The GLMRIS Report

GLMRIS Alternatives - Risk of Adverse Impacts from the Movement through the CAWS and Establishment of Aquatic Nuisance Species in the Great Lakes and Mississippi River Basins

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1 WITH PROJECT RISK ASSESSMENTS

Introduction

Without the availability of observed or practical data to measure effectiveness of a particular alternative, the GLMRIS team developed a predictive model to help forecast the efficacy of a plan based on the best available information. To this end, a qualitative risk assessment was conducted to evaluate the potential risk of aquatic nuisance species (ANS) transferring between the basins through the Chicago Area Waterway System (CAWS), establishing in the newly invaded basin and causing adverse environmental, economic, and sociopolitical consequences.

Thirty five (35) ANS of Concern currently found in the Great Lakes (GL) or Mississippi River (MR) basins were evaluated in a risk assessment for baseline conditions, referred to as the without project risk assessment The risk assessment for without project conditions was used to determine whether potential adverse impacts would occur due to interbasin transfer and establishment (see Risk of Adverse Impacts from the Movement through the CAWS and Establishment of Aquatic Nuisance Species in the Great Lakes and Mississippi River Basins in Appendix C). The risk assessment identified 13 ANS anticipated to have a high or medium risk of adverse impacts in the newly invaded basin within the next 50 years. The 23 ANS rated low risk were not considered further at this time. The without project risk assessment, which establishes the risk for the No New Federal Action – Sustained Activities Alternative, serves as the point of comparison for the with project risk assessments.

Methodology

Plans were formulated for ANS of Concern that exhibited "high" or "medium" risk in the without project risk assessment. Qualitative risk assessments were used to evaluate whether the implementation of each Great Lakes and Mississippi River Interbasin Study (GLMRIS) alternative ('With Project' condition) resulted in risk reduction (See *GLMRIS Assessment Approach for Characterizing the Risks of Adverse Impact from the Movement through the CAWS and Establishment of Aquatic Nuisance Species in the Great Lakes and Mississippi River Basins* in Appendix C). As in the without project condition assessment, the with project risk assessment is based on two components: (1) the probability of an ANS entering and becoming successfully established in a new basin and (2) the consequences of that establishment on ecological, economic, and social aspects of the new basin's environment. These components together allow for the estimation of the risk of adverse impacts occurring as a result of the establishment of a "new" ANS (each basin currently includes previously established ANS) in a new basin. This may be depicted by the following risk model:

Risk (likelihood) of adverse impacts occurring as a result of the establishment of ANS *X* in Basin *Y*	=	**Probability of ANS *X* becoming established in Basin *Y* (Basin *Y* becomes *exposed* to ANS *X*)**	×	The consequences of ANS *X* becoming established in Basin *Y* (the *effects* to Basin *Y* of exposure to ANS *X*)

The establishment assessment addresses the bold term of the risk model above.

This term examines the probability that an ANS will successfully transfer from one basin to the other using one or more of the CAWS aquatic pathways and become established in the new basin. The probability of establishment is determined as follows:

$$\mathbf{P_{establishment} = P_{path} \times P_{arrival} \times P_{passage} \times P_{colonize} \times P_{spread}}$$

where:

P_{path} = Probability that a complete aquatic pathway is available for interbasin transfer;

$P_{arrival}$ = Probability that the ANS will arrive at the pathway from its current distribution within a specified time;

$P_{passage}$ = Probability that the ANS can successfully move through the aquatic pathway from one basin to the other;

$P_{colonize}$ = Probability that the ANS can establish a colony in the newly invaded basin;

P_{spread} = Probability that the ANS can spread to elsewhere in the new basin; and

$P_{establishment}$ = Probability of the ANS becoming established in the new basin.

The consequence assessment qualitatively considers three categories of consequences: environmental, economic, and social. The overall consequences from the establishment of a new ANS are estimated as:

Overall Consequences = **Environmental Consequences** + **Economic Consequences** + **Social/Political Consequences**

Environmental Consequences = Effects on ecosystem structure and function, including effects on resident specimens, populations, communities, and habitats.

Economic Consequences = Effects on economic activities, such as changes in employment, unemployment, and earnings; changes in labor force and income.

Social/Political Consequences = Perceived effects on leisure, recreation or subsistence activities, as well as changes in regulatory requirements.

Overall Consequences = Qualitative combination of all environmental, economic, and social consequences.

TABLE 1 Consequence Ratings of the GLMRIS High and Medium Risk ANS (Grippo 2013)[a]

Species	Consequences			
	Environmental	Economic	Social/Political	Total Overall
Bighead Carp	H (M)	M (M)	H (M)	H
Bloody Red Shrimp	H (H)	M (M)	M (H)	H
Diatom	L (M)	M (H)	M (H)	M
Fishhook Waterflea	H (M)	M (M)	M (M)	H
Grass Kelp	L (M)	M (H)	M (H)	M
Red Algae	L (M)	M (H)	M (H)	M
Reed Sweetgrass	M (H)	M (M)	M (M)	M
Ruffe	M (M)	M (M)	M (M)	M
Scud	M (H)	N (L)	N (L)	M
Silver Carp	H (M)	H (M)	H (M)	H
Threespine Stickleback	M (M)	N (L)	N (L)	M
Tubenose Goby	M (M)	L (M)	L (L)	M
VSHv	L (M)	M (H)	H (L)	M

a Uncertainty associated with each consequence element is indicated in parenthesis.

GLMRIS alternatives were formulated to control one or more of the following $P_{establishment}$ elements:

- the presence of a continuously available aquatic pathway (the CAWS) connecting the MR and GL basins ($P_{pathway}$);
- the arrival of ANS from its current location to the CAWS pathway ($P_{arrival}$); or
- the interbasin transfer of ANS through the CAWS aquatic pathway ($P_{passage}$).

The primary goal of the GLMRIS alternatives is to control entry into the new basin rather than formulate post-entry control measures, therefore, for all with project risk assessments, $P_{colonization}$, P_{spread} and overall consequences were assumed to remain unchanged even with the implementation of an alternative. $P_{colonization}$ and P_{spread} assessments addressed whether the ANS is able to find appropriate habitat and reproduce in and spread throughout the invaded basin. The consequences assessment conducted for the without project assessment assumed an ANS had successfully entered and become established within the new basin and therefore the consequence ratings remained unchanged (see Table 1).

The with project risk assessments were completed for the following 'high' and 'medium' Risk ANS (Tables 2 and 3), which have the identified dispersal mechanisms:

TABLE 2 GLMRIS High and Medium Risk Mississippi River Basin Aquatic Nuisance Species

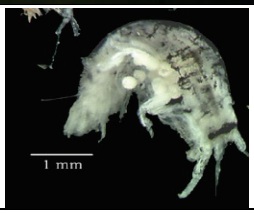
Mississippi River Basin Species			
Species Type	**Species Name**	**Picture**	**Dispersal Mechanism**
Fish	Bighead carp *Hypophthalmichthys nobilis*		Active Swimming
	Silver carp *Hypophthalmichthys molitrix*		Active Swimming
Crustacean	Scud *Apocorophium lacustre*		Passive Drift, Benthic Movement, Hull Fouling, Ballast Water

TABLE 3 GLMRIS High and Medium Risk Great Lakes Basin Aquatic Nuisance Species

Great Lakes Basin Species			
Species Type	**Species Name**	**Picture**	**Dispersal Mechanism**
Fish	Ruffe *Gymnocephalus cernuus*		Active Swimming, Ballast Water
	Threespine stickleback *Gasterosteus aculeatus*		Active Swimming, Ballast Water
	Tubenose goby *Proterorhinus semilunaris*		Active Swimming, Ballast Water

TABLE 3 (CONT.)

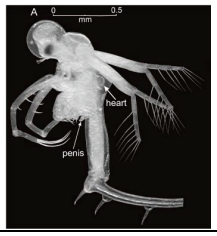
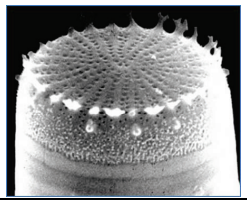
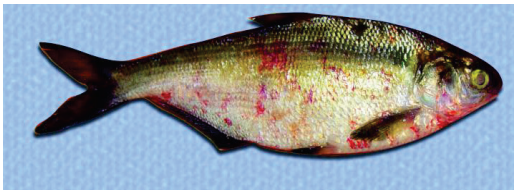
Great Lakes Basin Species			
Species Type	**Species Name**	**Picture**	**Dispersal Mechanism**
Crustacean	Bloody red shrimp *Hemimysis anomala*		Passive Drift, Ballast Water
	Fishhook waterflea *Cercopagis pengoi*		Passive Drift, Hull Fouling, Ballast Water
Plants	Reed sweetgrass *Glyceria maxima*		Passive Drift, Temporary Vessel Attachment
Algae	Diatom *Stephanodiscus binderanus*		Passive Drift, Temporary Vessel Attachment
	Grass kelp *Enteromorpha flexuosa*		Passive Drift, Temporary Vessel Attachment
	Red algae *Bangia atropurpurea*		Passive Drift, Temporary Vessel Attachment

TABLE 3 (CONT.)

Great Lakes Basin Species			
Species Type	**Species Name**	**Picture**	**Dispersal Mechanism**
Virus	Viral Hemorrhagic Septicemia Virus *Novirhabdovirus*		Passive Drift, Host Transport

The risk assessments took into consideration the time for alternative implementation. The alternatives and timing of with project measures during the planning horizon are found in Table 4. Alternatives are comprised of nonstructural and structural measures. Nonstructural measures are those that do not require construction and can be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, due to the uncertainty pertaining to time required to pass and implement new laws or regulations. Structural measures are those that require construction of an ANS control measure, for example a physical barrier or GLMRIS Lock. Nonstructural measures are a component of every with project alternative and vary per ANS.

