E.5 LAKEFRONT HYDROLOGIC SEPARATION

E.5.1 ANS Potentially Invading the Great Lakes Basin

E.5.1.1 Crustaceans

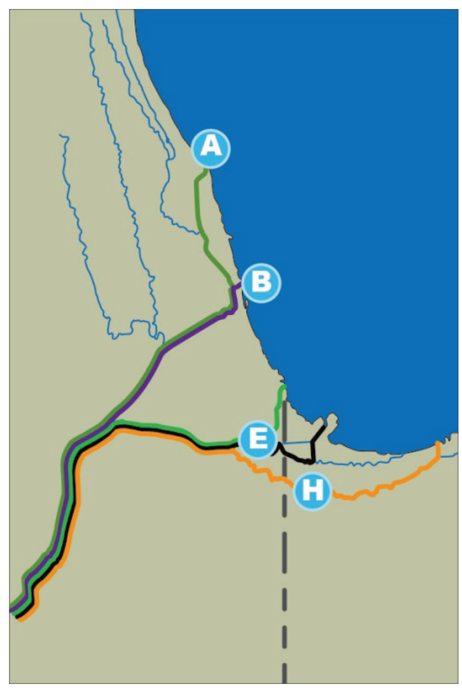
E.5.1.1.1 Scud (*Apocorophium lacustre*)

E.5.1.2 Fish

E.5.1.2.1 Bighead Carp (*Hypophthalmichthys nobilis*)

LAKEFRONT 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) 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}).

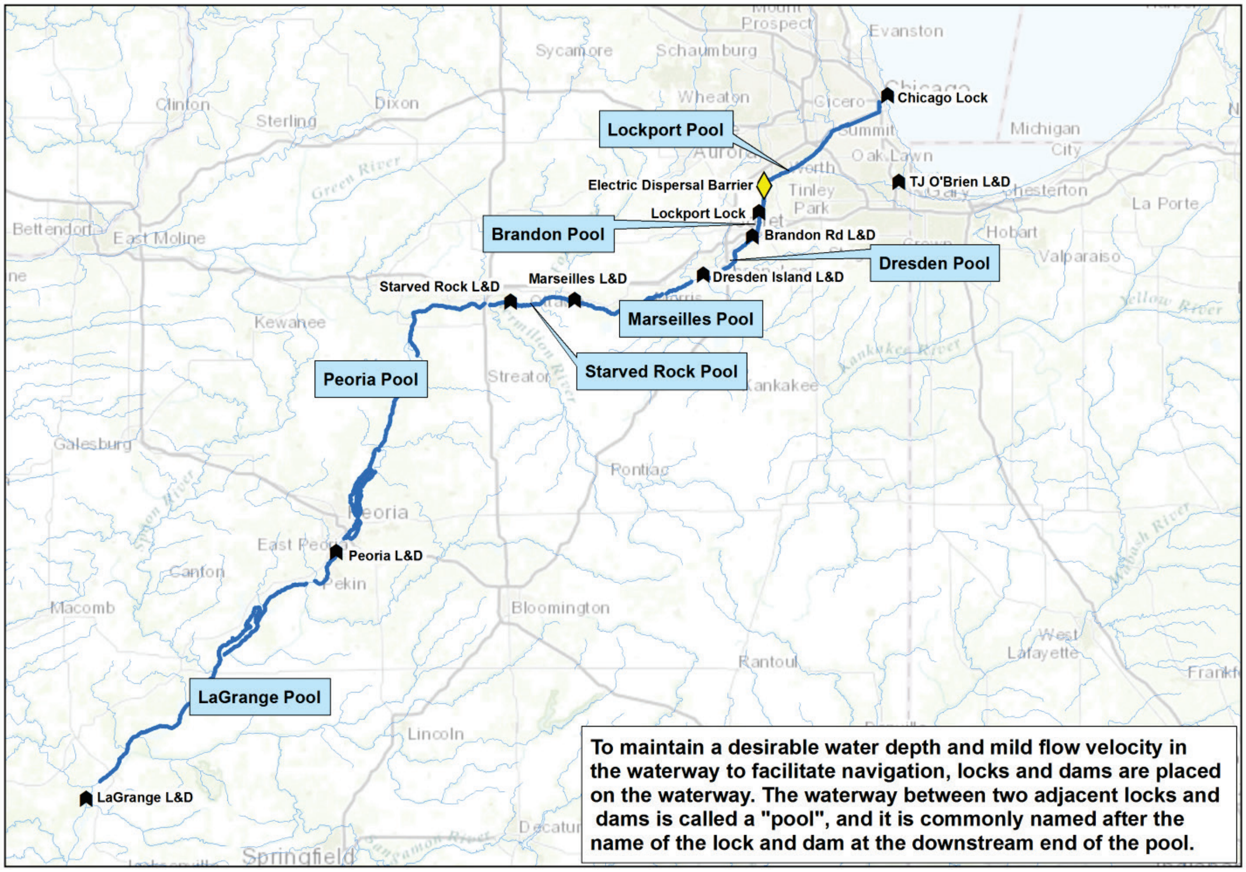


Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant[b]
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant[b]
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant[b]
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant[b]
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the bighead carp.
[b] Control Points (A), (B), and (E) 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp as a result of 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the current and potential abundance and reproductive capacity of bighead carp. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp being removed 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 2011), 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. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{25}.

d. *Existing Physical Human/Natural Barriers*

T_0: There are no barriers to the movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the WPS in Wilmette, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in the Brandon Road Lock and Dam (ACRCC 2012). 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_0.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's 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 Lakefront 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
Lakefront 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 Lockport Pool upstream of Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately; however, these measures are not expected to affect the arrival of the bighead carp at Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

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

Uncertainty of Arrival

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

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam through this aquatic pathway; therefore, uncertainty remains none.

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

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

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

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

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 this aquatic pathway.

T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for bighead carp at the WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Wilmette, Illinois, and would 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 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.

The Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of bighead carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the bighead carp through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through this 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion or human-mediated transport of bighead carp through this aquatic pathway.
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 Lakefront 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 this aquatic pathway. The physical barrier is

expected to control the natural dispersion and human-mediated transport of this species through this aquatic pathway, because this species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the bighead carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Although 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 bighead carp and vessels potentially transporting bighead carp eggs and larvae in ballast and bilge 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.

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 RiverBasin.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of bighead carp passing through this aquatic pathway. 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
Lakefront 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}: 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 high.
T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through this pathway. The physical barrier is expected to control the passage of bighead carp through this pathway 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

LAKEFRONT 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

Lakefront 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the bighead carp as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp removed 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 2011), 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. Therefore, nonstructural

measures are not expected to affect the current and potential abundance and reproductive capacity of bighead carp.

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: There are no barriers to movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at Brandon Road Lock and Dam since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's 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 Lakefront 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
Lakefront 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 Lockport Pool upstream of Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the bighead carp through aquatic pathways at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

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

Uncertainty of Arrival

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

Evidence for Uncertainty Rating

T_0: Bighead carp have been captured in the pathway.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the bighead carp through aquatic pathways to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.

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

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

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

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

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Chicago, Illinois, and would 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 bighead carp through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of bighead carp 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures would be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Structural measures would be implemented at T_{25}.

T_{10}: See T_0. 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 Lakefront 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 this aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of this species through this aquatic pathway, because this species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the bighead carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Although 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 bighead carp and vessels potentially transporting bighead carp eggs and larvae in ballast and bilge 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of bighead carp passing through this aquatic pathway. 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
Lakefront 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}: See 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 high.

T_{25}: Structural measures as part of the Lakefront 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 bighead carp through the aquatic pathway up to 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

LAKEFRONT 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.

Lakefront 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 Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp as a result of 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the bighead carp via 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp removed 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 2011), 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. Therefore, nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity of bighead carp.

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: There are no barriers to the movement of bighead carp from their current position to Brandon Road Lock and Dam.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at Brandon Road Lock and Dam since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's 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 Lakefront 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
Lakefront 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 Lockport Pool upstream of Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's arrival at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

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

Uncertainty of Arrival

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

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's arrival through aquatic pathways at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of 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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.

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

The physical barrier would be constructed in the channel at Calumet City, Illinois, and would 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 bighead carp through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Calumet River water prior to its discharge to the Mississippi River side of the physical barrier. The ANSTP would not be designed to treat Mississippi River Basin water; therefore, the ANSTP would not be an effective control for bighead carp because the species originates in the Mississippi River Basin.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of bighead carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through this aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through this 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures would be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Structural measures would be implemented at 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 Lakefront 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 this aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of this species through this aquatic pathway, because this species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the bighead carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Although 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 bighead carp and vessels potentially transporting bighead carp eggs and larvae 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 from water on the Lake Michigan side of the barrier prior to discharge to the Mississippi River side of the barrier. Bighead carp are in the Mississippi River Basin.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of bighead carp passing through this aquatic pathway. 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
Lakefront 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}: See 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 high.

T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The physical barrier is expected to control the passage of bighead carp through this pathway 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

LAKEFRONT 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.

Lakefront 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 Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for bighead carp.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp as a result of natural dispersion through aquatic pathways to Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp removed 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 2011), 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. Therefore, nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity of bighead carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. Reproductive capacity would remain the same but would no longer result in an exponential population growth because 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 the 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of bighead carp at the CAWS since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).
T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for 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
Lakefront 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 Lockport Pool upstream of Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's arrival at Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

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

Evidence for Uncertainty Rating

T_0: Bighead carp have been captured in the pathway.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's arrival through aquatic pathways at Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.

T_{10}: See T_{10}.

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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for bighead carp at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, Illinois, and would 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 bighead carp through this aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion or 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through this 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures would be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Structural measures would be implemented at 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 Lakefront 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 this aquatic pathway. The physical barrier is expected to control the vessel-mediated transport and natural dispersion of bighead carp through the aquatic pathway because the species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the bighead carp.

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

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Although 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessments.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 bighead carp and vessels potentially transporting bighead carp eggs and larvae 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 from water on the Lake Michigan side of the barrier prior to discharge to the Mississippi River side of the barrier. Bighead carp are in the Mississippi River Basin.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of bighead carp passing through this aquatic pathway. 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
Lakefront 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The physical barrier is expected to control the passage of bighead carp through the aquatic pathway up to 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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 PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

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

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that would separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative would separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. The uncertainty is low.
T_{50}: See T_{25}.

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

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of bighead carp as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp removed 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 2011), 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. Therefore, nonstructural measures are not expected to affect the current and potential abundance and reproductive capacity of bighead carp.

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

T_{25}: See T_{10}. Reproductive capacity would remain the same but would no longer result in an exponential population growth because 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 the movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of bighead carp to the Brandon Road Lock and Dam since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat for 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
Lakefront 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 Lockport Pool upstream of Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's arrival at the Brandon Road Lock and Dam through aquatic pathways. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of arrival remains high.

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

Uncertainty of Arrival

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

Evidence for Uncertainty Rating

T_0: Bighead carp have been captured in the pathway.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bighead carp's arrival through aquatic pathways at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of

bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

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

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

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 this aquatic pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.
The physical barrier would be constructed in the channel at Hammond, Indiana, and would 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 to a 0.2% ACE event.
Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of bighead carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through this 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Structural measures would be implemented at 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 Lakefront 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 this aquatic pathway. The physical barrier is expected to control the vessel-mediated transport and natural dispersion of bighead carp 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the bighead carp.

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

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Although 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 Lakefront Hydrologic Separation

Alternative's low probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast and bilge water would pass through the aquatic pathway. Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of bighead carp passing through the aquatic pathway. 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
Lakefront 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The physical barrier is expected to control the passage of the bighead carp through the aquatic pathway up to a 0.2% ACE event and to control the passage of vessels that may potentially transport bighead carp eggs, larvae, and fry in ballast and bilge water. 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

References

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USACE (U.S. Army Corps of Engineers). 2011a. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System. Great Lakes and Mississippi River Interbasin Study GLMRIS.

