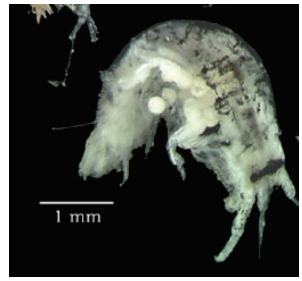
E.6 MID-SYSTEM HYDROLOGIC SEPARATION

E.6.1 ANS Potentially Invading the Great Lakes Basin

E.6.1.1 Crustaceans

E.6.1.1.1 Scud (*Apocorophium lacustre*)



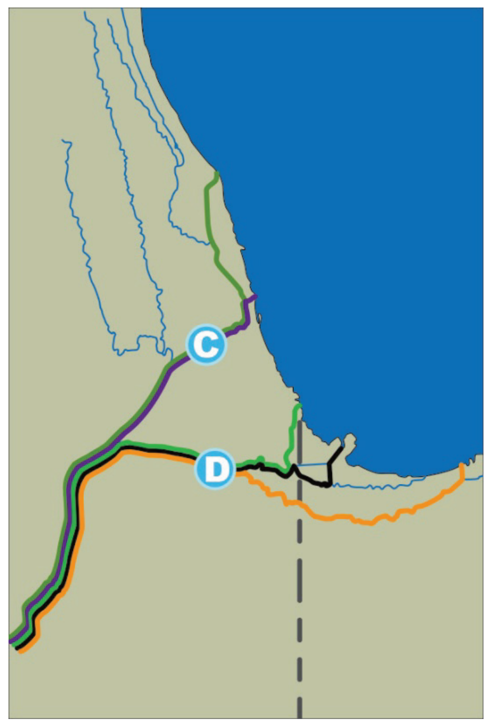
This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies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

Mid-system Hydrologic Separation Alternative Measures

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

[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 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 ANSTP is not designed to treat Mississippi River Basin water, and, therefore, has no impact on the *A. lacustre*'s probability ratings.



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
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 cell indicates 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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *A. lacustre*.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an Aquatic Nuisance Species Treatment Plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal

(CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* from natural dispersion through aquatic pathways to the Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* from human-mediated transport through aquatic pathways to the Brandon Road Lock and Dam.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Mississippi River Basin.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of *A. lacustre* at the Brandon Road Lock and Dam. 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). Hence, the species is likely at or close to the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution or reduce its probability of arrival at the Brandon Road Lock and Dam.

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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 the Brandon Road Lock and Dam in the Illinois River (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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 the Brandon Road Lock and Dam in the Illinois River (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-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 Hydrologic Separation 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, crawling, and passive drift) of *A. lacustre* through aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.
The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.
The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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.

Overall, the Mid-system Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion or 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway to the WPS. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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* which originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *A. lacustre* 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	Low	Low
Mid-system Hydrologic Separation 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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *A. lacustre*.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an ANSTP, and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam 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 Hydrologic Separation 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 moved through several locks as it moved northward from the lower Mississippi River Basin.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Stickney, Illinois. However, the physical barrier is not

expected to control the arrival of *A. lacustre* at the CAWS. 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). 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 Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways to Brandon Road Lock and Dam. 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 in the Illinois River (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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 in the Illinois River (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-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 Hydrologic Separation 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, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is not expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

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 Mississippi River Basin, suggesting that the locks are not a barrier. The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway to the CRCW. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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. Overall, the Mid-system Hydrologic Separation Alternative's high probability of passage 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *A. lacustre* 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_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 Hydrologic Separation 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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *A. lacustre*.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated

water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* from human-mediated transport through aquatic pathways to the Brandon Road Lock and Dam.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 are between the current location of *A. lacustre* and the Calumet Harbor. However, this species is at or close to the pathway and moved through several locks as it moved northward from the lower Mississippi River Basin.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *A. lacustre* at the CAWS. 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 in the Illinois River (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 Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 in the Illinois River (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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 in the Illinois River (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-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 Hydrologic Separation 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, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *A. lacustre* to the Brandon Road Lock and Dam. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

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 Mississippi River Basin, which suggests that the locks are not a barrier.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway to Calumet Harbor. The physical barrier is expected to control the natural transport and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting it in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *A. lacustre* 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	Low	Low
Mid-system Hydrologic Separation 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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is low.

T_{50}: See T_0.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Medium	–	***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

T_0: 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 Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for *A. lacustre*.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the

Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *A. lacustre* at the Brandon Road Lock and Dam. 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 in the Illinois River (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 Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 in the Illinois River (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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways to the Brandon Road Lock and Dam. 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 in the Illinois River (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}: MEDIUM-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 Hydrologic Separation 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, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois. This alternative includes the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

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 Hydrologic Separation 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 Hydrologic Separation Rating[a]	Low	Medium	***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 Hydrologic Separation 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 Hydrologic Separation 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}. The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 *A. lacustre*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *A. lacustre* 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 Hydrologic Separation 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 control 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}: The Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *A. lacustre*.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the

Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* from natural dispersion to the Brandon Road Lock and Dam through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* to the Brandon Road Lock and Dam 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 Hydrologic Separation 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 Mississippi River Basin.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *A. lacustre* at the Brandon Road Lock and Dam. 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 in the Illinois River (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 Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways to the Brandon Road Lock and Dam. 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 in the Illinois River (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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *A. lacustre* 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 in the Illinois River (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}: MEDIUM-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 Hydrologic Separation 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, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway).

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway to the BSBH. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

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 Hydrologic Separation 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 Hydrologic Separation Rating[a]	Low	Medium	***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 Hydrologic Separation 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 Hydrologic Separation 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}: The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Great Lakes Basin 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 *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *A. lacustre* 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 Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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

NBIC (National Ballast Information Clearinghouse). 2012. NBIC Online Database. Electronic publication. Smithsonian Environmental Research Center and United States Coast Guard. http://invasions.si.edu/nbic. Accessed April 20, 2012.

USACE (U.S. Army Corps of Engineers). 2011. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System.

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.6.1.2 Fish

E.6.1.2.1 Bighead Carp (*Hypophthalmichthys nobilis*)

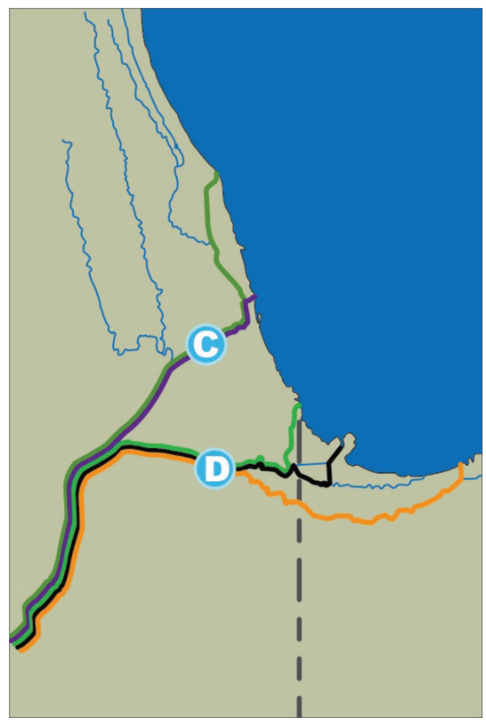
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 T_{25}.

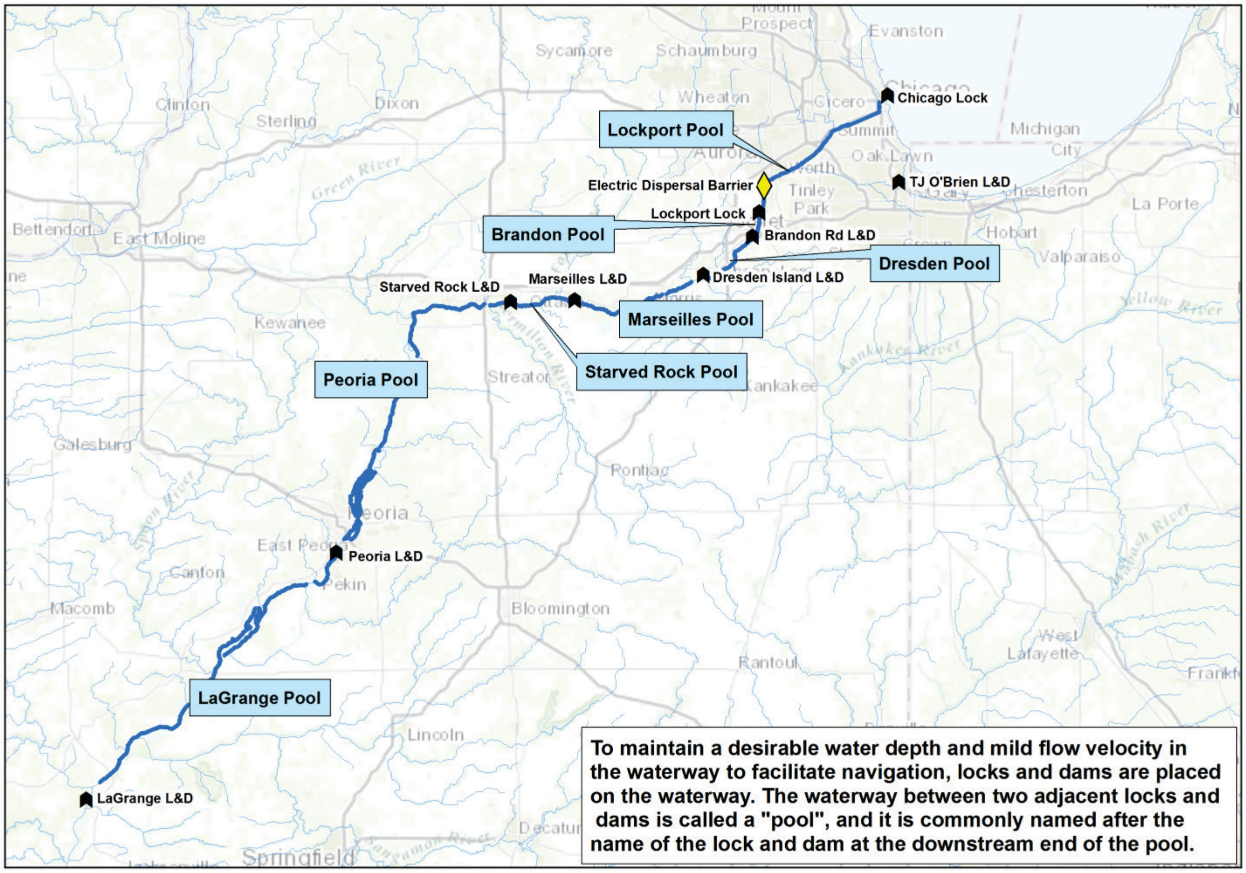
Mid-system Hydrologic Separation Alternative Measures

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

[a] Control Points (C) and (D) include an 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 ANSTP 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship

Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.

T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp from natural dispersion through aquatic pathways to the Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp from human-mediated transport through aquatic pathways to the Brandon Road Lock and Dam. Human-mediated transport is not needed for this species to arrive at the pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative, which contains nonstructural measures that could be implemented at T_0, is not expected to affect the current and potential abundance and reproductive capacity. Controlled harvest and overfishing measures have resulted in the removal of more than 1.3 million pounds of Asian carp from the Illinois River from 2010 to 2012 (ACRCC 2013). The bighead carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that bighead carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.

T_{10}: See T_0.

T_{25}: See T_0. Reproductive capacity would remain the same but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, maintain abundance at a sustained level.
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 to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the Chicago Area Waterway System (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 Hydrologic Separation Alternative is not expected to affect the distance from the pathway for the bighead carp.
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 Hydrologic Separation Alternative is not expected to affect the suitability of habitat for the bighead carp.
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 Hydrologic Separation 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 the Lockport Pool upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures are not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation 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 bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: Bighead carp actively swim and do not require humans for dispersal. There is no vessel traffic through the pathway, and, therefore, no potential for bighead carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. However, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the physical barrier.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat in 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the 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 the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of the bighead carp 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 control the passage of the bighead carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the bighead carp through the aquatic pathway. The physical barrier is expected to control the passage of the bighead carp up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, uncertainty is 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi

River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp from natural dispersion through aquatic pathways to the Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp from human-mediated transport through aquatic pathways to the Brandon Road Lock and Dam.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the current and potential abundance and reproductive capacity. Nonstructural measures such as controlled harvest and overfishing measures have resulted in the removal of more than 1.3 million pounds of Asian carp from the Illinois River between 2010 and 2012 (ACRCC 2013). The bighead carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that bighead carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.
T_{10}: See T_0.
T_{25}: See T_0. Reproductive capacity would remain the same, but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, maintain abundance at a sustained level.
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 to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See $T_{0.}$

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation Alternative is not expected to affect the distance from the pathway for the bighead carp.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the bighead carp.