TABLE 4 Timing of With Project Measures Per Alternative

Alternatives	Timing of With Project Measures			
	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action*				
Nonstructural Control Technologies				
Nonstructural Measures				
Mid-System Control Technologies without a Buffer Zone				
Nonstructural Measures				
Structural Measures				
Control Technology Alternative with a Buffer Zone				
Nonstructural Measures				
Structural Measures				
Lakefront Hydrologic Separation				
Nonstructural Measures				
Structural Measures				

TABLE 4 (CONT.)

Alternatives	Timing of With Project Measures			
	T_0	T_{10}	T_{25}	T_{50}
Mid-System Hydrologic Separation				
Nonstructural Measures				
Structural Measures				
Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone				
Nonstructural Measures				
Structural Measures				
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone				
Nonstructural Measures				
Structural Measures				
* With project risk assessments are compared with the without project risk assessments (Grippo 2013) to evaluate whether an alternative provides risk reduction.				
Highlighted cells indicate when With Project measures are implemented.				

The "With Project" risk assessments were conducted for the same four timesteps encompassing the 50-year period used for the without project assessments and the five CAWS pathways. The time steps are:

T_0 = Potential for establishment based on the current distribution of the ANS;
T_{10} = Potential for establishment 10 years from the present time;
T_{25} = Potential for establishment 25 years from the present time; and
T_{50} = Potential for establishment 50 years from now.

Though a risk assessment was conducted for all five pathways, the with project condition summary presents information regarding the pathway or pathways that have the highest $P_{establishment}$. If more than one pathway had the highest rating, then the pathway that had the highest uncertainty for the probability element that drove the with project condition rating is presented. One example is the threespine stickleback with project risk assessment for the Mid-System Control Technology with a Buffer Zone Alternative. This Alternative includes, among other measures, a control point comprised of a physical barrier, and a control point comprised of a GLMRIS Lock, electric barrier, ANS treatment plant and screened sluice gates. These control points result in a 'low' $P_{passage}$ for the threespine stickleback. The uncertainty of $P_{passage}$ for the physical barrier control point is rated 'low,' while the uncertainty for the control point comprised of a GLMRIS Lock, electric barrier, ANS treatment plant and screened sluice gates is rated 'high.' Consequently, this document reports the GLMRIS Lock, electric barrier, ANS treatment plant and screened sluice gate rating because this control point had a higher uncertainty. The pathways with the highest $P_{establishment}$ rating and highest uncertainty rating are the weakest link in the alternative, and indicate the expected risk reduction provided by the alternative.

Probability Ratings

Several notations were used to illustrate changes in probability and uncertainty ratings between the with project and without project risk assessments. For example, when an alternative reduces the rating for a probability element, its uncertainty or the overall $P_{establishment}$, the cell identifying the effected elements and their ratings are shaded. In addition, the changed rating is italicized and bolded.

New notations,were also used to document conditional probabilities. For example, except for the Nonstructural Alternative, significant time is required to implement the alternatives. As such, risk reduction due to alternative implementation may occur after a species has transferred into the invaded basin. For example, assume that a hypothetical Alternative Z lowers $P_{passage}$ through the CAWS from "high" to "low", but Alternative Z would require 25 years to be implemented (Table *.*). If an ANS's $P_{establishment}$ is "high" prior to when the alternative is implemented (i.e., within the preceding 25 years), then there is a high probability the ANS will have transferred to and established within the new basin prior to implementation of Alternative Z. In Table 5 and 6, Alternative Z may have a "low" rating for Risk of Establishment after 25 years, but this rating is conditional on the ANS not becoming established in the newly invaded basin within the first 25 years. In such cases, the Low|NPE notation was used to signify that an alternative can be effective in reducing a probability of establishment in later years but only if the species did not established in earlier years. NPE stands for "no prior establishment."

TABLE 5 Example Probability Element Table for Conditional Notation – No New Federal Action – Sustained Activities

Probability of Establishment Summary								
Probability Element	**T_0**		**T_{10}**		**T_{25}**		**T_{50}**	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
$P_{pathway}$	High	None	High	None	High	None	High	None
$P_{arrival}$	High	Low	High	Low	High	Low	High	Low
$P_{passage}$	High	Medium	High	Low	High	Low	High	Low
$P_{colonizes}$	High	Low	High	Low	High	Low	High	Low
$P_{spreads}$	High	Low	High	Low	High	Low	High	Low
$P_{establishment}$	High	-[a]	High	-	High	-	High	-

[a] "-" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

TABLE 6 Example Probability Element Table for Conditional Notation – Alternative Z Implemented at T_{25}

Probability of Establishment Summary								
Probability Element	**T_0**		**T_{10}**		**T_{25}**		**T_{50}**	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
$P_{pathway}$	High	None	High	None	High	None	High	None
$P_{arrival}$	High	Low	High	Low	High	Low	High	Low
$P_{passage}$	High	Medium	High	Low	***Low***	Low	***Low***	Low
$P_{colonizes}$ [b]	High	Low	High	Low	High	Low	High	Low
$P_{spreads}$ [b]	High	Low	High	Low	High	Low	High	Low
$P_{establishment}$	High	-[a]	High	-	***Low|NPE***[c]	-	***Low|NPE***	-

[a] "-" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

[b] These probability ratings remain unchanged from the No New Federal Action Risk Assessments which are documented in Grippo et al. (2013).

[c] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

When an alternative is implemented, $P_{establishment}$ may already be "low" for some species. If the alternative reduces an additional probability element $P_{pathway}$, $P_{arrival}$ or $P_{passage}$ to "low" then the number of elements that are "low" in the with project risk assessment are noted adjacent to the probability rating (Table 7 and 8). Assume an ANS has $P_{arrival}$ equal to "low" for the first 25 years; consequently, $P_{establishment}$ equals "low" for those timesteps. Now, suppose Alternative X lowers the ANS's $P_{passage}$ to "low" in 10 years. When the number of low elements increases the additional reduction in $P_{establishment}$ is indicated by appending the number of elements with a low rating in parenthesis after the $P_{establishment}$ rating. Thus, the initial rating of low becomes low(2) at T_{25} indicating the probability of establishment has two low elements as a result of the alternative. See Table 7 and 8 for an example.

TABLE 7 Example Probability Element Table with Additional Low Probability Elements Due to No New Federal Action Alternative

Probability Element	**T_0**		**T_{10}**		**T_{25}**		**T_{50}**	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
$P_{pathway}$	High	None	High	None	High	None	High	None
$P_{arrival}$	Low	Low	Low	Medium	Low	Medium	Medium	High
$P_{passage}$	High	Medium	High	Medium	High	Low	High	Low
$P_{colonizes}$	Medium	High	Medium	High	Medium	High	Medium	High
$P_{spreads}$	Medium	High	Medium	High	Medium	High	Medium	High
$P_{establishment}$	Low	-[a]	Low	-	Low	-	Medium	-

[a] "-" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

TABLE 8 Example Probability Element Table with Additional Low Probability Elements Due to Alternative X Implemented at T_{25}[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
$P_{pathway}$	High	None	High	None	High	None	High	None
$P_{arrival}$	Low	Low	Low	Medium	Low	Medium	Medium	High
$P_{passage}$	High	Medium	High	Medium	***Low***	Low	***Low***	Low
$P_{colonizes}$	Medium	High	Medium	High	Medium	High	Medium	High
$P_{spreads}$	Medium	High	Medium	High	Medium	High	Medium	High
$P_{establishment}$	Low	-[b]	Low	-	***Low(2)***	-	***Low***	-

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] "-" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating

Residual Risk

After implementation of a GLMRIS alternative, residual risk will remain in the aquatic pathway and in the nonaquatic pathway. Residual risk in the aquatic pathway, refers to the risk of transfer through aquatic pathways along the GL and MR basin divide but outside the CAWS, and the risk remaining after implemention of the GLMRIS alternatives in the CAWS. The aquatic pathways along the GL and MR basin divide, known as GLMRIS Focus Area 2 are discussed in Appendix N. As for the risk of ANS transfer and establishment in GLMRIS Focus Area 2, no attempt was made to reflect this risk in the risk assessments described here. As for the risk remaining in the CAWS aquatic pathway, if an alternative reduces the "high" or "medium" ratings of one or more of the probability elements to a "low," then the resultant risk of adverse impacts for that ANS would be reduced to "low."

A "low" risk rating does not indicate that "No" risk remains. For example, after implementation of the lakefront hydrologic separation alternative, the tubenose goby was rated a "low" risk because the physical barriers used to create the hydrologic separation are constrained by the storm size they were designed to withhold. No combination of high or medium risk ANS and alternative received a risk rating of "None." A rating of "None" would indicate there is no risk of adverse impacts due to transfer through the CAWS.

As for residual risk in the nonaquatic pathway, the GLMRIS Alternatives address, to some level, non-aquatic pathways because each alternative includes nonstructural measures, such as public education and monitoring, that may deter but not completely address ANS transfer through non-aquatic pathways (see Appendix A for additional detail on non-aquatic pathways). However, residual risk of interbasin transfer through non-aquatic pathways would remain, although no attempt was made to reflect this risk in the risk assessments described here.

Alternative Plan 1: No New Federal Action

ANS Risk Reduction

For more information regarding the No New Federal Action Alternative, refer to Section 3.8 of the GLMRIS Report. As stated at the beginning of this document, risk assessments for without project conditions were completed on 35 GLMRIS ANS of Concern to determine whether potential adverse impacts would be expected due to ANS interbasin transfer and establishment (see Risk of Adverse Impacts from the Movement through the CAWS and Establishment of Aquatic Nuisance Species in

the Great Lakes and Mississippi River Basins in Appendix C). The risk assessments identified 13 GLMRIS ANS of Concern that were assessed as having a high or medium risk of adverse impacts in the newly invaded basin within the next 50 years. The without project risk assessment, which establishes the risk for the No New Federal Action – Sustained Activities Alternative, serves as the point of comparison for the risk reduction expected due to the implementation of GLMRIS Alternatives and is posted in each table presented in the remaining GLMRIS Alternative discussions of risk reduction.