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E.5.1.2.2 Silver Carp (*Hypophthalmichthys molitrix*)

LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

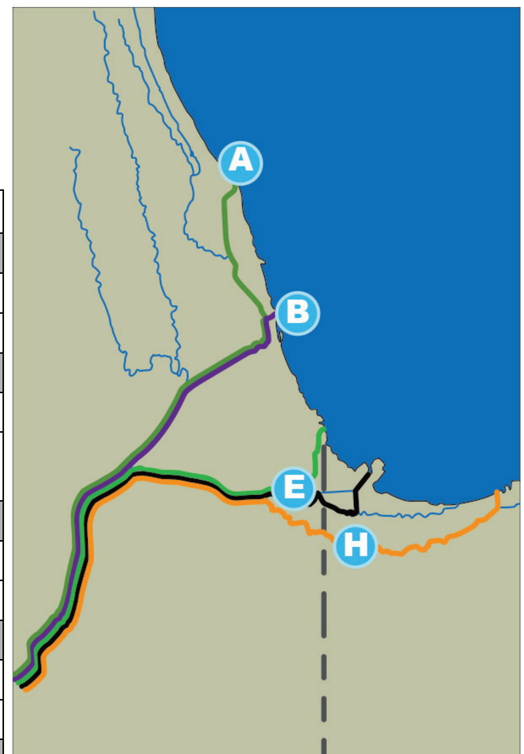
This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0) by local, state, and federal agencies and the public.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

Lakefront Hydrologic Separation Alternative Measures

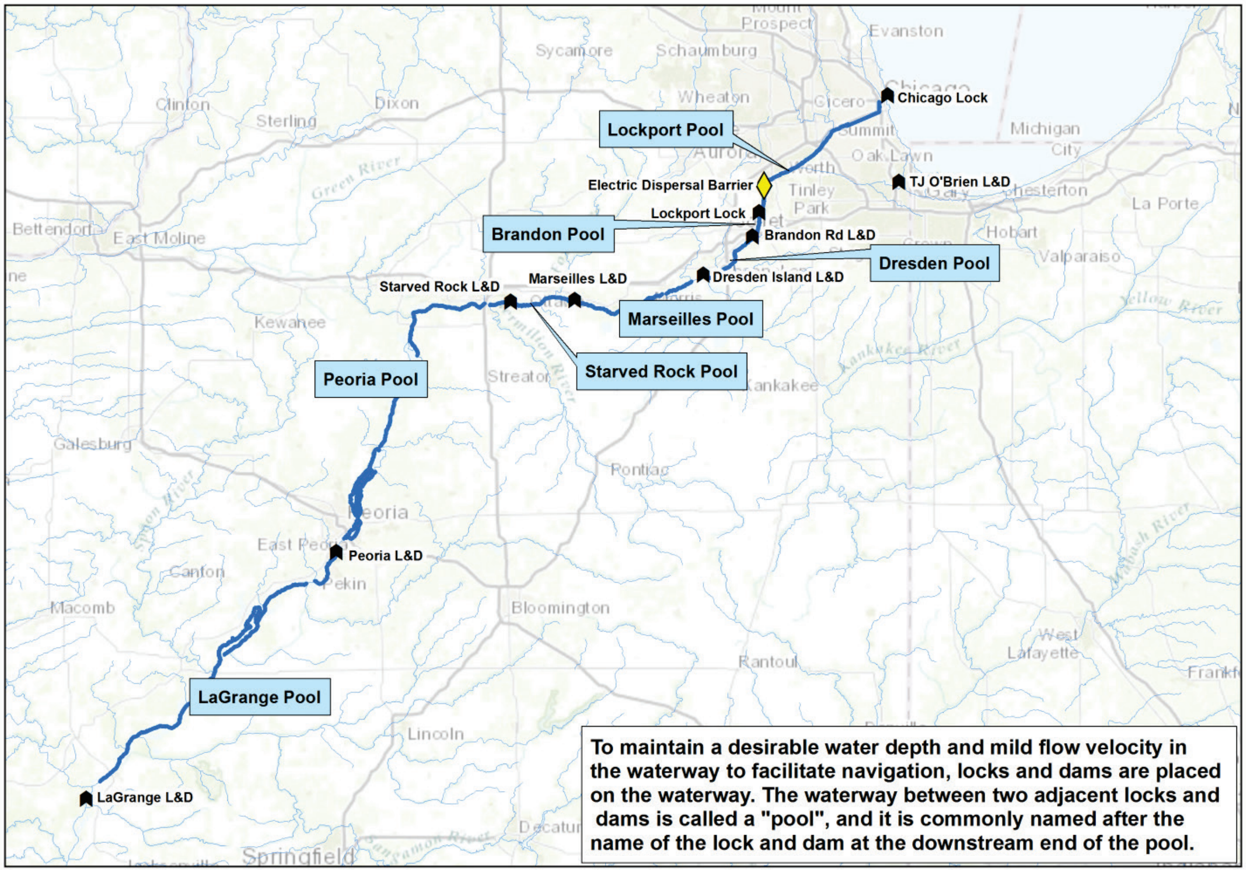
Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant[b]
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant[b]
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant[b]
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant[b]
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

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

[b] Control Points (A), (B), and (E) 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

LAKEFRONT 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.

Lakefront 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes an Aquatic Nuisance Species Treatment Plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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. Arrival of an individual specimen is examined here and drives the risk rating.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of silver carp at Brandon Road Lock and Dam as a result of 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, there is no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's probability of arrival at the Brandon Road Lock and Dam as a result of 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 Lakefront 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 of silver carp. Controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp being removed 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. 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. There are no barriers to movement of the silver carp from its current position to Brandon Road Lock and Dam.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the WPS in Wilmette, 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 has arrived at the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

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

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately; however, these measures alone are not expected to affect the silver carp's arrival at Brandon Road Lock and Dam. The silver carp has arrived 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 (MRWG 2013).

Therefore, the probability of 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of Brandon Road Lock and Dam in Rock Run Rookery Preserve Lake; however, there have been no observations upstream of the Brandon Road Lock and Dam. The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway. Overall, uncertainty remains none.
T_{10}: See T_0. See 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 Lakefront 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 silver carp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the WPS 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures 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 through this aquatic pathway, since 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion or human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0. 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 Lakefront Hydrologic Separation Alternative. Structural measures 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 this species through this aquatic pathway, because this species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that defined in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 silver carp and vessels potentially transporting silver carp eggs and larvae 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 aquatic 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of silver carp passing through this aquatic pathway. 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
Lakefront 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 as part of the Lakefront 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 the passage of silver carp through this aquatic pathway 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

LAKEFRONT 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.

Lakefront 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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. Arrival of an individual specimen is examined here and drives the risk rating.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of silver carp at Brandon Road Lock and Dam as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at Brandon Road Lock and Dam as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the current and potential abundance and reproductive capacity of silver carp. Controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp being removed 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. 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. There are no barriers to the 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the silver carp's 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for the silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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 Brandon Road Lock and Dam.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

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

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of Brandon Road Lock and Dam in Rock Run Rookery Preserve Lake, but there have been no observations upstream of the Brandon Road Lock and Dam.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway. Overall, the uncertainty remains none.
T_{10}: See T_0. See 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 Lakefront 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 silver carp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, Illinois, with the construction of a physical barrier and ANST.

The physical barrier would be constructed in the channel at the CRCW 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 flood 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures 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 vessel-mediated transport of the species through this 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures would 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 occur at 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of this species through this aquatic pathway, because this species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that defined in the No New Federal Action Risk Assessment.
T_{10}: See $T_{0.}$ See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 silver carp and vessels potentially transporting silver carp eggs and larvae 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of silver carp passing through this aquatic pathway. 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
Lakefront 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 as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the passage of silver carp through this aquatic pathway 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

LAKEFRONT 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.

Lakefront 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 Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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. Arrival of an individual specimen is examined here and drives the risk rating.

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 Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at Brandon Road Lock and Dam as a result of 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, there is no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at Brandon Road Lock and Dam as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures alone are not expected to affect the current and potential abundance and reproductive capacity of silver carp. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp being removed 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**.** 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. 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

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

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

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been captured in Dresden Island Pool, within 4 mi of Brandon Road Lock and Dam. The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at 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 (MRWG 2013). Therefore, the silver carp has 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: Silver carp have been captured approximately 4 mi downstream of Brandon Road Lock and Dam in the Rock Run Rookery Preserve Lake; however, there have been no observations upstream of the Brandon Road Lock and Dam.
The Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway. Overall, the uncertainty remains none.
T_{10}: See T_0. See 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 Lakefront 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 silver carp through this aquatic pathway.

T_{10}: See T_0.

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

The physical barrier would be constructed in the channel at Calumet City, 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 flood event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway to Brandon Road Lock and Dam.

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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures 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 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 Lakefront 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. Structural measures would be implemented at 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of this species through this aquatic pathway, because this species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that defined in the No New Federal Action Risk Assessment.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 silver carp and vessels potentially transporting silver carp eggs and larvae in ballast and bilge 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of silver carp passing through this aquatic pathway. 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
Lakefront 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 as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the passage of silver carp through this aquatic pathway 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 $T_{10.}$

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

LAKEFRONT 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.

Lakefront 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 Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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. Arrival of an individual specimen is examined here and drives the risk rating.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of silver carp as a result of natural dispersion through aquatic pathways to the Brandon Road Lock and Dam.

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 Lakefront Hydrologic Separation Alternative is not expected to affect silver carp's arrival at Brandon Road Lock and Dam as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the current and potential abundance and reproductive capacity of silver carp. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp being removed 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. 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. 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

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

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

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Lakefront 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 Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative is not expected to affect the silver carp's arrival at 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 (MRWG 2013). Therefore, the silver carp has 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

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

The Lakefront Hydrologic Separation Alternative is not expected to affect the silver carp's arrival at 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway. Overall, the uncertainty remains none.

T_{10}: See T_0. See 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 Lakefront 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 silver carp through this aquatic pathway.

T_{10}: See T_0.

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

The physical barrier would be constructed in the channel at Calumet City, 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 flood 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures 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 this 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 Lakefront 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. Structural measures would not be implemented 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the natural dispersion and human-mediated transport of this species through this aquatic pathway, because the species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the CAWS habitat for the silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that defined in the No New Federal Action Risk Assessment.
T_{10}: See $T_{0.}$ See the Nonstructural Risk Assessment for this species.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 ilver carp and vessels potentially

transporting silver carp eggs or larvae in ballast and bilge 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of silver carp passing through this aquatic pathway. 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
Lakefront 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 as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the passage of silver carp through this aquatic pathway 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

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

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that 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 flood event. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative would separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE flood event. The uncertainty is low.
T_{50}: See T_{25}.

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

In determining the probability of arrival, the pathway is assumed to exist. Arrival of an individual specimen is examined here and drives the risk rating.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of silver carp at Brandon Road Lock and Dam as a result of 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 there is no potential for silver carp eggs and larvae to be transported through the pathway via vessel ballast tanks and voids.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of silver carp at the Brandon Road Lock and Dam as a result of 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the current and potential abundance and reproductive capacity of silver carp. Nonstructural measures such as controlled harvest and overfishing measures have resulted in more than 1.3 million lb of Asian carp being removed 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**.** See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}. Reproductive capacity would remain the same but would no longer result in exponential population growth because 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 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway.

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat for silver carp.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the silver carp's arrival 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 (MRWG 2013). Therefore, the silver carp has 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
Lakefront 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; however, there have been no observations upstream of the Brandon Road Lock and Dam.

The Lakefront Hydrologic Separation Alternative is not expected to affect the silver carp's arrival 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 (MRWG 2013). Therefore, the silver carp has arrived at the pathway. Overall, the uncertainty remains none.

T_{10}: See T_0. See 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 Lakefront 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 silver carp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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 flood event.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measure as part of this

alternative are expected to control the human-mediated transport of silver carp through this 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Structural measures would not be implemented 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The physical barrier is expected to control the vessel-mediated transport and natural dispersion of silver carp through the aquatic pathway because the species and vessels potentially transporting it 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of the habitat for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of passage rating does not differ from that defined in the No New Federal Action Risk Assessment.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that silver carp and vessels potentially transporting silver carp eggs, larvae, and fry in ballast and bilge water would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of silver carp passing through the aquatic pathway. Therefore, the probability of passage is reduced to low.

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

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Lakefront 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 as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this pathway. The physical barrier is expected to control the passage of silver carp through this aquatic pathway 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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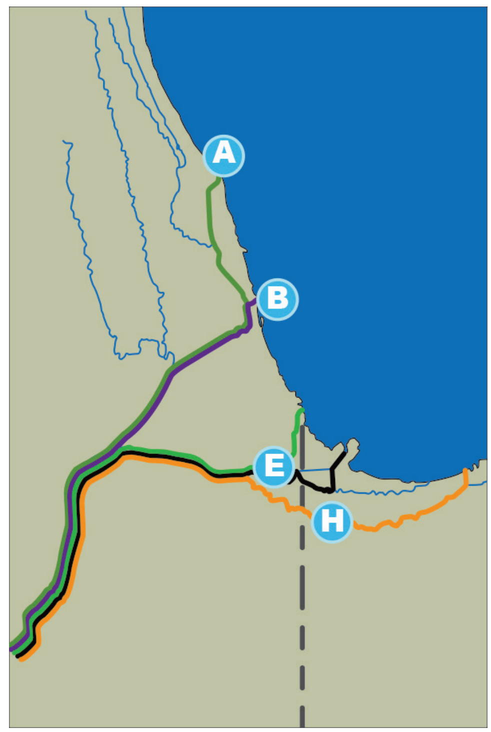
E.5.2 ANS Potentially Invading the Mississippi River Basin

E.5.2.1 Algae

E.5.2.1.1 Grass Kelp (*Enteromorpha flexuosa*)

LAKEFRONT 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) 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}).



Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measuresa	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

Lakefront 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 WPS and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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}: 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 Lakefront Hydrologic Separation Alternative is expected to affect the arrival for *E. flexuosa* from natural dispersion (i.e., current-driven passage) 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion and human-mediated dispersion 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 algaecides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS.

Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at its current infestations and its current abundance and distribution.
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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at the WPS in Wilmette, Illinois. However, the physical barrier is not expected to control the arrival of *E. flexuosa* to the CAWS. The closest that *E. flexuosa* has been recorded to the WPS was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that may 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to control the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. The Lakefront Hydrologic Separation Alternative would also 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 *E. flexuosa* abundance. Data 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 Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of arrival rating for this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion and distribution of *E. flexuosa*. However, surveys to identify the current locations of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.
Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

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

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

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

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *E. flexuosa* at the WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the WPS 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 passage of *E. flexuosa* by natural dispersion to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) from the Great Lakes Basin side of a control point 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 employed at the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes and 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). *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, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity; suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point is anticipated to be effective. 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 Lakefront Hydrologic Separation is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* 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 Lakefront 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 *E. flexuosa* through this 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Lake Michigan water for *E. flexuosa* 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, 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.
The Lakefront 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 Lakefront Hydrologic Separation Alternative, which includes construction of a physical barrier. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-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 Lake Michigan water for *E. flexuosa* prior to discharge into the CAWS.
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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage for *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 passage of this species through the CAWS by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Lake Michigan water for *E. flexuosa* prior to discharge into the CAWS. There are reports on UV effectiveness on other green algal species (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 h) 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 delayed or decreased germination in spores subjected to UV-B or UV-C radiation of any dose.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is expected to be an effective control for *E. flexuosa.* 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through this 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
Lakefront 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 where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through this 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 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 on *E. flexuosa*, and whether an additional treatment process would be 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

LAKEFRONT 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	High	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.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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}: 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 Lakefront Hydrologic Separation Alternative is expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion and human-mediated dispersion 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 algaecides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for how nonstructural measures are expected to impact the current abundance and reproductive capacity of *E. flexuosa*.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and its current abundance and distribution.

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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, Illinois. However, the physical barrier is not expected to control the arrival of *E. flexuosa* to the CAWS. The closest that *E. flexuosa* has been recorded to the CRCW was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that may 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures, such as managing nutrient loads to waterways, that may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The Lakefront 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* 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to control the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. The Lakefront Hydrologic Separation Alternative 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 *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species. The Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of arrival rating for this time step does not differ from that in the No New Federal Action Risk Assessment.

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

The Lakefront Hydrologic Separation Alternative includes measures that would reduce the likelihood that *E. flexuosa* would disperse; 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.
Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

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

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

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

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *E. flexuosa* at the CRCW in Chicago, Illinois, with the construction of a physical barrier and the ANSTP.

The physical barrier would be constructed in the channel at the CRCW 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 ACE event. The physical barrier is expected to control the current-driven passage of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam.

The ANSTP is expected to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 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, where 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. Based on water quality data, UV treatment of Lake Michigan water at the CRCW’s control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 *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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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

Lake Michigan water for *E. flexuosa* 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 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 Lakefront 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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-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 is expected to treat Lake Michigan water for *E. flexuosa* prior to discharge into the CAWS.
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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, Illinois, with the construction of a physical barrier and the 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 passage of this species through the CAWS by natural dispersion and human-mediated transport.

In addition, an ANSTP would treat Lake Michigan water for *E. flexuosa* prior to discharge into the CAWS. There are reports regarding UV effectiveness on other green algal species (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 h) 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 delayed or decreased germination in spores subjected to UV-B or UV-C radiation of any dose..

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is expected to be an effective control for *E. flexuosa*. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through this 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
Lakefront 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 where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through this 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, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, and length of exposure of UV radiation on *E. flexuosa*, and whether an additional treatment process would be 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

LAKEFRONT 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.

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

T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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}: 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 Lakefront Hydrologic Separation Alternative is expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to 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 affect human-mediated transport.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion and human-mediated dispersion 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 algaecides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce the probability of human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for how nonstructural measures may affect current abundance and reproductive capacity of *E. flexuosa*.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. Nonstructural measures such as agency monitoring may be used to locate areas where

E. flexuosa is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and its current abundance and distribution.

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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of *E. flexuosa* to the CAWS. The closest that *E. flexuosa* has been recorded to Calumet Harbor was on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may affect the distance from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that may 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce habitat suitability *for E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. The Lakefront Hydrologic Separation Alternative would also 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 *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of arrival rating for this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may 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-HIGH

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

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

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 *E. flexuosa* through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *E. flexuosa* at Calumet City, Illinois, with the construction of a physical barrier and the ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 purpose of the ANSTP is to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 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, where 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. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion o*f E. flexuosa* through this aquatic pathway.

T_{50}: See T_0.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 *E. flexuosa* through this 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Little Calumet River water for *E. flexuosa* 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 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 Lakefront 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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* 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 Little Calumet River water for *E. flexuosa* prior to discharge into the CAWS.
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 Lakefront 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. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease due to the adoption of water quality

standards and effluent discharge limitations currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012). These changes may reduce habitat suitability in the CAWS.
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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 *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 passage of this species through the CAWS by human-mediated transport and natural dispersion.

In addition, an ANSTP would treat Little Calumet River water for *E. flexuosa* prior to discharge into the CAWS. There are reports regarding UV effectiveness on other green algal species (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 delayed or decreased germination in spores subjected to UV-B or UV-C radiation of any dose.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is expected to be an effective control for *E. flexuosa*. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through this aquatic pathway by 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
Lakefront 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 where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through this 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, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, and length of exposure of UV radiation on *E. flexuosa*, and whether an additional treatment process would be 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 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

LAKEFRONT 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.

Lakefront 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 Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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}: 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 affect the invasion speed of *E. flexuosa*.
The Lakefront Hydrologic Separation Alternative is expected to affect the arrival for *E. flexuosa* from natural dispersion (i.e., current-driven passage) through aquatic pathways to 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 affect human-mediated transport.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* from natural dispersion and human-mediated dispersion 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 addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce 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 affect the current abundance and reproductive capacity of *E. flexuosa*.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform

the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce the probability of establishment near CAWS. The Lakefront Hydrologic Separation Alternative is expected to affect its 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival *E. flexuosa* to the CAWS. The closest that *E. flexuosa* has been recorded to Indiana Harbor 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 affect the distance from pathway.

The Lakefront Hydrologic Separation Alternative may 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. The Lakefront Hydrologic Separation Alternative would also 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 *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Lakefront Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* arriving through the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Lakefront Hydrologic Separation Alternative's low probability of arrival rating for this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion and distribution of *E. flexuosa*. However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may 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 Lakefront 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 *E. flexuosa* through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *E. flexuosa* at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 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), would be able to pass through the screens, where they would subsequently be 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. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* 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 Lakefront 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 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Little Calumet River water for *E. flexuosa* 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: None. The Lakefront 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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* 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 Little Calumet River water for *E. flexuosa* prior to discharge into the CAWS.

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 Lakefront 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. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease due to the adoption of water quality

standards and effluent discharge limitations currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012). These changes may reduce habitat suitability in the CAWS.
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
Lakefront 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 Lakefront 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 at this time step. Therefore, the Lakefront 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_{10}.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, Illinois, with the construction of a physical barrier and the 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 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 CAWS by human-mediated transport and natural dispersion.

In addition, an ANSTP would treat Little Calumet River water for *E. flexuosa* prior to discharge into the CAWS. There are reports of UV effectiveness on other green algal species (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 h) 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 delayed or decreased germination in spores subjected to UV-B or UV-C radiation of any dose.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is expected to be an effective control for *E. flexuosa*. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through this aquatic pathway by 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
Lakefront 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 through the aquatic pathway is expected to slow passage to an uncertain degree.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through this 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, further investigation and bench-scale studies would be needed prior to design and construction to determine the optimum wavelength, required dose, and length of exposure of UV radiation on *E. flexuosa*, and whether an additional treatment process would be 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(3)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) and (3) designate 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Alternative Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 affect the invasion speed of *E. flexuosa*.

The Lakefront Hydrologic Separation Alternative is expected to affect the arrival for *E. flexuosa* from natural dispersion through aquatic pathways to 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 affect human-mediated transport.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* from natural dispersion and human-mediated dispersion 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 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 the current abundance and reproductive capacity of *E. flexuosa*.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. The Lakefront Hydrologic Separation Alternative would also 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 its 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of *E. flexuosa* to the CAWS. The closest that *E. flexuosa* has been recorded to the BSBH 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that may 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways which may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* from natural dispersion through aquatic pathways to the CAWS. The Lakefront Hydrologic Separation Alternative would also 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 *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Lakefront 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 Lakefront Hydrologic Separation Alternative's low probability of arrival rating for this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The current of the lake may transport the species away from the pathway entrance; however, transport by boat is possible. The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to manage the dispersion and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions on the 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 Lakefront 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 *E. flexuosa* through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *E. flexuosa* at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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. Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of *E. flexuosa* 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 Lakefront 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 *E. flexuosa* through this 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. 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. There is recreational but not commercial vessel traffic to the BSBH from Lake Michigan (USACE 2011a, b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* 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.

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 Lakefront 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. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease due to the adoption of water quality standards and effluent discharge limitations currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012). These changes may reduce habitat suitability in the CAWS.

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
Lakefront 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: The Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that *E. flexuosa* and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would pass through the aquatic pathway. Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway. 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
Lakefront 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 through the aquatic pathway is expected to slow passage to an uncertain degree.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through this aquatic pathway. The physical barrier is expected to control the passage of *E. flexuosa* through the CAWS 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}: 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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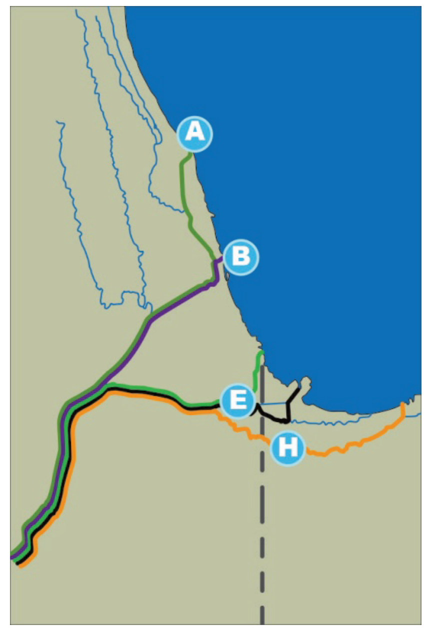
E.5.2.1.2 Red Algae (*Bangia atropurpurea*)

LAKEFRONT 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 T_0 by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.



Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

Lakefront 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	Medi	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 the WPS and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for red algae.

T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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}: MEDIUM

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

Factors That Influence Arrival of Species

b. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the Chicago Area Waterway System (CAWS) as a result of natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 dispersion.
These measures include restrictions on nutrient loads to waterways that may affect the current abundance or reproductive capacity of red algae.
T_{10}: See T_0. The distribution and abundance of red algae in the Great Lakes may decrease due to possible improvements in the water quality of southern Lake Michigan. These improvements may reduce the anthropogenic inputs into Lake Michigan preferred by this species.
T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the WPS in Wilmette, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS because the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways that may affect where red algae is able to establish and therefore its locations in relation to the CAWS. Red algae may be present at the WPS.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan for red algae.

T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for red algae during this time step.
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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restriction on nutrient loads to waterway; however, these measures are not expected to

affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Red algae are tolerant of a wide range of temperatures (see section 2f of the *Nonstructural Risk Assessment*). Therefore, appropriate habitat conditions are expected to continue to be present (see sections 2f, 2c of the *Nonstructural Risk Assessment*) along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change (see section 2f of the *Nonstructural Risk Assessment*). The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. As a result, the species' probability of arrival is expected to remain medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: Although red algae was historically present in southern Lake Michigan, recent surveys have not indicated its presence.

The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS. Therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: See T_0. The future population trends and the future rate of dispersion of red algae are uncertain. The effects of measures to improve water quality in Lake Michigan on red algae are also uncertain.
T_{50}: See T_{25}. The future effects of climate change on red algae and its habitat suitability in Lake Michigan are uncertain.

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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for red algae at the WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at WPS 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 Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) from Lake Michigan 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 employed at the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes and 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). 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; subsequently, they would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the Wilmette Pumping Station project location is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of red algae 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 Lakefront 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 via 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Lake Michigan water for red algae prior to its 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, there is no commercial vessel traffic into the North Shore Channel from downstream (USACE 2011a).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Lake Michigan water for red algae prior to its discharge into the CAWS.

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 Lakefront 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.

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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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, 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-h UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found delayed or decreased germination in spores subjected to UV-B or UV-C radiation at any dose. There are no specific reports in the literature that identify the effectiveness or dose-response of UV radiation on *B. atropurpurea* spore viability.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that of a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is anticipated to be an effective control for red algae. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of red algae passing through this 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
Lakefront 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 red algae's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through this 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 for red algae, and whether an additional treatment process would be 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 Rsk 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

LAKEFRONT 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.

Lakefront 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 the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for red algae.

T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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}: 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 Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways may affect the current abundance or reproductive capacity of red algae.
T_{10}: See T_0.See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, Illinois. However, the physical

barrier is not expected to control the arrival of red algae at the CAWS because 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where red algae is able to establish.
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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan for red algae.
T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for red algae during this time step.
T_{25}: See T_{10}.
T_{50}: See T_{10}. Future climate change or new environmental regulations may alter physical, chemical, and climatological suitability of the Great Lakes for red algae. Mean temperature in particular is expected to increase (Wuebbles et al. 2010). However, red algae can tolerate a wide range of temperatures 2–26°C (35.6–78°F) (Kipp 2011; Garwood 1982) and is globally distributed across wide latitudes from boreal to tropical (Guiry and Guiry 2012).