T_{10}: See T_0.

T_{25}: See $T_{0.}$

T_{50}: See $_0$.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Hydrologic Separation 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 at the Lockport Pool upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the

Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Bighead carp have been captured in the pathway.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation 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 bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

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

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through

the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the physical barrier.
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 Hydrologic Separation Alternative is not expected to affect habitat suitability for bighead carp in the aquatic pathway.
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 Hydrologic Separation 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 Hydrologic Separation Alternative contains nonstructural measures that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the 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 Hydrologic Separation 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 a physical barrier and an ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.
The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of the bighead carp 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 control the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the passage of the bighead carp up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this

treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the current and potential abundance and reproductive capacity. Nonstructural measures such as controlled harvest and overfishing measures have resulted in the removal of more than 1.3 million pounds of Asian carp from the Illinois River between 2010 and 2012 (ACRCC 2013). The bighead carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that bighead carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.
T_{10}: See T_0.
T_{25}: See T_0. Reproductive capacity would remain the same but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, maintain abundance at a sustained level.

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 to the Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation Alternative is not expected to affect the distance from the pathway for the bighead carp.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the bighead carp.

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 Hydrologic Separation 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 the Lockport Pool upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The

bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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_{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 Hydrologic Separation 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 bighead carp through the aquatic pathway.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

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

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of the bighead carp 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 control the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the passage of the bighead carp up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty of passage is reduced from high to low.

T_{50}: See T_{10}.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this

treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the current and potential abundance and reproductive capacity. Nonstructural measures such as controlled harvest and overfishing measures have resulted in the removal of more than 1.3 million pounds of Asian carp from the Illinois River between 2010 and 2012 (ACRCC 2013). The bighead carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that bighead carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.
T_{10}: See T_0.
T_{25}: See T_{10}. Reproductive capacity would remain the same but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, maintain abundance at a sustained level.
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 to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at the CAWS. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the suitability of the 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 Hydrologic Separation 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 the Lockport Pool upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the

Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating
T_0: Bighead carp have been captured in the pathway.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation 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 bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. However, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

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

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat.

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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that can be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois. This alternative includes the construction of a physical barrier and an ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of the bighead carp 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 control the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to affect the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the passage of the bighead carp up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty of passage is reduced from high to 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this

treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the current and potential abundance and reproductive capacity. Nonstructural measures such as controlled harvest and overfishing measures have resulted in the removal of more than 1.3 million pounds of Asian carp from the Illinois River between 2010 and 2012 (ACRCC 2013). The bighead carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that bighead carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.
T_{10}: See T_0.
T_{25}: See T_0. Reproductive capacity would remain the same but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, maintain abundance at a sustained level.
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 to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 at the Lockport Pool upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the

Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating
T_0: Bighead carp have been captured in the pathway.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, 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 Hydrologic Separation 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 bighead carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}. **T_{10}:** See the Nonstructural Risk Assessment for this species.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat.

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 Hydrologic Separation 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 Hydrologic Separation Alternative contains nonstructural measures that can be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, theMid-system Hydrologic Separation Alternative is expected to reduce 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of bighead carp 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 control the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The physical barrier is expected to control the passage of the bighead carp up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty of passage is reduced from high to low, given that the species has not already passed through the pathway.

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.6.1.2.2 Silver Carp (*Hypophthalmichthys molitrix*)

MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

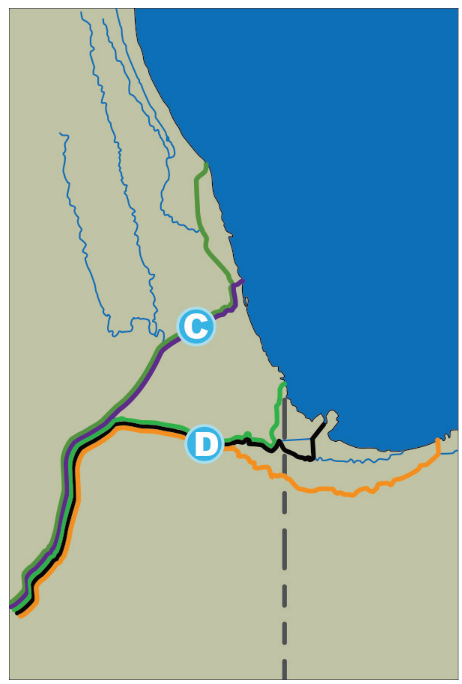
This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state and federal agencies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

Mid-system Hydrologic Separation Alternative Measures

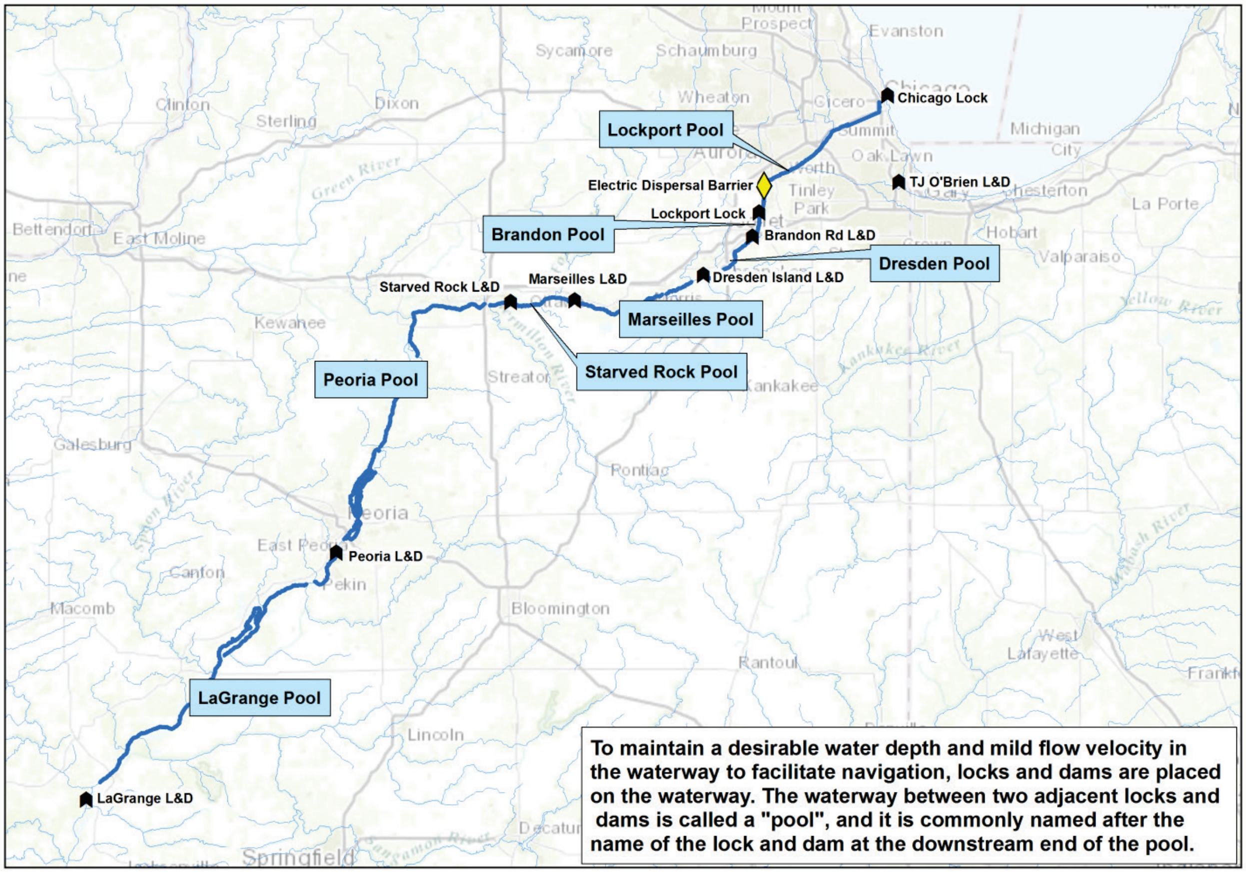
Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Calumet Harbor	Nonstructural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

[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 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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 RISK OF ESTABLISHMENT/UNCERTAINTY

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

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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**
Silver carp are active swimmers. The expansion rate of the silver carp is 33.18 km/yr (20.62 river miles/yr) (Jerde et al. 2010).

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for silver carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
Silver carp actively swim and do not require humans for dispersal. There is no vessel traffic through the pathway and therefore no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for silver carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways. Human-mediated transport is not needed for this species to arrive at the pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity. Controlled harvest and overfishing measures have resulted in the removal of over 1.3 million pounds of Asian carp from the Illinois River from 2010 to 2012 (ACRCC 2013). The silver carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007) and federal and state agencies have implemented components of the *National Management and*

Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that silver carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.

T_{10}: See T_0.

T_{25}: See T_0. Reproductive capacity would remain the same, but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, maintain abundance at a sustained level.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movement of the silver carp from its current position and the Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of silver carp at the Brandon Road Lock and Dam. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have 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 Hydrologic Separation Alternative is not expected to affect the distance from the pathway for the silver carp.

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 Hydrologic Separation Alternative is not expected to affect the suitability of habitat for the silver carp.

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 Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been captured in the Dresden Island Pool, within 4 mi of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately; however, these measures are not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam.

In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway.

Overall, the probability of adult silver carp having arrived at the pathway is 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the Rock Run Rookery Preserve Lake, but there have been no observations upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of silver carp at the pathway. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, the uncertainty remains none.

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

T_{25}: See T_{10}.

T_{50}: See T_{10}.

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 Hydrologic Separation 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 silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: Silver carp actively swim and do not require humans for dispersal. There is no vessel traffic through the pathway and therefore no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation 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 physical barrier is expected to control the vessel-

mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).
T_{50}: See T_{25}.

c. ***Existing Physical Human/Natural Barriers***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.
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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat in 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver

carp through the aquatic pathway. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially transporting silver carp eggs, larvae. and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage for the silver carp 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 control the passage of the silver carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the silver carp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event

exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, uncertainty is 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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 RISK OF ESTABLISHMENT/UNCERTAINTY

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

Evidence for Probability Rating

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the

Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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
Silver carp are active swimmers. The expansion rate of the silver carp is 33.18 km/yr (20.62 river miles/yr) (Jerde et al. 2010).
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam via human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity. Controlled harvest and overfishing measures have resulted in the removal of over 1.3 million pounds of Asian carp from the Illinois River between 2010 and 2012 (ACRCC 2013). The silver carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that silver carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.
T_{10}: See T_0.

T_{25}: See T_0. Reproductive capacity would remain the same, but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, would maintain abundance at a sustained level.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movement of the silver carp from its current position into the CAWS. The silver carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of silver carp at the Brandon Road Lock and Dam. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have 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 Hydrologic Separation Alternative is not expected to affect the distance from the pathway for the silver carp.
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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the silver carp.
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 Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been captured in the Dresden Island Pool, within 4 mi of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways.
In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the Rock Run Rookery Preserve Lake, but there have been no observations upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation 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 silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation 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 physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the physical barrier.
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 Hydrologic Separation Alternative is not expected to affect habitat suitability for the silver carp 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	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative contains nonstructural measures that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially transporting silver carp eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of the silver carp 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 control the passage of the silver carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to affect the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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 RISK OF ESTABLISHMENT/UNCERTAINTY

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

Evidence for Probability Rating

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated

water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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
Silver carp are active swimmers. The expansion rate of the silver carp is 33.18 km/yr (20.62 river miles/yr) (Jerde et al. 2010).

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
Silver carp actively swim and do not require humans for dispersal. There is no vessel traffic through the pathway and therefore no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity. Controlled harvest and overfishing measures have resulted in the removal of over 1.3 million pounds of Asian carp from the Illinois River from 2010 to 2012 (ACRCC 2013). The silver carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that silver carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.