Alternative Plan 2: Nonstructural Control Technologies

ANS Risk Reduction

For more information regarding the Nonstructural Control Technologies Alternative (i.e. Nonstructural Alternative), refer to Section 3.9 of the GLMRIS Report. The Nonstructural Alternative includes measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The expected risk reduction resulting from implementation of the Nonstructural Alternative is described below. Because risk reduction of the Nonstructural Alternative depends on actions of numerous agencies and the public, the uncertainty associated with this alternative is generally higher than that obtained with hydrologic separation alternatives. A detailed discussion of this alternative's risk assessment analysis including uncertainty for each of the 13 high and medium risk species can be found in the with project risk assessments.

ANS Potentially Invading the Great Lakes Basin

Scud (Apocorophium lacustre)

The scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008). The Nonstructural Alternative would not reduce the scud's risk of establishment in the GL basin compared to the risk identified for the No New Federal Action – Sustained Activities Alternative. Please see the with project risk assessments for the Nonstructural Alternative for the scud. The scud is likely already present at the CAWS and can be transported via vessel movement. The Nonstructural Alternative does not impact vessel movement in the CAWS.

Silver Carp and Bighead Carp (Hypophthalmichthys sp.)

The silver and bighead carp have been found in the DesPlaines River in Rock Run Rookery (ACRCC, 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. The Nonstructural Alternative would not reduce the risk of establishment of the bighead or silver carp when compared to the No New Federal Action – Sustained Activities conditions. Under the No New Federal Action conditions, numerous nonstructural measures to address bighead and silver carp are already being implemented by federal, state, and local entities. After evaluating the nonstructural measures currently available, no additional nonstructural measures were identified that would further decrease the probability of passage of the species into the Great Lakes Basin. If in the future, new nonstructural technologies are developed that would be effective against these species, further analysis would need to be conducted. A detailed discussion of this analysis can be found in these species' Nonstructural Alternative risk assessment.

ANS Potentially Invading the Mississippi River Basin

The Nonstructural Alternative would not reduce the risk of establishment of the following Great Lakes high and medium risk ANS: diatom (*Stephanodiscus binderanus*), red algae (*Bangia atropurpurea*), fishhook water flea (*Cercopagis pengoi*), bloody red shrimp (*Hemimysis anomala*), threespine stickleback (*Gasterosteus aculeatus*), ruffe (*Gymnocephalus cernuus*), and VHSv (*Novirhabdovirus*). Nonstructural measures would not eliminate the aquatic pathway between the Great Lakes and Mississippi River basins. The diatom, red algae, fishhook water flea, bloody red shrimp, threespine stickleback, and VHSv have already arrived in the lower Lake Michigan Basin and cannot be controlled with nonstructural measures such as aquatic pesticides or piscicides due to their widespread distribution. Though not currently identified as being in the southern Lake Michigan Basin, the ruffe has dispersed throughout various parts of the Great Lakes and also cannot be successfully controlled with nonstructural measures.

The Nonstructural Alternative would reduce the probability of establishment of the following Great Lakes ANS:

Grass Kelp (Enteromorpha flexuosa)

A 2003 study indicated that the closest population to the CAWS of *E. flexuosa* is in Muskegon Lake in Michigan, as well as in two nearby inland lakes and lagoons (Sturtevant 2011). Because there are nonstructural measures, such as algaecides, that would target reducing the abundance of grass kelp in these lakes, the Nonstructural Alternative as described in the risk assessment is expected to reduce the opportunities for the species to disperse beyond its current locations.

This alternative reduces the likelihood grass kelp will arrive at the CAWS, and consequently, reduces its probability of arrival from medium to low at T_{10}, T_{25} and T_{50}. The uncertainty about the probability of arrival rating is medium at T_{10} and T_{25}, and high at T_{50}.

The comprehensive implementation of the Nonstructural Alternative as identified in the risk assessment would reduce the risk of *E. flexuosa* from medium to low for time steps T_{10}, T_{25}, and T_{50} (Table 9).

TABLE 9 Risk Ratings for Nonstructural Alternative– Grass Kelp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (M)	M (M)	M (M)	M (M)	H (M)	H (M)	H (M)	H (M)	L	M	M	M	M	L	M	M	M
Nonstructural Control Technologies	L (M)	***L*** (M)	***L*** (M)	***L*** ***(H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Reed Sweetgrass (Glyceria maxima)

Reed sweetgrass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois

Beach State Park, north of Waukegan, Illinois. The population was treated with aquatic herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012). The Nonstructural Alternative for this species would include monitoring followed by aquatic herbicide treatment, if it is encountered. This alternative reduces the likelihood reed sweetgrass would arrive at the CAWS, and consequently, reduces its probability of arrival from medium to low at T_{50}. The uncertainty about the $P_{arrival}$ rating is low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the T_{50} risk of adverse impacts from establishing in the MR basin from medium to low at T_{50} (Table 10).

TABLE 10 Risk Ratings for Nonstructural Alternative – Reed Sweetgrass[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (L)	L (L)	M (M)	L (M)	M (M)	M (M)	M (M)	L	L	L	M	M	L	L	L	M
Nonstructural Control Technologies	L (L)	L (L)	L (L)	***L*** ***(L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Tubenose Goby (Proterorhinus semilunaris)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as portions of the Detroit River system. This species is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011), and a population has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011). The tubenose goby is an active swimmer, but is able to disperse more quickly through ballast water transfer. Ballast/bilge water management of ships that travel in waters where tubenose gobies occur, a nonstructural measure, is expected to delay the time it takes the tubenose goby to arrive at the CAWS pathway. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is expected that this species can swim from its current location to the CAWS by T_{25}. This alternative reduces the likelihood the tubenose goby will arrive at the CAWS at T_{10}, and consequently, the probability of arrival is reduced from a medium to a low at T_{10}. The uncertainty about the arrival rating is medium.

The comprehensive implementation of the Nonstructural Alternative as identified in the risk assessment would reduce the risk of tubenose goby from medium to low at T_{10} (Table 11).

TABLE 11 Risk Ratings for Nonstructural Alternative – Tubenose Goby[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	M (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	M	M	M	M	L	M	M	M
Nonstructural Control Technologies	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	***L***	M	M		L	***L***	M	M

[a] The table cells with highlighted bold italics indicate a rating change.

[a] Uncertainty associated with each probability element is indicated in parenthesis.

Alternative Plan 3: Mid-System Control Technologies without a Buffer Zone

ANS Risk Reduction

See GLMRIS Report Section 3.10 for a description of the Mid-System Control Technologies without a Buffer Zone Alternative. This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25}. This alternative includes measures, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies involved in these alternatives are known, the combination of technologies and application of the technologies are non-traditional. For instance, ultraviolet radiation (UV) is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while U.S. Army Corps of Engineers (USACE) currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. As a result, the uncertainty associated with the technologies' impact on ANS passage is higher than the uncertainty of ANS passage associated with the hydrologic separation alternatives. The hydrologic separation alternatives include physical barriers, which has uncertainty based on the size of the design storm event. A detailed discussion of this alternative's with project risk assessment analysis, including uncertainty for each of the 13 high and medium risk species, can be found in with project risk assessments.

ANS Potentially Invading the Great Lakes Basin

Scud (Apocorophium lacustre)

Scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008). This alternative would not reduce the scud's risk of establishment in the GL basin compared to the risk identified for the No New Federal Action Alternative. Please see this Alternative's With Project Risk Assessment for the scud. The scud is likely present at the CAWS and can be transported via vessel

movement. This alternative provides for continued vessel movement in the CAWS and would not reduce the risk of the scud.

Bighead Carp (Hypophthalmichthys nobilis)

Bighead carp have been found in the DesPlaines River in Rock Run Rookery (ACRCC, 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric barriers.

Nonstructural measures such as piscicides, overfishing, etc., would work to limit the population of bighead carp below the barrier. The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage ofbighead carp through ballast and bilge water transfer.

The electric barrier on the downstream side of the GLMRIS Lock is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock would flush the lock with water from the aquatic nuisance species treatment plant (ANSTP), and is expected to address the passive drift of bighead carp eggs, larvae and fry that may pass through the electric barrier and enter the lock. This alternative reduces the likelihood of bighead carp passing through the CAWS at T_{25} and T_{50} and consequently, reduces the $P_{Passage}$ from medium to low for T_{25} and T_{50}. The uncertainty about the probability of passage rating is medium.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of bighead carp from a medium to a low at T_{25} and T_{50} (Table 12).

TABLE 12 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Bighead Carp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Silver Carp (Hypophthalmichthys molitrix)

Silver carp have been found in the DesPlaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric barriers.

Nonstructural measures such as piscicides, overfishing, etc., are expected to control the population of silver carp immediately below the control points. The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS lock are expected to control the passage of the silver carp through ballast and bilge water.

The electric barrier on the downstream side of the GLMRIS lock is expected to control the entry of swimming silver carp into the CAWS, while the pump-driven filling and emptying system of the GLMRIS lock would flush the lock with water from the ANSTP, and is expected to address the passive drift of silver carp eggs, larvae and fry that may pass through the electric barrier and enter the lock. This alternative reduces the likelihood of silver carp passing through the aquatic pathway; and therefore, the probability of passage is reduced from a medium to a low at T_{25} and T_{50}. The uncertainty about the passage rating is medium.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of silver carp from a medium to a low at T_{25} and T_{50} (Table 13).

