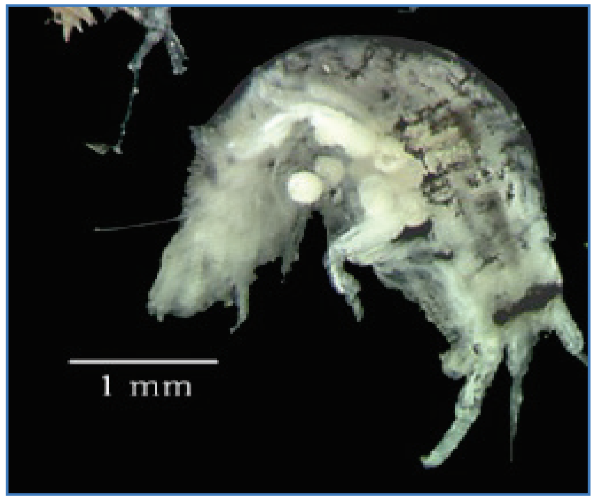
E.3 MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE

E.3.1 ANS Potentially Invading the Great Lakes Basin

E.3.1.1 Crustaceans

E.3.1.1.1 Scud (*Apocorophium lacustre*)

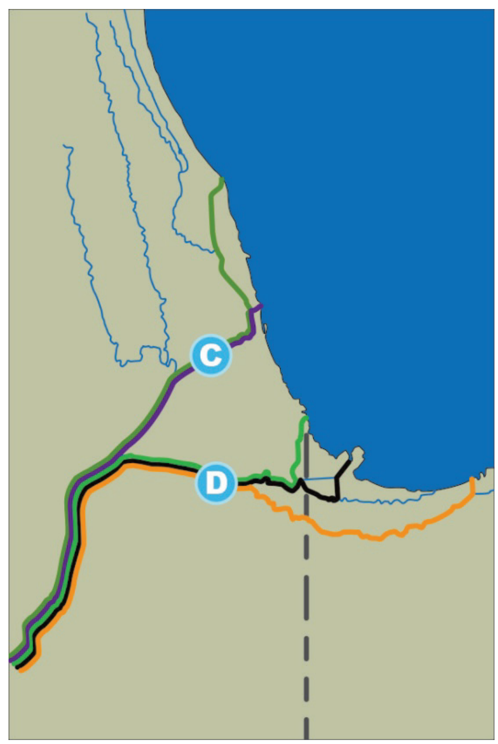


MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at T_0 (in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant[b]
		Electric Barrier[c]
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant[b]
		Electric Barrier[c]
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier[c]
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier[c]
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier[c]
		GLMRIS Lock



[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the *Apocorophium lacustre*
[b] Control Points (C) and (D) include an ANS Treatment Plant (ANSTP) that removes ANS from water on the Lake Michigan side of the physical barrier prior to its discharge to the Mississippi River side. The ANS Treatment Plant is not designed to treat Mississippi River Basin water and therefore has no impact on *A. lacustre's* probability ratings.
[c] The Control Technology with a Buffer Zone Alternative also includes an electric barrier at Control Points (C) and (D), which is ineffective for *A. lacustre* and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.

T_{10}: See T_0. Abundance is expected to increase beyond T_0 levels.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers. This species is at or close to the pathway and has moved through several locks as it moved northward from the lower MRB.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect *A. lacustre*'s arrival at the Chicago Area Waterway System (CAWS) via human-mediated transport or natural dispersion. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.

T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the WPS through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the WPS through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to remove ANS from Chicago Sanitary and Ship Canal (CSSC) water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water; therefore, the ANSTP would not be an effective control for *A. lacustre*, since the species originates in the Mississippi River Basin.

The GLMRIS Lock at Stickney, Illinois, is expected to address *A. lacustre* that could passively drift into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *A. lacustre* is known to foul the hulls of vessels. The GLMRIS Lock would not address the passage of *A. lacustre* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney. The electric barriers would have no effect on the natural dispersion of *A. lacustre*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: The sluice gate at the WPS is a barrier that could retard dispersion by boat transport. The scud moved through several locks as it moved northward from the lower Mississippi River Basin, suggesting locks are not a barrier.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to treat water used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The electric barrier is not effective at controlling the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway. However, this ANS Control is not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *A .lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A .lacustre* via hull fouling through the aquatic pathway. Therefore, the uncertainty remains low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)[a]	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the Brandon Road Lock and Dam as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the Brandon Road Lock and Dam as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.
T_{10}: Abundance is expected to increase beyond T_0 levels.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers. This species is at or close to the pathway and has moved through several locks as it moved northward from the lower MRB.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect *A. lacustre*'s arrival at the Brandon Road Lock and Dam via human-mediated transport or natural dispersion. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.

T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50} : HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to treat water that is used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The GLMRIS Lock at Stickney, Illinois, is expected to address *A. lacustre* that could passively drift into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. The *A. lacustre* is known to foul hulls of vessels. The GLMRIS Lock would not address the passage of *A. lacustre* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of *A. lacustre*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: *A. lacustre* moved through several locks as it moved northward from the lower MRB, suggesting locks are not a barrier.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to treat water used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The electric barrier is not effective at controlling the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway. However, this ANS Control is not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_0.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A. lacustre* via hull fouling on vessels. Therefore, the uncertainty remains low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating.

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone does not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.
T_{10}: Abundance is expected to increase beyond T_0 levels.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: The T.J. O'Brien Lock and Dam is between the current location of *A. lacustre* and the Calumet Harbor. However, this species is at or close to the pathway and has moved through several locks as it moved northward from the lower MRB.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect *A. lacustre*'s arrival at the CAWS by human-mediated transport or natural dispersion. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.

T_{10}: See T_0. The species may be close to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to treat the water that is used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The GLMRIS Lock at Alsip, Illinois, is expected to address *A. lacustre* that could passively drift into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *A. lacustre* is known to foul hulls of vessels. The GLMRIS Lock would not address the passage of *A. lacustre* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *A. lacustre*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre*'s through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: Existing potential barriers include the three lock and dam structures along the pathway. *A. lacustre* moved through several locks as it moved northward from the lower MRB, suggesting locks are not a barrier.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to treat the water that is used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The electric barrier is not effective at controlling the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway. However, this ANS Control is not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Technology with a Buffer Zone Alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A. lacustre* via hull fouling on vessels. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	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)	Low	–[a]	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Medium	Medium	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)	Low	–[a]	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating.

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers; the species is likely already at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect *A. lacustre*'s arrival at the CAWS via human-mediated transport or natural dispersion. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River

(USGS 2011). The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.
T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW-HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to treat the water that is used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The GLMRIS Lock at Alsip, Illinois, is expected to address *A. lacustre* that could passively drift into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *A. lacustre* is known to foul hulls of vessels. The GLMRIS Lock would not address the passage of *A. lacustre* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *A. lacustre*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

$T_{10.}$ The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to treat water used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The electric barrier is not effective at controlling the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway. However, this ANS Control is not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A. lacustre* via hull fouling on vessels. Therefore, the uncertainty remains low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	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)	Low	–[a]	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	Medium	Medium	Medium	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)	Low	–[a]	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at Brandon Road Lock and Dam as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.

T_{10}: See T_0. Abundance is expected to increase beyond T_0 levels.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers**.** This species is at or close to the pathway and moved through several locks as it moved northward from the lower MRB.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect *A. lacustre*'s arrival at the CAWS via human-mediated transport or natural dispersion. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.

T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the MRB.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the BSBH through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River, just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect *A. lacustre*'s arrival at the BSBH through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW-HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to treat the water that is used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The GLMRIS Lock at Alsip, Illinois, is expected to address *A. lacustre* that could passively drift into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *A. lacustre* is known to foul hulls of vessels. The GLMRIS Lock would not address the passage of *A. lacustre* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *A. lacustre*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to treat the water that is used in the flushing of the GLMRIS Lock. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

The electric barrier is not effective at controlling the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway. However, this ANS Control is not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A. lacustre* via hull fouling on vessels. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

References

Grigorovich, I.A., T.R. Angradi, E.B. Emery, and M.S. Wooten. 2008. Invasion of the Upper Mississippi River system by saltwater amphipods. Fundamental and Applied Limnology/Archiv für Hydrobiologie, vol. 173(1), pp. 67–77.

Johnson, L., J. Gonzalez, C. Alvarez, M. Takada, and A. Himes. 2007. Managing Hull-Borne Invasive Species and Coastal Water Quality for California and Baja California Boats Kept in Saltwater. University of California ANR Publication 8359, California Sea Grant College Program Report Number T-061. 151 pp.

USGS (U.S. Geological Survey). 2011. NAS–Nonindigenous Aquatic Species. Apocorophium lacustre. http://nas.er.usgs.gov/queries/SpecimenViewer.aspx?SpecimenID=237724. Accessed April 20, 2012.

E.3.1.2 Fish

E.3.1.2.1 Bighead Carp (Hypophthalmichthys nobilis)

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

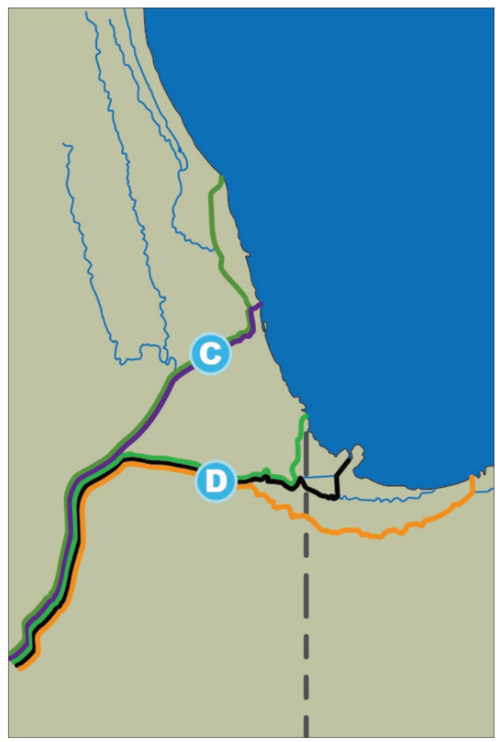
This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

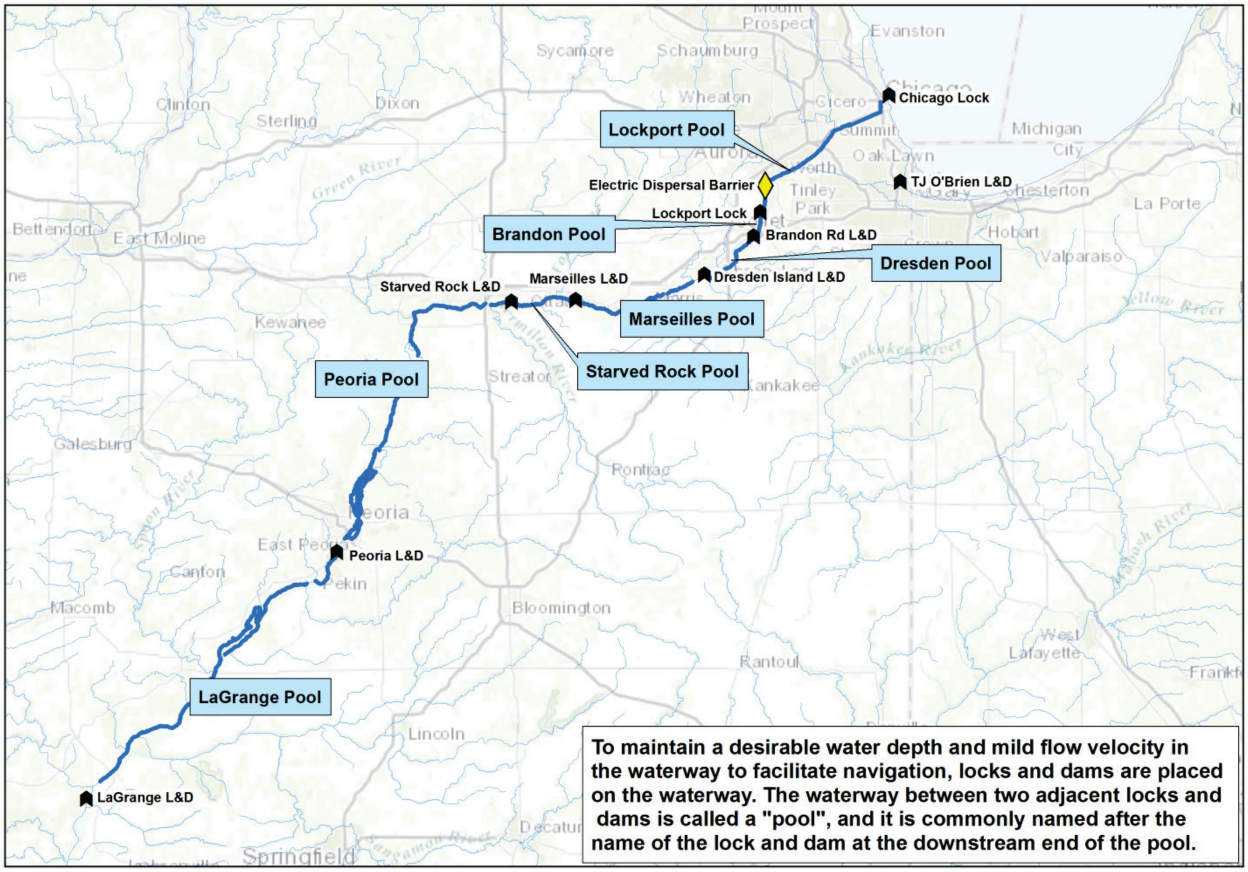
Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the bighead carp.