T_{10}: See T_0.
T_{25}: See T_0. Reproductive capacity would remain the same, but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, would maintain abundance at a sustained level.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movements of the silver carp from its current position into the CAWS. The silver carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of silver carp at the Brandon Road Lock and Dam. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have 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 Hydrologic Separation Alternative is not expected to affect the distance from the pathway for the silver carp.
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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the silver carp.
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 Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been captured in the Dresden Island Pool, within 4 mi of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the Rock Run Rookery Preserve Lake, but there have been no observations upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation 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 silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation 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 physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

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

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially

transporting silver carp eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of silver carp 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 control the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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 RISK OF ESTABLISHMENT/UNCERTAINTY

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

Evidence for Probability Rating

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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
Silver carp are active swimmers. The expansion rate of the silver carp is 33.18 km/yr (20.62 river miles/yr) (Jerde et al. 2010).

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
Silver carp actively swim and do not require humans for dispersal. There is no vessel traffic through the pathway and therefore no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity. Controlled harvest and overfishing measures have resulted in the removal of over 1.3 million pounds of Asian carp from the Illinois River from 2010 to 2012 (ACRCC 2013). The silver carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007), and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that silver carp remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.

T_{10}: See T_0.

T_{25}: See T_0. Reproductive capacity would remain the same, but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, would maintain abundance at a sustained level.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movements of the silver carp from its current position into the CAWS. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of silver carp at the CAWS. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat.

T_{10}: See T_0.

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 Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been captured in the Dresden Island Pool, within 4 mi of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the Rock Run Rookery Preserve Lake, but there have been no observations upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation 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 silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for silver carp at Alsip, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation 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 physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

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

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat.

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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that can be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially

transporting silver carp eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage of silver carp 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 control the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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: 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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 RISK OF ESTABLISHMENT/UNCERTAINTY

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

Evidence for Probability Rating

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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
Silver carp are active swimmers. The expansion rate of the silver carp is 33.18 km/yr (20.62 river miles/yr) (Jerde et al. 2010).
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
Silver carp actively swim and do not require humans for dispersal. There is no vessel traffic through the pathway and therefore no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the silver carp at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity. Controlled harvest and overfishing measures have resulted in the removal of over 1.3 million pounds of Asian carp from the Illinois River from 2010 to 2012 (ACRCC 2013). The silver carp has been listed as an injurious fish species under the Lacey Act (Federal Register 2007) and federal and state agencies have implemented components of the *National Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007). However, ongoing barrier defense monitoring indicates that silver carp

remain abundant in the Illinois River (Wyffels et al. 2013) at the current level of harvest, regulation, and management.

T_{10}: See T_0.

T_{25}: See T_{10}. Reproductive capacity would remain the same, but would no longer result in an exponential population growth as natural constraints, such as food and habitat availability, would maintain abundance at a sustained level.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None. There are no barriers to movements of the silver carp from its current position into the CAWS. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of silver carp at the Brandon Road Lock and Dam. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat.

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

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 Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been captured in the Dresden Island Pool, within 4 mi of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the Rock Run Rookery Preserve Lake, but there have been no observations upstream of the Brandon Road Lock and Dam.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways. In the spring of 2013, 60 adult silver carp were captured in the Rock Run Rookery Preserve Lake, a backwater in the Dresden Island Pool, 4 mi downstream of the Brandon Road Lock and Dam (Monitoring and Response Working Group [MRWG] 2013). Therefore, the silver carp have arrived at the pathway. Overall, the uncertainty remains none.

T_{10}: See T_0 and the Nonstructural Risk Assessment for this species.
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 Hydrologic Separation 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 silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam 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 Hydrologic Separation 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 physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.
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 Hydrologic Separation Alternative is not expected to affect the suitability of the habitat.
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 Hydrologic Separation 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 Hydrologic Separation Alternative contains nonstructural measures that can be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Lock and Dam is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.
The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially

transporting silver carp eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Medium	High	***Low***	***Low***

[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 control the passage for the silver carp 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 control the passage of the silver carp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the uncertainty remains high.

T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is 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: 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.6.2 ANS Potentially Invading the Mississippi River Basin

E.6.2.1 Algae

E.6.2.1.1 Grass Kelp (*Enteromorpha flexuosa*)

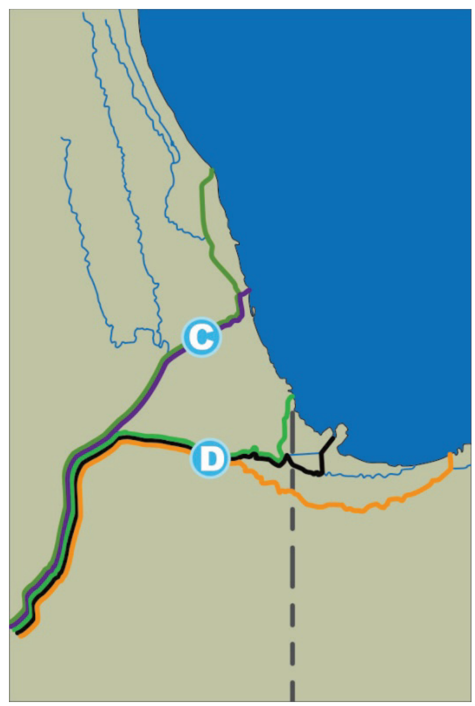
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 Hydrologic Separation Alternative Measures

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

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



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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

b. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 spread through aquatic pathways. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach may be used to determine where to target nonstructural control measures, in particular, 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 a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Hydrologic Separation 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 spread through aquatic pathways. Agency monitoring may be used to locate areas where *E. flexuosa* is established. Additionally, 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 is expected to affect the habitat suitability for this species at current infestations and reduce its ability to establish near CAWS. Overall, the Mid-system Hydrologic Separation Alternative is expected to affect the current abundance and distribution of *E. flexuosa*.

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 Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of *E. flexuosa* at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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 discussion on how nonstructural measures may impact the distance from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to limit the movement of *E. flexuosa* 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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, that are expected to affect 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and that are expected to affect the arrival of *E. flexuosa* from natural spread through aquatic pathways at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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). Nonstructural measures would include agency monitoring to locate areas where *E. flexuosa* is established. Additionally, 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 the abundance of *E. flexuosa.* Data and 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 Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the 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 Hydrologic Separation 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_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	Medium	***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.

The Mid-system Hydrologic Separation 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 record of this species was 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on the abundance of *E. flexuosa* 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*. Overall, 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 affect 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-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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to the 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic conditions similar to the current conditions .

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet radiation (UV) 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). *E. flexuosa* filaments and reproductive spores range in size from 0.16 µm to 3.6 mm (Hill 2001) and 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 Metropolitan Water Reclamation District of Greater Chicago between 2007 and 2011, it is expected that the turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney 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 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) *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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat CSSC water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce 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_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 Hydrologic Separation 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 Hydrologic Separation 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 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. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on *E. flexuosa*; however, there are reports on other algal species, including other species of green algae (chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure that ranged from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller sized and filamentous algae) lost 30% to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant to or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated impacts on photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* 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	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 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 pathway. *E. flexuosa* is considered a marine species, but it can tolerate freshwater habitats in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and 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 the abundance of *E. flexuosa* 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*. Flow within the

system is downstream and is expected to transport the species toward the Mississippi River basin. Therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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, and length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP, and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways at the 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and are expected to affect the arrival of *E. flexuosa* from natural dispersion and human-mediated transport through aquatic pathways at the CAWS. 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, algaecides. In addition, the implementation of a ballast/bilge-water exchange, 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 a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* as a result of natural dispersion through aquatic pathways at the CAWS. Nonstructural measures would include agency monitoring, which could 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 its ability to establish near CAWS.

Overall, the Mid-system Hydrologic Separation Alternative is expected to affect the current abundance and distribution of *E. flexuosa*.

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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of *E. flexuosa* at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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 discussion on how nonstructural measures may impact the distance from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to limit the movement of *E. flexuosa* 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 Hydrologic Separation Alternative includes nonstructural measures, such measures as managing nutrient loads to waterways, are expected to 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 Hydrologic Separation Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways in which *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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and are expected to affect the arrival of *E. flexuosa* as a result of natural dispersion through aquatic pathways at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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). 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 the abundance of *E. flexuosa.* Data and 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 Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the 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 Hydrologic Separation 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_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation 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 record of this species was 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on the abundance *of* *E. flexuosa* 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*. Overall, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See the Nonstructural Risk Assessment for this species.

The uncertainty revolving around the effectiveness of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative to control the arrival of *E. flexuosa* at the CAWS is thought to increase with time. Therefore, uncertainty is 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 Hydrologic Separation 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 *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current conditions.

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). *E. flexuosa* filaments and reproductive spores, which range in size from 0.16 µm to 3.6 mm (Hill 2001), 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, 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, it is expected that the turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Nonstructural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Hydrologic Separation 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 the Mid-system Hydrologic Separation Alternative. Nonstructural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce 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_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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that would 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 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. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat CSSC water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on *E. flexuosa*; however, there are reports on other algal species, including other species of green algae (chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation

(2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure that ranged from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller sized and filamentous algae) lost 30% to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant to or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated impacts on photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and 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 the abundance of *E. flexuosa* 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*. Overall, the uncertainty remains medium.

T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.

T_{25} The Mid-system Hydrologic Separation Alternative includes an ANSTP, and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways at the 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and are expected to affect the arrival of *E. flexuosa* as a result of natural dispersion and human-mediated spread through aquatic pathways at the CAWS. 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, 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 a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways at the CAWS. Nonstructural measures would

include agency monitoring to locate areas where *E. flexuosa* is established. Additionally, 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 its ability to establish near CAWS.

Overall, the Mid-system Hydrologic Separation Alternative is expected to affect the current abundance and distribution of *E. flexuosa*.

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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *E. flexuosa* at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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 discussion on how nonstructural measures may impact the distance from pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to limit the movement of *E. flexuosa* 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 Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways that are expected to 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measure that could be implemented at T_0 and are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. The closest to the WPS that *E. flexuosa* has been recorded 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). Nonstructural measures would include agency monitoring 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 the abundance of *E. flexuosa.* Data and 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 Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the 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 Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa* to the CAWS through aquatic pathways; therefore, the probability of arrival is reduced to low.

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	Medium	Medium	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation 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 record of this species was 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on the abundance of *E. flexuosa* 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*. Overall, 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 affect 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-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 Hydrologic Separation 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 *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to the 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from Cal-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 and maintain hydrologic conditions similar to the current conditions.

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). *E. flexuosa* filaments and reproductive spores, which typically range in size from 0.16 µm to 3.6 mm (Hill 2001), 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, 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, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Hydrologic Separation 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 the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce 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_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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that would 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 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. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on *E. flexuosa*; however, there are reports on other algal species, including other species of green algae (chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure that ranged from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller sized and filamentous algae) lost 30% to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant to or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated its impacts on photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, we anticipate that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 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 in which 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 the abundance of *E. flexuosa* 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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, and length of exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.

T_{25} The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and are expected to affect the arrival of *E. flexuosa* as a result of natural dispersion and human-mediated spread through aquatic pathways at the CAWS. 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, 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 a discussion on how nonstructural measures may affect current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS as a result of natural dispersion through aquatic pathways. Nonstructural measures would include agency monitoring 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 its ability to establish near the CAWS.

Overall, the Mid-system Hydrologic Separation Alternative is expected to affect the current abundance and distribution of *E. flexuosa*.

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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival *E. flexuosa* at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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 discussion on how nonstructural measures may impact the distance from pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to limit the movement of *E. flexuosa* 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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which are expected to 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS as a result of natural dispersion through aquatic pathways. The closest to the WPS that *E. flexuosa* has been recorded 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). Nonstructural measures would include agency monitoring to locate areas where *E. flexuosa* is established. Additionally, 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 the abundance of *E. flexuosa.* Data and 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 Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the 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 Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa* to the CAWS through aquatic pathways; therefore, the probability of arrival is reduced to low.

