-50 years.

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

Likewise, the probability of transfer via other means (3B), either natural or anthropogenic (e.g., bait buckets, intentional introduction), seems low within the next 50 years, given the apparent low level of recreational fishing in the area (this due to predominantly privately-ownd lands, i.e. inaccessability) and the species lack of status as a favored food fish in regional cuisines.

East Mud Lake, Chautauqua County, NY - 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 LRP - Biologist	Low	RC		
	USACE LRB - Biologist	Low	RC		
	NYSDEC - Great Lakes Fish Biologists	Low	RC		
	Team Ratings	**Low**	**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: This species likelihood of colonizing and establishing a sustainable population in close proximity to the pathway near East Mud Lake could be rated as "Medium" at best under certain conditions, but should probably be rated as "Low." Skipjack herring are a schooling migratory species that prefer fast flowing water over open, medium to large rivers and large reservoirs; whereas the hydraulic features in the East Mud Lake area consist of the lake itself (which is small), and several other small ponds, marshy/wetland areas, and streams over-grown by forest vegetation along certain reaches. This species has a greater probability of gradually establishing itself lower in the total pathway (i.e., up to and throughout the entire Allegheny River), still at some distance from the East Mud Lake area.

East Mud Lake, Chautauqua County, NY - 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 LRP - Biologist	High	MC		
	USACE LRB - Biologist	High	MC		
	NYSDEC - Great Lakes Fish Biologists	High	MC		
	Team Ratings	**High**	**MC**		

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

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

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

Remarks: It appears likely that skipjack herring will continue to slowly spread from their current locations in SW PA, through similar habitat upriver (i.e., at least up to and throughout the Allegheny River). If, however, this species were to establish themselves near the divide, they could quite easily move into the GLB. Climate change would not appear to affect this expansion in regard to rising temperatures, however, more severe rain events will likely lead to periodic increased turbidity, which may affect this species success.