TABLE 13 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Silver Carp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

ANS Potentially Invading the Mississippi River Basin

This alternative would not reduce the risk of adverse impacts from transfer of the following ANS through the CAWS and establishment in the MR basin: diatom (*Stephanodiscus binderanus*), red algae (*Bangia atropurpurea*), fishhook waterflea (*Cercopagis pengoi*), and VHSv (*Novirhabdovirus* sp.). These four species are either hull foulers or may transfer via temporary vessel attachment through the GLMRIS Lock. This alternative does not include a measure that successfully addresses hull fouling or temporary vessel attachment.

Grass Kelp (Enteromorpha flexuosa)

A 2003 study indicated that the closest population to the CAWS of *E. flexuosa* is in Muskegon Lake in Michigan, as well as in two nearby inland lakes and lagoons (Sturtevant 2011). This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric barriers. The ANSTP would remove grass kelp from water used to flush the GLMRIS Lock and diverted for water quality purposes and to maintain the current hydrologic conditions on the Mississippi River Basin side of the control point. However, the lock is not expected to control grass kelp's entry into or

passage through the CAWS. Grass kelp may temporarily attach to vessels, but the GLMRIS Lock would not dislodge algae from vessel hulls.

However, because of nonstructural measures, such as algaecides, that would target reducing the abundance of grass kelp in these lakes, the comprehensive implementation of the nonstructural measures described in the risk assessment is expected to reduce the opportunities for the species to disperse beyond its current locations. This alternative reduces the likelihood of grass kelp arriving at the CAWS, and consequently, reduce its probability of arrival from medium to low at T_{10} and T_{25}. The uncertainty about the $P_{arrival}$ rating is medium at T_{10} and T_{25} and high at T_{50}.

The comprehensive implementation of this alternative as identified in the risk assessment would reduce the risk of *E. flexuosa* from medium to low for time steps T_{10}, T_{25}, and T_{50} (Table 14).

TABLE 14 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Grass Kelp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (M)	M (M)	M (M)	M (M)	H (M)	H (M)	H (M)	H (M)	L	M	M	M	M	L	M	M	M
Mid-System Control Technologies without a Buffer Zone	L (M)	***L*** (M)	***L*** (M)	***L*** ***(H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[a] Uncertainty associated with each probability element is indicated in parenthesis.

Reed Sweetgrass (Glyceria maxima)

Reed sweetgrass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with aquatic herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012).

This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric. The ANSTPs are expected to inactivate reed sweetgrass in the water used to flush the GLMRIS Lock and diverted to the CAWS for water quality purposes and maintenance of the current hydrologic conditions in the Mississippi River Basin side of the control point. However, the lock is not expected to control this grass's passage through the CAWS. Reed sweetgrass plant fragments and seeds may temporarily attach to vessels, but the GLMRIS Lock is not expected to dislodge these from vessel hulls.

Though the control points containing GLMRIS Locks would not be effective for reed sweetgrass, nonstructural measures, such as monitoring are expected to identify the location of this species and aquatic herbicides are expected to eradicate it. These measures reduce the likelihood of reed sweetgrass arriving at the CAWS, and thus the alternative reduces the probability of arrival from medium to low at T_{50}. The uncertainty about the ($P_{arrival}$) rating is low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the T_{50} risk rating from medium to low at T_{50} (Table 15).

TABLE 15 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Reed Sweetgrass[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (L)	L (L)	M (M)	L (M)	M (M)	M (M)	M (M)	L	L	L	M	M	L	L	L	M
Mid-System Control Technologies without a Buffer Zone	L (L)	L (L)	L (L)	***L*** ***(L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Bloody Red Shrimp (Hemimysis anomala)

The species is established within Lake Michigan having been documented offshore of Jackson Harbor in 2007 and Waukegan Harbor in 2006 (Kipp et al. 2011). This species is not known to be a hull fouler or to temporarily attach to vessels. This alternative includes nonstructural measures and creates control points comprised ofGLMRIS Locks, ANSTPs, and electric barriers.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of bloody red shrimp by ballast and bilge water discharges. The GLMRIS Lock would include a pump-driven filling and emptying system that would flush ANS water from within the lock and fill it with ANS-treated water. This flushing is expected to control the passage of this species during lockages. The water treated by the ANSTP would be used to flush the GLMRIS Lock and for discharge to the MR basin side of the control point for water quality purposes and to maintain current downstream hydrologic conditions. The ANSTP is expected to inactivate the bloody red shrimp by treating the water with UV radiation. These measures reduce the likelihood of bloody red shrimp passing through the CAWS and reduce the probability of passage rating from a high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from high to low at T_{25} and T_{50}, assuming no prior establishment of the bloody red shrimp in the MR basin prior to T_{25} (Table 16). However, because bloody red shrimp's probability of establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 16 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Bloody Red Shrimp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	H	H	H	H	H
Mid-System Control Technologies without a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		H	H	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Threespine Stickleback (Gasterosteus aculeatus)

The threespine stickleback is considered established in southern Lake Michigan, and it has been found in the North Shore Channel, which connects to the Wilmette Pumping Station (Johnston 1991). This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric barriers.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of threespine stickleback through ballast and bilge water discharges. The threespine stickleback is documented in the CAWS. However, the electric barrier is expected to control the entry of additional swimming fish into the lock, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae and fry. The water treated by the ANSTP would be used to flush the GLMRIS Lock and for discharge to the MR basin side of the control point for water quality purposes and to maintain current downstream hydrologic conditions. The ANSTP would treat water for threespine stickleback by screening fish whose body depth was larger than 0.75 in. (19.05 mm), followed by pumping the water through UV radiation treatment process to inactivate all life stages of fish that pass through the screen. This alternative would reduce the likelihood of threespine stickleback passing through the CAWS and would reduce its probability of passage from high to low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{25} and T_{50}, assuming no prior establishment of the threespine stickleback in the MR basin prior to T_{25} (Table 17). However, because threespine stickleback's probability of establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 17 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Threespine Stickleback[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	M	M	M	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L|NPE***	***L|NPE***	M	M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Ruffe (Gymnocephalus cernuus)

The ruffe is not widespread, and there are no high-density populations in Lake Michigan outside of Green Bay (Bowen and Goehle 2011). This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric barriers.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of the ruffe through ballast and bilge water. The electric barrier is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae and fry during lockages. ANSTPs are expected to inactivate the ruffe in water used to flush the GLMRIS Lock and diverted to the Mississippi River Basin side of the control point for water quality purposes and maintenance of its current hydrologic conditions. The ANSTP would screen the water for fish whose body depth was larger than 0.75 in. (19.05 mm), followed by pumping the water through UV radiation treatment, and is expected to inactivate all life stages of fish that pass through the screen. This alternative reduces the likelihood of ruffe passing through the CAWS and reduces its probability of passage from a high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{50} (Table 18).

TABLE 18 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Ruffe[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	H (L)	H (L)	L	L	L	M	M	L	L	L	M
Mid-System Control Technologies without a Buffer Zone	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L (H)***	***L (H)***	L	L	***L* (2)**	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Tubenose Goby (Proterorhinus semilunaris)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as the Detroit River system, and is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011). A population of tubenose gobies has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011).

This alternative includes nonstructural measures and creates control points comprised of GLMRIS Locks, ANSTPs, and electric barriers. Nonstructural measures include the ballast/bilge water management of ships that travel in waters where tubenose gobies occur. These management measures are expected to delay the time it takes the tubenose goby to arrive at the CAWS pathway. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is expected this species can swim from its current location to the CAWS by T_{25}. This alternative reduces the likelihood of tubenose goby arriving at the CAWS at T_{10}, and consequently, the probability of arrival is reduced from a medium to a low at T_{10}. The uncertainty about the arrival rating is medium.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of the tubenose goby through ballast and bilge water. The electric barrier is expected to control the entry of swimming fish, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae and fry during lockages. ANSTPs are expected to inactivate the tubenose goby in water used to flush the GLMRIS Lock and diverted to the CAWS for water quality purposes and maintenance of its current hydrologic conditions. The ANSTP would screen the water for fish whose body depth was larger than 0.75 in. (19.05 mm), followed by pumping the water through UV radiation treatment and is expected to inactivate all life stages of fish that pass through the screen. The electric barrier, GLMRIS Lock and ANSTP are expected to control the passage of the tubenose goby through the CAWS. This alternative reduces the likelihood of tubenose goby passing through the CAWS and reduces it probability of passage through the CAWs from a high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at $T_{10,}$ T_{25} and T_{50} (Table 19).

TABLE 19 Risk Ratings for Mid-System Control Technologies without a Buffer Zone Alternative – Tubenose Goby[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	M (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	M	M	M	M	L	M	M	M
Mid-System Control Technologies without a Buffer Zone	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L (H)***	***L (H)***	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Alternative Plan 4: Control Technology with a Buffer Zone

ANS Risk Reduction

For information regarding the Control Technology Alternative with a Buffer Zone, refer to Section 3.11 of the GLMRIS Report. This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty in time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{10}. This alternative includes measures, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies involved in these alternatives are known, the combination of technologies and application of the technologies are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. As a result, the uncertainty associated with the technologies' impact on ANS passage is higher than the uncertainty of ANS passage associated with the hydrologic separation alternatives. The hydrologic separation alternatives include physical barriers, which has uncertainty based on the size of the design storm event. A new detailed discussion of this alternative's risk assessment analysis including uncertainty for each of the 13 high and medium risk species can be found in the with project risk assessments.