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	Medium	Medium	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation 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 record of this species was 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on the abundance of *E. flexuosa* 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*. Overall, 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 affect 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

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 Hydrologic Separation 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 *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to the 0.2%ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-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 and maintain hydrologic conditions similar to the current conditions.

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). *E. flexuosa* filaments and reproductive spores, which typically range in size from 0.16 µm to 3.6 mm (Hill 2001), 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, 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, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Hydrologic Separation 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 the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce 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_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	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that would 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 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on *E. flexuosa*; however, there are reports on other algal species, including other species of green algae (chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to

UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure that ranged from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller sized and filamentous algae) lost 30% to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant to or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated impacts on photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, we anticipate that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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.

This potential rate of spread of this species 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 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and 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 the abundance of *E. flexuosa* 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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, and length of exposure of UV radiation and whether an additional treatment process is needed to control passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–	***Low(2)***	–

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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.

T_{25} The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE-LOW

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 a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways at the 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and are expected to affect the arrival of *E. flexuosa* as a result of natural dispersion and human-mediated spread through aquatic pathways at the CAWS. 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, 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 a discussion on how nonstructural measures may affect current abundance and reproductive capacity of *E. flexuosa*.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* as a result of natural dispersion

through aquatic pathways at the CAWS. Nonstructural measures would include agency monitoring 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 its ability to establish near CAWS.

Overall, the Mid-system Hydrologic Separation Alternative is expected to affect the current abundance and distribution of *E. flexuosa*.

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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival *E. flexuosa* at the CAWS. The closest to the WPS that *E. flexuosa* has been recorded 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 discussion on how nonstructural measures may impact the distance from pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to limit the movement of *E. flexuosa* 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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which are expected to affect 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0 and that are expected to affect the arrival of *E. flexuosa* at the CAWS as a result of natural dispersion through aquatic pathways. The closest to the WPS that *E. flexuosa* has been recorded 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). Nonstructural measures would include agency monitoring to locate areas where *E. flexuosa* is established. Additionally, 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 the abundance of *E. flexuosa.* Data and 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 Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the 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 Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa* to the CAWS through aquatic pathways; therefore, the probability of arrival is reduced to low.

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	Medium	Medium	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation 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 record was 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on the abundance of *E. flexuosa* 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*. Overall, 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 affect 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

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 Hydrologic Separation 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 *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to the 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-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 and maintain hydrologic conditions similar to the current conditions.

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 greater than 0.75 in. (19.05 mm). *E. flexuosa* filaments and reproductive spores, which typically range in size from 0.16 µm to 3.6 mm (Hill 2001), 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, 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, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Hydrologic Separation 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 the Mid-system Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce 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_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	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on *E. flexuosa*; however, there are reports on other algal species, including other species of green algae (chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis* and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure that ranged from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller sized and filamentous algae) lost 30% to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant to or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated impacts to photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, we anticipate that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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.

The potential rate of spread of this species 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 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 in which industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and 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 the abundance of *E. flexuosa* 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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, and length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.

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.6.2.1.2 Red Algae (*Bangia atropurpurea*)

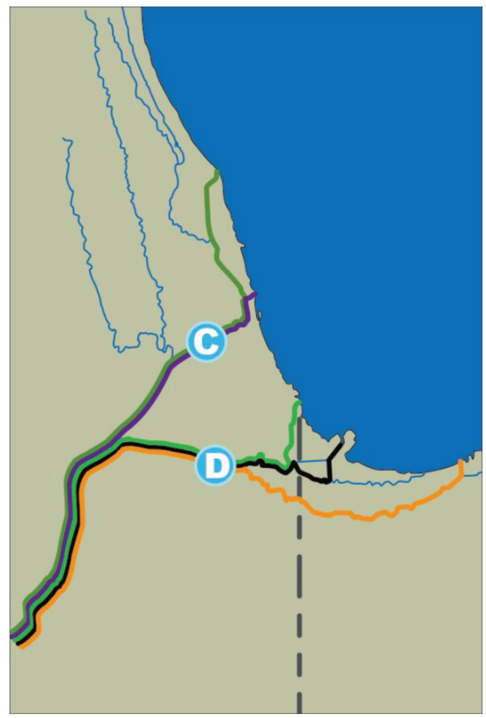
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 time step 25 (T_{25}).

Mid-system Hydrologic Separation Alternative Measures

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

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



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for red algae.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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

c. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae from natural dispersion (i.e., current-driven passage) 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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. 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 expected to be successful because of the prolonged monospore release, which promotes rapid population spread. In addition, the Mid-system Hydrologic Separation Alternative includes 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS. 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect where red algae is able to establish, and hence 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. 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. 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 Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. 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. See the Nonstructural Risk Assessment for this species.
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 Hydrologic Separation 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 red algae through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion of red algae through the aquatic pathway to the Brandon Road Lock and Dam.
The purpose of the ANSTP is to remove aquatic nuisance species (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 and maintain hydrologic conditions similar to the current conditions.

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 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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, 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, 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,it is expected that the turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for red algae prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse

the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water and via hull-fouling would be unable to traverse the barrier. The ANSTP would treat CSSC water for red algae prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 reduce 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_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 Hydrologic Separation Rating	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 Hydrologic Separation 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 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat CSSC water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae including *B. atropurpurea* and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination. There are no specific reports in the literature that identify the effectiveness or dose response of UV radiation on *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts to germination. Based on these findings, it is expected that the UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of red algae 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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 control the passage of the 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 red algae through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for red algae.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae from natural dispersion (i.e., current-driven passage) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterway which could 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not

expected to not control the arrival of red algae at the CAWS. 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect where it is able to establish and hence 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. 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 Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. 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. See the Nonstructural Risk Assessment for this species.

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 Hydrologic Separation 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 red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current conditions.

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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, 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, 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, it is expected that the turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for red algae prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water and via hull-fouling would be unable to traverse the barrier.

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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for red algae prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 reduce 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_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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the

passage for red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat CSSC water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae including *B. atropurpurea* and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination. There are no specific reports in the literature that identify the effectiveness or dose response of UV radiation on *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts on germination. Based on these findings, it is expected that the UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of red algae. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for red algae.
T_{10}: See T_0.
T_{25} The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the

Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae from natural dispersion (i.e., current-driven passage) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS. The species has been observed

in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at Calumet Harbor.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect where it is able to establish and hence 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at Calumet Harbor. 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 Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at Calumet Harbor. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

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 Hydrologic Separation 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 red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of red algae through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-Sag Channel water prior to its 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 the current conditions.

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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter 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, 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, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially

transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier.
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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River basin side of the control point.
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 Hydrologic Separation 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 reduce 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_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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae including *B. atropurpurea*, and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination. There are no specific reports in the literature that identify the effectiveness or dose response of UV radiation on *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts on germination. Based on these findings, it is expected that the UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of red algae through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	***Low***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for red algae.
T_{10}: See T_0.
T_{25} The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, IL. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae from natural dispersion (i.e.,current-driven passage) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as agency monitoring and control methods to manage red algae in the Great Lakes Basin, where it has been documented, are not expected to be successful because of the species' prolonged monospore release, which promotes rapid population growth.
In addition, the Mid-system Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways, which could 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS. 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 Hydrologic Separation Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect where it is able to establish and hence its location in relation to the CAWS.
T_{10}: See T_0.
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 Hydrologic Separation Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at Indiana Harbor. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. 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 Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at Indiana Harbor. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

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 Hydrologic Separation 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 red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-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 and maintain hydrologic conditions similar to the current conditions.

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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, 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, 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, it is expected the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable

to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 reduce 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_0. The discharge of common municipal contaminants, such as nutrients, metals, total dissolved solids, and sewage, may decrease as a result of 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for red algae through the aquatic pathway. Therefore, the 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae including *B. atropurpurea* and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination. There are no specific reports in the literature that identify the effectiveness or dose response of UV radiation on *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts to germination. Based on these findings, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated

transport to the Brandon Road Lock and Dam. 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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.
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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process is needed to control passage of red algae through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	***Low***	***Low***	***Low***	***Low***
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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for red algae.
T_{10}: See T_0.
T_{25} The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to

the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae from natural dispersion (i.e., current-driven passage) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS. 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 Hydrologic Separation Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect where red algae is able to establish and hence 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 Hydrologic Separation Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could 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_0. 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. 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_{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 Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of red algae through aquatic pathways at the CAWS. 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. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

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 Hydrologic Separation 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 red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of red algae through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Cal-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 and maintain hydrologic conditions similar to the current conditions.

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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, 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, 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, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier.

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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Damn. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 reduce 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_0. The discharge of common municipal contaminants, such as nutrients, metals, total dissolved solids, and sewage, may decrease as a result of 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the

passage for red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae including *B. atropurpurea*, and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination. There are no specific reports in the literature that identify the effectiveness or dose response of UV radiation on *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts to germination. Based on these findings, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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.

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 control 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process is needed to control passage of red algae through the ANSTP. Overall, the uncertainty is low.
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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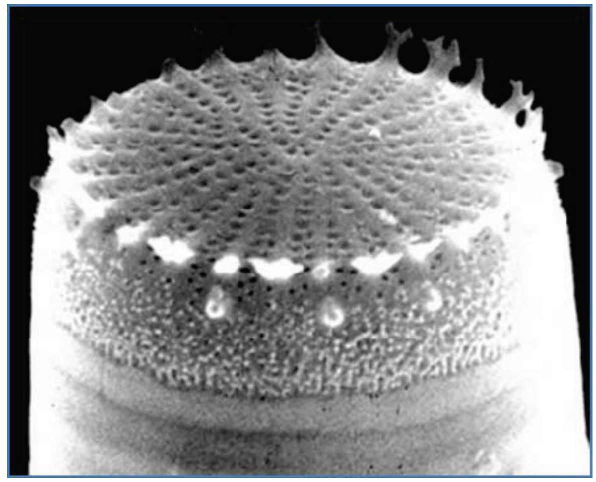
E.6.2.1.3 Diatom (*Stephanodiscus binderanus*)



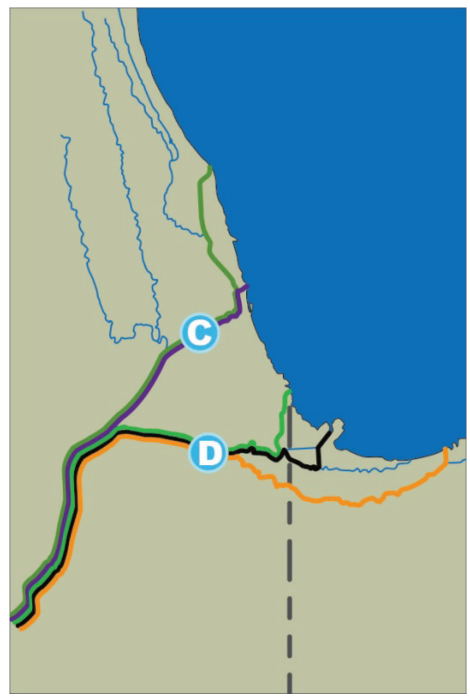
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 Hydrologic Separation Alternative Measures

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

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



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the *S. binderanus*.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an aquatic nuisance species treatment plant (ANSTP), and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algeacides which 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: There are no existing barriers; the species is likely already at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not

expected to control the arrival of *S. binderanus* at the CAWS. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs 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 Hydrologic Separation 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 Hydrologic Separation Alternative, restrictions on nutrient loads to waterways and application of algeacides 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algeacides 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. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). 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	Low	Low	Low	Low
Mid-system Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs 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}. 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 Hydrologic Separation 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 *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic condition similar to the current conditions.

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). *Stephanodiscus binderanus* filaments and reproductive spores which typically have a volume 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately. 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated

transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011a).
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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat CSSC water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation Alternative includes managing nutrient loads to waterways and application of algeacides, 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 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *Stephanodiscus binderanus* and vessels potentially transporting the species in ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* 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	High	High
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 *S. binderanus* 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the *S. binderanus*.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways and application of algeacides which 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. 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 Hydrologic Separation 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 Hydrologic Separation Alternative, restrictions on nutrient loads to waterways and application of algeacides 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algeacides which may reduce the productivity of this species but are not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways . 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. See Nonstructural Alternative Risk Assessment.
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	Low	Low	Low	Low
Mid-system Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. 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_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{10}. 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 Hydrologic Separation 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 *S. binderanus* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam.
The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic condition similar to the current conditions.