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_{25}. Red algae are tolerant of a wide range of temperatures (see section 2f of the Nonstructural Risk Assessment). It has been found in southern Lake Michigan in the vicinity of the CRCW (see section 2e of the *Nonstructural Risk Assessment*), and appropriate habitat conditions are expected to continue to be present (see sections 2c, 2f of the *Nonstructural Risk Assessment*) along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change (see section 2f of the *Nonstructural Risk Assessment*). The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the probability of arrival is expected to remain medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: See T_0. The future population trends and future rate of dispersion of red algae are uncertain. The effects measures to improve water quality in Lake Michigan would have on red algae are also uncertain.
T_{50}: See T_0. The future effects of climate change on red algae and its habitat suitability in Lake Michigan are uncertain.

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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for red algae at CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at CRCW 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 ANS from Lake Michigan 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 employed at the ANSTP would include screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, respectively, are expected to pass through the screens; subsequently, they would be pumped through the ANTSP 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. Based on water quality data, UV treatment of Lake Michigan water at the CRCW is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae 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 Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Lake Michigan water for red algae prior to its discharge into the CAWS. The physical barrier would 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 it in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier. The ANSTP would treat Lake Michigan water for red algae prior to its discharge into the CAWS.
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 Lakefront Hydrologic Separation Alternative includes nonstructural measure 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.

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
Lakefront 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 Lakefront 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 and human-mediated transport. The alternative does not include measures to address the immediate passage of red algae via current-driven passage or the Lake Michigan water diversion to Brandon Road Lock and Dam. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at CRCW in Chicago, 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.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the CAWS. 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-h UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found delayed or decreased germination in spores subjected to UV-B or UV-C radiation at any dose. There are no specific reports in the literature that identify the effectiveness or dose-response of UV radiation on *B. atropurpurea* spore viability.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is anticipated to be an effective control for red algae. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of red algae passing through this 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
Lakefront 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 red algae's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through this 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 the design and construction of the ANSTP, further investigation and bench-scale studies would be needed determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae, and whether an additional treatment process would be 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

LAKEFRONT 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	High	Medium	High	Medium	High	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.

Lakefront 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	High	Medium	High	Medium	High	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 Lakefront Hydrologic Separation Alternative does not affect the pathway for red algae.

T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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}: 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 Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways may affect the current abundance or reproductive capacity of red algae.
T_{10}: See T_0. The distribution and abundance of red algae in the Great Lakes may decrease due to possible improvements in the water quality of southern Lake Michigan. These improvements may reduce the anthropogenic inputs into Lake Michigan that are preferred by 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS because the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where red algae is able to establish, and therefore its location in relation to the CAWS. Red algae may be present at the Calumet Harbor.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan.

T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for red algae during this time step.
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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red

algae may be present at the Calumet Harbor. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Red algae are tolerant of a wide range of temperatures (see section 2f of the *Nonstructural Risk Assessment*). Red algae have been found in southern Lake Michigan (see section 2e of the Nonstructural Risk Assessment) and appropriate habitat conditions are expected to continue to be present (see sections 2f, 2c of the *Nonstructural Risk Assessment*) along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change (see section 2f of the *Nonstructural Risk Assessment*). The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the species' probability of arrival is expected to remain medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: See T_0. The future population trends of red algae are uncertain. The future rate of dispersion for this species is uncertain. The effects of measures to improve water quality in Lake Michigan on red algae are uncertain.
T_{50}: See T_{25}. The future effects of climate change on red algae and habitat suitability in Lake Michigan are uncertain.

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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for red algae at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 ANS from Little Calumet River 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 employed at the ANSTP would include screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, respectively, 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 because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at Calumet City, Illinois, is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Little Calumet River water for red algae prior to its discharge into the CAWS. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Little Calumet River water for red algae prior to its discharge into the CAWS.

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 Lakefront 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.

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
Lakefront 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 Lakefront 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 this aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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. 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 and human-mediated transport of red algae through this aquatic pathway.

The purpose of the ANSTP is to remove ANS from Little Calumet River water prior to discharge to the CAWS. 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-h UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found delayed or decreased germination in spores subjected to UV-B or UV-C radiation at any dose. There are no specific reports in the literature that identify the effectiveness or dose-response of UV radiation on *B. atropurpurea* spore viability.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is expected to be an effective control for red algae. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of red algae passing through this 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
Lakefront 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 red algae's passage through the CAWS via natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through this 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 still be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae, and whether an additional treatment process would be 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for red algae.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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}: 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 Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of red algae at the CAWS because 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}.

d. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 likely to be successful because of the species' prolonged monospore release, which promotes rapid population growth.

In addition, the Lakefront Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways, which may affect the current abundance or reproductive capacity of red algae.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of red algae outside of its current distribution or to affect its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan for red algae.
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_{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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. 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
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. The future population trends and future rate of dispersion of red algae are uncertain. The effects of measures to improve water quality in Lake Michigan on red algae are uncertain.

T_{50}: See T_{25}. The future effects of climate change on red algae and habitat suitability in Lake Michigan are uncertain.

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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for red algae at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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.

The purpose of the ANSTP is to remove ANS from Little Calumet River 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 employed at the ANSTP would include screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, respectively, are expected to pass through the screens; subsequently, they would be pumped through the ANTSP 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. Based on water quality data, UV treatment of Little Calumet River water at Calumet City, Illinois, is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Little Calumet River water for red algae prior to its 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 Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures would 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 Little Calumet River water for red algae prior to its discharge into the CAWS.

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 Lakefront 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.

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 due to the adoption of water quality standards and effluent discharge limitations that are currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012); these new standards may reduce the probability of red algae establishment in the CAWS.

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
Lakefront 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 Lakefront 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 this aquatic pathway by natural dispersion and 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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.

The purpose of the ANSTP is to remove ANS from Little Calumet River water prior to discharge to the CAWS. 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-h UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found delayed or decreased germination in spores subjected to UV-B or UV-C radiation at any dose. There are no specific reports in the literature that identify the effectiveness or dose-response of UV radiation on *B. atropurpurea* spore viability.

These studies indicated that UV radiation has effects on algae. The UV-C radiation that would be used in the ANSTP would be similar in design to that used in a disinfection system for a wastewater treatment facility. With targeted application, UV-C radiation is anticipated to be an effective control for red algae. 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.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of red algae passing through this aquatic pathway by 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
Lakefront 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 red algae's passage through the CAWS via natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through this 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 still be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae, and whether an additional treatment process would be 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. *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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of red algae at the CAWS because 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}.

d. *Current Abundance and Reproductive Capacity*

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the current abundance or reproductive capacity of red algae.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect where red algae is able to establish, and therefore its location in relation to the CAWS.

T_{10}: The species may be present at the BSBH. Alternatively, its range could contract, which would increase its distance from the 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may affect the habitat suitability of southern Lake Michigan for red algae.

T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for red algae during this time step.
T_{25}: 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Red algae are tolerant of a wide range of temperatures (see section 2f of the Nonstructural Risk Assessment). The species has been found in southern Lake Michigan in the vicinity of Indiana Harbor (see section 2e of the Nonstructural Risk Assessment), and appropriate habitat conditions are expected to continue to be present (see sections 2c, 2f of the Nonstructural Risk Assessment) along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change (see section 2f of the Nonstructural Risk Assessment).

The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. For these reasons, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect red algae's arrival at the CAWS through aquatic pathways. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. The future population trends and future rate of dispersion of red algae are uncertain. The effects of measures to improve water quality in Lake Michigan on red algae are also uncertain.

T_{50}: See T_{25}. The future effects of climate change on red algae and its habitat suitability in Lake Michigan are uncertain.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to not address the natural dispersion of red algae through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for red algae at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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. Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway to Brandon Road Lock and Dam.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the human-mediated transport of red algae through this 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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 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. There is recreational but not commercial vessel traffic to BSBH from Lake Michigan (USACE 2011a, b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. Water depth is adequate for red algae throughout the CAWS (Kipp 2011; LimnoTech 2010). This species has been found in the vicinity of BSBH. Lockport Lock and Dam may act as a temporary barrier to natural dispersion, but not to hull-mediated transport.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront Hydrologic Separation Alternative. Structural measures implemented 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.

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 Lakefront 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.

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 due to the adoption of water quality standards and effluent discharge limitations that are currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012); these new standards may reduce the probability of red algae establishment in the CAWS.

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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of red algae through the aquatic pathway by natural dispersion and 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that red algae and vessels potentially transporting the species in ballast and bilge water, or via hull-fouling, would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of red algae passing through the aquatic pathway. 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
Lakefront 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 implemented as part of the Lakefront Hydrologic Separation Alternative includes managing nutrient loads to waterways. The effectiveness of nutrient management on red algae abundance and its natural rate of dispersion is uncertain. Additionally, nonstructural measures alone are not expected to control the passage of red algae by natural dispersion and human-mediated transport through the aquatic pathway. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of red algae through this aquatic pathway. The physical barrier is expected to control the passage of red algae through the CAWS 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}: 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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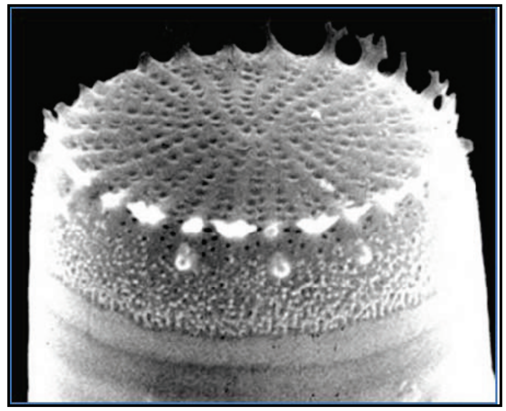
E.5.2.1.3 Diatom (*Stephanodiscus binderanus*)



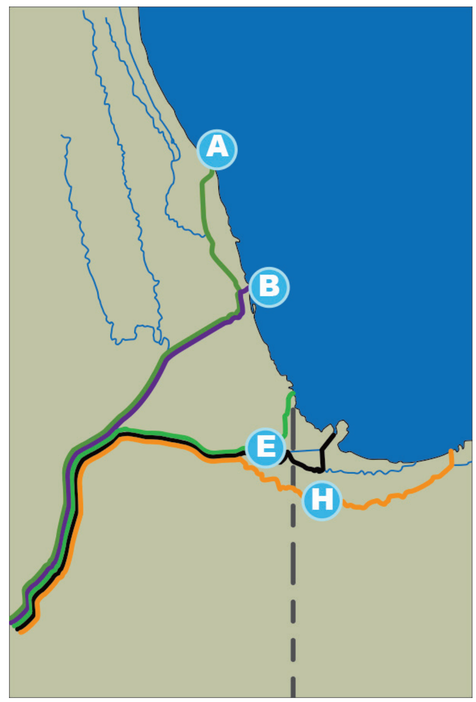
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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) 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}).

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

Lakefront 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 WPS and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for *S. binderanus*.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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

c. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides could affect the current abundance or reproductive capacity of *S. binderanus*.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.
T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the WPS in Wilmette, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically 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 Lakefront 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.
The Lakefront Hydrologic Separation Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides 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.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area (see section 2e of the *Nonstructural Risk Assessment*). The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways. 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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *S. binderanus* at the WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the WPS 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 passage of *S. binderanus* by natural dispersion (i.e., current-driven passage) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes and Mississippi River Interbasin Study (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) in size. *Stephanodiscus binderanus* filaments and reproductive spores, which have a volume of 830 μm^3 (Kipp 2011), 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 block the UV light from reaching them. On the basis of water quality data, UV treatment of Lake Michigan water at the WPS is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

There are reports on the effectiveness of UV radiation on algal species other than *S. binderanus*. 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.

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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* 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 Lakefront 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 this 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 Lakefront 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 Lake Michigan water for *S. binderanus* 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, 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. The Lakefront 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 Lakefront Hydrologic Separation Alternative, which includes construction of a physical barrier. 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 vessel-mediated transport of this species through the aquatic pathway because this species and vessels potentially transporting it in ballast and bilge water or attached to hulls would be unable to traverse the barrier. The ANSTP would treat Lake Michigan water for *S. binderanus* prior to discharge into the CAWS thereby controlling human-mediated transport of this species as well.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways and application of algaecides, which may

reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 and bilge 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 Lake Michigan water for *S. binderanus* prior to discharge into the CAWS. There is no published information in the literature documenting the effectiveness of UV radiation on *S. binderanus*; however, there are reports 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through this 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
Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through this 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 to UV radiation for *S. binderanus,* and whether an additional treatment process would be 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 2

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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for *S. binderanus*.

T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS from natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS due to human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides could affect the current abundance or reproductive capacity of *S. binderanus*.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.

T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically 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 Lakefront 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.

The Lakefront Hydrologic Separation Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Lakefront Hydrologic Separation Alternative, nonstructural measure such as restrictions on nutrient loads to waterways and application of algaecides 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways 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 occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.