ANS Potentially Invading the Great Lakes Basin

Scud (Apocorophium lacustre)

The scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008). The Control Technology with a Buffer Zone Alternative would not reduce the scud's risk of establishment in the GL basin compared to the risk identified in the No New Federal Action – Sustained Activities Alternative. Please see this alternative's With Project Risk Assessment for the scud. The scud is already present at the CAWS and can be transported via vessel movement. This alternative does not impact vessel movement in the CAWS.

Bighead carp (Hypophthalmichthys nobilis)

Bighead carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. This alternative includes the following measures at the Brandon Road Lock and Dam control point: nonstructural measures, GLMRIS Lock, and the electric barrier.

Nonstructural measures such as piscicides, overfishing, etc., would work to limit the population of bighead carp below the Brandon Road control point. Ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of the bighead carp through ballast and bilge water.

The electric barrier on the downstream side of the GLMRIS Lock would be designed to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock, would flush the lock with water from the CAWS Buffer Zone, and would address the passive drift of bighead carp eggs,larvae and fry that may pass through the electric barrier and enter the lock. This alternative reduces the likelihood of bighead carp passing through the aquatic pathway; and therefore the probability of passage is reduced from medium to low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is medium.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of bighead carp from medium to low at T_{25} and T_{50} (Table 20).

TABLE 20 Risk Ratings for Control Technology with a Buffer Zone Alternative – Bighead Carp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Mid-System Control Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L ***(M)***	***L*** ***(M)***	***L*** ***(M)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Silver Carp (Hypophthalmichthys molitrix)

Silver carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC, 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and the following measures at the Brandon Road Lock and Dam control point: nonstructural measures, GLMRIS Lock, and the electric barrier.

Nonstructural measures such as piscicides, overfishing, etc., would work to limit the population of silver carp below the Brandon Road control point. Ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of silver carp through ballast and bilge water.

The electric barrier on the downstream side of the GLMRIS Lock would be designed to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock would flush the lock with water from the CAWS Buffer Zone, and would address the passive drift of silver carp eggs, larvae and fry that may pass through the electric barrier and enter the lock. This alternative reduces the likelihood of silver carp passing through the aquatic pathway; and therefore, the probability of passage is reduced from a medium to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is medium.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of silver carp from medium to low at T_{25} and T_{50} (Table 21).

TABLE 21 Risk Ratings for Control Technology with a Buffer Zone Alternative – Silver Carp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Mid-System Control Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	***L (M)***	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

ANS Potentially Invading the Mississippi River Basin

This alternative would not reduce the risk of adverse impacts from transfer of the following ANS through the CAWS and establishment in the MR basin: diatom (*Stephanodiscus binderanus*), red algae (*Bangia atropurpurea*), fishhook waterflea (*Cercopagis pengoi*), and VHSv (*Novirhabdovirus* sp.). These four species are either hull foulers or may transfer via temporary vessel attachment through the GLMRIS lock. This alternative does not include a measure that successfully addresses hull fouling or temporary vessel attachment.

Grass Kelp (Enteromorpha flexuosa)

A 2003 study indicated that the closest population to the CAWS of grass kelp is in Muskegon Lake in Michigan, as well as in two nearby inland lakes and lagoons (Sturtevant 2011). In addition to other measures, this alternative includes GLMRIS Locks and ANSTP at the entrance to or within the CAWS.

ANSTP's UV treatment is expected to inactivate grass kelp in water. The treated water would be used to flush the GLMRIS Lock and diverted to the CAWS for water quality purposes and maintenance of its current hydrologic conditions. As for the GLMRIS Lock, grass kelp may temporarily attach to vessels, but the GLMRIS Lock would not dislodge algae from vessel hulls.

Though the control points containing GLMRIS Locks would not be effective for grass kelp, nonstructural measures, such as monitoring that would target identifying the location of this species and algaecides are expected to control the species. Nonstructural measures as described in the risk assessment are expected to reduce the opportunity for the species to disperse beyond its current locations. This alternative reduces the likelihood of grass kelp arriving at the CAWS, and consequently, reduce its probability of arrival from medium to low at T_{10}, T_{25}, and T_{50}. The uncertainty about the probability of arrival rating is medium at T_{10} and T_{25} and high at T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of grass kelp from medium to low for time steps T_{10}, T_{25}, and T_{50} (Table 22).

Table 22. Risk Ratings for Control Technology with a Buffer Zone Alternative – Grass Kelp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (M)	M (M)	M (M)	M (M)	H (M)	H (M)	H (M)	H (M)	L	M	M	M	M	L	M	M	M
Mid-System Control Technologies with a Buffer Zone	L (M)	***L*** (M)	***L*** (M)	***L*** ***(H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[a] Uncertainty associated with each probability element is indicated in parenthesis.

Reed Sweetgrass (Glyceria maxima)

Reed sweetgrass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with aquatic herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012).

In addition to other measures, this alternative includes GLMRIS Locks and ANSTPs at control points within the system. The ANSTPs are expected to inactivate reed sweetgrass from water used in the GLMRIS Lock and diverted to the Mississippi River Basin side of the control point for water quality purposes and maintenance of its current hydrologic conditions. However, the lock would not control this grass's entry into or passage through the CAWS. Reed sweetgrass plant fragments and seeds may temporarily attach to vessels, but the GLMRIS Lock would not dislodge these from vessel hulls.

Though the control points containing GLMRIS Locks would not be effective for reed sweetgrass, nonstructural measures, such as monitoring that would target identifying the location of this species and aquatic herbicides would eradicate the species. These measures reduce the likelihood of reed sweetgrass arriving at the CAWS, and thus the alternative reduces the probability of arrival from medium to low at T_{50}. The uncertainty about the probability of arrival rating is low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the T_{50} risk rating from medium to low (Table 23).

TABLE 23 Risk Ratings for Control Technology with a Buffer Zone Alternative – Reed Sweetgrass[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (L)	L (L)	M (M)	L (M)	M (M)	M (M)	M (M)	L	L	L	M	M	L	L	L	M
Mid-System Control Technologies with a Buffer Zone	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Bloody Red Shrimp (Hemimysis anomala)

The species is established within Lake Michigan having been documented offshore of Jackson Harbor in 2007 and Waukegan Harbor in 2006 (Kipp et al. 2011). This species is not known to be a hull fouler or to temporarily attach to vessels. The nonstructural measures, GLMRIS Lock, and ANSTP are expected to control the bloody red shrimp's passage through the CAWS, assuming this species has not already established in the MR basin prior to T_{10}.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of bloody red shrimp through ballast and bilge water. The GLMRIS Lock would include a pump-driven filling and emptying system that would flush ANS water from within the lock and fill it with ANS treated water. This flushing is expected to control the passage of this species during lockages. The water treated by the ANSTP would be used to flush the GLMRIS Lock and for discharge to the MR basin side of the control point for water quality purposes and maintenance of the current hydrologic conditions in the CAWS. The ANSTP is expected to inactivate the bloody red shrimp by treating the water with UV radiation. These measures reduce the likelihood of bloody red shrimp passing through the CAWS and reduce the probability of passage rating from a high to a low at T_{10}, T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from high to low at T_{10}, T_{25}, and T_{50}, assuming no prior establishment of the bloody red shrimp in the MR basin prior to T_{10} (Table 24). However, because bloody red shrimp's probability of establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 24 Risk Ratings for Control Technology with a Buffer Zone Alternative – Bloody Red Shrimp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	H	H	H	H	H
Mid-System Control Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (M)	***L (H)***	***L (H)***	***L (H)***	H	***L| NPE***	***L| NPE***	***L| NPE***	H	H	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Threespine Stickleback (Gasterosteus aculeatus)

The threespine stickleback is considered established in southern Lake Michigan, and it has been found in the North Shore Channel, which connects to the Wilmette Pumping Station (Johnston 1991). The GLMRIS Locks, ANSTPs and electric barriers are expected to control the threespine stickleback's passage through the CAWS, assuming this species has not already established in the MR basin.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of the threespine stickleback through ballast and bilge water. The threespine stickleback is documented in the CAWS. However, the electric barrier is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae and fry. The water treated by the ANSTP would be used to flush the GLMRIS Lock and for discharge to the MR basin side of the control point for water quality purposes and maintenance of current hydrologic conditions in the CAWS. The ANSTP would screen from the water fish whose body depth was larger than 0.75 in. (19.05 mm), followed by pumping it through a UV radiation treatment process to inactivate all life stages of fish that pass through the screen. This alternative reduces the likelihood of threespine stickleback passing through the CAWS and would reduce its probability of passage from high to low at T_{10}, T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{10}, T_{25}, and T_{50}, assuming no prior establishment of the threespine stickleback in the MR basin prior to T_{10} (Table 25). However, because threespine stickleback's probability of establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 25 Risk Ratings for Control Technology with a Buffer Zone Alternative – Threespine Stickleback[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	M	M	M	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	H (M)	***L (H)***	***L (H)***	***L (H)***	H	***L| NPE***	***L| NPE***	***L| NPE***		M	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Ruffe (Gymnocephalus cernuus)

The ruffe is not widespread, and there are no high-density populations in Lake Michigan outside of Green Bay (Bowen and Goehle 2011). The nonstructural measures, GLMRIS Locks, ANSTPs, and electric barriers are expected to control the ruffe's entry into the CAWS.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of the ruffe through ballast and bilge water discharge. The electric barrier is expected to control the entry of swimming fish, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae and fry during lockages. ANSTPs are expected to inactivate the ruffe in Lake Michigan water used to flush the GLMRIS Lock and diverted to the CAWS for water quality purposes and maintenance of its current hydrologic conditions. The ANSTP would screen the water for fish whose body depth was larger than 0.75 in. (19.05 mm), followed by pumping the water through UV radiation treatment, and is expected to inactivate all life stages of fish that pass through the screen. This alternative reduces the likelihood of ruffe passing through the CAWS and reduces its probability of passage through the CAWS from a high to a low at T_{10}, T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{50} (Table 26).