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 forms 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). *Stephanodiscus binderanus* filaments and reproductive spores which typically have a volume 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, 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 at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially

transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.
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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes managing nutrient loads to waterways and application of algeacides, 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 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *Stephanodiscus binderanus* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat CSSC water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation for *S. binderanus*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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 *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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the *S. binderanus*.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algeacides which 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp

2011), but this species historically occurs 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 Hydrologic Separation 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 Hydrologic Separation Alternative, restrictions on nutrient loads to waterways and application of algeacides 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways and application of algeacides which may reduce the productivity of this species but they are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. 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. 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	Low	Low	Low	Low
Mid-system Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.

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.

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 Hydrologic Separation 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 *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam.

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 condition similar to the current conditions.

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). *Stephanodiscus binderanus* filaments and reproductive spores which typically have a volume 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels

potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.
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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways and application of algeacides, 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 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP. The physical barrier in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *Stephanodiscus binderanus* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* 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	High	High	High	High
Mid-system Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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 *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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	High	Low	High	Low	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *S. binderanus*.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural spread through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algeacides which 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp

2011), but this species historically occurss 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 Hydrologic Separation 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 Hydrologic Separation Alternative, nonstructural measures such as restrictions on nutrient loads to waterways and application of algeacides 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways and application of algeacides which may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). 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	Low	Low	Low	Low
Mid-system Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.

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.

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 Hydrologic Separation 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 *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic condition similar to the current conditions.

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). *Stephanodiscus binderanus* filaments and reproductive spores which typically have a volume 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., passive drift) 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels

potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. However, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measure such as managing nutrient loads to waterways and application of algeacides, 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 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 Hydrologic Separation 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 Hydrologic Separation 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 Lakefront Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *Stephanodiscus binderanus* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanu*s.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is low.

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 Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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.

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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	High	Low	High	Low	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for *S. binderanus*.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural spread through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algeacides which 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this

species historically occurs 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 Hydrologic Separation 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 Hydrologic Separation Alternative, nonstructural measures such as restrictions on nutrient loads to waterways and application of algeacides 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways and application of algeacides which may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). 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	Low	Low	Low	Low
Mid-system Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. 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}. See the Nonstructural Risk Assessment for this species.

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 Hydrologic Separation 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 *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural disperison of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam.

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 condition similar to the current conditions.

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). *Stephanodiscus binderanus* filaments and reproductive spores which typically have a volume 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, 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 at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Non-structural 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. This alternative is expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways and application of algeacides, 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 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *Stephanodiscus binderanus* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is low.

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 Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

[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.

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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

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.6.2.2 Plants

E.6.2.2.1 Reed Sweetgrass (*Glyceria maxima*)

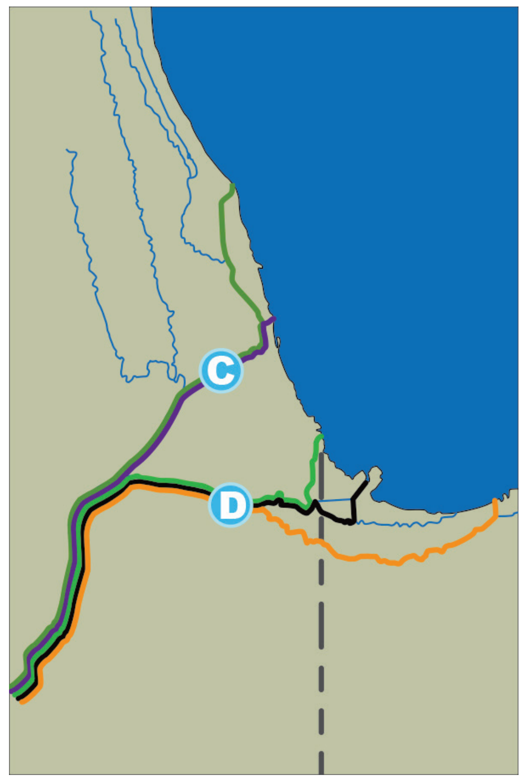
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 Hydrologic Separation Alternative Measures

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

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



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for reed sweetgrass.

T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}

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 on how nonstructural measures may impact the invasion speed of reed sweetgrass.

The Mid-system Hydrologic Separation 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 Waterway System (CAWS). Nonstructural measures include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may impact 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 on how nonstructural measures may impact human-mediated transport.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass by human-mediated transport through aquatic pathways to the CAWS. 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, promotion of the use of anti-fouling hull paints, and laws and regulations are expected to affect 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 this species for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to 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 ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may impact the current abundance and propagule pressure of the species. In addition, nonstructural measures also 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 Hydrologic Separation Alternative includes the construction of a physical barrier and Aquatic Nuisance Species Treatment Plant (ANSTP) at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of reed sweetgrass at the CAWS. 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 for a discussion on how nonstructural measures may impact the distance of reed sweetgrass from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to 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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat 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 Hydrologic Separation 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 Hydrologic Separation 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 (ANS) control methods to manage the species. Once the species is managed, education and outreach could control its future dispersion by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent dispersion by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: See T_0. Implementation of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative is expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways; 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 Hydrologic Separation 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.

Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative are expected to affect the arrival of reed sweetgrass to the WPS pathway for this species. 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 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 which 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}: MEDIUM-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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic condition similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes and Mississippi River Interbasin Study (GLMRIS) aquatic nuisance 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 ANS and other organic matter greater than 0.75 in. (19.05 mm). Reed sweetgrass plants, which typically reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 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 radiation would indiscriminately kill all species entrained in Lake Michigan water that pass through the 0.75-in. screens. The UV disinfection is expected to be effective for Lake Michigan water, which has low turbidity. Lamps, tube materials, ballasts, and other associated design features would be carefully selected to optimize performance and cost.

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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration is included in the ANS treatment process at Stickney 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Alternative Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass 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_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 Hydrologic Separation Rating[a]	Low	Medium	***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 Hydrologic Separation 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 Hydrologic Separation 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}: The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass fragments and seeds and vessels potentially transporting the species in ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the CAWS. The 0.4-in. screens of the ANSTP are expected to control plant fragments but not seeds from entering UV treatment. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that percent seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response of these plants to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass 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	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. . Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of reed sweetgrass through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for reed sweetgrass.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 on how nonstructural measures may impact the invasion speed of reed sweetgrass.

The Mid-system Hydrologic Separation 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 include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which are expected to 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 on how nonstructural measures may impact human-mediated transport.

The Mid-system Hydrologic Separation 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, promotion of the use of anti-fouling hull paints, and laws and regulations are expected to affect the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of reed sweetgrass.

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 the arrival of reed sweetgrass at the CAWS through aquatic pathways.

Nonstructural measures include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may affect the current abundance and propagule pressure of the species. In addition, nonstructural measures would also 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of reed sweetgrass at the CAWS. 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 for a discussion on how nonstructural measures may impact the distance of reed sweetgrass from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to control the species, thereby affecting reed sweetgrass's 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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass in the CAWS.

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 Hydrologic Separation 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 Hydrologic Separation 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 ANS control methods to manage the species. Once the species is managed, education and outreach could control its future dispersion by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent dispersion by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: See T_0. Implementation of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative is expected to affect the arrival for this species at the CAWS through aquatic pathways; 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 Hydrologic Separation 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.

Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Therefore, 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 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 which 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}: MEDIUM-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 Alternative Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of

the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current conditions.

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). Reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration is included in the ANS treatment process at Stickney 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation Rating[a]	Low	Medium	***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 Hydrologic Separation 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 Hydrologic Separation 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}: The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass plant fragments and seeds and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured the rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that percent seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response of these plants to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of reed sweetgrass. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for reed sweetgrass.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 on how nonstructural measures may impact the invasion speed of reed sweetgrass.

The Mid-system Hydrologic Separation 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 include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which are expected to 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 on how nonstructural measures may impact human-mediated transport.

The Mid-system Hydrologic Separation 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 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, promotion of the use of anti-fouling hull paints, and laws and regulations are expected to affect the human-mediated transport of reed sweetgrass to the CAWS aquatic pathway.

c. Current Abundance and Reproductive Capacity

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of reed sweetgrass.

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species and are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways.

Nonstructural measures would include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may affect the current abundance and propagule pressure of the species. In addition, nonstructural measures also include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform to 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of reed sweetgrass at the CAWS. 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 for a discussion on how nonstructural measures may impact the distance of reed sweetgrass from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to control 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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat 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 Hydrologic Separation 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 Hydrologic Separation 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. Nonstructural measures such as 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 ANS control methods to manage the species. Once the species is managed, education and outreach could control its future dispersion by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent dispersion by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: See T_0. Implementation of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative is expected to affect the arrival of reed sweetgrass 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 Hydrologic Separation 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.

Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative 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 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 which 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}: MEDIUM-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 Hydrologic Separation 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 Hydrologic Alternative includes structural measures that would be implemented at T_{25}. The alternative would create a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of

the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam.

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 a hydrologic condition similar to the current conditions.

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). Reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board, 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport because the species and vessels potentially transporting it in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass 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_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 Hydrologic Separation Rating[a]	Low	Medium	***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 Hydrologic Separation 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 Hydrologic Separation 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}: The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass seeds and fragments and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that percent seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response of these plants to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	Medium	Medium
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For 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 reed sweetgrass through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for reed sweetgrass.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 on how nonstructural measures may impact the invasion speed of reed sweetgrass.

The Mid-system Hydrologic Separation 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 ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which are expected to 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 on how nonstructural measures may impact human-mediated transport.

The Mid-system Hydrologic Separation 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 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, promotion of the use of anti-fouling hull paints, and laws and regulations are expected to affect the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of reed sweetgrass.

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species and are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Nonstructural measures would include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may affect the current abundance and propagule pressure of the species. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Additionally, 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of reed sweetgrass at the CAWS. 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 for a discussion on how nonstructural measures may impact the distance of reed sweetgrass from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to 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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat for the 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that would 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 ANS control methods to manage the species. Once the species is managed, education and outreach could control its future dispersion by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent dispersion by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: See T_0. Implementation of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative is expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways; 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 Hydrologic Separation 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.
Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative 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 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 which 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

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of

the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam.

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 condition similar to the current conditions.

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). Reed sweetgrass plants, which typically reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the CAWS. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass.

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	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation 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. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass plant fragments and seeds and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that the percent seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response of these plants to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	High	High
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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.

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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For 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 reed sweetgrass through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***	***Low***
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(2)***	–	***Low(2)***	–

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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for reed sweetgrass.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 on how nonstructural measures may impact the invasion speed of reed sweetgrass.

The Mid-system Hydrologic Separation 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 ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which are expected to 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 on how nonstructural measures may impact human-mediated transport.

The Mid-system Hydrologic Separation 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 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, promotion of the use of anti-fouling hull paints, and laws and regulations are expected to affect the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of reed sweetgrass.

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species and are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Nonstructural measures include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may affect the current abundance and propagule pressure of the species. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Additionally, 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of reed sweetgrass at the CAWS. 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 for a discussion on how nonstructural measures may impact the distance of reed sweetgrass from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to control 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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat 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 Hydrologic Separation 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 Hydrologic Separation 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 ANS control methods to manage the species. Once this species is managed, education and outreach could control its future dispersion by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent dispersion by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: See T_0. 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). Implementation of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative is

expected to affect the arrival of this species at the CAWS through aquatic pathways; 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 Hydrologic Separation Rating[a]	Low	Low	Low	***Low***

[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 as part of the Mid-system Hydrologic Separation Alternative are expected to affect the arrival of reed sweetgrass at the CAWSthrough aquatic pathways . Therefore, uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Implementation of nonstructural measures as part of the Mid-system Hydrologic Separation Alternative by local, state, and federal agencies are expected to slow the arrival of this species through aquatic pathways at the CAWS; therefore, uncertainty is low.

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the

natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam.

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 condition similar to the current conditions.

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). Reed sweetgrass plants, which typically reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-System Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass.
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	Medium	Medium
Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass plant fragments and seeds and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that percent seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response of these plants to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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	High	High
Mid-system Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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.