[b] Control Points (C) and (D) include an ANS Treatment Plant (ANSTP) that removes ANS from water on the Lake Michigan side of the physical barrier prior to its discharge to the Mississippi River side. The ANS Treatment Plant is not designed to treat Mississippi River Basin water, and therefore has no impact on the bighead carp's probability ratings.



Risk Assessment Reference Map



◊ The current Electric Dispersal Barrier System located approximately 5 mi upstream of the Lockport Lock and Dam is assumed to continue operation through T_{50}.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the bighead carp at the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp from human-mediated transport at this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity of the bighead carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of bighead carp from their current position and Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes Mississippi River Interbasin Study (GLMRIS) Lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect bighead carp's arrival at the CAWS via human-mediated transport or natural dispersion. The bighead

carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).
T_{50}: See T_0.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the CAWS. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0–T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge into the Mississippi River Basin side of the control point as well as supply the GLMRIS Lock with ANS treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for bighead carp, because the species is located in the Mississippi River Basin. The nonstructural measures of 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 discharge.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of bighead carp that could passively drift against the current into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Stickney, Illinois, to control passage of bighead carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of bighead carp through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Although requiring ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to remove ANS in CSSC water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for bighead carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming bighead carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. **P(colonizes) T0-T50: HIGH**

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. **P(spreads) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the bighead carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp from human-mediated transport at this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity of the bighead carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of bighead carp from their current position and Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the bighead carp's arrival at the CAWS via human-mediated transport or natural dispersion. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the CAWS. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.
The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge into the Mississippi River Basin side of the control point, as well as to supply the GLMRIS Lock with ANS treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for bighead carp, because the species is located in the Mississippi River Basin. The nonstructural measures of 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 discharge.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of bighead carp that could passively drift against the current into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Stickney, Illinois, to control passage of bighead carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of bighead carp through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented

at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the bighead carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Although requiring ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to remove ANS in CSSC water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for bighead carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming bighead carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. **P(colonizes) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. **P(spreads) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0–T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0–T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the bighead carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp from human-mediated transport at this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity of the bighead carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the bighead carp’s current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers
T_0: There are no barriers to movement of bighead carp from their current position and Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the bighead carp’s arrival at the CAWS via human-mediated transport or natural dispersion. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the CAWS. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0–T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point, as well as to supply the GLMRIS Lock with ANS treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for bighead carp, because the species is located in the Mississippi River Basin. The nonstructural measures of 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 discharge.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of bighead carp that could passively drift against the current into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Alsip, Illinois, to control passage of bighead carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of bighead carp through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented

at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Although requiring ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.
T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for bighead carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming bighead carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0–T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0–T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the bighead carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp from human-mediated transport at this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity of the bighead carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of bighead carp from their current position and Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the bighead carp's arrival at the CAWS via human-mediated transport or natural dispersion. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the CAWS. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in the Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point, as well as to supply the GLMRIS Lock with ANS treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for bighead carp, because the species is located in the Mississippi River Basin. The nonstructural measures of 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 discharge.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of bighead carp that could passively drift against the current into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Alsip, Illinois, to control passage of bighead carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of bighead carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the bighead carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Although requiring ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for bighead carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming bighead carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0–T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0–T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the bighead carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp from human-mediated transport at this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity of the bighead carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of bighead carp from their current position and Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the bighead carp's arrival at the CAWS via human-mediated transport or natural dispersion. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the CAWS. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0–T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point, as well as to supply the GLMRIS Lock with ANS treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for bighead carp, because the species is located in the Mississippi River Basin. The nonstructural measures of 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 discharge.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of bighead carp that could passively drift against the current into the lock chamber and then be transported upstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Alsip, Illinois, to control passage of bighead carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of bighead carp through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented

at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of bighead carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming bighead carp. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of bighead carp through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Although requiring ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.
T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for bighead carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming bighead carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 4 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. **P(colonizes) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. **P(spreads) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

References

ACRCC (Asian Carp Regional Coordinating Committee). 2009. Asian Carp Rapid Response Workgroup Wraps Up Main Operation On Chicago Sanitary Ship Canal – Illinois DNR. Press release dated December 6, 2009. http://www.asiancarp.us/news/acrccwrapupildnr.htm. Accessed June, 27, 2013.

ACRCC (Asian Carp Regional Coordinating Committee). 2012. FY 2012 Asian carp control strategy framework. http://asiancarp.us/documents/2012Framework.pdf. Accessed June 21, 2013.

E.3.1.2.2 Silver Carp (Hypophthalmichthys molitrix)

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

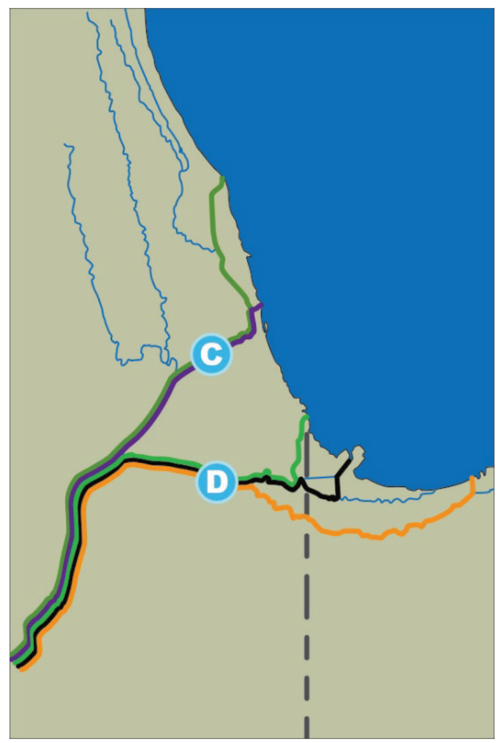
This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

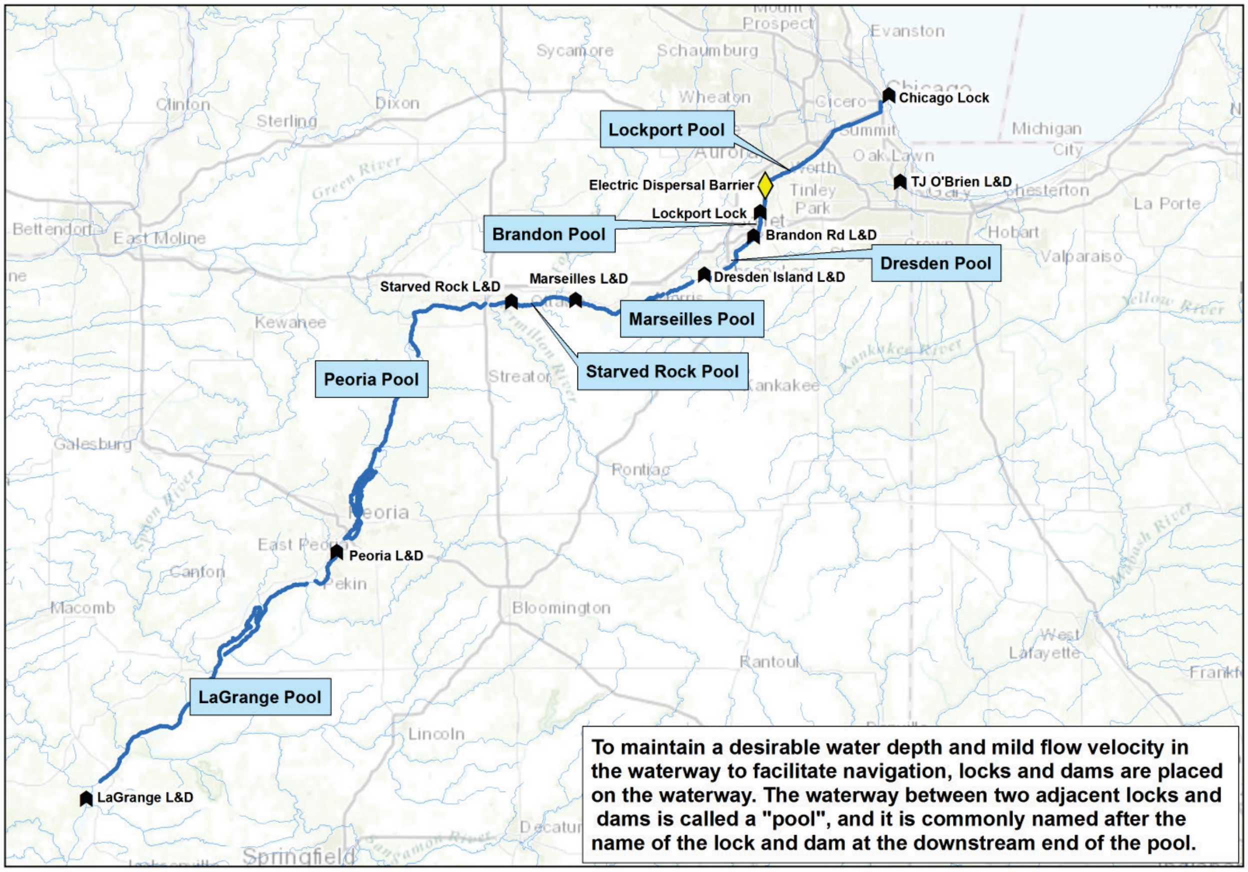
Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant[b]
		Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the silver carp.

[b] Control Points (C) and (D) include an ANS Treatment Plant (ANSTP) that removes ANS from water on the Lake Michigan side of the physical barrier prior to its discharge to the Mississippi River side. The ANS Treatment Plant is not designed to treat Mississippi River Basin water and therefore has no impact on the silver carp's probability ratings.



Risk Assessment Reference Map



◊ The current Electric Dispersal Barrier System located approximately 5 mi upstream of the Lockport Lock and Dam is assumed to continue operation through T_{50}.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the silver carp at the Chicago Area Water System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers
T_0: None. There are no barriers to movement of silver carp from their current position to Brandon Road Lock and Dam. The silver carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the silver carps' arrival at the Brandon Road Lock and Dam via human-mediated transport or natural dispersion. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the

Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance of the silver carp from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the CAWS. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge into the Mississippi River Basin side of the control point as well as supply the GLMRIS Lock with ANS-treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for silver carp, since the species is located in the Mississippi River Basin. 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 discharge.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of silver carp that could passively drift against the current into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Stickney, Illinois, to control passage of silver carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures, such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of silver carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the silver carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to remove ANS in CSSC water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for silver carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming silver carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. **P(colonizes) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. **P(spreads) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the silver carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.

T_{10}: See T_0**.** See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movement of silver carp from their current position and Brandon Road Lock and Dam. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the silver carps' arrival at the Brandon Road Lock and Dam via human-mediated transport or natural dispersion. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001).

Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance of silver carp from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the CAWS. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge into the Mississippi River Basin side of the control point as well as supply the GLMRIS Lock with ANS-treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for silver carp, since the species is located in the Mississippi River Basin. 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 discharge.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of silver carp that could passively drift against the current into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Stickney, Illinois, to control passage of silver carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures, such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of silver carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the silver carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to remove ANS in CSSC water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for silver carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming silver carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 4 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. **P(colonizes) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. **P(spreads) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the silver carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers
T_0: None. There are no barriers to movement of silver carp from their current position to the Brandon Road Lock and Dam. The silver carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect silver carps' arrival at the Brandon Road Lock and Dam via human-mediated transport or natural dispersion. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001).

Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).
T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance of silver carp from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the CAWS. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point as well as supply the GLMRIS Lock with ANS-treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for silver carp, since the species is located in the Mississippi River Basin. 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 discharge.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of silver carp that could passively drift against the current into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Alsip, Illinois, to control passage of silver carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures, such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of silver carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the silver carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for silver carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming silver carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the silver carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers
T_0: None. There are no barriers to movement of silver carp from their current position and Brandon Road Lock and Dam. The silver carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the silver carps' arrival at the Brandon Road Lock and Dam via human-mediated transport or natural dispersion. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001).

Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).
T_{50}: See T_{25}.

*e. **Distance from Pathway***

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance of silver carp from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

*f. **Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented below the Brandon Road Lock and Dam in the Dresden Pool.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the CAWS. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point as well as supply the GLMRIS Lock with ANS-treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for silver carp, since the species is located in the Mississippi River Basin. 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 discharge.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of silver carp that could passively drift against the current into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Alsip, Illinois, to control passage of silver carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures, such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of silver carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the silver carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for silver carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming silver carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the silver carp at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movement of silver carp from their current position to the Brandon Road Lock and Dam. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the silver carps' arrival at the Brandon Road Lock and Dam via human-mediated transport or natural dispersion. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001).

Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the distance of silver carp from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the CAWS. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Silver carp have been documented below the Brandon Road Lock and Dam in Dresden Pool. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Silver carp have arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, that includes construction of an ANSTP, a GLMRIS Lock, and electric barriers both upstream and downstream of the lock.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point as well as supply the GLMRIS Lock with ANS-treated water. The ANSTP would not be designed to treat water from the Mississippi River Basin; therefore, the ANSTP would not be an effective control for silver carp, since the species is located in the Mississippi River Basin. 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 discharge.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of silver carp that could passively drift against the current into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

Electric barriers would be constructed downstream of the GLMRIS Lock within an engineered channel at Alsip, Illinois, to control passage of silver carp through the lock. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barriers would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barriers are without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures, such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of silver carp through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Nonstructural and structural measures are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The GLMRIS Lock is expected to control the passage of silver carp eggs, larvae, and fry; the electric barrier is expected to control the passage of swimming silver carp. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of silver carp through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS for the silver carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at $T_{0.}$ Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for silver carp because the species is located in the Mississippi River Basin.

The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the upstream passage of swimming silver carp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the

passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electrical barrier area using nets, electrofishing, and/or piscicides. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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E.3.2 ANS Potentially Invading the Mississippi River Basin

E.3.2.1 Algae

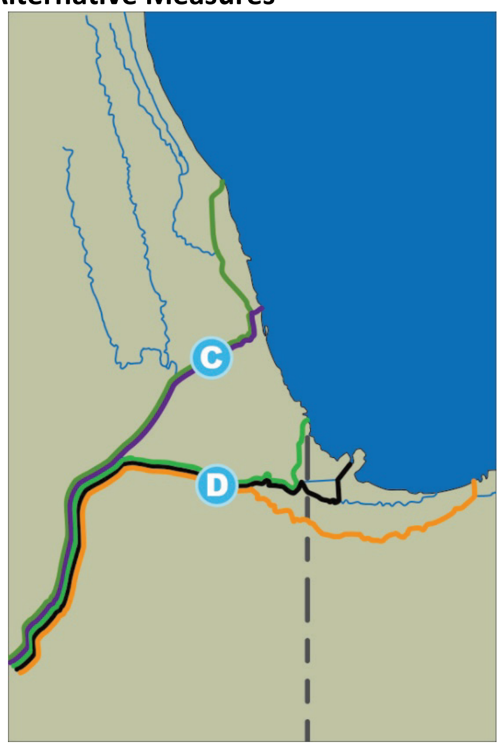
E.3.2.1.1 Grass Kelp (Enteromorpha flexuosa)

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technology without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock



[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for *E. flexuosa.*

[b] The Mid-system Control Technologies without a Buffer Zone Alternative includes an electric barrier at Control Points (C) and (D), which is ineffective for *E. flexuosa* and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, particularly algaecides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts

on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce the ability of establishment near the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of *E. flexuosa* at the CAWS by human-mediated transport or natural dispersion. The closest that *E. flexuosa* has been recorded to the WPS was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution, thereby affecting its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes Basin for *E. flexuosa*. In particular, mean water

temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Mediu	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage *E. flexuosa* populations where they exist; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes Nonstructural measures, which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal (CSSC) water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet radiation (UV) to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Enteromorpha flexuosa* filaments and reproductive spores, which range in size from 0.16 µm to 0.14 in. (3.6 mm) (Hill 2001), are expected to pass through the screens. Subsequently, they would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses *E. flexuosa* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *Enteromorpha flexuosa* is known to foul hulls of vessels (Lougheed and Stevenson 2004). The GLMRIS Lock would not address the passage of *E. flexuosa* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of *E. flexuosa*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. Nor are they expected to control the human-mediated transport of *E. flexuosa* through the GLMRIS Lock by hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to pass through the aquatic pathway via hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The

GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.
The electric barrier would have no effect on the passage of *E. flexuosa*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.
Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *E. flexuosa* passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains high.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *E.flexuosa* via hull fouling on vessels. Overall, the uncertainty remains medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Chicago River and Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, particularly algaecides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce the ability of establishment near CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: None.
T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of *E. flexuosa* at the CAWS by human-mediated transport or natural dispersion. The closest that *E. flexuosa* has been recorded to the WPS was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution, thereby affecting its arrival at the CAWS through aquatic pathways.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for *E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* can be found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, water temperature is expected to remain suitable. However, changes in nutrients and

conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50} : HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from CSSC water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Enteromorpha flexuosa* filaments and reproductive spores, which range in size from 0.16 µm to 0.14 in. (3.6 mm) (Hill 2001), are expected to pass through the screens. Subsequently, they would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses *E. flexuosa* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *Enteromorpha flexuosa* is known to foul hulls of vessels (Lougheed and Stevenson 2004). The GLMRIS Lock would not address the passage of *E. flexuosa* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of *E. flexuosa*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. Nor are they expected to control the human-mediated transport of *E. flexuosa* through the GLMRIS Lock by hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to pass through the aquatic pathway via hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.

T_{10}: See T_0.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}:

The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier would have no effect on the passage of *E. flexuosa*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *E. flexuosa* passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *E.flexuosa* via hull fouling on vessels. Overall, the uncertainty remains medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, particularly algaecides. In addition, the implementation of a ballast/bilge-water exchange program education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may

reduce habitat suitability for this species at current infestations and reduce ability of establishment near CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: None.
T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of *E. flexuosa* at the CAWS by human-mediated transport or natural dispersion. The closest that *E. flexuosa* has been recorded to the WPS was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution, thereby affecting its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes Basin for *E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients

and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may manage the spread and distribution of *E. flexuosa*. However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Enteromorpha flexuosa* filaments and reproductive spores, which range in size from 0.16 µm to 0.14 in. (3.6 mm) (Hill 2001), are expected to pass through the screens. Subsequently, they would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses *E. flexuosa* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *Enteromorpha flexuosa* is known to foul hulls of vessels (Lougheed and Stevenson 2004). The GLMRIS Lock would not address the passage of *E. flexuosa* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *E. flexuosa*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. Nor are they expected to control the human-mediated transport of *E. flexuosa* through the GLMRIS Lock by hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of

E. flexuosa through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to pass through the aquatic pathway via hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.

T_{10}: See T_0.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of *E. flexuosa*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *E. flexuosa* passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains high.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.
In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *E.flexuosa* via hull fouling on vessels. Overall, the uncertainty remains medium.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, particularly algaecides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may

reduce habitat suitability for this species at current infestations and reduce ability of establishment near CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and Electric Barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of *E. flexuosa* at the CAWS by human-mediated transport or natural dispersion. The closest that *E. flexuosa* has been recorded to the WPS was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from the pathway.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution, thereby affecting its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for *E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and

conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*. However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_{25}. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures, which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Enteromorpha flexuosa* filaments and reproductive spores, which range in size from 0.16 µm to 0.14 in. (3.6 mm) (Hill 2001), are expected to pass through the screens. Subsequently, they would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses *E. flexuosa* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *Enteromorpha flexuosa* is known to foul hulls of vessels (Lougheed and Stevenson 2004). The GLMRIS Lock would not address the passage of *E. flexuosa* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *E. flexuosa*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.
T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures, which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. Nor are they expected to control the human-mediated transport of *E. flexuosa* through the GLMRIS Lock by hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to pass through the aquatic pathway via hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.
T_{10}: See T_0.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.
The electric barrier would have no effect on the passage of *E. flexuosa*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.
Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *E. flexuosa* passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move through the aquatic pathway is expected to slow passage to an uncertain degree.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *E. flexuosa* via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, particularly algaecides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may

reduce habitat suitability for this species at current infestations and reduce ability of establishment near CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: None.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois; however, these structural measures are not expected to affect the arrival of *E. flexuosa* at the CAWS. The closest that *E. flexuosa* has been recorded to the WPS was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution, thereby affecting its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes Basin for *E. flexuosa*. Mean water temperature in particular is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and

conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*. However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_{25}. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Enteromorpha flexuosa* filaments and reproductive spores, which range in size from 0.16 µm to 0.14 in. (3.6 mm) (Hill 2001), are expected to pass through the screens. Subsequently, they would be pumped through the ANSTP and exposed to UV disinfection.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses *E. flexuosa* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *Enteromorpha flexuosa* is known to foul hulls of vessels (Lougheed and Stevenson 2004).

The GLMRIS Lock would not address the passage of *E. flexuosa* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *E. flexuosa*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes Nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. Nor are they expected to control the human-mediated transport of *E. flexuosa* through the GLMRIS Lock by hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to pass through the aquatic pathway via hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.

T_{10}: See T_0.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of *E. flexuosa*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *E. flexuosa* passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
T_0: See the Nonstructural Risk Assessment for this species.
This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move through the aquatic pathway is expected to slow passage to an uncertain degree.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *E. flexuosa* via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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E.3.2.1.2 Red Algae (*Bangia atropurpurea*)

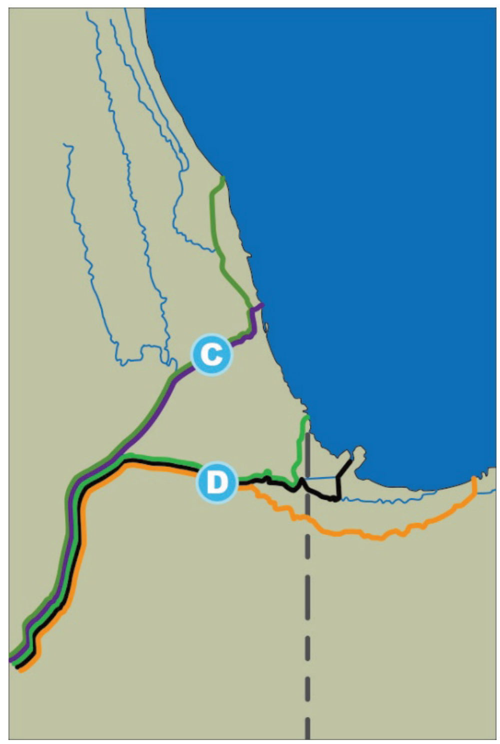
MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measure would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the red algae.
[b] The Mid-system Control Technologies without a Buffer Zone Alternative includes an electric barrier at Control Points (C) and (D), which is ineffective for red algae and does not impact its probability rating.



PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

b. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae from natural dispersion through aquatic pathways to the Chicago Area Water System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this Species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures such as agency monitoring and control methods to manage red algae in the Great Lakes and other locations where it has been documented are not likely to be successful because of the prolonged monospore release which promotes rapid population spread.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect the current abundance or reproductive capacity of red algae.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species (ANS) treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of red algae at the CAWS by human-mediated transport or natural dispersion.

The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where it is able to establish, and thus its locations in relation to the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter (Kipp 2011), respectively, are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, EPA 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, is expected to address red algae filaments and reproductive spores that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. Red algae is known to foul hulls of vessels (Lin and Blum 1977). The GLMRIS Lock would not address the passage of the red algae due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of red algae.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of red algae through the aquatic pathway to the Brandon Road Lock and Dam. This species has been found to attach to vessel hulls (Lin and Blum 1977). The GLMRIS Lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling. This species has been found to attach to vessel hulls (Lin and Blum 1977). The GLMRIS Lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae establishing in the CAWS and thereby reducing the abundance of spores and filaments in the CAWS. However, the transport of spores and filaments through the CAWS would not be affected.

T_{10}: See T_0.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier is not effective at controlling the passage of red algae. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of red algae through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of red algae passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of red algae through the

aquatic pathway; however, these measures are not expected to control the human-mediated transport of red algae via hull fouling on vessels. Overall, the uncertainty remains high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: *Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier*

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the current abundance or reproductive capacity of red algae.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of red algae at the CAWS by human-mediated transport or natural dispersion. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which may affect where it is able to establish, and thus its location in relation to the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW. Therefore, the uncertainty remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50} : HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter (Kipp 2011), respectively, are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, is expected to address red algae filaments and reproductive spores that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. Red algae is known to foul hulls of vessels (Lin and Blum 1977). The GLMRIS Lock would not address the passage of the red algae due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of red algae.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as

part of this alternative are not expected to control the human-mediated transport of red algae through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae establishing in the CAWS and thereby reducing the abundance of spores and filaments in the CAWS. However, the transport of spores and filaments through the CAWS would not be affected.

T_{10}: See T_0.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier is not effective at controlling the passage of red algae. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of red algae through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of red algae passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion of red algae through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of red algae via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the current abundance or reproductive capacity of red algae.

T_{10}: See $T_{0.}$ See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of red algae at the CAWS by human-mediated transport or natural dispersion. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Calumet Harbor.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where it is able to establish, and thus its location in relation to the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Calumet Harbor. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Calumet Harbor. Therefore, the uncertainty remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter (Kipp 2011), respectively, are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address red algae filaments and reproductive spores that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. Red algae is known to foul hulls of vessels (Lin and Blum 1977). The GLMRIS Lock would not address the passage of the red algae due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of red algae.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of red algae through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae establishing in the CAWS and thereby reducing the abundance of spores and filaments in the CAWS. However, the transport of spores and filaments through the CAWS would not be affected.

T_{10}: See T_0.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of red algae. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of red algae through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of red algae passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion of red algae through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of red algae via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the current abundance or reproductive capacity of red algae.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of red algae at the CAWS by human-mediated transport or natural dispersion. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where it is able to establish, and thus its location in relation to the CAWS.

T_{10}: See T_{10}.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor. Therefore, the uncertainty remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0–T_{50}: LOW–MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter (Kipp 2011), respectively, are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by

MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address red algae filaments and reproductive spores that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. Red algae is known to foul hulls of vessels (Lin and Blum 1977). The GLMRIS Lock would not address the passage of the red algae due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of red algae.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of red algae through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae establishing in the CAWS and thereby reducing the abundance of spores and filaments in the CAWS. However, the transport of spores and filaments through the CAWS would not be affected.