TABLE 26 Risk Ratings for Control Technology with a Buffer Zone Alternative – Ruffe[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	H (L)	H (L)	L	L	L	M	M	L	L	L	M
Mid-System Control Technologies without a Buffer Zone	L (L)	L (M)	L (M)	M (H)	H (M)	***L (H)***	***L (H)***	***L (H)***	L	***L (2)***	***L (2)***	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Tubenose Goby (Proterorhinus semilunaris)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as the Detroit River system, and is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011). A population of tubenose gobies has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011).

This alternative includes nonstructural measures and GLMRIS Locks, electric barriers, and an ANSTP within or at the entry of the CAWS along Lake Michigan. The tubenose goby is an active swimmer but is able to disperse more quickly through ballast water transfer. The nonstructural measures include ballast/bilge water management of ships that travel in waters where tubenose gobies occur which could delay the time it would take for this species to arrive at the CAWS pathway. Because the tubenose goby is an active swimmer, even with ballast/bilge water management it is expected that this species can swim from its current location to the CAWS by T_{25}. This alternative reduces the likelihood of tubenose goby arriving at the CAWS at T_{10}, and consequently, the probability of arrival is reduced from a medium to a low at T_{10}. The uncertainty about the probability of arrival rating is medium.

The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are also expected to control the passage of the tubenose goby through the pathway by ballast and bilge water discharge. As for the control points along the lake, the electric barrier is expected to control the entry of swimming fish, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae and fry during lockages. The water treated by the ANSTP would be used to flush the GLMRIS Lock and for discharge to the MR basin side of the control point for water quality purposes. The ANSTP would screen the water for fish whose body depth was larger than 0.75 in. (19.05 mm), followed by pumping the water through UV radiation treatment and is expected to inactivate all life stages of fish that pass through the screen. This alternative reduces the likelihood of the tubenose goby passing through the CAWS and reduces it probability of passage through the CAWs from a high to a low at T_{10}, T_{25} and T_{50}. The uncertainty about the probability of passage rating is high.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{10}, T_{25}, and T_{50} (Table 27).

TABLE 27. Risk Ratings for Control Technology with a Buffer Zone Alternative – Tubenose Goby[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	M (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	M	M	M	M	L	M	M	M
Mid-System Control Technologies without a Buffer Zone	L (L)	***L*** (M)	M (M)	M (M)	H (M)	***L (H)***	***L (H)***	***L (H)***	L	***L* (2)**	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Alternative Plan 5: Lakefront Hydrologic Separation

Alternative Plan Description – ANS Risk Reduction

For more information regarding the Lakefront Hydrologic Separation Alternative, refer to Section 3.12 of the GLMRIS Report. This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25}. When compared to alternatives that do not rely solely on hydrologic separation, the hydrologic separation alternatives were assessed as having lower uncertainty when comparing the impact the alternative had on ANS passage through the CAWS. A detailed discussion of this alternative's risk assessment analysis including uncertainty for each of the 13 high and medium risk species can be found in the with project risk assessments.

ANS Potentially Invading the Great Lakes Basin

Scud (Apocorophium lacustre)

The scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008).

This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures. The physical barriers in this alternative are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). These measures reduce the likelihood of scud passing through the CAWS and reduce the probability of passage rating from a high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{25} and T_{50}. However, because scud's probability of

establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the GL basin prior to the implementation of this alternative (Table 28).

TABLE 28. Risk Ratings for Lakefront Hydrological Separation Alternative – Scud[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H	M	M	M	M	M
Lakefront Hydrological Separation	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	***L*** (L)	***L*** (L)	H	H	***L| NPE***	***L| NPE***	M	M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Bighead Carp (Hypophthalmichthys nobilis)

Bighead carp have been found in the DesPlaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. This alternative includes the construction of a physical barriers in the CAWS, ANSTPs, and nonstructural measures.

The physical barriers in this alternative are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). These measures reduce the likelihood of bighead carp passing through the CAWS and reduce the probability of passage rating from a medium to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{25} and T_{50} (Table 29).

TABLE 29 Risk Ratings for Lakefront Hydrological Separation Alternative – Bighead Carp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Lakefront Hydrological Separation	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L*** ***(L)***	***L*** ***(L)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[a] Uncertainty associated with each probability element is indicated in parenthesis.

Silver Carp (Hypophthalmichthys molitrix)

Silver carp have been found in the DesPlaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately four miles downstream from the Brandon Road Lock and Dam. This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures.

The physical barriers in this alternative are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). These measures reduce the likelihood that silver carp will pass through the CAWS and reduce the probability of passage rating from a medium to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{25} and T_{50} (Table 30).

TABLE 30 Risk Ratings for Lakefront Hydrological Separation Alternative – Silver Carp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Lakefront Hydrological Separation	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L*** ***(L)***	***L*** ***(L)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

ANS Potentially Invading the Great Lakes Basin

Grass Kelp (Enteromorpha flexuosa)

A 2003 study indicated that the closest population of grass kelp is in Muskegon Lake in Michigan, and it was found in two nearby inland lakes and lagoons (Sturtevant 2011). This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures.

The nonstructural measures, such as aquatic herbicides, would target reducing the abundance of grass kelp in these lakes, the comprehensive implementation of this alternative as described in the risk assessment is expected to reduce the opportunities for the species to disperse beyond its current locations. This alternative reduces the likelihood grass kelp will arrive at the CAWS, and consequently, reduces its probability of arrival from medium to low at T_{10}, T_{25}, and T_{50}. The uncertainty about the probability of arrival rating is medium at T_{10} and T_{25} and high at T_{50}.

Additionally, the physical barriers and ANSTPs in this alternative are expected to control the passage of the species through the CAWS. The physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP is expected to inactivate the grass kelp with UV radiation and is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood that grass kelp will pass through the CAWS,

and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

This alternative would reduce the risk of grass kelp's adverse impacts in the MR Basin. This alternative is expected to control grass kelp's arrival to and movement through the CAWS, and thus reduce the likelihood that it will establish in the MR basin.

The comprehensive implementation of this GLMRIS alternative as identified in the risk assessment reduces the risk of adverse impacts from grass kelp's establishment in the MR basin from medium to low for time steps T_{10}, T_{25}, and T_{50} (Table 31).

TABLE 31 Risk Ratings for Lakefront Hydrological Separation Alternative – Grass Kelp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (M)	M (M)	M (M)	M (M)	H (M)	H (M)	H (M)	H (M)	L	M	M	M	M	L	M	M	M
Lakefront Hydrological Separation	L (M)	***L*** (M)	***L*** (M)	***L*** ***(H)***	H (M)	H (M)	***L*** ***(L)***	***L*** ***(L)***	L	***L***	***L*** ***(2)***	***L*** ***(2)***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Red Algae (Bangia atropurpurea)

Red algae was first recorded from Lake Erie in 1964 (Edwards and Harrold 1970). In the Great Lakes, it spread from Lake Erie to southern Lake Michigan within a decade (Lin and Blum 1977). Based on recent data from Lake Michigan, red algae (Division Rhodophyta) is rarely found in the Lake Michigan watershed (Whitman 2012).

This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures. The physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP is expected to inactivate red algae with UV radiation and is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of red algae passing through the CAWS, and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of adverse impacts from establishment in the MR basin from medium to low at T_{25} and T_{50}. However, because red algae's probability of establishment is medium at T_0 and T_{10}, there is a medium probability that it may have transferred to and established in the MR Basin prior to the implementation of this alternative (Table 32).

TABLE 32 Risk Ratings for Lakefront Hydrological Separation Alternative – Red Algae[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M	M	M	M	M	M
Lakefront Hydrological Separation	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	***L (L)***	***L (L)***	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Diatom (Stephanodiscus binderanus)

The diatom was first recorded in Lake Michigan in 1938 and appeared in Lake Ontario in the late 1940s to early 1950s (Kipp 2011). While the diatom is common in the Great Lakes, it has fluctuated in abundance; its population has declined as nutrient inputs into the Great Lakes declined (Kipp 2011).

This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures. The physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP is expected to inactivate the diatom with UV radiation and is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of the diatom passing through the CAWS, and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of adverse impacts from establishment in the MR basin from medium to low at T_{25} and T_{50} (Table 33). However, because the diatom's probability of establishment is medium at T_0 and T_{10}, there is a medium probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 33 Risk Ratings for Lakefront Hydrological Separation Alternative – Diatom[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M	M	M	M	M	M
Lakefront Hydrological Separation	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	***L (L)***	***L (L)***	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Reed Sweetgrass (Glyceria maxima)

Reed sweetgrass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with aquatic herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012).

This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures. Nonstructural measures for this species would include monitoring followed by aquatic herbicide treatment if it is encountered. These measures reduce the likelihood that reed sweetgrass will arrive at the CAWS, and thus, the alternative reduces the probability of arrival from medium to low at T_{50}. The uncertainty about the probability of arrival rating is low.

The physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP is expected to inactivate reed sweetgrass by treating the water with UV radiation and is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of reed sweetgrass passing through the CAWS, and consequently, reduces its probability of passage from medium to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS alternative would reduce the risk of adverse impacts from reed sweetgrass' establishment in the MR basin from medium to low at time step T_{50} (Table 34).

TABLE 34 Risk Ratings for Lakefront Hydrological Separation Alternative – Reed Sweetgrass[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (L)	L (L)	M (M)	L (M)	M (M)	M (M)	M (M)	L	L	L	M	M	L	L	L	M
Lakefront Hydrological Separation	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	***L (L)***	***L (L)***	L	L	***L (2)***	***L (2)***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Fishhook Waterflea (Cercopagis pengoi)

The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures.

The physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP is expected to inactivate the fishhook waterflea by treating the water with UV radiation and is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood that the fishhook waterflea will pass through the CAWS, and consequently, reduces its probability of passage from medium to a low at T_{25} and from high to low at T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of adverse impacts from establishment in the MR basin from medium to low at T_{25} and high to low at T_{50} (Table 35).

TABLE 35 Risk Ratings for Lakefront Hydrological Separation Alternative – Fishhook Waterflea[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H	H	L	L	M	H
Lakefront Hydrological Separation	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	***L*** (L)	***L*** (L)	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Bloody Red Shrimp (Hemimysis anomala)

The species is established within Lake Michigan having been documented offshore of Jackson Harbor in 2007 and Waukegan Harbor in 2006 (Kipp et al. 2011). This alternative includes the construction of a physical barriers in the CAWS, ANSTPs, and nonstructural measures.

Physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP is expected to inactivate the bloody red shrimp with UV radiation and is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of bloody red shrimp passing through the CAWS, and consequently, reduces its probability of passage from high to low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of adverse impacts from bloody red shrimp establishment in the MR basin from high to low at T_{25} and T_{50}, assuming no prior establishment of the bloody red shrimp in the MR basin prior to T_{25} (Table 36). However, because bloody red shrimp's probability of establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 36 Risk Ratings for Lakefront Hydrological Separation Alternative – Bloody Red Shrimp[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	H	H	H	H	H
Lakefront Hydrological Separation	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L*** (L)	***L*** (L)	H	H	***L|NPE***	***L|NPE***		H	H	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Threespine stickleback (Gasterosteus aculeatus)

The threespine stickleback is considered established in southern Lake Michigan, and it has been found in the North Shore Channel, which connects to the Wilmette Pumping Station (Johnston 1991). This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures.

Physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP would remove threespine stickleback whose body depth was larger than 0.75 in. (19.05 mm) by screening those fish, followed by pumping the water

through a UV radiation treatment process to inactivate all life stages of fish that pass through the screen. The ANSTP is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of threespine stickleback passing through the CAWS, and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of adverse impacts from establishment in the MR basin from medium to low at T_{25}, and T_{50}, assuming no prior establishment of the threespine stickleback in the MR basin prior to T_{25} (Table 37). However, because threespine stickleback's probability of establishment is high at T_0 and T_{10}, there is a high probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 37 Risk Ratings for Lakefront Hydrological Separation Alternative – Threespine Stickleback[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	M	M	M	M	M
Lakefront Hydrological Separation	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L*** (L)	***L*** (L)	H	H	***L| NPE***	***L| NPE***		M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Ruffe (Gymnocephalus cernuus)

The ruffe is not widespread, and there are no high-density populations in Lake Michigan outside of Green Bay (Bowen and Goehle 2011). This alternative includes the construction of physical barriers in the CAWS, ANSTPs, and nonstructural measures.

Physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP would remove ruffe whose body depth was larger than 0.75 in. (19.05 mm) by screening those fish, followed by pumping the water through a UV radiation treatment process to inactivate all life stages of fish that pass through the screen. The ANSTP is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of ruffe passing through the CAWS, and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of adverse impacts from establishment in the MR basin from medium to low at T_{50} (Table 38).

TABLE 38 Risk Ratings for Lakefront Hydrological Separation Alternative – Ruffe[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	H (L)	H (L)	L	L	L	M	M	L	L	L	M
Lakefront Hydrological Separation	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L*** (L)	***L*** (L)	L	L	***L*** **(2)**	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Tubenose Goby (Proterorhinus semilunaris)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as the Detroit River system, and is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011). A population of tubenose gobies has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011).

This alternative includes the construction of a physical barrier in the CAWS, ANSTPs, and nonstructural measures. Nonstructural measures include ballast/bilge water management of ships that travel in waters where tubenose gobies occur. This management measure is expected to delay the time it takes the tubenose goby to arrive at the CAWS pathway. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is expected that this species can swim from its current location to the CAWS by T_{25}. This alternative reduces the likelihood of tubenose goby arriving at the CAWS at T_{10}, and consequently, the probability of arrival is reduced from a medium to a low at T_{10}. The uncertainty about the probability of arrival rating is medium.

Physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barriers. The ANSTP would remove tubenose goby whose body depth was larger than 0.75 in. (19.05 mm) by screening those fish, followed by pumping the water through a UV radiation treatment process to inactivate all life stages of fish that pass through the screen. The ANSTP is expected to control the passage of this species from the GL to the MR basin. This alternative reduces the likelihood of tubenose goby passing through the CAWS, and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{10}, T_{25}, and T_{50} (Table 39).

TABLE 39 Risk Ratings for Lakefront Hydrological Separation Alternative – Tubenose Goby[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	M (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	M	M	M	M	L	M	M	M
Lakefront Hydrological Separation	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L*** (L)	***L*** (L)	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

VHSv (Novirhabdovirus sp.)

VHSv was first reported in the Great Lakes in 2003 from Lake St. Clair (Elsayed et al. 2006), and by 2010 it had spread to all five Great Lakes (MNDR 2010). Benthic macroinvertebrates sampled in Lake Michigan have tested positive for the virus (Faisal et al. 2012). This alternative includes the construction of a physical barrier in the CAWS, ANSTPs, and nonstructural measures.

Physical barriers are expected to control the bypass of flood waters except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The water treated by the ANSTP would be discharged to the MR Basin side of the physical barrier and used to maintain water quality and current hydrologic conditions downstream of the barrier. The ANSTP would use UV radiation to inactivate VHSv and is expected to control the passage of VHSv through the CAWS. This alternative reduces the likelihood of VHSv passing through the CAWS, and consequently, reduces its probability of passage from high to a low at T_{25} and T_{50}. The uncertainty about the probability of passage rating is low at T_{25} and T_{50}.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from medium to low at T_{25} and T_{50}, assuming no prior establishment of VHSv in the MR basin prior to T_{25}. However, because VHSv's probability of establishment is medium at T_0 and T_{10}, there is a medium probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

TABLE 40 Risk Ratings for Lakefront Hydrological Separation Alternative – VHSv[a,b]

Alternatives	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M	M	M	M	M	M
Lakefront Hydrological Separation	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	***L*** (L)	***L*** (L)	M	M	***L|NPE***	***L|NPE***		M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

Alternative Plan 6: Mid-System Hydrologic Separation

ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, which may therefore require an extended period of time for implementation. The structural measures are assumed to be implemented at T_{25}.

The results of the with-project risk assessments of this alternative are the same as the Lakefront Hydrologic Separation Alternative. Please see Alternative Plan 5: Lakefront Hyrdological Separation for the discussion of ANS risk reduction provided by this alternative.

Alternative Plan 7: Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone

ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, which may therefore require an extended period of time for implementation The structural measures are assumed to be implemented at T_{25}.

The results of the with-project risk assessments of this alternative are the same as the Mid-System Control Technology without a Buffer Zone Alternative. Please see Alternative Plan: 3Mid-System Control Technologies without a Buffer Zone for the discussion of ANS risk reduction provided by this alternative.

Alternative Plan 8: Mid-System Separation CSSC Open Control Technologies with a Buffer Zone

ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, which may therefore require an extended period of time for implementation. The remaining structural measures are assumed to be implemented at T_{25}.

The results of the with-project risk assessments of this alternative are the same as the Mid-System Control Technology without a Buffer Zone Alternative. Please see Alternative Plan 3: Mid-System Control Technologies without a Buffer Zone> for the discussion of ANS risk reduction provided by this alternative.

2 CONCLUSION

A risk assessment was conducted for the 13 high and medium risk ANS for each GLMRIS Alternative. The results are tabulated for each ANS in Tables 41–53. Generally, nonstructural alternatives are effective for species that are of limited distribution and abundance and whose populations are distant from the CAWS pathway. For example, nonstructural measures such as public education, monitoring, and use of aquatic herbicides are expected to reduce the abundance and distribution of some ANS, such as the grass kelp and reed sweetgrass, and reduce the likelihood these species will arrive at the CAWS. Additionally, the implementation of ballast water management in areas where the tubenose goby is known to be established, is expected to slow its arrival to the CAWS. Implementation of nonstructural measures could also slow the potential passage of some ANS through the CAWS.

In general, the structural components of the following alternatives — Control Technology without a Buffer Zone (Flow Bypass), Control Technology with a Buffer Zone, Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone (Hybrid Cal-Sag Open) and the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone (Hybrid CSSC Open) — would not be effective against the interbasin transfer of ANS that foul hulls or temporarily attach to vessels. However, each alternative includes nonstructural measures. These nonstructural measures are expected to impact the arrival of grass kelp and reed sweetgrass to the CAWS, both of which can transfer through temporary attachment to vessels. Consequently, the nonstructural measures in these alternatives provide for risk reduction for these particular species. Measures to address hull fouling and temporary vessel attachment would need to be further explored if nonstructural measures do not impact a species' probability of establishment.

The hydrologic separation alternatives generally would control the transfer of all GLMRIS high and medium risk species through the CAWS aquatic pathway, as long as these alternatives are implemented prior to the species transferring through the CAWS and establishing in the newly invaded basin. These alternatives are expected to control the transfer of future ANS through the CAWS aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE events). Compared to the other alternatives, the hydrologic separation alternatives have lower levels of uncertainty with regard to their impact on ANS passage through the CAWS.