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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For 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 reed sweetgrass through the ANSTP. Overall, the uncertainty is 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

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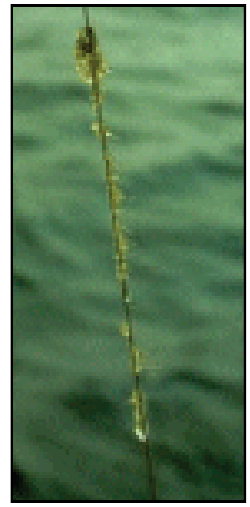
E.6.2.3 Crustaceans

E.6.2.3.1 Fishhook Waterflea (*Cercopagis pengoi*)



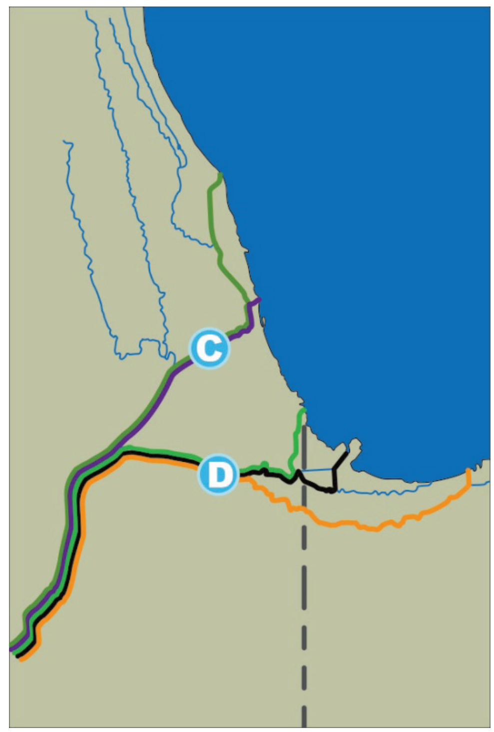
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 time step 25 (T_{25}).

Mid-system Hydrologic Separation Alternative Measures

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

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



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	Medium	***Low***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the fishhook waterflea.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment Plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship

Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea from natural dispersion (i.e., passive drift) 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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of the fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson

et al. 2012). The 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the WPS are uncertain, but this species may be at the WPS. 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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**

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 Hydrologic Separation 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 fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois with construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and it is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic condition similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes Mississippi River Interbasin Study (GLMRIS) aquatic nuisance species (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 ranges between 0.02 to 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), 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 constituents, such as iron, nitrate, and natural organic matter. On the basis of water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels

would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's low probability of passage rating for 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide — alone and in combination) on a range of zooplankton, including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76 to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% killed in all treatments except ultrasound), while cladocerans were the least-affected group (>99% killed only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea 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 Hydrologic Separation 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 control 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 implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of fishhook waterflea through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	Medium	***Low***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the fishhook waterflea.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the

Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea from natural dispersion (i.e., passive drift) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois However, the physical barrier is not expected to control the arrival of fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival for 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). The 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See Nonstructural Alternative Risk Assessment.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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**

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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Stickney, Illinois. This alternative includes the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic condition similar to the current conditions.

The treatment technologies completed at 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 ranges between 0.02 to 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures that which 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative is expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's low probability of passage rating for 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or via hull fouling would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide — alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76 to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% killed in all treatments except ultrasound), while cladocerans were the least-affected group (>99% killed only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea 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 Hydrologic Separation 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 at this time step; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive

river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, there are no data specifically on the effects of UV on the fishhook waterflea. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation on the fishhook waterflea. 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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of fishhook waterflea through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	Medium	***Low***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for fishhook waterflea.
T_{10}: See T_0.

T_{25} The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea from natural dispersion (i.e., swimming and passive drift) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea 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 Hydrologic Separation 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 Calumet Harbor pathway entrance (Benson et al. 2012).
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of fishhook waterflea at the CAWS. The fishhook

waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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

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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam.

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 the hydrologic condition similar to the current conditions.

The treatment technologies completed at 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 ranges between 0.02 to 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, 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway

because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the

passage for the fishhook waterflea through the aquatic pathway. Therefore, the Mid-system Hydrologic Separation Alternative's low probability of passage rating for 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide — alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76 to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% killed in all treatments except ultrasound), while cladocerans were the least-affected group (>99% killed only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea 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 Hydrologic Separation 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 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 implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *fishhook waterflea* through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the fishhook waterflea.

T_{10}: See T_0.

T_{25} The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the fishhook waterflea from natural dispersion (i.e., passive drift) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the fishhook waterflea 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois However, the physical barrier is not expected to control the arrival of fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival for 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). The 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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**

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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that may be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois. This alternative includes the construction of a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam.
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 and maintain the hydrologic condition similar to the current conditions.

The treatment technologies completed at 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 ranges between 0.02 to 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, 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it in ballast and bilge water or via hull fouling

would be unable to traverse the barrier. However, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's low probability of passage rating for 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide — alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76 to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% killed in all treatments except ultrasound), while cladocerans were the least-affected group (>99% killed only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is 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 Hydrologic Separation Rating[a]	Low	Low	***Low***	***Low***

[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.

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 implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier.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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of fishhook waterflea through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, ANS Treatment Plant

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 Hydrologic Separation 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	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the fishhook waterflea.
T_{10}: See T_0.
T_{25} The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea at the CAWS from natural dispersion (i.e., passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the fishhook waterflea through aquatic pathways at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The 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**

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic condition similar to the current conditions.

The treatment technologies completed at 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). The fishhook waterflea, which ranges between 0.02 to 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, 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway.

$_{50}$: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway

because vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the

passage for the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's low probability of passage rating for 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting it in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide — alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76 to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% killed in all treatments except ultrasound), while cladocerans were the least-affected group (>99% killed only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is 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 Hydrologic Separation Rating[a]	Low	Low	***Low***	***Low***

[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.

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 at this time step; therefore, the uncertainty remains low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: Structural measures implemented as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *fishhook waterflea* through the ANSTP. Overall, the uncertainty is 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

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E.6.2.3.2 Bloody Red Shrimp (*Hemimysis anomala*)

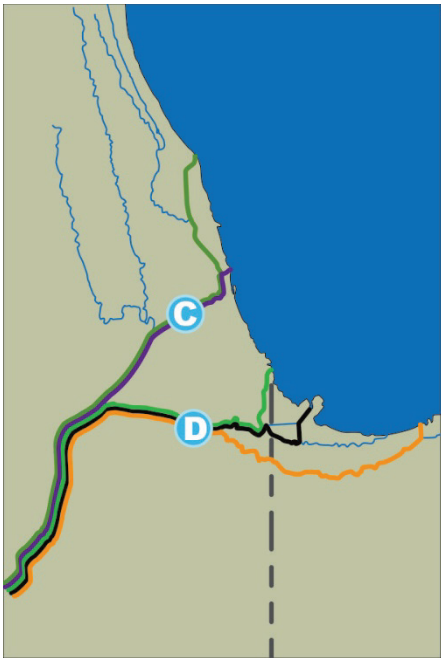
MID-SYSTEM HYDROLOGIC SEPARATION

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 Hydrologic Separation Alternative Measures

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

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



PATHWAY 1

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

MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.

T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an Aquatic Nuisance Species Treatment Plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control 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 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Rating 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 Hydrologic Separation Alternative is not expected to affect the arrival of the bloody red shrimp 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 WPS 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 Hydrologic Separation Rating Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (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 treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes Mississippi River Interbasin Study (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 where 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 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 water at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 the bloody red shrimp prior to discharge into the Mississippi River

Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011a).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels would be unable to traverse the barrier. The ANSTP would treat CSSC water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting it in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the human-mediated transport and natural dispersion of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for bloody red shrimp 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 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating	Medium	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 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 dispersionor human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION ALTERNATIVE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current conditions.

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 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 where 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 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 water at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 the bloody red shrimp prior to discharge into the Mississippi River

Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting the species in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for bloody red shrimp 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 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating	Medium	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 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 dispersionor human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION ALTERNATIVE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: The species was identified as established in Lake Michigan in 2007 (Kipp et al. 2011). It has not yet been identified at the CRCW; however, whether the species has already arrived at the harbor is unknown. Concealment behavior makes the bloody red shrimp difficult to locate during the day, possibly explaining why it was not found earlier in the Great Lakes. The Mid-system Hydrologic Separation 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 Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that could be implemented . Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming or passive drift) of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the

natural dispersion (i.e., swimming or passive drift) of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

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 the current conditions.

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 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 where it would subsequently be pumped through the ANSTP 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected o 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 the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative's high probability of passage rating designated 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois. This alternative includes the construction of a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting the species in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the passage of this species through the CAWS by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for bloody red shrimp 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 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating	Medium	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 the bloody red shrimp through the aquatic pathway by natural dispersionor 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 dispersionor human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION ALTERNATIVE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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.

The Mid-system Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: The species was identified as established in Lake Michigan in 2007 (Kipp et al. 2011). It has not yet been identified at Indiana Harbor; however, whether the species has already arrived at the harbor is unknown. Concealment behavior makes the bloody red shrimp difficult to locate during the day, possibly explaining why it was not found earlier in the Great Lakes.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the

natural disperison (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

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 the current conditions.

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 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, where 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural disperison (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 Hydrologic Separation 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 Hydrologic Separation 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 the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. However, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting the species in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the passage of this species through the aquatic pathway by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for bloody red shrimp 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 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Low	Low	***Low***	***Low***

[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.

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 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION ALTERNATIVE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	***Low***	***Low***	***Low***
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the bloody red shrimp 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative creates a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

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 the current conditions.

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 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, where 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to

control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because it and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative creates a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting it in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for bloody red shrimp 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 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation Rating[a]	Low	Low	***Low***	***Low***

[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. 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 for the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, the uncertainty is 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

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E.6.2.4 Fish

E.6.2.4.1 Threespine Stickleback (*Gasterosteus aculeatus*)

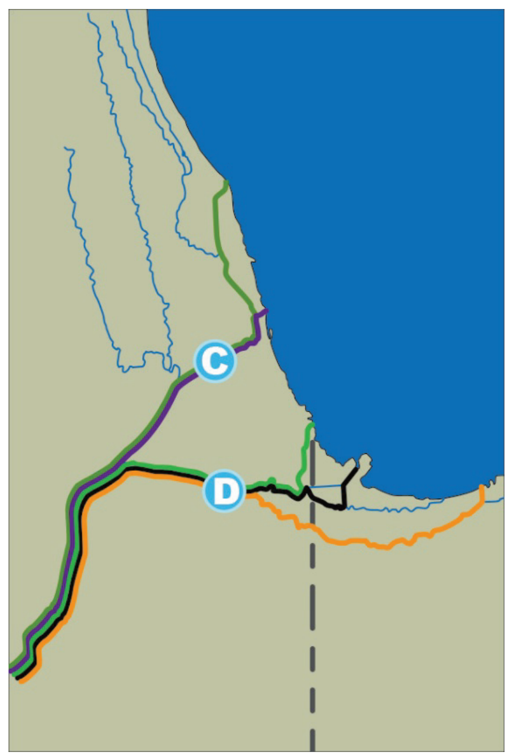
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 time step 25 (T_{25}).

Mid-system Hydrologic Separation Alternative Measures

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

[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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the threespine stickleback.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship

Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the Chicago Area Waterway System (CAWS) from natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative can 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 WPS.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS, because, 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 the 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to reduce the habitat suitability for the threespine stickleback 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. 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 the Lockport Lock and Dam (INHS undated). Overall, the probability of arrival remains high.

T_{10}: See T_0.

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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback. 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 the Lockport Lock and Dam (INHS undated). Overall, 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.
The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.
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 and maintain hydrologic condition similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes Mississippi River Interbasin Study (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 some sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of 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 1896–1900) 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 the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney 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 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 and salinity, and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of the threespine stickleback through this 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures 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 the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures alone are not expected to address the natural dispersion or human-mediated transport of threespine stickleback 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat CSSC water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point.
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to reduce the probability of passage of the threespine stickleback through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the threespine stickleback prior to discharge into the Mississippi River basin side of the control point. There is no specific information in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' eggs and larvae. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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 radiation-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), 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 the threespine stickleback and to determine whether additional treatment processes are needed to control passage of the threespine stickleback through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be needed to control passage of threespine stickleback through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the threespine stickleback.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the

Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS from natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative can 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS, because, 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 the 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to reduce the habitat suitability for the threespine stickleback 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. 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 the 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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 the 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.
The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.
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 and maintain hydrologic condition similar to the current conditions.