T_{10}: See T_0.

T_{25}: See T_{10}. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease due to the adoption of water quality standards and effluent discharge limitations that are currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012).

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of red algae. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of red algae through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of red algae passing through the aquatic pathway. Therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species. This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion of red algae through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of red algae via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the current abundance or reproductive capacity of red algae.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of red algae at the CAWS by human-mediated transport or natural dispersion. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where red algae is able to establish, and thus its location in relation to the CAWS.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0–T_{50}: LOW–MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter (Kipp 2011), respectively, are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005;, Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address red algae filaments and reproductive spores that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. Red algae is known to foul hulls of vessels (Lin and Blum 1977). The GLMRIS Lock would not address the passage of the red algae due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of red algae.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of red algae through the aquatic pathway via hull fouling. This species is known to foul hulls of

vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species because the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae establishing in the CAWS and thereby reducing the abundance of spores and filaments in the CAWS. However, the transport of spores and filaments through the CAWS would not be affected.
T_{10}: See T_0.
T_{25}: See T_{10}. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease due to the adoption of water quality standards and effluent discharge limitations that are currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012).
T_{50}: See T_{025}

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of red algae. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of red algae through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of red algae passing through the aquatic pathway. Therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion of red algae through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of red algae via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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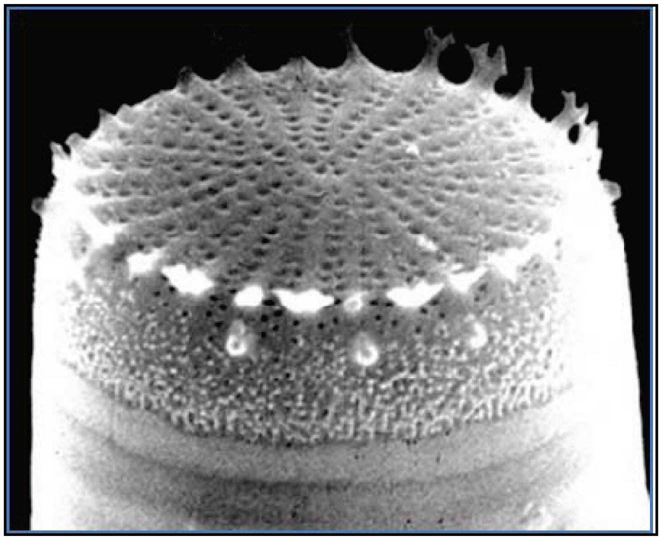
E.3.2.1.3 Diatom (*Stephanodiscus binderanus*)

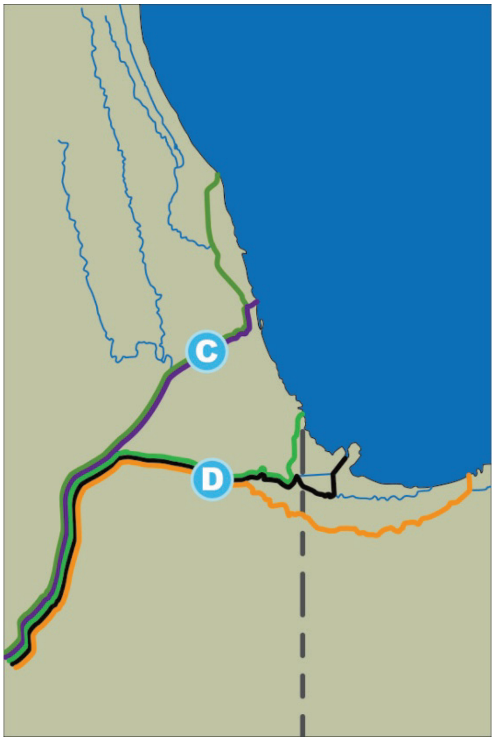


MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station		Nonstructural Measures[a]
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Chicago River Controlling Works		Nonstructural Measures[a]
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Calumet Harbor		Nonstructural Measures[a]
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Indiana Harbor		Nonstructural Measures[a]
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Burns Small Boat Harbor		Nonstructural Measures[a]
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock



[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the *Stephanodiscus binderanus.*
[b] The Mid-system Control Technologies without a Buffer Zone Alternative includes an Electric Barrier at Control Points (C) and (D); however, it is ineffective for *S. binderanus* and does not impact the probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways that may affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS by human-mediated transport or natural dispersion. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

As part of the Mid-system Control Technologies without a Buffer Zone Alternative, nonstructural measures, such as restrictions on nutrient loads to waterways, could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes restrictions on nutrient loads to waterways that may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* through at the CAWS aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) from Chicago Sanitary and Ship Canal (CSSC) water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. *S. binderanus* filaments and reproductive spores, which typically have a size of 830 μm^3 (Kipp 2011), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration at Stickney, Illinois, is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001 Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses *S. binderanus* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *S. binderanus* is small (size of diatom, 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the passage of *S. binderanus* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of *S. binderanus*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway via hull fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull-fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to the Brandon Road Lock and Dam.

T_{10}: See T_0.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier is not effective at controlling the passage of *S. binderanus*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *S. binderanus* via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Alternative Rating 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	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways that may affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS by human-mediated transport or natural dispersion. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Mid-system Control Technologies without a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes restrictions on nutrient loads to waterways that may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}*:* See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and to supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *S. binderanus* filaments and reproductive spores, which have a size of 830 μm^3 (Kipp 2011), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration at Stickney, Illinois, is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS lock at Stickney, Illinois, addresses *S. binderanus* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *S. binderanus* is small (size of diatom, 830 μm^3) (Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the passage of *S. binderanus* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of *S. binderanus*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway via hull fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull-fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to the Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier is not effective at controlling the passage of *S. binderanus*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *S. binderanus* via hull fouling on vessels. Overall, the uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways that may affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS by human-mediated transport or natural dispersion. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Mid-system Control Technologies without a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes restrictions on nutrient loads to waterways that may reduce the productivity of this species, but these restrictions are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and to supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. *S. binderanus* filaments and reproductive spores, which have a size of 830 μm^3 (Kipp 2011), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration at Alsip, Illinois, is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses *S. binderanus* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *S. binderanus* is small (size of diatom, 830 μm^3) (Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the passage of *S. binderanus* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *S. binderanus*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway via hull fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull-fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to the Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of *S. binderanus*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *S. binderanus* via hull fouling on vessels. Overall, the uncertainty remains high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways that may affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS by human-mediated transport or natural dispersion. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Mid-system Control Technologies without a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes restrictions on nutrient loads to waterways that may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWSthrough aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. *S. binderanus* filaments and reproductive spores, which typically have a size of 830 μm^3 (Kipp 2011), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration at Alsip, Illinois, is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses *S. binderanus* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *S. binderanus* is small (size of diatom, 830 μm^3) (Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the passage of *S. binderanus* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *S. binderanus*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as

part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway via hull fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 µm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull-fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 µm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to the Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of *S. binderanus*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains low.

T_{50}: See T_{25}. The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains medium.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passageof *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway; however, these measures are not expected to control the human-

mediated transport of *S. binderanus* via hull fouling on vessels. Overall, the uncertainty remains high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways that could affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS by human-mediated transport or natural dispersion. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Mid-system Control Technologies without a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes restrictions on nutrient loads to waterways that may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. *S. binderanus* filaments and reproductive spores, which typically have a size of 830 μm^3 (Kipp 2011), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration at Alsip, Illinois, is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses *S. binderanus* that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. *S. binderanus* is small (size of diatom, 830 μm^3) (Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the passage of *S. binderanus* due to hull fouling because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of *S. binderanus*.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway via hull fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull-fouling. *Stephanodiscus binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to the Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0. *S. binderanus* is sensitive to nutrient levels. The discharge of nutrients may decrease due to the adoption of water quality standards and effluent discharge

limitations currently proposed for the CAWS (Illinois Pollution Control Board 2012). However, the potential impact of these future water quality changes is uncertain.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of *S. binderanus*. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains low.
T_{50}: See $T_{25.}$ The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage remains medium.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *S. binderanus* via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

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E.3.2.2 Plants

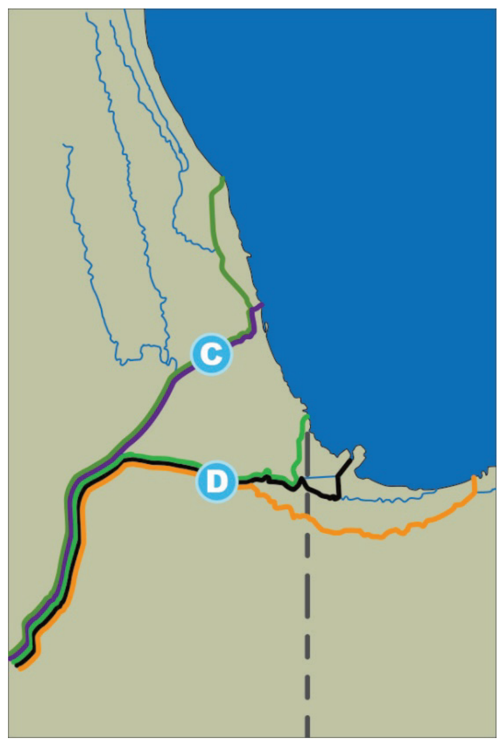
E.3.2.2.1 Reed Sweetgrass (Glyceria maxima)

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock



[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the reed sweetgrass.
[b] The Mid-system Control Technologies without a Buffer Zone Alternative includes an electric barrier at Control Points (C) and (D), which is ineffective for reed sweetgrass and does not affect its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

c. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect the invasion speed of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass by natural dispersion through aquatic pathways to the Chicago Area Water System (CAWS). Nonstructural measures would include aquatic nuisance species control methods, such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect this human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, promoting the use of antifouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion of how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species.

Nonstructural measures include aquatic nuisance species control methods, such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the current abundance and propagule pressure of the species. In addition, nonstructural measures would include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. *Existing Physical Human/Natural Barriers*

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport or natural dispersion. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).
T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may contain the species, thereby affecting its arrival at the CAWS through aquatic pathways.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating [a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of aquatic nuisance species control methods to manage the species. Once the species is managed, education and outreach could control its future spread by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented aquatic nuisance species control methods and identify surviving populations requiring further management.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Implementation of nonstructural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to affect the arrival of this species at the CAWS; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities, coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control), would control the spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012; TNC-GIST 2005). Implementing a comprehensive program that expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore, the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois. The alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal (CSSC) water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with water treated for aquatic nuisance species.

The treatment technologies in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude aquatic nuisance species and other organic matter larger than 0.75 in., (19.05 mm). It is expected that reed sweetgrass plants, which can reach a height of 8.2 ft (2.5 m) (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens.

Seeds of reed sweetgrass, which can range in size from 0.06 to 0.08 in. (1.5 to 2 mm) (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the turbidity of the CSSC at the Stickney, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against aquatic nuisance species (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses reed sweetgrass fragments and seeds that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream. Reed sweetgrass is capable of spreading by seeds, roots, or rhizome fragments that may be transported short distances by boats (DPIWE 2002). The GLMRIS is not expected to address the passage of reed sweetgrass attached to vessels because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of reed sweetgrass.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of the reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of reed sweetgrass through the GLMRIS Lock by temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of The Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier would have no effect on the passage of reed sweetgrass. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of reed sweetgrass passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of reed sweetgrass via temporary attachment to vessel hulls. Overall, the uncertainty remains medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect the invasion speed of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include aquatic nuisance species control methods, such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, promoting the use of antifouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion of how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species, thereby affecting its arrival at the CAWS through aquatic pathways.

Nonstructural measures include aquatic nuisance species control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the current abundance and propagule pressure of the species. In addition, nonstructural measures would include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport or natural dispersion. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may contain the species, thereby affecting its arrival at the CAWS through aquatic pathways.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating [a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of aquatic nuisance species control methods to manage the species. Once the species is managed, education and outreach could control its future spread by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented aquatic nuisance species control methods and identify surviving populations requiring further management.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Implementation of nonstructural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to affect the arrival of this species through aquatic pathways at the CAWS; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Therefore, the uncertainty associated is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities, coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control), would control the spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012: TNC-GIST 2005). Implementing a comprehensive program that expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore, the uncertainty is low.

3. **P(passage) T_0-T_{50} : LOW-MEDIUM**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois. The alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with water treated for aquatic nuisance species.

The treatment technologies in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life forms currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude aquatic nuisance species and other organic matter larger than 0.75 in. (19.05 mm). It is expected that reed sweetgrass plants, which can reach a height of 8.2 ft (2.5 m) (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 0.06 to 0.08 in. (1.5 to 2 mm) (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the turbidity of the CSSC at the Stickney, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the aquatic nuisance species treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against aquatic nuisance species (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity and upon the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses reed sweetgrass plant fragments and seeds that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream. Reed sweetgrass is capable of spreading by seeds, roots, or rhizome fragments that may be transported short distances by boats (DPIWE 2002). The GLMRIS Lock would not address the passage of reed sweetgrass attached to vessels, because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of reed sweetgrass.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative.

Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of the reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of reed sweetgrass through the GLMRIS Lock by temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier would have no effect on the passage of reed sweetgrass. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of reed sweetgrass passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of reed sweetgrass via temporary attachment to vessel hulls. Overall, the uncertainty remains medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect the invasion speed of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include aquatic nuisance species control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, promoting the use of antifouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion of how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species, thereby affecting its arrival at the CAWS through aquatic pathways.
Nonstructural measures include aquatic nuisance species control methods, such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the current abundance and propagule pressure of the

species. In addition, nonstructural measures would include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport or natural dispersion. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may contain the species, thereby affecting its arrival at the CAWS through aquatic pathways.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of aquatic nuisance species control methods to manage the species. Once the species is managed, education and outreach could control its future spread by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented aquatic nuisance species control methods and identify surviving populations requiring further management.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Implementation of nonstructural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the arrival of this species at the CAWS; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities, coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control), would control the spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012; TNC-GIST 2005). Implementing a comprehensive program that expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore, the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois. The alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with water treated for aquatic nuisance species.

The treatment technologies in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude aquatic nuisance species and other organic matter larger than 0.75 in. (19.05 mm). It is expected that reed sweetgrass plants, which can reach a height of 8.2 ft (2.5 m) (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 0.06 to 0.08 in. (1.5 to 2 mm) (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against aquatic nuisance species (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006 Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses reed sweetgrass plant fragments and seeds that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream. Reed sweetgrass is capable of spreading by seeds, roots, or rhizome fragments that may be transported short distances by boats (DPIWE 2002). The GLMRIS Lock would not address the passage of reed sweetgrass attached to vessels, because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of reed sweetgrass.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures

alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of the reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of reed sweetgrass through the GLMRIS Lock by temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of reed sweetgrass. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of reed sweetgrass passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of reed sweetgrass via temporary attachment to vessel hulls. Overall, the uncertainty remains medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect the invasion speed of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include aquatic nuisance species control methods, such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, promoting the use of antifouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass through the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion of how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures may affect the current abundance and propagule pressure of the species, thereby affecting its arrival at the CAWS through aquatic pathways.

Nonstructural measures include aquatic nuisance species control methods, such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the current abundance and propagule pressure of the species. In addition, nonstructural measures would include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport or natural dispersion. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may contain the species, thereby affecting its arrival at the CAWS through aquatic pathways.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the availability of suitable habitat within southern Lake Michigan for reed sweetgrass.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations followed by rapid implementation of aquatic nuisance species control methods to manage the species. Once the species is managed, education and outreach could control its future spread by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented aquatic nuisance species control methods and identify surviving populations requiring further management.

The Mid-system Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Implementation of nonstructural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative is expected to affect the arrival of this species at the CAWS; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating [a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities, coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control), would control the spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012; TNC-GIST 2005). Implementing a comprehensive program that expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore, the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with water treated for aquatic nuisance species.

The treatment technologies in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude aquatic nuisance species and other organic matter larger than 0.75 in. (19.05 mm). It is expected that reed sweetgrass plants, which can reach a height of 8.2 ft (2.5 m) (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 0.06 to 0.08 in. (1.5 to 2 mm) (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the aquatic nuisance species treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against aquatic nuisance species (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006 Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses reed sweetgrass plant fragments and seeds that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream. Reed sweetgrass is capable of spreading by seeds, roots, or rhizome fragments that may be transported short distances by boats (DPIWE 2002). The GLMRIS Lock would not address the passage of reed sweetgrass through the aquatic pathway attached to vessels because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of reed sweetgrass.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of the reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of reed sweetgrass through the GLMRIS Lock by temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of reed sweetgrass. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of reed sweetgrass passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	High	High
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species. This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of reed sweetgrass via temporary attachment to vessel hulls. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect the invasion speed of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include aquatic nuisance species control methods, such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may affect human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge-water exchange program education and outreach, promoting the use of antifouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion of how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures may affect the current abundance and propagule pressure of the species, thereby affecting the arrival of reed sweetgrass at the CAWS through aquatic pathways.

Nonstructural measures include aquatic nuisance species control methods, such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the current abundance and propagule pressure of the species. In addition, nonstructural measures would include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport or natural dispersion. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may contain the species, thereby affecting the arrival of reed sweetgrass at the CAWS through aquatic pathways.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat within the CAWS for reed sweetgrass.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating [a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of aquatic nuisance species control methods to manage the species. Once the species is managed, education and outreach could control its future spread by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented aquatic nuisance species control methods and identify surviving populations requiring further management.

The Mid-system Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Implementation of nonstructural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to affect the arrival of this species at the CAWS; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating [a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities, coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control), would control the spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012; TNC-GIST 2005). Implementing a comprehensive program that expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore, the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with water treated for aquatic nuisance species.

The treatment technologies in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude aquatic nuisance species and other organic matter larger than 0.75 in. (19.05 mm). It is expected that reed sweetgrass plants, which can reach a height of 8.2 ft (2.5 m) (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 0.06 to 0.08 in. (1.5 to 2 mm) (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the aquatic nuisance species treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against aquatic nuisance species (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses reed sweetgrass fragments and seeds that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream. Reed sweetgrass is capable of spreading by seeds, roots, or rhizome fragments that may be transported short distances by boats (DPIWE 2002). The GLMRIS Lock would not address the passage of reed sweetgrass attached to vessels, because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of reed sweetgrass.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of the reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of reed sweetgrass through the GLMRIS Lock by temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size: 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the availability of suitable habitat within the CAWS for reed sweetgrass.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of reed sweetgrass. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of reed sweetgrass passing through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	High	High
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of reed sweetgrass via temporary attachment to vessel hulls. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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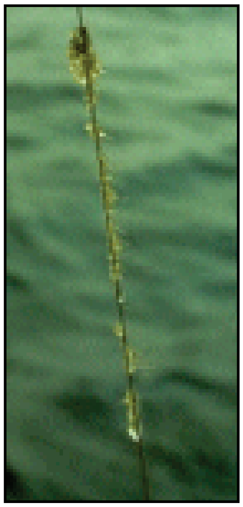
E.3.2.3 Crustaceans

E.3.2.3.1 Fishhook Waterflea (*Cercopagis pengoi*)



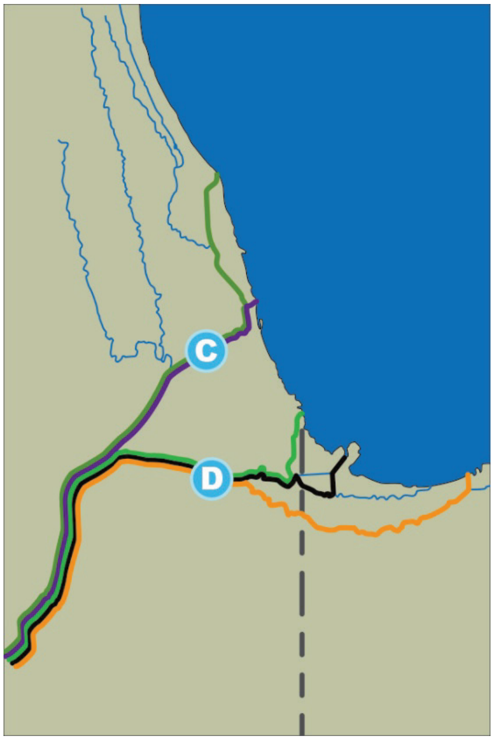
MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station		Nonstructural Measures[a]
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Chicago River Controlling Works		Nonstructural Measures[a]
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Calumet Harbor		Nonstructural Measures[a]
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Indiana Harbor		Nonstructural Measures[a]
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Burns Small Boat Harb		Nonstructural Measures[a]
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the fishhook waterflea.
[b] The Mid-system Control Technologies without a Buffer Zone Alternative includes an electric barrier at Control Points (C) and (D), which is ineffective for the fishhook waterflea and does not impact its probability rating.



PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Low	Medium	Medium	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)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	Medium	Low	Medium	Medium	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)	Low	–[a]	Low	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative does not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

A. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None. The species is close to or at the WPS pathway entrance (Benson et al. 2012).
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of the fishhook waterflea at the CAWS by human-mediated transport or natural dispersion. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the WPS are uncertain, but this species may be at the WPS.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.

T_{10}: See T_0. There are no predicted significant differences in habitat components along Lake Michigan in the near or foreseeable future that would affect the arrival of this species.

T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the WPS are uncertain, but this species may be at the WPS. The species is close to or at the pathway; therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The species is close to or at the pathway. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the WPS are uncertain, but this species may be at the WPS. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW-HIGH**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) from Chicago Sanitary and Ship Canal (CSSC) water prior to its discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and to supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can “shade” and “encase” target species, thus blocking UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the fishhook waterflea, which could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

The electric barrier at the lake side entrance to the Stickney GLMRIS Lock would be an ineffective control for the fishhook waterflea. This species’ passage through the U-shaped engineered channel would not be affected by electric current.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of the fishhook waterflea through the GLMRIS Lock by hull fouling. This species has been found in hull scrapes and is considered a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock does not address hull fouling species, since the Lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. However, the species is expected to still be able to pass through the GLMRIS Lock by hull fouling on vessels. This species has been found in hull scrapes and is considered to be a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address hull fouling species, since the Lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. Future water quality in the CAWS may improve with current plans to close two power plants and update wastewater treatment (Illinois Pollution Control Board 2012).

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Medium	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier is not effective at controlling the passage of the fishhook waterflea. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains medium.

T_{50}: See T_{25}. The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains high.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of the fishhook waterflea via hull fouling through the aquatic pathway. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Low	Medium	Medium	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)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	Medium	Low	Medium	Medium	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)	Low	–[a]	Low	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None. The species is close to or at the CRCW pathway entrance (Benson et al. 2012).
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of the fishhook waterflea at the CAWS by human-mediated transport or natural dispersion. The species is close to or at the pathway. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the CRCW are uncertain, but this species may be at the CRCW.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.

T_{10}: See T_0. There are no predicted significant differences in habitat components along Lake Michigan in the near or foreseeable future that would affect the arrival of this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The species is close to or at the pathway. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the CRCW are uncertain, but this species may be at the CRCW. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The species is close to or at the pathway. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the CRCW are uncertain, but this species may be at the CRCW. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50} : LOW-HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the fishhook waterflea at Stickney, Illinois with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from CSSC water prior to its discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can "shade" and "encase" target species, thus blocking the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the fishhook waterflea, which could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

The electric barrier at the lake side entrance to the Stickney GLMRIS Lock would be an ineffective control for the fishhook waterflea. This species' passage through the U-shaped engineered channel would not be affected by electric current.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as

part of this alternative are not expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. Specifically, this alternative is not expected to control the human-mediated transport of the fishhook waterflea through the GLMRIS Lock via hull fouling. This species has been found in hull scrapes and is considered a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address the human-mediated transport of this species via hull fouling because the Lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010) and could be transported through the GLMRIS Lock by this type of human-mediated transport. The GLMRIS Lock would not address the human-mediated transport of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. Future water quality in the CAWS may improve with current plans to close two power plants and update wastewater treatment (Illinois Pollution Control Board 2012).

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Medium	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The electric barrier would have no effect on the passage of the fishhook waterflea. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains medium.

T_{50}: See T_{25}. The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains high.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of the fishhook waterflea via hull fouling through the aquatic pathway. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Medium	Low	Medium	Medium	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)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	Medium	Low	Medium	Medium	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)	Low	–[a]	Low	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone does not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None. The species is close to or at the Calumet Harbor pathway entrance (Benson et al. 2012).

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of the fishhook waterflea at the CAWS by human-mediated transport or natural dispersion. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the Calumet Harbor are uncertain, but this species may be at the Calumet Harbor.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the Calumet Harbor are uncertain, but this species may be at the Calumet Harbor. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the Calumet Harbor are uncertain, but this species may be at the Calumet Harbor. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW-HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to its discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens. It would subsequently be pumped through the ANSTP and be exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can "shade" and "encase" target species, thus blocking the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the fishhook waterflea, which could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. The fishhook waterflea is known to foul hulls of vessels (Sylvester and & MacIsaac 2010). The GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

The electric barrier at the lake side entrance to the Alsip GLMRIS Lock would be an ineffective control for the fishhook waterflea. This species' passage through the U-shaped engineered channel would not be impacted by electric current.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. Specifically, this alternative is not expected to control the human-mediated transport of the fishhook waterflea through the GLMRIS Lock via hull fouling. This species has been found in hull scrapes and is considered to be a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address the human-mediated transport of this species via hull fouling because the Lock does not dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010) and could be transported through the GLMRIS Lock by this type of human-mediated transport. The GLMRIS Lock would not address the human-mediated transport of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Medium	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of the fishhook waterflea. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains medium.

T_{50}: See T_{25}. The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains high.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of the fishhook waterflea via hull fouling through the aquatic pathway. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: *Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier*

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None. The species is close to or at the Indiana Harbor pathway entrance (Benson et al. 2012).

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of the fishhook waterflea at the CAWS by human-mediated transport or natural dispersion. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the Indiana Harbor are uncertain, but this species may be at the Indiana Harbor.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.