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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area (see section 2e of the *Nonstructural Risk Assessment*). The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0. *S. binderanus* is documented to have declined significantly in Lake Michigan, and this species is not consistently found in phytoplankton surveys (see section 2c of the *Nonstructural Risk Assessment*). Future improvements in water quality in southern Lake Michigan may continue to reduce the abundance of *S. binderanus* near the CRCW. However, the species is not expected to be eliminated.

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 Lakefront 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 *S. binderanus* through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *S. binderanus* at the CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the CRCW 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 passage of *S. binderanus* by natural dispersion (i.e., current-driven passage) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 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) in size. *Stephanodiscus binderanus* filaments and reproductive spores, which have a volume of 830 μm^3 (Kipp 2011), are expected to pass through the screens. They would subsequently be pumped through the ANTSP 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. On the basis of water quality data, UV treatment of Lake Michigan water at the CRCW project location is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

There are reports on the effectiveness of UV radiation on algal species other than *S. binderanus*. 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.

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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* 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 Lakefront 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 this 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 Lakefront 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 Lake Michigan water for *S. binderanus* 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 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. Surface water is present year-round, and water depth is adequate throughout the CAWS (LimnoTech 2010).

The Lakefront 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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. 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 passage of the species by natural dispersion and vessel-mediated transport 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

Lake Michigan water for *S. binderanus* prior to discharge into the CAWS, thereby controlling human-mediated transport of this species as well.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS and thereby reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of *S. binderanus* through the aquatic pathway via natural dispersion or human-mediated transport. Therefore, the Lakefront Hydrologic Separation Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 and bilge water or 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 CAWS by human-mediated transport and natural dispersion.

In addition, an ANSTP would treat Lake Michigan water for *S. binderanus* prior to discharge into the CAWS. There are reports on algal species other than *S. binderanus*.

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 to UV radiation for *S. binderanus*.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through this 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
Lakefront 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 reduce the uncertainty of passage for *S. binderanus* through this 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through this 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 to UV radiation for *S. binderanus,* and whether an additional treatment process would be 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

LAKEFRONT 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	High	Medium	High	Medium	High	Medium	High
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.

Lakefront 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	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 Lakefront Hydrologic Separation Alternative does not affect the pathway for *S. binderanus*.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS due to natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways could affect the current abundance or reproductive capacity of *S. binderanus*.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.
T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers
T_0: None.

T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981) and is likely at the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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.

The Lakefront Hydrologic Separation Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Lakefront Hydrologic Separation Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides, 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 occurs in Lake Michigan offshore of Chicago

(Makarewicz and Baybutt 1981). Hence the species is likely at the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.
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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area (see section 2e of the *Nonstructural Risk Assessment* for this species).
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways. 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_0. 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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *S. binderanus* at Calumet City, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 passage of *S. binderanus* by natural dispersion (i.e., current-driven passage) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Little Calumet River water prior to discharge to the Mississippi River Basin side of the physical barrier. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening 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) in size. *Stephanodiscus binderanus* filaments and reproductive spores, which 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. On the basis of water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, project location is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

There are reports on the effectiveness of UV radiation on algal species other than *S. binderanus*. 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.

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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of *S. binderanus* 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 Lakefront 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 this 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 Lakefront 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 Little Calumet River water for *S. binderanus* 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 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. Surface water is present year-round, and water depth is adequate throughout the CAWS (LimnoTech 2010).

The Lakefront 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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. 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 vessel-mediated transport of this species through the aquatic pathway because this 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 Little Calumet River water for *S. binderanus* prior to discharge into the CAWS, thereby controlling human-mediated transport of the species as well.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS and thereby reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of *S. binderanus* through this aquatic pathway via natural dispersion or human-mediated transport. Therefore, the Lakefront Hydrologic Separation Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or attachment to vessel hulls 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, an ANSTP would treat Little Calumet River water for *S. binderanus* prior to discharge into the CAWS. There are reports on algal species other than *S. binderanus*. 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through this 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
Lakefront 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 reduce the uncertainty of passage for *S. binderanus* through this 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through this 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 to UV radiation for *S. binderanus*, and whether an additional treatment process would be 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for *S. binderanus*.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS due to natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS due to human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides could affect the current abundance or reproductive capacity of *S. binderanus*.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, but can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.
T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of *S. binderanus* at the CAWS. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically 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 Lakefront 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.

The Lakefront Hydrologic Separation Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Lakefront Hydrologic Separation Alternative, nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides could affect habitat suitability for this species.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algaecides, 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 occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.
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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating
T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area (see section 2e of the *Nonstructural Risk Assessment* for this species).
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways. 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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *S. binderanus* at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 passage of *S. binderanus* by natural dispersion (i.e., current-driven passage) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Little Calumet River water prior to discharge to the Mississippi River Basin side of the physical barrier. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water.

The treatment technologies included in the ANSTP would include screening 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) in size. *Stephanodiscus binderanus* filaments and reproductive spores, which 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. On the basis of water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, project location is anticipated to be effective. 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.

There are reports on the effectiveness of UV radiation on algal species other than *S. binderanus*. 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.

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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* 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 Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Little Calumet River water for *S. binderanus* 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: None. The Lakefront 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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. 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 vessel-mediated transport of this species through the aquatic pathway because this 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 Little Calumet River water for *S. binderanus* prior to discharge into the CAWS, thereby controlling human-mediated transport of this species as well.

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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways and application of algaecides, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS and thereby reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront Hydrologic Separation Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 *Stephanodiscus binderanus* and vessels potentially transporting the species in ballast and bilge water or 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 CAWS by human-mediated transport and natural dispersion.

In addition, an ANSTP would treat Little Calumet River water for *S. binderanus* prior to discharge into the CAWS. There are reports on algal species other than *S. binderanus*. 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through this aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is low.

T_{50}: See T_{25}. Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through this aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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 reduce the uncertainty of passage for S. *binderanus* through this 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through this 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 to UV radiation for *S. binderanus*, and whether an additional treatment process would be 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to an extreme storm event, a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS due to natural dispersion (i.e., current-driven passage) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. *Current Abundance and Reproductive Capacity*

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides could affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0.

T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.

T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. *Existing Physical Human/Natural Barriers*

T_0: None.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. 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). The species is likely already at the pathway.

T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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.

The Lakefront Hydrologic Separation Alternative is not expected to reduce the habitat suitability for *S. binderanus* in southern Lake Michigan. As part of the Lakefront Hydrologic Separation Alternative, nonstructural measures such as restrictions on nutrient loads to waterways and application of algaecides 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
With Lakefront 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 Lakefront Hydrologic Separation Alternative includes restrictions on nutrient loads to waterways and application of algaecides, 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 occurs in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Hence, the species is likely already at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.
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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area (see section 2e of the *Nonstructural Risk Assessment*).

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for *S. binderanus* at the CAWS through aquatic pathways. 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for *S. binderanus* at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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 an extreme storm event, a 0.2% ACE event. The physical barrier at the Hammond control point is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to affect the human-mediated transport of *S. binderanus* through this 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 Lakefront 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 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. There is recreational but not commercial vessel traffic to the BSBH from Lake Michigan (USACE 2011a, b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however,

these measures alone are not expected to affect the natural dispersion or human-mediated transport of *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 Lakefront Hydrologic Separation Alternative which includes construction of a physical barrier. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through this 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.
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 Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways and application of algaecides, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS and thereby reduce 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.
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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that can be implemented at T_0; however, these measures alone are not expected to affect passage for *S. binderanus* through the aquatic pathway via natural dispersion or human-mediated transport. Therefore, the Lakefront Hydrologic Separation Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway. Therefore, the probability of passage is low.

T_{50}: See T_{25}. The physical barrier, implemented as part of the Lakefront Hydrologic Separation Alternative, reduces the likelihood that *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would pass through the aquatic pathway. Therefore, the probability of passage is reduced to low.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways. The effectiveness of nutrient management on *S. binderanus* abundance and its natural rate of dispersion is uncertain. Additionally, nonstructural measures alone are not expected to reduce uncertainty associated with the uncertainty of passage for *S. binderanus* via natural dispersion or human-mediated transport through the aquatic pathway. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through this aquatic pathway. The physical barrier is expected to control passage of *S. binderanus* through the CAWS 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}: 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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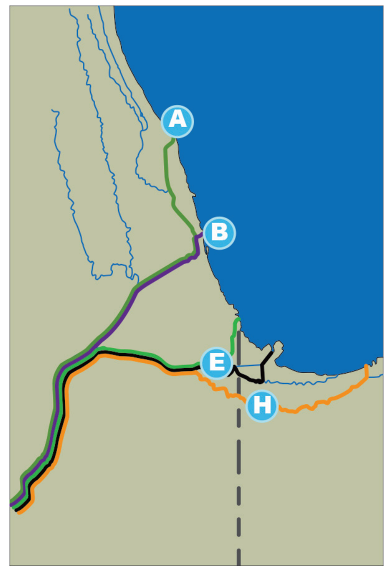
E.5.2.2 Plants

E.5.2.2.1 Reed Sweetgrass (*Glyceria maxima*)

LAKEFRONT 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 T_0 by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.



Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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

d. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the invasion speed of reed sweetgrass.

The Lakefront 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, which may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect human-mediated transport.

The Lakefront 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 human-mediated transport at the CAWS 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. Additionally, the implementation of a ballast/bilge water exchange program, education and outreach, promoting the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures include ANS control methods, such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, which may affect the current abundance and propagule pressure of the species, which is expected to affect reed sweetgrass's arrival at the CAWS through aquatic pathways. Additionally, 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at the WPS in Wilmette, 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 affect the distance of reed sweetgrass from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that may control the species 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 Lakefront Hydrologic Separation Alternative is not expected to reduce the availability of suitable 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	Low	Low	Low	Medium
Lakefront 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 Lakefront 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 to 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 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 Lakefront 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 Lakefront 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 Lakefront 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
Lakefront 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.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to reduce the arrival of reed sweetgrass at 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 the spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012, TNC-GIST 2005). Implementing a comprehensive program 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for reed sweetgrass at the Wilmette Pumping Station in Wilmette, Illinois, with the construction of a physical barrier and the ANSTP.

The physical barrier would be constructed in the channel at the WPS 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 reed sweetgrass through this aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS in Lake Michigan water prior to discharge into the CAWS. The ANSTP would be constructed at Wilmette, Illinois, and would treat Lake Michigan water used to improve CAWS water quality. The ANSTP would be a flow-through system that passes incoming water through a 0.75-in. screen followed by ultraviolet (UV) radiation as a treatment process against 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.

Self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. Adult reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 1.5 to 2 mm (Washington State Noxious Weed Control Board 2012), is expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

The performance of UV treatment is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS project location is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of reed sweetgrass 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 Lakefront 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 this 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan 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, 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 Lakefront 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 Lakefront 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 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 Lake Michigan water for reed sweetgrass prior to discharge into the CAWS.
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 Lakefront 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_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Lakefront 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 Lakefront 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 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}: The Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the Wilmette Pumping Station in Wilmette, Illinois, with the construction of a physical barrier and the 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 passage of this species through the CAWS by human-mediated transport and natural dispersion.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS. The 0.4-in. screens of the ANSTP would 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 irradiation 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. Peykarestan and Seify (2012) measured rate of germination and seedling growth of red bean 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 anticipated that the 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through this aquatic pathway via natural dispersion and the Lake Michigan diversion. 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
Lakefront 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 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through this 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. Priior 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 on reed sweetgrass, and the need for an additional treatment process 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

LAKEFRONT 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.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Chicago River at the Chicago River Controlling Works. 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 affect the invasion speed of reed sweetgrass.

The Lakefront 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 may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect human-mediated transport.

The Lakefront 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. Additionally, the implementation of a ballast/bilge water exchange program, education and outreach, promoting the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect current abundance and reproductive capacity of reed sweetgrass.

The Lakefront 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, which is 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, which may affect the current abundance and propagule pressure of the species, and are expected to affect reed sweetgrass's arrival at the CAWS through aquatic pathways. Additionally, 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at the CRCW in Chicago, 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 affect the distance of reed sweetgrass from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the species 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 Lakefront Hydrologic Separation Alternative is not expected to affect the availability of suitable 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	Low	Low	Low	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass through aquatic pathways to the CAWS. 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 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative is expected to reduce the probability of arrival of this species through aquatic pathways to 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
Lakefront 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 Lakefront Hydrologic Separation Alternative are expected to control 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 Risk Assessment for this species.

The Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for reed sweetgrass at CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at CRCW 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 Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from Great Lakes Basin side of a control point 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 and UV treatment 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). Adult reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 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.

The performance of UV treatment is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the CRCW control point is anticipated to be effective. 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 Lakefront 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 Lakefront 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 this 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan 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 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 Lakefront 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 Lakefront 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 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 Lake Michigan water for reed sweetgrass prior to discharge into the CAWS.

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 Lakefront Hydrologic Separation Alternative is not expected to reduce the probability of passage due to suitable habitat availability.

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
Lakefront 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 Lakefront 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 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}: The Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 Lake Michigan water for reed sweetgrass prior to discharge into the CAWS. The 0.4-in. screens of the ANSTP would 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 irradiation 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. 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 anticipated that the 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through this aquatic pathway by 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
Lakefront 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 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through this 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 on reed sweetgrass, and the need for an additional treatment process 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

LAKEFRONT 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.