The treatment technologies included 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 some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of 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 turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures 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 the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to reduce the probability of passage of the threespine stickleback through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There is no specific information published in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' eggs and larvae. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10- to 15-min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fish (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. screens. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of the threespine stickleback and to determine whether additional treatment processes are needed to control passage of the threespine stickleback through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be needed to control passage of threespine stickleback through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the threespine stickleback.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback 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 Hydrologic Separation Alternative is not expected to affect the arrival for the threespine stickleback via 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 Hydrologic Separation Alternative can 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS, because, 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 the 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to reduce the habitat suitability for the threespine stickleback 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. 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). 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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). 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.
The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.
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 the control point.

ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic condition similar to the current conditions.

The treatment technologies included 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 some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of 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 depths 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 turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of the threespine stickleback through this aquatic pathway.

$\mathbf{T_{50}}$: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

$\mathbf{T_{0}}$: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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.

$\mathbf{T_{10}}$: See T_0.

$\mathbf{T_{25}}$: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures 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 Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. 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.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information published in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fish eggs and larvae. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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 radiation-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10- to 15-min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fish (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. screens. 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 passage of threespine stickleback through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process would be needed to control passage of threespine stickleback through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the threespine stickleback.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected

from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS from natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for 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 Hydrologic Separation Alternative can 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.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS, because, 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 the 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to reduce the habitat suitability for the threespine stickleback 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. The species has already arrived at the pathway. 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 the 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 Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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 the 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.

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 the control point.

ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic condition similar to the current conditions.

The treatment technologies included 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 some threespine sticklebacks, which have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of 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 depths less than 0.75 in. (19.05 mm) are not 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 turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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 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 and salinity and upon the size and type of organism.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of the threespine stickleback through this aquatic pathway.

$\mathbf{T_{50}}$: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

$\mathbf{T_{0}}$: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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.

$\mathbf{T_{10}}$: See T_0.

$\mathbf{T_{25}}$: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Hydrologic Separation Alternative. Structural measures 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 Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. 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.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 and human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information published in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10- to 15-min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fish (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 passage of threespine stickleback through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process would be

needed to control passage of threespine stickleback through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the threespine stickleback.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected

from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS from natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative can 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 BSBH.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS, because, 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 the 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. 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 the 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback. 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 the 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.

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 the control point.

ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic condition similar to the current conditions.

The treatment technologies included 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 some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of 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 depths 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 turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of the threespine stickleback through this 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures 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 Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. 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.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information published in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10- to 15-min exposure to 145 μW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fish (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 on fish has not been tested extensively. 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. screens. 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 passage of threespine stickleback through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be

needed to control passage of the threespine stickleback and its various life stages through the ANSTP. Overall, the uncertainty is 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

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E.6.2.4.2 Ruffe (*Gymnocephalus cernuus*)

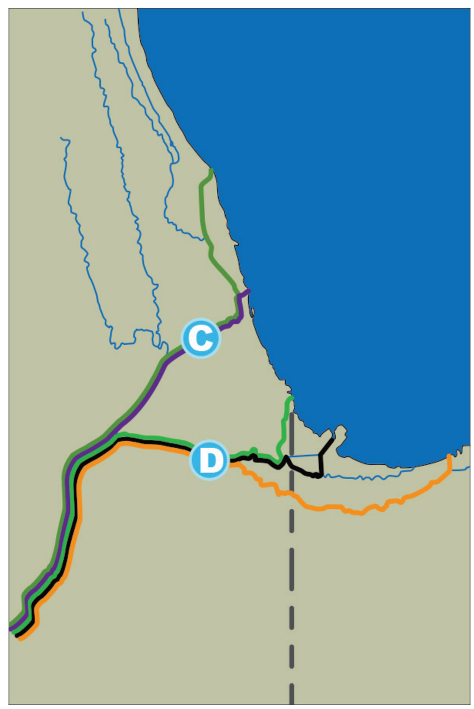
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 Hydrologic Separation Alternative Measures

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

[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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are anticipated that would reduce or eliminate the hydrologic connection between WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal

(CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 (FWS 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}. 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes for the species to arrive. Currently, 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. Overall, 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 will 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 Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes for the ruffe to arrive. Currently, 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). Overall, the uncertainty remains low.
T_{10}: The probability increases that ruffe will 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 will 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Stickney, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event.

The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic conditions similar to the current conditions.

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. 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 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 a body width less than 0.75 in. (19.05 mm) are expected to be able 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 at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures 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 the ruffe prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat CSSC water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the ruffe through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, this physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. There is no specific information in the literature documenting the effects of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on fish eggs and the larvae of other species. 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 the 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), 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 ASNTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75 in. screens. 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 the passage of ruffe through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: The potential speed of natural dispersion through the CAWS is uncertain. Although habitat may not be optimal, it may not prohibit passage.

Nonstructural measures alone are not expected to reduce the uncertainty of passage for the ruffe through the aquatic pathways 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank

flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 would be needed to control passage of ruffe through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are anticipated that would 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 Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for the ruffe 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Stickney, Illinois. However, the physical barrier is not

expected to control 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 Hydrologic Separation 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 (FWS 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. Nonstructural measures as part of the alternative may increase the time it takes for the species to arrive at the CAWS pathway. Currently, 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. Overall, 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 will 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 Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes for the species to arrive at the CAWS. Currently, 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. Overall, the uncertainty remains low.
T_{10}: The probability increases that ruffe will 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 will 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Stickney, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic conditions similar to the current conditions.

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 screens due to 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 a body width less than 0.75 in. (19.05 mm) are expected to be able 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 at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures 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 the ruffe prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's high probability of passage rating for 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. There is no specific information in the literature documenting the effects of UV radiation on survivability of the eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' eggs and larvae. 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), 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 in 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 water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.74-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 passage of ruffe through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 reduce the uncertainty of passage for the ruffe through the CAWS 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 would be needed to control passage of the ruffe through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival for 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 Hydrologic Separation 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 Hydrologic Separation 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_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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 (FWS 1996; Bauer et al. 2007), having dispersed 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes for the ruffe to arrive at the CAWS. Currently, 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. Overall, 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 will 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 Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival for the ruffe at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes for the species to arrive at the CAWS. Currently, 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. Overall, the uncertainty remains low.

T_{10}: The probability increases that ruffe will 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 will 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Alsip, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic conditions similar to the current conditions.

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 less than 0.75 in. (19.05 mm) are expected to still be able 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 at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 Cal-Sag Channel water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. There is no specific information in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' eggs and larvae. 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that

UV-B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), 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. screens. 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 passage of ruffe through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 reduce the uncertainty of passage for 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the ruffe through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP, and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 (FWS 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures may increase the time it takes the ruffe to arrive at the CAWS pathway. Currently, 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}: See T_0. Over 50 years, the probability increases that ruffe will have time to disperse to Indiana 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 Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures may increase the time it takes for the ruffe to arrive at the CAWS pathway. Currently, 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 will 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 will 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Alsip, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

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 the current conditions.

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 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 the 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 a body width less than 0.75 in. (19.05 mm) are expected to be able 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, 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures 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 Cal-Sag Channel water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' eggs and larvae. 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-

B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), 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. screens. 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 passage of the ruffe through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 reduce the uncertainty of passage for the ruffe through the CAWS 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 Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 would be needed to control passage of the ruffe through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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 Hydrologic Separation 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 (FWS 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures may increase the time it takes for the ruffe to arrive at the CAWS pathway. Currently, 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. Overall, the probability of arrival remains low.
T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0. Over 50 years, the probability increases that ruffe will 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 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 Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. Nonstructural measures may increase the time it takes for the ruffe to arrive at the CAWS pathway. Currently, 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. Overall, the uncertainty remains low.
T_{10}: See T_0. The probability increases that ruffe will 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}: See T_{10}. The probability increases that ruffe will 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Alsip, Illinois. This alternative includes the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species 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 and maintain hydrologic conditions similar to the current conditions.

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 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 the 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 less than 0.75 in. (19.05 mm) are expected to be able 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 at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip 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.

Overall, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. There is no specific information in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' eggs and larvae. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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, as well as gill, eye, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), 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. screens. 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 passage of the ruffe through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 reduce the uncertainty of passage for the ruffe through the CAWS 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 Hydrologic Separation Alternative are expected to affect the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 would be needed to control the passage of the ruffe through the ANSTP. Overall, the uncertainty is low.
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.6.2.4.3 Tubenose goby (*Proterorhinus semilunaris*)

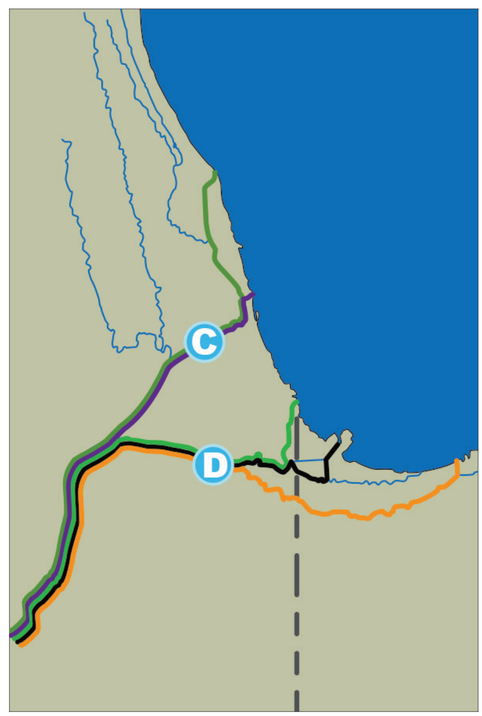
MID-SYSTEM HYDROLOGIC SEPARATION ALTERNATIVE

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 Hydrologic Separation Alternative Measures

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

[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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***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.

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the tubenose goby.

T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an Aquatic Nuisance Species Treatment Plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby at the Chicago Area Waterway System (CAWS) from natural dispersion (i.e., swimming and passive drift) 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 Hydrologic Separation 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, may 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 Hydrologic Separation 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, may 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 the occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation 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. Owing 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 arrival 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. The 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 Hydrologic Separation Alternative includes nonstructural measures such as ballast/bilge-water exchange programs which are expected to increase the time it takes for the tubenose goby 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. Nonstructural measures such as ballast/bilge-water exchange programs are expected to increase the time the tubenose goby 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 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).

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The Mid-system Hydrologic Separation 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. The Mid-system Hydrologic Separation 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. Therefore, the probability of arrival is reduced to low.

T_{25}: There is no commercial vessel transport to the WPS, and the implementation of nonstructural measures such as a ballast/bilge-water exchange program is 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 disperse 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 Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative 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. Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative 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}. The Mid-system Hydrologic Separation 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 dispersion rates become less certain. Therefore, the uncertainty remains medium.

T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) 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 and maintain hydrologic conditions similar to the current ones.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes Mississippi River Interbasin Study (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), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a 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 mm by 1.3 mm) in size (Pallas 1811), and fish with a body width of less than 0.75 in. (19.05 mm) 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 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 water at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of the tubenose goby through this 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 Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, or fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There is no specific information published in the literature documenting the effectiveness of UV radiation on survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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, and 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. Sharma et al. (2008) reported that UV-B radiation (10-15 min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to

Zagarese and Williamson (2001), early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of 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. screens. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby to determine whether additional treatment processes are needed to control the passage of tubenose goby through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to

control passage of the tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby at the CAWS via 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 Hydrologic Separation Alternative includes nonstructural measures that would 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 Hydrologic Separation 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 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. Owing 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 arrival 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. The 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 Hydrologic Separation Alternative includes nonstructural measures such as ballast/bilge-water exchange programs are expected to 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. Nonstructural measures such as ballast/bilge-water exchange programs are expected to increase the time the tubenose goby 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 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).

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: The Mid-system Hydrologic Separation 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. The Mid-system Hydrologic Separation 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. Therefore, the probability of arrival is reduced to low.