TABLE 41 Scud – Risk Ratings for GLMRIS Alternatives[a,b]

Scud	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H	M	M	M	M	M
Nonstructural Control Technologies	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H		M	M	M	M
Mid-System Control Technologies without a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H		M	M	M	M
Technology Alternative with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H		M	M	M	M
Lakefront Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	***L*** (L)	***L*** (L)	H	H	***L***	***L***		M	M	***L***	***L***
Mid-System Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	***L*** (L)	***L*** (L)	H	H	***L***	***L***		M	M	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H		M	M	M	M
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H	H	H	H		M	M	M	M

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 42 Bighead Carp – Risk Ratings for GLMRIS Alternatives[a,b]

Bighead Carp	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M		L	L	M	M
Nonstructural Control Technologies	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M		L	L	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***
Technology Alternative with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L ***(M)***	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***
Lakefront Hydrologic Separation	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (L)***	***L (L)***	L	L	***L***	***L***	H	L	L	***L***	***L***
Mid-System Hydrologic Separation	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (L)***	***L (L)***	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 43 Silver Carp – Risk Ratings for GLMRIS Alternatives[a,b]

Silver Carp	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M	H	L	L	M	M
Nonstructural Control Technologies	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	M (H)	M (H)	L	L	M	M		L	L	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***
Technology Alternative with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L ***(M)***	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***
Lakefront Hydrologic Separation	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (L)***	***L (L)***	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Hydrologic Separation	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (L)***	***L (L)***	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	L (M)	L (H)	***L (M)***	***L (M)***	L	L	***L***	***L***		L	L	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 44 Grass Kelp – Risk Ratings for GLMRIS Alternatives[a,b]

Grass Kelp	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (M)	M (M)	M (M)	M (M)	H (M)	H (M)	H (M)	H (M)	L	M	M	M	M	L	M	M	M
Nonstructural Control Technologies	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Mid-System Control Technologies without a Buffer Zone	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Technology Alternative with a Buffer Zone	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Lakefront Hydrologic Separation	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	***L (L)***	***L (L)***	L	***L***	***L (2)***	***L (2)***		L	***L***	***L***	***L***
Mid-System Hydrologic Separation	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	***L (L)***	***L (L)***	L	***L***	***L (2)***	***L (2)***		L	***L***	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	L (M)	***L*** (M)	***L*** (M)	***L (H)***	H (M)	H (M)	H (M)	H (M)	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 45 Red Algae – Risk Ratings for GLMRIS Alternatives[a,b]

Red Algae	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M	M	M	M	M	M
Nonstructural Control Technologies	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Mid-System Control Technologies without a Buffer Zone	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Technology Alternative with a Buffer Zone	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Lakefront Hydrologic Separation	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	***L (L)***	***L (L)***	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Hydrologic Separation	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	***L (L)***	***L (L)***	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Mid-System Separation CSSC Open Technologies with a Buffer Zone	M (H)	M (H)	M (H)	M (H)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 46 Diatom – Risk Ratings for GLMRIS Alternatives[a,b]

Diatom	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M	M	M	M	M	M
Nonstructural Control Technologies	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Mid-System Control Technologies without a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Technology Alternative with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Lakefront Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	***L (L)***	***L (L)***	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	***L (L)***	***L (L)***	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (H)	H (H)	H (H)	H (H)	M	M	M	M		M	M	M	M

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

TABLE 47 Reed Sweetgrass – Risk Ratings for GLMRIS Alternatives[a,b]

Reed Sweetgrass	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (L)	L (L)	M (M)	L (M)	M (M)	M (M)	M (M)	L	L	L	M	M	L	L	L	M
Nonstructural Control Technologies	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***
Mid-System Control Technologies without a Buffer Zone	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***
Technology Alternative with a Buffer Zone	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***
Lakefront Hydrologic Separation	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	***L (L)***	***L (L)***	L	L	***L (2)***	***L (2)***		L	L	L	***L***
Mid-System Hydrologic Separation	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	***L (L)***	***L (L)***	L	L	***L (2)***	***L (2)***		L	L	L	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	L (L)	L (L)	L (L)	***L (L)***	L (M)	M (M)	M (M)	M (M)	L	L	L	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 48 Fishhook Waterflea – Risk Ratings for GLMRIS Alternatives[a,b]

Fishhook Waterflea	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H	H	L	L	M	H
Nonstructural Control Technologies	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H		L	L	M	H
Mid-System Control Technologies without a Buffer Zone	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H		L	L	M	H
Technology Alternative with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H		L	L	M	H
Lakefront Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	***L*** (L)	***L*** (L)	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	***L*** (L)	***L*** (L)	L	L	***L***	***L***		L	L	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H		L	L	M	H
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	L (M)	L (M)	M (L)	H (L)	L	L	M	H		L	L	M	H

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 49 Bloody Red Shrimp – Risk Ratings for GLMRIS Alternatives[a,b]

Bloody Red Shrimp	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	H	H	H	H	H
Nonstructural Control Technologies	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	H (L)	H (L)	H	H	H	H		H	H	H	H
Mid-System Control Technologies without a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		H	H	***L***	***L***
Technology Alternative with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (M)	***L (H)***	***L (H)***	***L (H)***	H	***L| NPE***	***L| NPE***	***L| NPE***		H	***L***	***L***	***L***
Lakefront Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L*** (L)	***L*** (L)	H	H	***L| NPE***	***L| NPE***		H	H	***L***	***L***
Mid-System Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L*** (L)	***L*** (L)	H	H	***L| NPE***	***L| NPE***		H	H	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		H	H	***L***	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		H	H	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 50 Threespine Stickleback – Risk Ratings for GLMRIS Alternatives[a,b]

Threespine Stickleback	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	H (L)	H (L)	H	H	H	H	M	M	M	M	M
Nonstructural Control Technologies	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	H (L)	H (L)	H	H	H	H		M	M	M	M
Mid-System Control Technologies without a Buffer Zone	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Technology Alternative with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	H (M)	***L (H)***	***L (H)***	***L (H)***	H	***L| NPE***	***L| NPE***	***L| NPE***		M	***L***	***L***	***L***
Lakefront Hydrologic Separation	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L*** (L)	***L*** (L)	H	H	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Hydrologic Separation	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L*** (L)	***L*** (L)	H	H	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (N)	H (N)	H (N)	H (N)	H (M)	H (L)	***L (H)***	***L (H)***	H	H	***L| NPE***	***L| NPE***		M	M	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 51 Ruffe – Risk Ratings for GLMRIS Alternatives[a,b]

Ruffe	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	H (L)	H (L)	L	L	L	M	M	L	L	L	M
Nonstructural Control Technologies	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	H (L)	H (L)	L	L	L	M		L	L	L	M
Mid-System Control Technologies without a Buffer Zone	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L (H)***	***L (H)***	L	L	***L (2)***	**L**		L	L	L	***L***
Technology Alternative with a Buffer Zone	L (L)	L (M)	L (M)	M (H)	H (M)	***L (H)***	***L (H)***	***L (H)***	L	***L (2)***	***L (2)***	***L***		L	L	L	***L***
Lakefront Hydrologic Separation	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L*** (L)	***L*** (L)	L	L	***L (2)***	***L***		L	L	L	***L***
Mid-System Hydrologic Separation	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L*** (L)	***L*** (L)	L	L	***L (2)***	***L***		L	L	L	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L (H)***	***L (H)***	L	L	***L (2)***	***L***		L	L	L	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	L (L)	L (M)	L (M)	M (H)	H (M)	H (M)	***L (H)***	***L (H)***	L	L	***L (2)***	***L***		L	L	L	***L***

[a] The table cells with highlighted bold italics indicate a rating change. (2) designates an increase in the number of low elements.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 52 Tubenose Goby – Risk Ratings for GLMRIS Alternatives[a,b]

Tubenose Goby	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	L (L)	M (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	M	M	M	M	L	M	M	M
Nonstructural Control Technologies	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	H (L)	H (L)	L	***L***	M	M		L	***L***	M	M
Mid-System Control Technologies without a Buffer Zone	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L (H)***	***L (H)***	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Technology Alternative with a Buffer Zone	L (L)	***L*** (M)	M (M)	M (M)	H (M)	***L (H)***	***L (H)***	***L (H)***	L	***L (2)***	***L***	***L***		L	***L***	***L***	***L***
Lakefront Hydrologic Separation	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L*** (L)	***L*** (L)	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Mid-System Hydrologic Separation	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L*** (L)	***L*** (L)	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L (H)***	***L (H)***	L	***L***	***L***	***L***		L	***L***	***L***	***L***
Mid-System Separation CSSC Open Technologies with a Buffer Zone	L (L)	***L*** (M)	M (M)	M (M)	H (M)	H (M)	***L (H)***	***L (H)***	L	***L***	***L***	***L***		L	***L***	***L***	***L***

[a] The table cells with highlighted bold italics indicate a rating change.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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TABLE 53 VHSv – Risk Ratings for GLMRIS Alternatives[a,b]

VHSv	Establishment Elements Potentially Impacted by Alternative												Consequences of Establishment	Risk of Adverse Impacts			
Alternatives	$P_{arrival}$				$P_{passage}$				$P_{establishment}$								
	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}	T_0	T_{10}	T_{25}	T_{50}		T_0	T_{10}	T_{25}	T_{50}
No New Federal Action	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M	M	M	M	M	M
Nonstructural Control Technologies	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M		M	M	M	M
Mid-System Control Technologies without a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M		M	M	M	M
Technology Alternative with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M		M	M	M	M
Lakefront Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	***L*** (L)	***L*** (L)	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Hydrologic Separation	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	***L*** (L)	***L*** (L)	M	M	***L| NPE***	***L| NPE***		M	M	***L***	***L***
Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M		M	M	M	M
Mid-System Separation CSSC Open Technologies with a Buffer Zone	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	H (L)	M	M	M	M		M	M	M	M

[a] The table cells with highlighted bold italics indicate a rating change. Low|NPE means low, given no prior establishment in previous time steps.

[b] Uncertainty associated with each probability element is indicated in parenthesis.

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