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

T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 affect the invasion speed of reed sweetgrass.

The Lakefront 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 may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect human-mediated transport.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that 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. Additionally, the implementation of a ballast/bilge water exchange program, education and outreach, promoting the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural may affect the current abundance and reproductive capacity of reed sweetgrass.

The Lakefront 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 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, which may affect the current abundance and propagule pressure of the species and reed sweetgrass's arrival at the CAWS through aquatic pathways. The Nonstructural alternative 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at Calumet City, 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 description on how nonstructural measures may affect the distance of reed sweetgrass from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the species 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 Lakefront Hydrologic Separation Alternative is not expected to affect the availability of suitable 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	Low	Low	Low	Medium
Lakefront 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 Lakefront 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 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative are expected to reduce the probability of arrival for this species at Calumet Harbor at this time step; 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
Lakefront 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.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the arrival of reed sweetgrass at the Calumet Harbor pathway. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for reed sweetgrass at Calumet City, Illinois, with the construction of a physical barrier and the ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from the Great Lakes Basin side of a control point 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 and UV treatment to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Adult reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 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.

The performance of UV treatment is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City (Illinois) project location is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass 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 Lakefront 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 this 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Little Calumet River 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 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 Lakefront 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 Lakefront 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 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 Little Calumet River water for reed sweetgrass prior to discharge into the CAWS.

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 Lakefront Hydrologic Separation Alternative is not expected to reduce the probability of passage due to suitable habitat availability.

T_{10}: See T_0.

T_{25}: See T_0. Upgrading wastewater treatment plants and the closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from some eutrophication; therefore, the suitability of water quality in the CAWS for reed sweetgrass may change. The availability of suitable substrate is not expected to increase.

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
Lakefront 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 Lakefront 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 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}: The Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 reed sweetgrass fragments and seeds 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 passage of this species through the aquatic pathway by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Little Calumet River water for reed sweetgrass prior to discharge into the CAWS. The 0.4-in. screens of the ANSTP would 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 irradiation 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. 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 anticipated that the 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through this aquatic pathway by 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
Lakefront 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 reed sweetgrass through this 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 as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through this 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 on reed sweetgrass, and the need for an additional treatment process 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
LAKEFRONT 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.

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

T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 affect the invasion speed of reed sweetgrass.

The Lakefront 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 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 may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect human-mediated transport.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures 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. Additionally, the implementation of a ballast/bilge water exchange program, education and outreach, promoting the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the current abundance and reproductive capacity of reed sweetgrass.

The Lakefront 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, which is 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 impact the current abundance and propagule pressure of the species, which is expected to impact reed sweetgrass's arrival at the CAWS through aquatic pathways. 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and the ANSTP at Calumet City, 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 affect the distance of reed sweetgrass from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the species 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 Lakefront 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.

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
Lakefront 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 Lakefront 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 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 Lakefront 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 Lakefront 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}: Implementation of nonstructural measures as part of the Lakefront Hydrologic Separation Alternative is expected to reduce the probability of arrival of this species at Indiana Harbor at this time step; 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
Lakefront 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.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the arrival of reed sweetgrass at the Indiana Harbor pathway. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for reed sweetgrass at Calumet City, Illinois, with the construction of a physical barrier and the ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from the Great Lakes Basin side of a control point 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 and UV treatment to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Adult reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments would be excluded by the screens. Seeds of reed sweetgrass, which can range in size from 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.

The performance of UV treatment is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City (Illinois) project location is anticipated to be effective. 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 Lakefront 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 Lakefront 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 this 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Little Calumet River 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 the 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 Lakefront 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 Lakefront 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 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 Little Calumet River water for reed sweetgrass prior to discharge into the CAWS.
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 Lakefront Hydrologic Separation Alternative is not expected to reduce the probability of passage due to availability of suitable habitat.
T_{10}: See T_0.
T_{25}: See T_0. Upgrading wastewater treatment plants and closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from some eutrophication; therefore, the suitability of water quality in the CAWS for reed sweetgrass may change. The availability of suitable substrate is not expected to increase.
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
Lakefront 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 Lakefront 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 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_{10}.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, Illinois, with the construction of a physical barrier and the 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 passage of this species through the CAWS by human-mediated transport and natural dispersion.

In addition, an ANSTP would treat Little Calumet River water for reed sweetgrass prior to discharge into the CAWS. The 0.4-in. screens of the ANSTP would 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 irradiation 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. 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 anticipated 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through this aquatic pathway by 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
Lakefront 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 control 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through this 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 on reed sweetgrass, and the need for an additional treatment process 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(3)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (3) 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative would separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 affect the invasion speed of reed sweetgrass.

The Lakefront 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 may affect the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect human-mediated transport.

The Lakefront 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. Additionally, the implementation of a ballast/bilge water exchange program, education and outreach, promoting the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the current abundance and reproductive capacity of reed sweetgrass.

The Lakefront 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 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, which may affect the current abundance and propagule pressure of the species and reed sweetgrass's arrival at the CAWS through aquatic pathways. Additionally, 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 affect the distance of reed sweetgrass from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the species 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 Lakefront Hydrologic Separation Alternative is not expected to affect the availability of suitable 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	Low	Low	Low	Medium
Lakefront 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 Lakefront 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 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 Lakefront 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 Lakefront 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 Lakefront 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to control the arrival of reed sweetgrass at the BSBH pathway. 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}: 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to address the natural dispersion (i.e., current-driven passage) reed sweetgrass through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for reed sweetgrass at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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. Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of reed sweetgrass 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to address the human-mediated transport of reed sweetgrass through this 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 Lakefront 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 Brandon Road Lock and Dam. 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. There is recreational but not commercial vessel traffic to the BSBH from Lake Michigan (USACE 2011a, b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront 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 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.
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 Lakefront Hydrologic Separation Alternative is not expected to reduce the probability of passage due to availability of suitable habitat.
T_{10}: See T_0.
T_{25}: See T_0. Upgrading wastewater treatment plants and closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from some eutrophication; therefore, the suitability of water quality in the CAWS for reed sweetgrass may change. The availability of suitable substrate is not expected to increase.
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
Lakefront 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 Lakefront 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 and 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 Assessments.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that the reed sweetgrass plant fragments and seeds and vessels potentially transporting the species in ballast water or attached to hulls would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway. 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
Lakefront 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.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures such as managing nutrient loads to waterways. The effectiveness of nutrient management on reed sweetgrass abundance and its natural rate of dispersion are uncertain. Nonstructural measures alone are not expected to reduce the uncertainty of passage for 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through this aquatic pathway. The physical barrier is expected to control the passage of reed sweetgrass through the aquatic pathway 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

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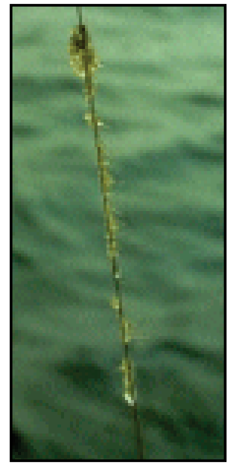
E.5.2.3 Crustaceans

E.5.2.3.1 Fishhook Waterflea (*Cercopagis pengoi*)



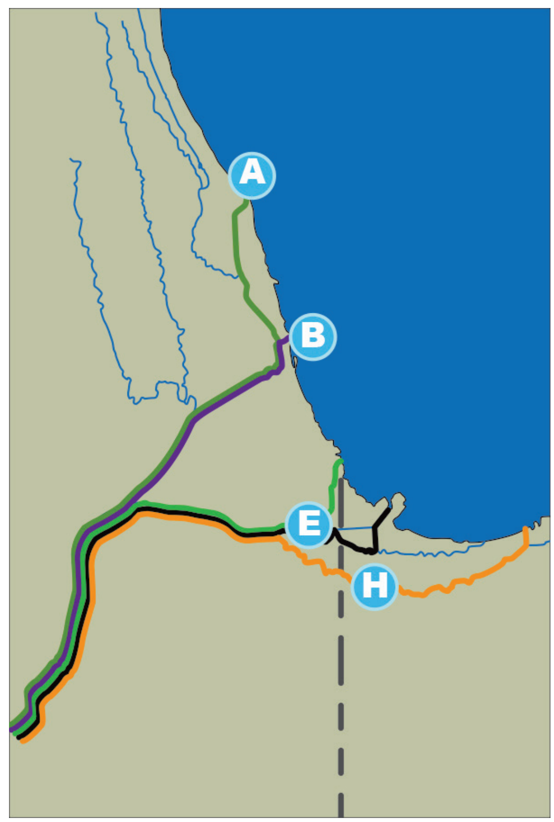
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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) 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}).

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

Lakefront 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for the fishhook waterflea.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an aquatic nuisance species treatment plant (ANSTP), and a physical barrier in the North Shore Channel at the WPS. 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

e. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the fishhook waterflea from natural dispersion (i.e., 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at WPS in Wilmette, 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). Its exact location and distance from the WPS are uncertain, but this species may be at the WPS.
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the WPS are uncertain, but this species may be at the WPS. 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the WPS are uncertain, but this species may be at the WPS. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative creates a control point for the fishhook waterflea at WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at WPS 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 passage of the fishhook waterflea by natural dispersion (i.e., passive drift) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) from the Great Lakes Basin side of a control point 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 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. The fishhook waterflea ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007) and is expected to pass through the screens; it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the Wilmette Pumping Station control point is expected to be effective. 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. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea 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 Lakefront 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 fishhook waterflea through this 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the fishhook waterflea 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, 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 Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-mediated transport of this species through the aquatic pathway because this 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 Lake Michigan water for the fishhook waterflea prior to its discharge into the CAWS, thereby controlling human-mediated transport of this species as well.
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 Lakefront 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 following 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the fishhook waterflea 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 in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at WPS in Wilmette, 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 and bilge water or 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 CAWS via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Lake Michigan water for the fishhook waterflea prior to its discharge into the CAWS. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV radiation, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook waterflea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200 to 800 L 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% kill in all treatments except ultrasound), while cladocerans were the least affected group (>99% kill 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea passing through this 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
Lakefront 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 via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through this 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 the fishhook waterflea through the ANSTP. Overall, 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

LAKEFRONT 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.

Lakefront 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for fishhook waterflea.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, 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). Its exact location and distance from the CRCW are uncertain, but this species may be at the CRCW.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from the 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address natural dispersion (i.e., passive drift) of the fishhook waterflea through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the fishhook waterflea at CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at CRCW 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 an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from the Great Lakes Basin side of a control point 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. The fishhook waterflea ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007) and is expected to pass through the screens; it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of CRCW control point is expected to be effective. 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. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the fishhook waterflea prior to its discharge into the CAWS. 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 or 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 Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-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 Lake Michigan water for the fishhook waterflea prior to its discharge into the CAWS, thereby controlling human-mediated transport of this species as well.

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 Lakefront 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 following 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
Lakefront 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 Lakefront 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 fishhook waterflea 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 passage of this species through the CAWS via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Lake Michigan water for the fishhook waterflea prior to its discharge into the CAWS. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV radiation, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook waterflea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 L 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% kill in all treatments except ultrasound), while cladocerans were the least affected group (>99% kill 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea passing through this 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
Lakefront 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 this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the passage via natural dispersion and human-mediated transport of the fishhook waterflea through this 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 the fishhook waterflea through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for fishhook waterflea.
T_{10}: See T_0.

T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Calumet Harbor pathway entrance (Benson et al. 2012).
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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). Its exact location and distance from Calumet Harbor are uncertain, but this species may be at Calumet Harbor.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit movement of the fishhook waterflea outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from Calumet Harbor are uncertain, but this species may be at 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from Calumet Harbor are uncertain, but this species may be at 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the fishhook waterflea at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the passage of the fishhook waterflea by natural dispersion (i.e., passive drift) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from the Great Lakes Basin side of a control point 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. The fishhook waterflea ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007) and is expected to pass through the screens; it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City (Illinois) control point is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through this aquatic pathway.

T_{50}: See T_0.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Great Lakes Basin water for the fishhook waterflea 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: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-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 Great Lakes Basin water for the fishhook waterflea prior to its discharge into the Mississippi River Basin side of the control point, thereby controlling human-mediated transport of the species as well.

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 Lakefront 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
Lakefront 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 Lakefront 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 fishhook waterflea through this aquatic pathway via 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 and bilge water or 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 via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Great Lakes Basin water for the fishhook waterflea prior to its discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV radiation, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook waterflea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 L 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% kill in all treatments except ultrasound), while cladocerans were the least affected group (>99% kill 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea passing through this 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
Lakefront 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 this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through this 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 the 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for fishhook waterflea.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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). Its exact location and distance from Indiana Harbor are uncertain, but this species may be at Indiana Harbor.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution or reduce its probability of arrival at the CAWS.

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

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

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to reduce 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from Indiana Harbor are uncertain, but this species may be at 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from Indiana Harbor are uncertain, but this species may be at 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the fishhook waterflea at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from the Great Lakes Basin side of a control point 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. The fishhook waterflea ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007) and is expected to pass through the screens; it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City (Illinois) control point is expected to be effective. 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. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea 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 Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Great Lakes Basin water for the fishhook waterflea prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control 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. 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 Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-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 Great Lakes Basin water for the fishhook waterflea prior to its discharge into the Mississippi River Basin side of the control point, thereby controlling human-mediated transport of this species as well.