T_{25}: The Mid-system Hydrologic Separation 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 disperse 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 Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures as part of the Mid-system Hydrologic Separation Alternative 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 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). Therefore, the uncertainty is low.

T_{10}: See T_0. The Mid-system Hydrologic Separation 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}. The Mid-system Hydrologic Separation 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 dispersion rates become less certain. Therefore, uncertainty remains medium.

T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) 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 and maintain hydrologic conditions similar to the current ones.

The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium- risk Great Lakes Mississippi River Interbasin Study (GLMRIS) ANS of Concern and their various life stages currently found in the Great Lakes Basin. It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009) and would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5mm by 1.3 mm) (Pallas 1811), and fish with a body width of less than 0.75 in. (19.05 mm) are expected to able 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 thus control 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. 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 Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There is no specific information published in the literature documenting the effectiveness of UV radiation on the survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of 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. screens. 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 passage of the tubenose goby through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from

the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby at the CAWS via 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 Hydrologic Separation 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 Hydrologic Separation 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 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. Owing 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. The 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 aquatic pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures such as ballast/bilge-water exchange programs that are expected to 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. Nonstructural measures such as ballast/bilge-water exchange programs are expected to increase the time the tubenose goby 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 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).

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The Mid-system Hydrologic Separation 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}: The Mid-system Hydrologic Separation 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 disperse by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to 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 Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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. The 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). Therefore, the uncertainty is low.

T_{10}: See T_0. The Mid-system Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 dispersion rates become less certain. Therefore, its uncertainty remains medium.

T_{50}: See T_{25}.

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 Hydrologic Separation 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 tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the

natural dispersion of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current ones.

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 tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009) and 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 mm by 1.3 mm) in size (Pallas 1811), and fish with a body width of less than 0.75 in. (19.05 mm) 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. 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. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. 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.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information published in the literature documenting the effectiveness of UV radiation on the survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. 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 the 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, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 $\mu W\ cm^{-2}$) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of the lack of photoprotective pigments and/or extensions of the integument.

These cited studies examined solar UV-A and UV-B exposure to fish as stated and demonstrated damage to the fish eggs and embryos. Based on the damage found on fish eggs and embryos, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate fish eggs and embryos. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate target species and determine the influence of local water quality. Pilot-scale testing would be required to evaluate dose requirements, possible interferences, and other design questions.

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. screens. Site-specific and 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 passage of the tubenose goby through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation Rating[a]	Medium	Medium	***Low***	***Low***

[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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.

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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.

T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect 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 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. Owing to the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to reduce the probability of arrival 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. The 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 Hydrologic Separation Alternative includes nonstructural measures that are expected to 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 are expected to increase the time the tubenose goby takes to arrive at the CAWS 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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. The Mid-system Hydrologic Separation 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 aquatic pathway. The Mid-system Hydrologic Separation 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. Therefore, the probability of arrival is reduced to low.

T_{25}: There is commercial vessel transport to Indiana Harbor from ports where the tubenose goby is located.

The Mid-system Hydrologic Separation 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 disperse by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersion 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 Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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. The Mid-system Hydrologic Separation 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 the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 dispersion rates become less certain. Therefore, its uncertainty of arrival remains medium.
T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current ones.

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 tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a 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 mm by 1.3 mm) in size (Pallas 1811), and fish with a body width of less than 0.75 in. (19.05 mm) 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. 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. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. 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.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, 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 Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information published in the literature documenting the effectiveness of UV radiation on the survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation to other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. Studies by Sucré et al. (2012) showed that UV-B exposure at low intensities (50 and 80 $\mu W\ cm^{-2}$) elicited strong damage to the osmoregulatory function in early larvae of European sea bass (*Dicentrarchus labrax*). 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 the 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, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of 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 passage of the tubenose goby through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up

to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.
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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby at the CAWS via 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 Hydrologic Separation 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 via 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 Hydrologic Separation 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 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. Owing 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 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 Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. The 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 for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures that are expected to 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 are expected to increase the time the tubenose goby takes to arrive at the CAWS 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 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).

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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. The Mid-system Hydrologic Separation 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. The Mid-system Hydrologic Separation 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. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. The Mid-system Hydrologic Separation 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 disperse 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 Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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. The Mid-system Hydrologic Separation 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}. The Mid-system Hydrologic Separation 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 dispersion rates become less certain. Therefore, the uncertainty remains medium.

T_{50}: See T_{25}.

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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

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 the current ones.

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 tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a 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 mm by 1.3 mm) in size (Pallas 1811), and fish with a body depth of less than 0.75 in. (19.05 mm) 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. 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. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 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 Hydrologic Separation Alternative. Structural measures 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 the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. 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.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and an ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, 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 is no specific information published in the literature documenting the effectiveness of UV radiation on the survivability of eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation to other fishes. The studies summarized here primarily report the effects of increased solar UV radiation on fish and not UV as a disinfection process such as that proposed in the ANSTP. Studies by Sucré et al. (2012) showed that UV-B exposure at low intensities (50 and 80 $\mu W\ cm^{-2}$) elicited strong damage to the osmoregulatory function in early larvae of European sea bass (*Dicentrarchus labrax*). 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 the 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, and 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. Sharma et al. (2008) reported that UV-B radiation (10–15 min exposure to 145 µW cm^{-2}) reduced the survival rate of Indian carp (*Catla catla*) larvae. According to Zagarese and Williamson (2001), early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of 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. screens. 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 passage of the tubenose goby through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. 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 Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.
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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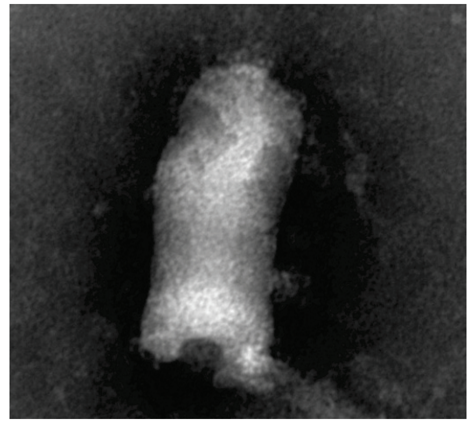
E.6.2.5 Virus

E.6.2.5.1 Viral Hemorrhagic Septicemia (*Novirhabdovirus sp.*)



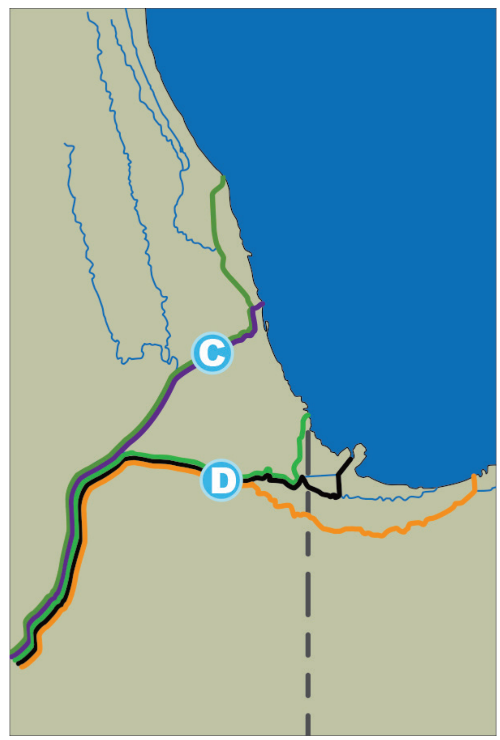
MID-SYSTEM HYDROLOGIC SEPARATION

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 Hydrologic Separation Alternative Measures

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

[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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILILTY 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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for viral hemorrhagic septicemia (VHSv).
T_{10}: See T_0.

T_{25}: The Mid-system Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of VHSv from natural dispersion (i.e., infected host and passive drift) 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 Hydrologic Separation 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 Hydrologic Separation 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_{25}. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the dispersion or virulence of this species.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not

expected to control 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).
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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has dispersed throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan.

The Mid-system Hydrologic Separation 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). 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 Hydrologic Separation 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 disperse rapidly in the Great Lakes has been documented.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.

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

In determining the probability of passage, it is assumed the species has 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation 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 a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Stickney, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the natural dispersion of VHSv to Brandon Road Lock and Dam.
The purpose of the ANSTP is to remove aquatic nuisance species (ANS) 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 and maintain hydrologic conditions similar to the current conditions.
The treatment technologies included in the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes Mississippi River Interbasin Study (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). VHSv 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 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 Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Non-Structural Alternative Risk Assessment.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting contaminated water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 this aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's high probability of passage 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the barrier is expected to control the passage of this species through the aquatic pathway by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200–280 nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. 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 would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of VHSv 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	Low	Low
Mid-system Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. The physical barrier is expected to control passage up to an extreme

storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for VHSv.

T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion (i.e., infected host and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 dispersion 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. However, the physical barrier is not

expected to control 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).
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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). 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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). 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, it is assumed the species has 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation 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 a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Stickney and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of VHSv to Brandon Road Lock and Dam.
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 and maintain hydrologic conditions similar to the current conditions.

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). VHSv 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 are expected to pass through the screens, where 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv to Brandon Road Lock and Dam. The ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species from Lake Michigan to the CAWS, since vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of VHSv to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the physical barrier. The ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's high probability of passage 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200–280 nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. 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 would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of VHSv 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	Low	Low
Mid-system Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. The physical barrier is expected to control passage up to an extreme

storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for VHSv.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion (i.e., infected host and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the dispersion 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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).

T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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}: 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 Hydrologic Separation 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 Hydrologic Separation 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). 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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). 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, it is assumed the species has 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of VHSv to Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current conditions.

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). VHSv 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 are expected to pass through the screens, where 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Mid-system Hydrologic Separation Alternative's high probability of passage 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore the physical barrier is expected to control the passage of this species through the aquatic pathway by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200–280 nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV exposure, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of VHSv 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	Low	Low
Mid-system Hydrologic Separation 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 control 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through

the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: 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 Hydrologic Separation Alternative does not affect the pathway for VHSv.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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 Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion (i.e., infected host and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 dispersion or virulence of this species in Lake Michigan.

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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation 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). 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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). 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, it is assumed the species has 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 Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation 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 a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Alsip and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of VHSv to Brandon Road Lock and Dam.

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 and maintain hydrologic conditions similar to the current conditions.

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). VHSv 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 are expected to pass through the screens, where 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion 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 Hydrologic Separation Alternative includes nonstructural measures which 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the pathway because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that would 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 Mid-system Hydrologic Separation Alternative's high probability of passage 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control passage of this species through the aquatic pathway by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200–280 nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. 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 would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of VHSv 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	Low	Low
Mid-system Hydrologic Separation 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 control the passage for 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 as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of VHSv by natural dispersion and vessels. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is 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 HYDROLOGIC SEPARATION: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

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 Hydrologic Separation 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	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***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

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Hydrologic Separation Alternative does not affect the pathway for VHSv.
T_{10}: See T_0.
T_{25}: The Mid-system Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water

collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

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, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion (i.e., infected host and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Hydrologic Separation 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 Hydrologic Separation 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 dispersion 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 Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. However, the physical barrier is not expected to control 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).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation 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, dispersion, 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 Hydrologic Separation 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 Hydrologic Separation 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). 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 Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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). 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, it is assumed the species has 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 Hydrologic Separation 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of VHSv by natural dispersion to Brandon Road Lock and Dam.

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 the current conditions.

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). VHSv 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 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 control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip 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.

Overall, the Mid-system Hydrologic Separation Alternative is expected to control the natural dispersion of VHSv through the aquatic pathway.

$_{50}$: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures are not expected to address the human-mediated passage 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Hydrologic Separation 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 Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv to Brandon Road Lock and Dam. The physical barrier is expected to control the passage of the species through the pathway because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

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 Hydrologic Separation 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 Hydrologic Separation 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 Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's high probability of passage 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 Hydrologic Separation 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 a physical barrier and ANSTP.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200–280 nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. 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 would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Hydrologic Separation Alternative reduces the likelihood of VHSv 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	Low	Low
Mid-system Hydrologic Separation 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 control 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. See the Nonstructural Risk Assessment for this species.

T_{25}: Structural measures as part of the Mid-system Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With 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 exposure of UV radiation, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is 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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