T_{10}: See T_0. There are no predicted significant differences in habitat components along Lake Michigan in the near or foreseeable future that would affect the arrival of this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the Indiana Harbor are uncertain, but this species may be at the Indiana Harbor. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the Indiana Harbor are uncertain, but this species may be at the Indiana Harbor. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the fishhook waterflea at Alsip, Illinois, with the construction of an ANSP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to its discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and to supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can "shade" and "encase" target species, thus blocking the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the fishhook waterflea, which could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

The electric barrier at the lake side entrance to the Alsip GLMRIS Lock would be an ineffective control for the fishhook waterflea. This species' passage through the U-shaped engineered channel would not be impacted by electric current.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. This alternative is not expected to control the human-mediated transport of the fishhook waterflea through the GLMRIS Lock by hull fouling. This species has been found in hull scrapes and is considered to be a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock does not address hull fouling species, since the Lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. However, the species is expected to still be able to pass through the GLMRIS Lock by hull fouling on vessels. This species has been found in hull scrapes and is considered to be a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address hull fouling species, since the Lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of the fishhook waterflea. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains low.

T_{50}: See T_{25}. The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway. Therefore, the probability of passage remains medium.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of the fishhook waterflea via hull fouling through the aquatic pathway. Therefore, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

Mid-system Control Technologies without a Buffer Zone Rating 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)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
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.

EVIDENCE FOR ESTIMAT1ING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of the fishhook waterflea at the CAWS by human-mediated transport or natural dispersion. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the BSBH are uncertain, but this species may be at the BSBH.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.
T_{10}: See T_0. There are no predicted significant differences in habitat components along Lake Michigan in the near or foreseeable future that would affect the arrival of this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the BSBH are uncertain, but this species may be at the BSBH. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the BSBH are uncertain, but this species may be at the BSBH. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW-MEDIUM**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates a control point for the fishhook waterflea at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to its discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and to supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can "shade" and "encase" target species, thus blocking the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the fishhook waterflea, which could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

The electric barrier at the lake side entrance to the Alsip GLMRIS Lock would be an ineffective control for the fishhook waterflea. This species' passage through the U-shaped engineered channel would not be affected by electric current.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. This alternative is not expected to control the human-mediated transport of the fishhook waterflea through the GLMRIS Lock by hull fouling. This species has been found in hull scrapes and is considered to be a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock does not address hull fouling species, since the Lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. However, the species is expected to still be able to pass through the GLMRIS Lock by hull fouling on vessels. This species has been found in hull scrapes and is considered to be a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address hull fouling species, since the Lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The electric barrier is not effective at controlling the passage of the fishhook waterflea. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway via human-mediated transport. Therefore, the probability of passage remains low.

T_{50}: See T_{25}. The Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway via human-mediated transport. Therefore, the probability of passage remains medium.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway; however, these measures are not expected to control the

human-mediated transport of the fishhook waterflea via hull fouling through the aquatic pathway. Therefore, the uncertainty remains high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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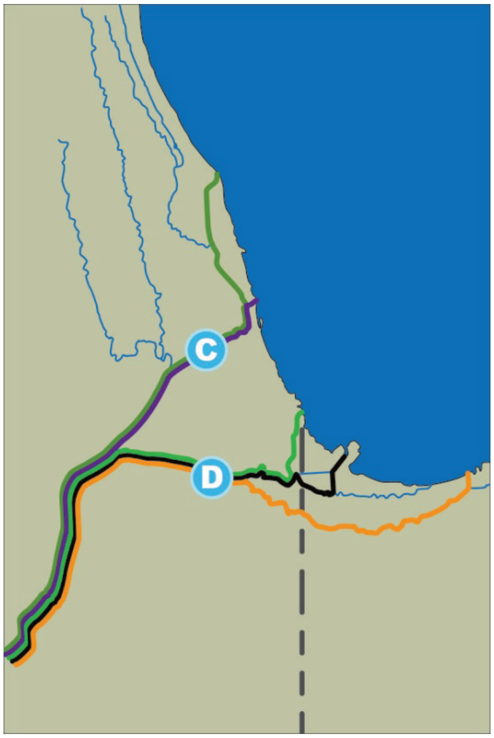
E.3.2.3.2 Bloody Red Shrimp *(Hemimysis anomala)*

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock



[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the bloody red shrimp.
[b] The Mid-system Control Technologies without a Buffer Zone Alternative includes an electric barrier at Control Points (C) and (D), which is ineffective for bloody red shrimp and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an aquatic nuisance species (ANS) treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of the bloody red shrimp at the CAWS by human-mediated transport or natural dispersion. The species is already established in Lake Michigan and is likely already at

the pathway having been documented by the U.S. Geological Survey (USGS) one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the bloody red shrimp in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS by natural dispersion or human-mediated transport. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of the species arriving at the CAWS remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Chicago Sanitary and Ship Canal (CSSC) water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration and ultraviolet (UV) radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001, Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The electric barrier at the lake side entrance to the Stickney GLMRIS Lock would be an ineffective control for the bloody red shrimp. This species passage through the U-shaped engineered channel is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from the ANSTP. Without the lock flushing, the lock could transport this species into the Mississippi River Basin side of the control point. After the lock gates are closed, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for bloody red shrimp prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock would help control the passage of bloody red shrimp through the aquatic pathway due to this type of human-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. CSSC water would be treated for bloody red shrimp by the ANSTP prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock would help control the passage of the bloody red shrimp through the aquatic pathway due to this type of human-mediated transport.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to treat CSSC water for ANS prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of the resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

The GLMRIS Lock is expected to address the passage of the bloody red shrimp by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier would have no effect on the passage of the bloody red shrimp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Mid-system Control Technologies without a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, the GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the bloody red shrimp from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. Overall, the uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability of the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative, which contains nonstructural measures that could be implemented immediately, is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to be able to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The electric barrier at the lake side entrance to the Stickney GLMRIS Lock would be an ineffective control for the bloody red shrimp. This species passage through the U-shaped engineered channel is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport this species into the Mississippi River Basin side of the control point. After the lock gates are closed, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

Overall, the Mid-system Control Technologies without a Buffer Zone is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for bloody red shrimp prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. CSSC water would be treated for bloody red shrimp by the ANSTP prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The purpose of the ANSTP is to treat CSSC water for ANS prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of the resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

The GLMRIS Lock is expected to address the passage of the bloody red shrimp by natural dispersion (i.e., passive drift) through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier would have no effect on the passage of the bloody red shrimp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-System Control Technologies without a Buffer Zone Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage for the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage for the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Mid-system Control Technologies without a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, the GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the bloody red shrimp from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. Therefore, the uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	Non	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and Brandon Road Lock and Dam over the next 50 years.
The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).

T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability of the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative, which contains nonstructural measures that could be implemented immediately, is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH–LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to be able to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al.2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The electric barrier at the lake side entrance to the Alsip GLMRIS Lock would be an ineffective control for the bloody red shrimp. This species passage through the U-shaped engineered channel is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport this species into the Mississippi River Basin side of the control point. After the lock gates are closed, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for bloody red shrimp prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for bloody red shrimp by the ANSTP prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to affect the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Control Technologies without a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. The purpose of the ANSTP is to treat Cal-Sag Channel water for ANS prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of the resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

The GLMRIS Lock is expected to address the passage of the bloody red shrimp by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier would have no effect on the passage of the bloody red shrimp.

Overall, the Mid-System Control Technologies without a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Mid-system Control Technologies without a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, the GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the bloody red shrimp from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. Overall, the uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM
MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Medium	High	High	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	***Low***	High	***Low***	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability of the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative, which contains nonstructural measures that could be implemented immediately, is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already at the pathway. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-System Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways . The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005, Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The electric barrier at the lake side entrance to the Alsip GLMRIS Lock would be an ineffective control for the bloody red shrimp. This species passage through the U-shaped engineered channel is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-drive filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport this species into the Mississippi River Basin side of the control point. After the lock gates are closed, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for bloody red shrimp prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for bloody red shrimp by the ANSTP prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-System Control Technologies without a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to treat Cal-Sag Channel water for ANS prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of the resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

The GLMRIS Lock is expected to address the passage of the bloody red shrimp by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier would have no effect on the passage of the bloody red shrimp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	High	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species. This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Control Technologies without a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, the GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the bloody red shrimp from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. Overall, the uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Low	Low	Medium	High	High	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	***Low***	High	***Low***	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Control Technologies without a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability of the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS by natural dispersion or human-mediated transport. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of the species arriving at BSBH remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-System Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. The species is already established in Lake Michigan and is likely already at the pathway having been documented by the U.S. Geological Survey (USGS) one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barriers.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS-treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens. It would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the NS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001;Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The electric barrier at the lake side entrance to the Alsip GLMRIS Lock would be an ineffective control for the bloody red shrimp. This species passage through the U-shaped engineered channel is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport this species into the Mississippi River Basin side of the control point. After the lock gates are closed, the lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for bloody red shrimp prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for bloody red shrimp by the ANSTP prior to its discharge into the Mississippi River Basin side of the control point. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the passage of the bloody red shrimp due to this type of human-mediated transport.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The purpose of the ANSTP is to treat Cal-Sag Channel water for ANS prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of the resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

The GLMRIS Lock is expected to address the passage of the bloody red shrimp by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier would have no effect on the passage of the bloody red shrimp.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species. This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Control Technologies without a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, the GLMRIS Lock is a novel technology that will need to be designed, built, and calibrated in order to control the bloody red shrimp from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal designed and operating parameters. Overall, the uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(colonizes) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for P(spreads) are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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E.3.2.4 Fish

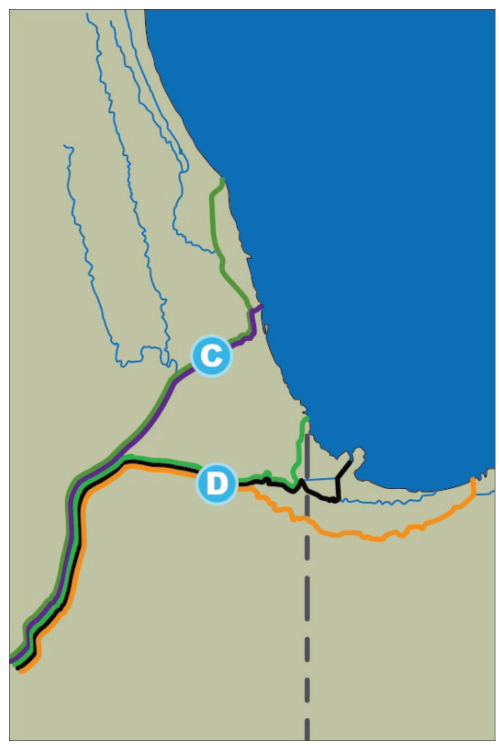
E.3.2.4.1 Threespine Stickleback (*Gasterosteus aculeatus*)

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock



Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the threespine stickleback.		

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the WPS.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an aquatic nuisance species treatment plant (ANSTP), GLMRIS Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of the threespine stickleback to the CAWS by human-mediated transport or natural dispersion since in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone is not expected to reduce the threespine stickleback's distance from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback through aquatic pathways to the CAWS. The species has already arrived at the pathway. The threespine stickleback is established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback which is already present at the pathway. The threespine stickleback is established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the uncertainty of arrival remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Chicago Sanitary and Ship Canal water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens due to their size. Larval fish and eggs which range in size from 0.16 to 0.17 in (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, as well as fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV disinfection.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of threespine stickleback that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier would address the transfer of threespine stickleback. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for threespine stickleback prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. CSSC water would be treated for

threespine stickleback by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessments.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.
The ANSTP would treat CSSC water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of

African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the threespine stickleback.

The GLMRIS Lock is expected to address the passage of threespine stickleback eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the threespine stickleback from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Control Technologies without a Buffer Zone Alternative may reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the CRCW.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the threespine stickleback to the CAWS since in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the threespine stickleback's distance from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. See Nonstructural Alternative Risk Assessment.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback through aquatic pathways to the CAWS. The species has already arrived at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback which is already present at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50} : HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002) would be excluded by the screens due to their size. Larval fish and eggs which range in size from 0.16 to 0.17 in (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, as well as fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of the threespine stickleback that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of threespine stickleback. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier

is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for threespine stickleback prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. CSSC water would be treated for threespine stickleback by the ANSTP prior to discharge into the Mississippi River

Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented immediate T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessments.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and an electric barrier at Stickney, Illinois.
The ANSTP would treat CSSC water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent

delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the threespine stickleback.

The GLMRIS Lock is expected to address the passage of threespine stickleback eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Assessment Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the threespine stickleback from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Assessment Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Assessment Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Assessment Risk Assessment for this species.
It is uncertain whether the Mid-system Control Technologies without a Buffer Zone Alternative may reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at Calumet Harbor.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the threespine stickleback to the CAWS since in addition to being established in southern Lake Michigan; the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the threespine stickleback's distance from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. See the Nonstructural Assessment Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback through aquatic pathways to the CAWS. The species has already arrived at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0. See the Nonstructural Assessment Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback which is already present at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002) would be excluded by the screens due to their size. Larval fish and eggs which range in size from 0.16 to 0.17 in (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, as well as fish with body widths less than 0.75 in. (19.05 mm), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006; EPA 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address the eggs, larvae, and fry of threespine stickleback that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of threespine stickleback. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for threespine stickleback prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Assessment Risk Assessment for this species.

The Mid-system Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Implementation structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for threespine stickleback by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as

discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessments.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.
The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin

and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the threespine stickleback.

The GLMRIS Lock is expected to address the passage of threespine stickleback eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See Nonstructural Alternative Risk Assessment.

Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the threespine stickleback from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from human-mediated transport.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

It is uncertain whether the Mid-system Control Technologies without a Buffer Zone Alternative may reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None. The threespine stickleback has arrived at Indiana Harbor.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the threespine stickleback to the CAWS since in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the threespine stickleback's distance from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback through aquatic pathways to the CAWS. The species has already arrived at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was also found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback which is already present at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was also found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002) would be excluded by the screens due to their size. Larval fish and eggs which range in size from 0.16 to 0.17 in (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, as well as fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006, Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address the eggs, larvae, and fry of threespine stickleback that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of threespine stickleback. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier

is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for threespine stickleback prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for threespine stickleback by the ANSTP prior to discharge into the Mississippi River

Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.
T_{10}: See T_0. Habitat in the CAWS is expected to remain suitable for the threespine stickleback.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessments.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.
The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-

dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response o UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the threespine stickleback.

The GLMRIS Lock is expected to address the passage of threespine stickleback eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the threespine stickleback from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	None	High	None	High	None	High	None
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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

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

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Control Technologies without a Buffer Zone Alternative may reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the BSBH.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the threespine stickleback to the CAWS since in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the threespine stickleback's distance from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. Habitat near the BSBH is expected to remain suitable for the threespine stickleback.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback through aquatic pathways to the CAWS. The species has already arrived at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was also found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Control Technologies without a Buffer Zone Alternative Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the BSBH pathway and is established in the CAWS. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback which is already present at the pathway. The threespine stickleback is established in southern Lake Michigan; the threespine stickleback was also found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: HIGH–LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002) would be excluded by the screens due to their size. Larval fish and eggs which range in size from 0.16 to 0.17 in (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, as well as fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of threespine stickleback that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of threespine stickleback. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced, U shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier

is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for threespine stickleback prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for threespine stickleback by the ANSTP prior to discharge into the Mississippi River

Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessments.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.
The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of

hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the threespine stickleback.

The GLMRIS Lock is expected to address the passage of threespine stickleback eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the threespine stickleback from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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E.3.2.4.2 Ruffe (Gymnocephalus cernuus)

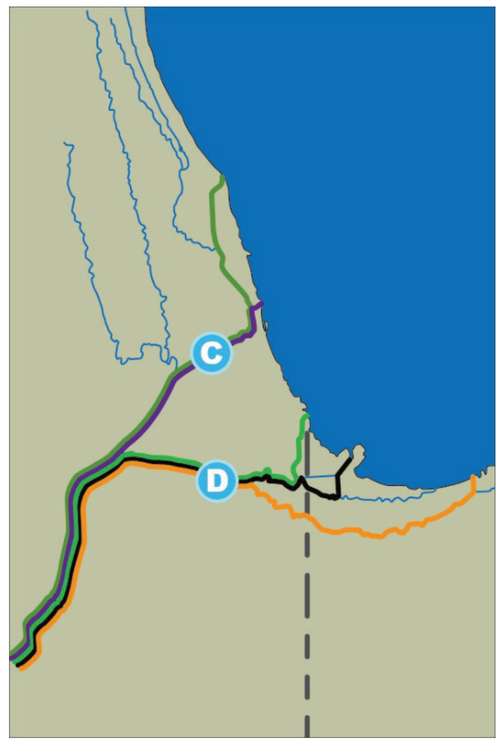
MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the ruffe.



PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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***	***High***	***Low***	***High***
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 highlighted table cells indicate a rating change in the probability element. Low(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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an aquatic nuisance species treatment plant (ANSTP), Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of the ruffe at the CAWS by human-mediated transport or natural dispersion. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs that may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can disperse quickly by vessel-mediated transport and can quickly become abundant (USFWS 1996; Bauer et al. 2007), having extended across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to the WPS by dispersing through the suitable habitat along Lake Michigan or by vessel transport to southern Lake Michigan. Nonstructural measures such as ballast/bilge water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to disperse to the WPS by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to disperse to the WPS by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to disperse to the WPS by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS. Therefore, the uncertainty remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and an electric barrier.

The purpose of the ANSTP is to remove ANS from Chicago Sanitary and Ship Canal (CSSC) water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions that are similar to the current condition. The ANSTP would also supply the GLMRIS Locks with ANS treated water. 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 treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC water at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of ruffe that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

The electric barrier would address the transfer of ruffe. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for ruffe prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. CSSC water would be treated for ruffe by the ANSTP prior to discharge into the Mississippi River Basin Side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.
The ANSTP would treat CSSC water for the ruffe prior to discharge into the Mississippi River Basin Side of the control point. There are reports on the effects of UV irradiation on

fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream dispersion of the ruffe.

The GLMRIS Lock is expected to address the passage of ruffe eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built and calibrated in order to control transfer of the ruffe. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary [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***	***High***	***Low***	***High***
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 highlighted table cells indicate a rating change in the probability element. Low(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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Stickney, Illinois. However, none of these structural measures is expected to affect the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs that may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can disperse quickly by vessel-mediated transport and can quickly become abundant (USFWS 1996; Bauer et al. 2007), having extended across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to the CRCW by dispersing through the suitable habitat along Lake Michigan or by vessel transport to southern Lake Michigan. Nonstructural measures such as ballast/bilge water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to disperse to the CRCW by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the CRCW. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to disperse to the CRCW by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the CRCW. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to disperse to the CRCW by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the CRCW. Therefore, the uncertainty remains high.

3. P(passage) T_0-T_{50} : HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water. 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 treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC water at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of ruffe that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

The electric barrier would address the transfer of ruffe. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for ruffe prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. CSSC water would be treated for ruffe by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport.

Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The ANSTP would treat CSSC water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream dispersion of the ruffe.

The GLMRIS Lock is expected to address the passage of ruffe eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated to control transfer of

the ruffe. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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***	***High***	***Low***	***High***
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 highlighted table cells indicate a rating change in the probability element. Low(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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs that may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can disperse quickly by vessel-mediated transport and can quickly become abundant (USFWS 1996; Bauer et al. 2007), having disperse across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: Ruffe could move closer to the Calumet Harbor by dispersing through the suitable habitat along Lake Michigan or by vessel transport to southern Lake Michigan. Nonstructural measures such as ballast/bilge water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to disperse to the Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Calumet Harbor. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to disperse to the Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Calumet Harbor. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to disperse to the Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Calumet Harbor. Therefore, the uncertainty remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water. 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 treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and s fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel water at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of ruffe that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

The electric barrier would address the transfer of ruffe. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for ruffe prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for ruffe by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. ***Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating [a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream dispersion of the ruffe.

The GLMRIS Lock is expected to address the passage of ruffe eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating [a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated to control transfer of

the ruffe. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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***	***High***	***Low***	***High***
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 highlighted table cells indicate a rating change in the probability element. Low(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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway for the ruffe.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures is expected to act as physical barriers to the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs, which may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can disperse quickly by vessel-mediated transport and can quickly become abundant (USFWS 1996; Bauer et al. 2007), having extended across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to Indiana Harbor by dispersing through the suitable habitat along Lake Michigan or by vessel transport. Alternatively, its range could contract, decreasing its probability of arriving. Nonstructural measures such as ballast/bilge water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to disperse to Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to Indiana Harbor. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to disperse to the Indiana Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Indiana Harbor. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to disperse to the Indiana Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Indiana Harbor. Therefore, the uncertainty remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water. 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 treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel water at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration would be included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of ruffe that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of ruffe. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for ruffe prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for ruffe by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See $T_{0.}$

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream dispersion of the ruffe.

The GLMRIS Lock is expected to address the passage of ruffe eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built and calibrated to control transfer of the ruffe. Research needs would include modeling and laboratory and field testing to

determine the optimal design and operating parameters. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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***	***High***	***Low***	***High***
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 highlighted table cells indicate a rating change in the probability element. Low(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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs, which may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can disperse quickly by vessel-mediated transport and can quickly become abundant (USFWS 1996; Bauer et al. 2007), having extended across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to BSBH by dispersing through the suitable habitat along Lake Michigan or by vessel transport. Alternatively, its range could contract, decreasing its probability of arriving. Nonstructural measures such as ballast/bilge water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.).

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to disperse to Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to BSBH. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-system Control Technologies without a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to disperse to the BSBH by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the BSBH. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to disperse to the BSBH by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the BSBH. Therefore, the uncertainty remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water. The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Locks are expected to control the passage of the ruffe through ballast and bilge water discharge.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel water at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of ruffe that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted during lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of ruffe. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for ruffe prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the human-mediated transport of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for ruffe by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. In addition,

nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of ruffe through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating [a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.
The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in

these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream dispersion of the ruffe.

The GLMRIS Lock is expected to address the passage of ruffe eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built and calibrated to control transfer of the ruffe. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, further

investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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E.3.2.4.3 Tubenose goby (Proterorhinus semilunaris)

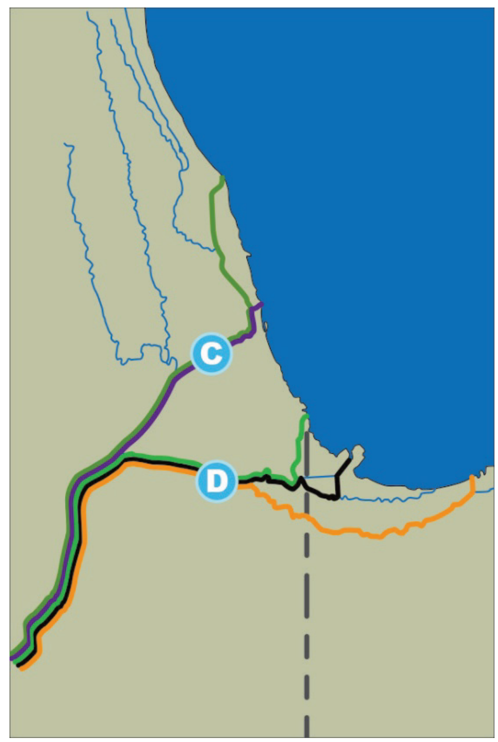
MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the tubenose goby.



PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
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]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
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***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW-MEDIUM**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of tubenose goby from natural dispersion through aquatic pathways to the Chicago area Waterway System (CAWS).

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach, which can be used to determine where to target nonstructural control measures, in particular piscicides However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.
If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation (water drawdown) is not expected to be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Due to the tubenose goby's small size and widespread distribution,

controlled harvest and overfishing are also not expected to be effective control measures to affect the arrival of the tubenose goby at the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an aquatic nuisance species (ANS) treatment plant, Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of the tubenose goby at the CAWS by human-mediated transport or natural dispersion. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs, which may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

Nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Control Technologies without a Buffer Zone Alternative’s low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. There is no commercial vessel transport to the WPS, and the implementation of nonstructural measures such as a ballast/bilge water exchange program are expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, over time, the probability increases that the species would have time to spread to the WPS by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the WPS. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, trends in future populations and spread rates become less certain. Therefore, the uncertainty remains medium.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would

create a control point for the tubenose goby at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions. The ANSTP would also supply the GLMRIS locks with ANS-treated water. 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 discharge.

The treatment technologies included in the ANSTP would include screening, filtration and ultraviolet radiation (UV) to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Chicago Sanitary and Ship Canal (CSSC) at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of tubenose goby that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of tubenose goby. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for tubenose goby prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the

natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. CSSC water would be treated for tubenose goby by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.

The ANSTP would treat Lake Michigan water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP. The GLMRIS Lock would address the passage of tubenose goby eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

The electric barrier is expected to control the downstream dispersion of the tubenose goby.

The GLMRIS Lock is expected to address the passage of tubenose goby eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the tubenose goby from transferring. Research needs would include modeling, laboratory testing, and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
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]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
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***	–	***Low***	–

[a] The highlighted table cell indicates a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program education and outreach and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular piscicides. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation (water drawdown) is not expected be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Due to the tubenose goby's small size and widespread distribution,

controlled harvest and overfishing are not expected to be effective control measures to affect the arrival of tubenose goby at the CAWS pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois. However, none of these structural measures are expected to act as physical barriers to the arrival of the tubenose goby at the CAWS. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs, which may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

Nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.
T_{25}: See T_{10}.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the tubenose goby in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the CRCW. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, trends in future populations and spread rates become less certain. Therefore, uncertainty remains medium.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

3. P(passage) T_0-T_{50} : HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for the tubenose goby at Stickney, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.
The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current condition. The ANSTP would also supply the GLMRIS locks with ANS-treated

water. 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 discharge.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV disinfection.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, addresses the eggs, larvae, and fry of tubenose goby that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of tubenose goby. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for tubenose goby prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway

to Brandon Road Lock and Dam. CSSC water would be treated for tubenose goby by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Stickney, Illinois.
The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the

consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument. Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs and embryos. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.7-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the tubenose goby.

The GLMRIS Lock is expected to address the passage of tubenose goby eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the tubenose goby from transferring. Research needs would include modeling, laboratory testing, and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
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]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
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***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular piscicides. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation (water drawdown) is not expected to be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Due to the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to affect the arrival of tubenose goby at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of the tubenose goby at the CAWS by human-mediated transport or natural dispersion. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs which may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

Nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced from medium to low.

T_{25}: See T_{10}. The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the Calumet Harbor. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, trends in future populations and spread rates become less certain. Therefore, its uncertainty remains medium.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for the tubenose goby at Alsip, Illinois, with the construction of an ANSTP , GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS locks with

ANS-treated water. 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 discharge.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of tubenose goby that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of tubenose goby. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for tubenose goby prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to

Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for tubenose goby by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS Lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.
The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African

catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the tubenose goby.