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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the fishhook waterflea through the aquatic pathway via 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_{10}.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 and bilge water or 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 CAWS via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Great Lakes Basin water for the fishhook waterflea prior to its discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV radiation, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook waterflea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200–800 L 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% kill in all treatments except ultrasound), while cladocerans were the least affected group (>99% kill 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the fishhook waterflea passing through this 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
Lakefront 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 control the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through this 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 the 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to an extreme storm event, a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. 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). Its exact location and distance from BSBH are uncertain, but this species may be at BSBH.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution or to affect its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from BSBH are uncertain, but this species may be at 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the fishhook waterflea's arrival at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). Its exact location and distance from BSBH are uncertain, but this species may be at 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the fishhook waterflea at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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 an extreme storm event, a 0.2% ACE event. The Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea 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 Lakefront 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 this 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam. 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. There is recreational but not commercial vessel traffic to the BSBH from Lake Michigan (USACE 2011a,b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront 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 Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the fishhook waterflea through the aquatic pathway via 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana. This alternative includes the construction of a physical barrier. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that the fishhook waterflea and vessels potentially transporting the species in ballast and bilge water or via hull fouling will pass through the aquatic pathway. Overall, the Lakefront Hydrologic Separation Alternative

reduces the likelihood of the fishhook waterflea passing through the aquatic pathway. 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
Lakefront 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 control the passage of the fishhook waterflea through the aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through this 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

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E.5.2.3.2 Bloody Red Shrimp (*Hemimysis anomala*)

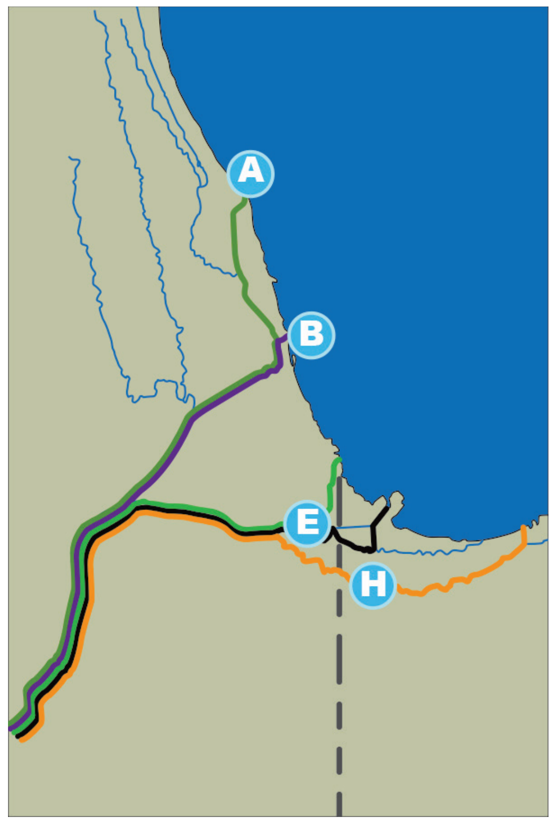
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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 T_0 by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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	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.

Lakefront 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 WPS and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the bloody red shrimp as a result of 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the bloody red shrimp as a result of human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at the WPS in Wilmette, 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 Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival 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
Lakefront Hydrologic Separation Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival through aquatic pathways 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). 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 Lakefront 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 bloody red shrimp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for the bloody red shrimp at the WPS in Wilmette, Illinois. This alternative includes the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at the WPS 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 passage of the bloody red shrimp by natural dispersion to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes and 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 ranges between 0.2 and 0.5 in. (6 and 13 mm) in size (Kipp et al. 2011) and would be able to pass through the screens; it would subsequently be 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. On the basis of water quality data, UV treatment of Lake Michigan water at the WPS project location is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of the bloody red shrimp 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 Lakefront 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 this 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 Lakefront 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 the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the bloody red shrimp prior to discharge into the CAWS. The physical barrier would 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated passage 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 vessel-mediated transport of this species through the aquatic pathway because this species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Lake Michigan water for the bloody red shrimp prior to discharge into the CAWS, thereby controlling human-mediated transport of this species as well.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat within the CAWS for the bloody red shrimp.

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

Probability of Passage[a]

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Alternative 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 bloody red shrimp and vessels potentially transporting the species in ballast and bilge 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 via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Lake Michigan water for bloody red shrimp prior to its discharge into the CAWS. Published data is not available describing the effects of UV radiation on the bloody red shrimp; however, the 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the bloody red shrimp passing through this 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
Lakefront Hydrologic Separation Alternative Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone, as part of the Lakefront Hydrologic Separation Alternative, are not expected to reduce the uncertainty of the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Lakefront Hydrologic Separation Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through this aquatic pathway. The physical barrier is expected to control passage of the bloody red shrimp 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 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

LAKEFRONT 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	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.

Lakefront 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 CRCW and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival as a result of natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival as a result of human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the Chicago River and Controlling Works in Chicago, 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 Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the bloody red shrimp outside of their current distribution or reduce their probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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
Lakefront Hydrologic Separation Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival through aquatic pathways to 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). 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
Lakefront Hydrologic Separation Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival through aquatic pathways to 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). 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 Lakefront 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 bloody red shrimp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the bloody red shrimp at the CRCW in Chicago, Illinois. This alternative includes the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the CRCW 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 ACE event. The physical barrier is expected to control the passage of the bloody red shrimp to Brandon Road Lock and Dam via natural dispersion.

The purpose of the ANSTP is to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. The bloody red shrimp ranges between 0.2 and 0.5 in. (6 and 13 mm) in size (Kipp et al. 2011) and would be able to pass through the screens; it would subsequently be 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. On the basis of water quality data, UV treatment of Lake Michigan water at the CRCW control point is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of the bloody red shrimp 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 Lakefront 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 this 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 Lakefront 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 the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for bloody red shrimp prior to its discharge into the CAWS. The physical barrier would 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 Lakefront 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 Lakefront 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. In addition, the physical barrier is expected to control the natural dispersion and vessel-mediated transport of this species through the aquatic pathway because this species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the physical barrier. The ANSTP would treat Lake Michigan water for bloody red shrimp prior to its discharge into the CAWS, thereby controlling human-mediated transport of this species as well.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat within the CAWS for the bloody red shrimp.

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

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

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the bloody red shrimp through the aquatic pathway via natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 bloody red shrimp and vessels potentially transporting the species in ballast and bilge 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 via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Lake Michigan water for bloody red shrimp prior to discharge into the CAWS. Published data is not available describing the effects of UV radiation on the bloody red shrimp; however, the 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the bloody red shrimp passing through this 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
Lakefront Hydrologic Separation Alternative Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty of the species passing through the aquatic pathway remains low.

T_{25}: Structural measures, as part of the Lakefront Hydrologic Separation Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through this aquatic pathway. The physical barrier is expected to control passage of the bloody red shrimp 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 construction and design, 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 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

LAKEFRONT 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	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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.

T_{10}: See T_0.

T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival as a result of natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival as a result of human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to reduce 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
Lakefront Hydrologic Separation Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival through aquatic pathways to 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). 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
Lakefront Hydrologic Separation Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival 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 Lakefront 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 bloody red shrimp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the bloody red shrimp at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 an extreme storm event, a 0.2% ACE event. The physical barrier would likely control the bloody red shrimp's passage to Brandon Road Lock and Dam via natural dispersion.

The purpose of the ANSTP is to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake 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. The bloody red shrimp ranges between 0.2 and 0.5 in. (6 and 13 mm) in size (Kipp et al. 2011) and would be able to pass through the screens; it would subsequently be 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. On the basis of water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of the bloody red shrimp 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 Lakefront 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 this 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 Lakefront 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 Little Calumet River water for the bloody red shrimp prior to its discharge into the CAWS. The physical barrier would 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated passage 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 vessel-mediated transport of this species through the aquatic pathway because this species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Little Calumet River water for bloody red shrimp prior to its discharge into the CAWS, thereby controlling human-mediated transport of the species as well.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat within the CAWS for the bloody red shrimp.

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

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

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the bloody red shrimp through the aquatic pathway via natural dispersion or human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 bloody red shrimp and vessels potentially transporting the species in ballast and bilge 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 Little Calumet River water for bloody red shrimp prior to its discharge into the CAWS. Published data is not available about 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 Lakefront Hydrologic Separation Alternative is expected to reduce the likelihood of the bloody red shrimp passing through this 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
Lakefront Hydrologic Separation Alternative Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Lakefront Hydrologic Separation Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through this aquatic pathway. The physical barrier is expected to control passage of the bloody red shrimp 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 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

LAKEFRONT 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	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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for bloody red shrimp.
T_{10}: See T_0.

T_{25} The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival as a result of natural dispersion to the CAWS through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to reduce 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
Lakefront Hydrologic Separation Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival 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
Lakefront Hydrologic Separation Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival 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 Lakefront 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 bloody red shrimp through this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the bloody red shrimp at Calumet City, Illinois. This alternative includes the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the passage of the bloody red shrimp to Brandon Road Lock and Dam via natural dispersion.

The purpose of the ANSTP is to remove aquatic nuisance species from the Great Lakes Basin side of a control point 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake 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. The bloody red shrimp ranges between 0.2 and 0.5 in. (6 and 13 mm) in size (Kipp et al. 2011) and would be able to pass through the screens; it would subsequently be 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. On the basis of water quality data, UV treatment of Little Calumet River water at the Calumet City (Illinois) project location is anticipated to be effective. 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 the water, such as turbidity, salinity, and the size and type of organism.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of the bloody red shrimp 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 Lakefront 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 this 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 Lakefront 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 Little Calumet River water for the bloody red shrimp prior to discharge into the CAWS. The physical barrier would 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and vessel-mediated transport of this species through the aquatic pathway because this species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Little Calumet River water for bloody red shrimp prior to its discharge into the CAWS, thereby controlling human-mediated transport of this species as well.
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 Lakefront Hydrologic Separation Alternative is not expected to affect suitability of habitat within the CAWS for the bloody red shrimp.
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
Lakefront Hydrologic Separation Alternative Rating[a]	Low	Low	***Low***	***Low***

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

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront Hydrologic Separation Alternative's low 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 bloody red shrimp and vessels potentially transporting the species in ballast and bilge 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 via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Little Calumet River water for bloody red shrimp prior to its discharge into the CAWS. Published data is 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 Lakefront Hydrologic Separation Alternative reduces the likelihood of the bloody red shrimp passing through this 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
Lakefront Hydrologic Separation Alternative 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: The bloody red shrimp is not a strong swimmer, and the upstream flow direction and lack of vessel transport in the Grand Calumet River would inhibit dispersal toward Brandon Road Lock and Dam. 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, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through this aquatic pathway via natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Lakefront Hydrologic Separation Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through this aquatic pathway. The physical barrier is expected to control passage of the bloody red shrimp 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 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	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.

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Alternative Rating[a]	High	High	***Low***	***Low***

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

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Alternative Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to an extreme storm event, a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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, because the bloody red shrimp has likely already arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of the bloody red shrimp at the pathway. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor, a half mile (0.8 km) offshore, in 2006 (Kipp et al. 2011).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or reduce its probability of arrival at the CAWS.

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

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

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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
Lakefront Hydrologic Separation Alternative Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival 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
Lakefront Hydrologic Separation Alternative Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the bloody red shrimp's arrival 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_{10}.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the bloody red shrimp at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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 an extreme storm event, a 0.2% ACE event. The physical barrier at the Hammond control point is expected to control the natural dispersion of the bloody red shrimp 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the human-mediated transport of the bloody red shrimp through this aquatic pathway.

T_{10}: See T_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Lakefront 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 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. There is recreational but not commercial vessel traffic to BSBH from Lake Michigan (USACE 2011a,b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures 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 via human-mediated transport. 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 Lakefront 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 this aquatic pathway. The physical barrier is expected to control the natural dispersion and vessel-mediated transport of the bloody red shrimp through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bile 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 Lakefront Hydrologic Separation Alternative is not expected to affect the suitability of habitat within the CAWS for the bloody red shrimp.
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
Lakefront Hydrologic Separation Alternative Rating[a]	Low	Low	***Low***	***Low***

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

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the bloody red shrimp through the aquatic pathway via natural dispersion or human-mediated transport. Therefore, the Lakefront Hydrologic Separation Alternative's low 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that bloody red shrimp and vessels potentially transporting the species in ballast and bilge water would pass through the aquatic pathway. 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
Lakefront Hydrologic Separation Alternative 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, as part of the Lakefront Hydrologic Separation Alternative, are not expected to control the bloody red shrimp's passage through the CAWS via natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Lakefront Hydrologic Separation Alternative, are expected to control the natural dispersion and human-mediated transport of bloody red shrimp through this aquatic pathway. The physical barrier is expected to control the passage of this species 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

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E.5.2.4 Fish

E.5.2.4.1 Threespine Stickleback (*Gasterosteus aculeatus*)

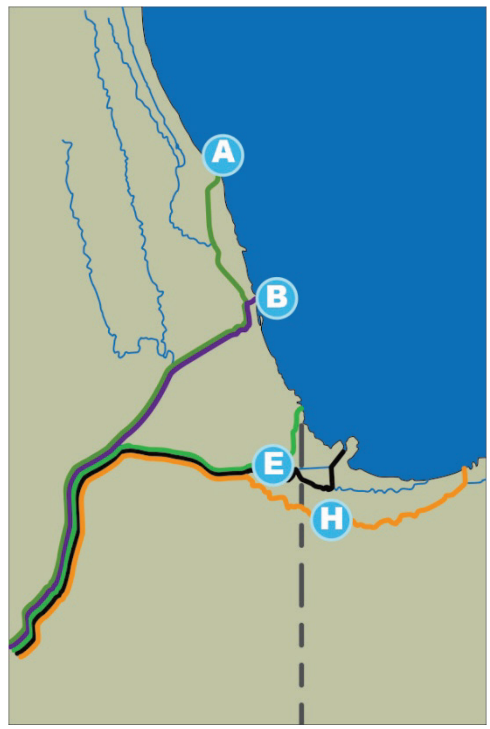
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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) 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}).