The GLMRIS Lock is expected to address the passage of tubenose goby eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the tubenose goby from transferring. Research needs would include modeling, laboratory testing, and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
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]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
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***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures may reduce the arrival of the tubenose goby from human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to reduce the current abundance or reproductive capacity of the tubenose goby. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular piscicides. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation (water drawdown) is not expected to be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Due to the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to affect the arrival of the tubenose goby at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of the tubenose goby at the CAWS by human-mediated transport or natural dispersion. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may affect the tubenose goby's distance from the pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes; consequently, ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. There is commercial vessel transport to Indiana Harbor from ports where the tubenose goby is located (section 2b of the Nonstructural Risk Assessment for this species). The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to Indiana Harbor. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, trends in future populations and spread rates become less certain. Therefore, its uncertainty remains medium.
T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would

create a control point at Alsip, Illinois. The alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS locks with ANS-treated water. 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 discharge.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of tubenose goby that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of tubenose goby. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for tubenose goby prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the

natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for tubenose goby by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

$\mathbf{T_{10}}$: See T_0.

$\mathbf{T_{25}}$: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois.

The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the tubenose goby.

The GLMRIS Lock is expected to address the passage of tubenose goby eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

$\mathbf{T_{50}}$: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the tubenose goby from transferring. Research needs would include modeling, laboratory testing, and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
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]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating Summary[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	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
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***	–	***Low***	–

[a] The highlighted table cell indicates a rating change in the probability element.
[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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS from human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular piscicides In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect current abundance or reproductive capacity of the tubenose goby. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular piscicides. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation (water drawdown) is not expected to be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Due to the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to impact the arrival of the tubenose goby at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0:

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative would include the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of the tubenose goby at the CAWS by human-mediated transport or natural dispersion. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that may affect the tubenose goby's distance from the pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes; consequently, ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Control Technologies without a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, the probability increases that that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the BSBH. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. However, over time, trends in future populations and spread rates become less certain. Therefore, its uncertainty remains medium.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that could be implemented at T_{25}. Structural measures would create a control point for the tubenose goby at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions. The ANSTP would also supply the

GLMRIS locks with ANS-treated water. 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 discharge.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to inactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, addresses the eggs, larvae, and fry of tubenose goby that could passively drift into the lock chamber and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream.

The electric barrier is expected to address the transfer of tubenose goby. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed smooth-surfaced U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for tubenose goby prior to its discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to Brandon Road Lock and Dam. Cal-Sag Channel water would be treated for tubenose goby by the ANSTP prior to discharge into the Mississippi River Basin side of the control point. The ANSTP, GLMRIS lock, and electric barrier are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Control Technologies without a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures include the construction of an ANSTP, GLMRIS Lock and electric barrier at Alsip, Illinois.

The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. According to Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The electric barrier is expected to control the downstream passage of the tubenose goby.

The GLMRIS Lock is expected to address the passage of tubenose goby eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the tubenose goby from transferring. Research needs would include modeling, laboratory testing, and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. Overall, uncertainty is high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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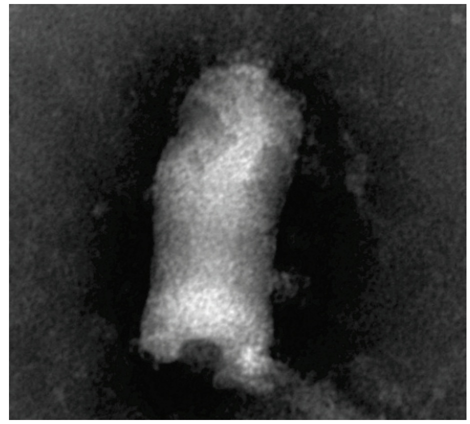
Zagarese, H.E., and C.E. Williamson. 2001. The implications of solar UV radiation exposure for fish and fisheries. *Fish and Fisheries*, vol. 2, no. 3, pp. 250–260.

E.3.2.5 Virus

E.3.2.5.1 Viral Hemorrhagic Septicemia (*Novirhabdovirus* sp.)



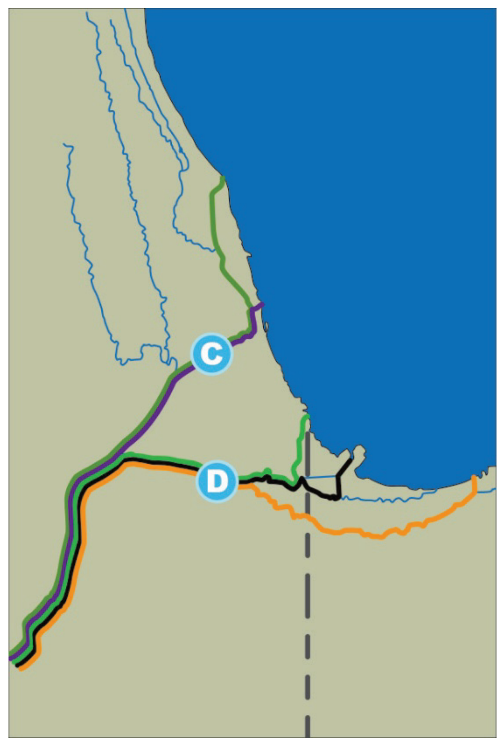
MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Control Technologies without a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the VHSv.



PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative does not affect the existence of the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of viral hemorrhagic septicemia (VHSv) from natural dispersion through aquatic pathways at the Chicago Area Waterway System (CAWS).

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from human-mediated transport through aquatic pathways.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species.

d. ***Existing Physical Human/Natural Barriers***
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an aquatic nuisance species (ANS) treatment plant (ANSTP), a Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock, and electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of VHSv at the CAWS by human-mediated transport or natural dispersion. VHSv was reported in Lake Michigan near Waukegan in Illinois, and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: VHSv was reported in Lake Michigan near Waukegan, Illinois, and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009).

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan. There are no barriers to the movement of this species by boat, current, or host fish.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois, and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: VHSv is considered to be established in Lake Michigan and was documented offshore of the Waukegan and Winthrop harbors in Illinois (section 2e of the Nonstructural Risk Assessment). Its ability to spread rapidly in the Great Lakes has been documented.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois, and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and an electric barrier.

The purpose of the ANSTP is to remove ANS from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv organisms typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. The species would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, it is expected that the turbidity of the CSSC at the Stickney, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, is expected to address VHSv that could passively drift into the lock chamber in contaminated water or infected fish and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock’s pump-driven filling and emptying systems would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. VHSv is small: its size is 170–180 nm length by 60–70 nm width (Skall et al. 2005; Elsayed et al. 2006), and it may adhere to vessel hulls that pass through contaminated water. The GLMRIS Lock would not address the passage of VHSv due to attachment to vessel hulls because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of VHSv.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of VHSv through the GLMRIS Lock by temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of VHSv through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the

human-mediated transport of this species via hull-fouling because the lock does not dislodge attached organisms from vessel hulls.
T_{50}: See T_0.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Stickney, Illinois.
The electric barrier would have no effect on the passage of VHSv. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of VHSv through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms.
Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of VHSv passing through the aquatic pathway. Therefore, the probability of passage remains high.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of VHSv through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of VHSv via temporary attachment to vessel hulls. Overall, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv from natural dispersion through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv from human-mediated transport through aquatic pathways at the CAWS.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_{25}. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Stickney, Illinois. However, these structural measures are not expected to affect the arrival of VHSv at the CAWS by human-mediated transport or natural dispersion. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: VHSv was reported in Lake Michigan near Waukegan, Illinois, and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009).

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_{25}. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan, Illinois. There are no barriers to the movement of this species by boat, current, or host fish.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: VHSv is considered to be established in Lake Michigan and was documented offshore of the Waukegan and Winthrop harbors in Illinois (section 2e of the Nonstructural Risk Assessment). Its ability to spread rapidly in the Great Lakes has been documented.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0–T_{50} : HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Stickney, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and an electric barrier.

The purpose of the ANSTP is to remove ANS from Chicago Sanitary and Ship Canal water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv organisms typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. The species would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, it is expected that the turbidity of the CSSC at the Stickney, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Stickney, Illinois, is expected to address VHSv that could passively drift into the lock chamber in contaminated water or infected fish and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying systems would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. VHSv is small: its size is 170–180 nm length by 60–70 nm width (Skall et al. 2005; Elsayed et al. 2006), and it may adhere to vessel hulls that pass through contaminated water. The GLMRIS Lock would not address the passage of VHSv due to attachment to vessel hulls because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Stickney, Illinois. The electric barriers would have no effect on the natural dispersion of VHSv.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Electric Barrier Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of VHSv through the GLMRIS Lock by temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of VHSv through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via hull-fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_0.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Stickney, Illinois.

The electric barrier would have no effect on the passage of VHSv. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of VHSv through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of VHSv passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of VHSv through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of VHSv via temporary attachment to vessel hulls. Overall, the uncertainty remains low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of VHSv at the CAWS by human-mediated transport or natural dispersion. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan. There are no barriers to the movement of this species by boat, current, or host fish.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: VHSv is considered to be established in Lake Michigan and was documented offshore of the Waukegan and Winthrop harbors in Illinois (section 2e). Its ability to spread rapidly in the Great Lakes has been documented.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is likely already arrived at the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and an electric barrier.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv organisms typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. The species would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address VHSv that could passively drift into the lock chamber in contaminated water or infected fish and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying systems would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. VHSv is small: it is 170–180 nm length by 60–70 nm width (Skall et al. 2005; Elsayed et al. 2006), and it may adhere to vessel hulls that pass through contaminated water. The GLMRIS Lock would not address the passage of VHSv due to attachment to vessel hulls because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of VHSv.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of VHSv through the GLMRIS Lock by temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of VHSv through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via hull-fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of VHSv. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of VHSv through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of VHSv passing through the aquatic pathway via human-mediated transport. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of VHSv through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of VHSv via temporary attachment to vessel hulls. Overall, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative would not affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, and electric barrier at Alsip, Illinois. However, these structural measures are not expected to affect the arrival of VHSv at the CAWS by human-mediated transport or natural dispersion. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan, Illinois. There are no barriers to the movement of this species by boat, current, or host fish.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: VHSv is considered to be established in Lake Michigan and was documented offshore of the Waukegan and Winthrop harbors in Illinois, but has not yet been reported from southern Lake Michigan.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0–T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, GLMRIS Lock, and electric barrier.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv organisms typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. The species would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address VHSv that could passively drift into the lock chamber in contaminated water or infected fish and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying systems would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. VHSv is small: its size is 170–180 nm length by 60–70 nm width (Skall et al. 2005; Elsayed et al. 2006), and it may adhere to vessel hulls that pass through contaminated water. The GLMRIS Lock would not address the passage of VHSv due to attachment to vessel hulls because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of VHSv.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of VHSv through the GLMRIS Lock by temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of VHSv through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via hull-fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_0.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measure would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of VHSv. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of VHSv through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of VHSv passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of VHSv through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of VHSv via temporary attachment to vessel hulls. Overall, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM CONTROL TECHNOLOGIES WITHOUT A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

Mid-system Control Technologies without a Buffer Zone Rating 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	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	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.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Alsip, Illinois; however, these structural measures are not expected to affect the arrival of VHSv at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.
T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), and this could affect the virulence, spread, or abundance of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan, Illinois. There are no barriers to the movement of this species by boat, current, or host fish.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: VHSv is considered to be established in Lake Michigan and was documented offshore of the Waukegan and Winthrop harbors in Illinois (section 2e of the Nonstructural Risk Assessment). Its ability to spread rapidly in the Great Lakes has been documented.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: HIGH**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of an ANSTP, a GLMRIS Lock, and an electric barrier.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations, and supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). VHSv organisms typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. The species would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The GLMRIS Lock at Alsip, Illinois, is expected to address VHSv that could passively drift into the lock chamber in contaminated water or infected fish and then be transported downstream of the lock. After a vessel enters a lock and the sector gates close, the lock's pump-driven filling and emptying systems would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The flushing operation would be conducted for lockages of vessels traveling both upstream and downstream. VHSv is small: its size is 170–180 nm length by 60–70 nm width (Skall et al. 2005; Elsayed et al. 2006), and it may adhere to vessel hulls that pass through contaminated water. The GLMRIS Lock would not address the passage of VHSv due to attachment to vessel hulls because the lock does not dislodge attached organisms from hulls.

Electric barriers would be constructed upstream and downstream of the GLMRIS Lock at Alsip, Illinois. The electric barriers would have no effect on the natural dispersion of VHSv.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of VHSv through the GLMRIS Lock by temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Control Technologies without a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of VHSv through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via temporary attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via hull-fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_0.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Control Technologies without a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Control Technologies without a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Control Technologies without a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, and an electric barrier at Alsip, Illinois.

The electric barrier would have no effect on the passage of VHSv. The GLMRIS Lock and ANSTP are expected to control the natural dispersion of VHSv through the aquatic pathway. However, these ANS Controls are not expected to control the human-mediated transport of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms.

Overall, the Mid-system Control Technologies without a Buffer Zone Alternative would not reduce the likelihood of VHSv passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Control Technologies without a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion of VHSv through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of VHSv via temporary attachment to vessel hulls. Overall, the uncertainty remains low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

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