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

Lakefront 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for threespine stickleback.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the threespine stickleback from natural dispersal 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 Lakefront 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.
The Lakefront Hydrologic Separation Alternative is not expected to reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the WPS.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the WPS in Wilmette, Illinois. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS

since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 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
Lakefront 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 Lakefront 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 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species has been documented in the North Shore Channel, just beyond the entrance to the WPS pathway.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at WPS 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 passage of the threespine stickleback by natural dispersion to (i.e., swimming and passive drift) Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth ranging from 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, and fish with body widths less than 0.75 in. (19.05 mm) are expected to be able 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. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Lakefront 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 this 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 Lakefront 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. The ANSTP would treat Lake Michigan water for the threespine stickleback 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, 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. 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 Lakefront 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 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 Lake Michigan water for the threespine stickleback prior to discharge into the CAWS.
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 Lakefront 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_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
Lakefront 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 Lakefront 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. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, or fry in ballast or bilge 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 Lake Michigan water for the threespine stickleback prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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. Zagarese and Williamson (2001) found that the 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 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. (19.05 mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through this 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
Lakefront 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 Lakefront 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. 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 would be needed to control passage of threespine stickleback through the ANSTP. 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 2

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

LAKEFRONT 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.

Lakefront 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for threespine stickleback.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback 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 Lakefront 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.
The Lakefront Hydrologic Separation Alternative is not expected to reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the CRCW.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, Illinois. However, the physical

barrier is not expected to control the arrival of the threespine stickleback at the CAWS since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront 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 CRCW is expected to remain suitable for the threespine stickleback.
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
Lakefront 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 Lakefront 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 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the CRCW pathway.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at the CRCW 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 threespine stickleback through the aquatic pathway.
The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth ranging from 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, and fish with a body depth 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. Based on water quality data, UV treatment of Lake Michigan Water at the CRCW control point is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 this 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the threespine stickleback 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 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 Lakefront 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 Lakefront 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 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 Lake Michigan water for the threespine stickleback prior to discharge into the CAWS.

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 Lakefront Hydrologic Separation Alternative is not expected to affect habitat suitability for 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_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
Lakefront 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 Lakefront 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. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae or fry in ballast or bilge 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 Lake Michigan water for the threespine stickleback prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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, and 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. Zagarese and Williamson (2001) found that the 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 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. (19.05 mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through this 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
Lakefront 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through this 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 would be needed to control passage of threespine stickleback through the ANSTP. 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for threespine stickleback.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the threespine stickleback at the CAWS from natural dispersal through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront 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.
The Lakefront Hydrologic Separation Alternative is not expected to reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at Calumet Harbor.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not

expected to control the arrival of the threespine stickleback at the CAWS since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 Calumet Harbor is expected to remain suitable for the threespine stickleback.

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
Lakefront 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 Lakefront 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 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the Calumet Harbor pathway.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the threespine stickleback at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from Little Calumet River 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth ranging from 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, and fish with a body depth less than 0.75 in. (19.05 mm) are expected to be able 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. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Little Calumet River water for the threespine stickleback 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 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 Lakefront 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 Lakefront 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 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 Little Calumet River water for the threespine stickleback prior to discharge into the CAWS.
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 Lakefront Hydrologic Separation Alternative is not expected to affect habitat suitability for 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_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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, or fry in ballast and bilge 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 Little Calumet River water for the threespine stickleback prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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, and 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. Zagarese and Williamson (2001) found that the 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 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. (19.05 mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Lakefront 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 Lakefront 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. 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 would be needed to control passage of threespine stickleback through the ANSTP. 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for the threespine stickleback.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the threespine stickleback 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 Lakefront 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.
The Lakefront Hydrologic Separation Alternative is not expected to reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at Indiana Harbor.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not

expected to control the arrival of the threespine stickleback at the CAWS since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 Indiana Harbor 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
Lakefront 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 Lakefront 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 Lockport Lock and Dam (INHS undated).Therefore, 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
Lakefront Hydrologic Separation Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the Indiana Harbor pathway.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Calumet City, 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 threespine stickleback through the aquatic pathway to Brandon Road Lock and Dam.
The purpose of the ANSTP is to remove ANS from Little Calumet River 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase) and a body depth ranging from 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, and fish with a body depth less than 0.75 in. (19.05 mm) are expected to be able 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. Based on water quality data, UV treatment of Cal-Sag Channel at the Calumet City, Illinois, control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. The ANSTP would treat Little Calumet River water for the threespine stickleback 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 Lakefront 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 Lakefront 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 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 Little Calumet River water for the threespine stickleback prior to discharge into the CAWS.
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 Lakefront Hydrologic Separation Alternative is not expected to affect habitat suitability for 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_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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 threespine stickleback and vessels potentially transporting threespine stickleback eggs, larvae, or fry in ballast and bilge 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 Little Calumet River water for the threespine stickleback prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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, and 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation 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 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. (19.05 mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the threespine stickleback 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	Medium	Low	Low	Low
Lakefront 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 Lakefront 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. 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 would be needed to control passage of threespine stickleback through the ANSTP. 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 5

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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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:

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating:

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the threespine stickleback at the CAWS from natural dispersal through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.

The Lakefront 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.

The Lakefront Hydrologic Separation Alternative is not expected to reduce the current abundance or reproductive capacity of the threespine stickleback in the Great Lakes.

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

d. Existing Physical Human/Natural Barriers

T_0: None. The threespine stickleback has arrived at the BSBH.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of the threespine stickleback at the CAWS since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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
Lakefront 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 Lakefront 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 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the threespine stickleback which is already present at the pathway. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Lakefront 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 Lakefront 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 Brandon Road Lock and Dam. 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. There is recreational, but not commercial, vessel traffic to the BSBH from Lake Michigan (USACE 2011a,b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront 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 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.

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 Lakefront 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_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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that the threespine stickleback and vessels potentially transporting the species in ballast and bilge water would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of threespine stickleback passing through the aquatic pathway. 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
Lakefront 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; 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; therefore, the uncertainty remains low.

T_{25}: Structural measures as part of the Lakefront 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. 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

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E.5.2.4.2 Ruffe (*Gymnocephalus cernuus*)

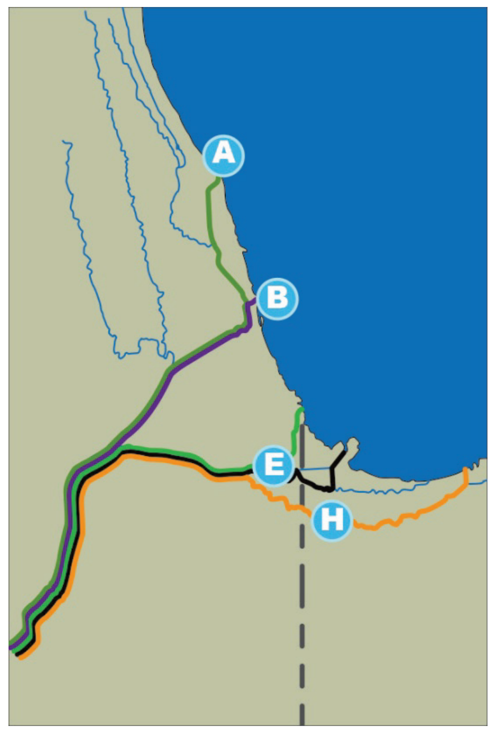
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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 T_0 by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

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



PATHWAY 1

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

LAKEFRONT 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.

Lakefront 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 the WPS and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an aquatic nuisance species Treatment Plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the Chicago Area Waterway System (CAWS) via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the ruffe's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the WPS in Wilmette, 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}.

d. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the ruffe outside of its current distribution.
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_0. 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 Lakefront 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 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	Low	Low	Low	Medium
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. 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 would have time to disperse to the WPS by natural dispersion alone or by a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. Therefore, the uncertainty remains low.
T_{10}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. Therefore, the uncertainty remains medium.
T_{25}: See T_{10}.
T_{50}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at the WPS in Wilmette, Illinois, with the construction of a physical barrier and an ANSTP.
The physical barrier would be constructed in the channel at WPS 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 passage of the ruffe by natural dispersion (i.e., swimming and passive drift) to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 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 ruffe, which typically have a total 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. are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe 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 Lakefront 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 Lakefront 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 Lake Michigan water for ruffe 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, 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 Lakefront 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 Lakefront Hydrologic Separation Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of 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 Lake Michigan water for ruffe prior to discharge into the CAWS.
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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Lakefront 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. See the Nonstructural Risk Assessment for this species.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 or larvae 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 Lake Michigan water for the ruffe prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarias 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through this 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
Lakefront 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 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through this 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 for the ruffe and its various life stages, 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

LAKEFRONT 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.

Lakefront 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 the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the ruffe's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, 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}.

d. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the ruffe outside of its current distribution.

T_{25}: See T_{10}.

T_{50}: See T_{10}. In the future, the distance of the ruffe from the CAWS could increase or decrease. Examples of future changes potentially affecting the distribution of ruffe in the Great Lakes include natural population growth, climate change, new diseases, and new ANS.

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

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to disperse to the CRCW by natural dispersion alone or by 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe to the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at the CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the CRCW 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 an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) and human-mediated transport of the ruffe through the aquatic pathway.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 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 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. are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan Water at the CRCW control point is expected to be effective. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately. 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 Lakefront 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 Lake Michigan water for the ruffe 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 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 Lakefront 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 Lakefront 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 physical barrier. The ANSTP would treat Lake Michigan water for ruffe prior to discharge into the CAWS.
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 Lakefront 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
Lakefront Hydrologic Separation Rating[a]	High	High	***Low***	***Low***

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

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Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that can be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 and bilge 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 Lake Michigan water for the ruffe prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarias 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through this 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
Lakefront 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 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through this 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 for the ruffe and its various life stages, 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

LAKEFRONT 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.

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

T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the ruffe's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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}.

d. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to limit movement of the ruffe outside of its current distribution.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10} and 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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Over 50 years, the probability increases that ruffe would have time to disperse to Calumet Harbor by natural dispersion alone or by a combination of human-mediated transport to the southern Great Lakes and natural dispersion to 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.
T_{10}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains medium.
T_{25}: See T_{10}.
T_{50}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Calumet City, 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 Little Calumet River 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 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 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. are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City (Illinois) control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately. 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 Lakefront 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 Little Calumet River water for the ruffe 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 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 Lakefront 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 Lakefront 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 Little Calumet River water for the ruffe prior to discharge into the CAWS.

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 Lakefront 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
Lakefront 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 Lakefront 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 ruffe through the aquatic pathway. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 and bilge 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 Little Calumet River water for the ruffe prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarias 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through this aquatic pathway by 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
Lakefront 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 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 Lakefront Hydrologic Separation Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway by natural dispersion and human-mediated transport. 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 for the ruffe and its various life stages, 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 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM
LAKEFRONT 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.

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

T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the ruffe from natural dispersal through aquatic pathways to the CAWS.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the ruffe's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. ***Existing Physical Human/Natural Barriers***
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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}.

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

The Lakefront 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.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the ruffe outside of its current distribution.

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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Overall, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Given time to naturally disperse, the species may be able to reach the pathway over a 50-year period. The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.
T_{10}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains medium.
T_{25}: See T_{10}.
T_{50}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Calumet City, Illinois, with the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 Little Calumet River 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 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 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. are expected to pass through the 0.75-in. screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is expected to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe 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 Lakefront 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 Lakefront 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 Little Calumet River water for the ruffe 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 Lakefront 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 Lakefront 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 Little Calumet River water for the ruffe prior to discharge into the CAWS.
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 Lakefront 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
Lakefront 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 Lakefront 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 ruffe through the aquatic pathway. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 and bilge 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 Little Calumet River water for the ruffe prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarias 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through this 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
Lakefront 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 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 Lakefront 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. 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 for the ruffe and its various life stages, 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 5

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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) and (3) designate 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the ruffe's arrival at the CAWS as a result of human-mediated transport through aquatic pathways.

c. ***Existing Physical Human/Natural Barriers***

T_0: None.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of ruffe to 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}.

d. ***Current Abundance and Reproductive Capacity***

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See T_0. The abundance of the ruffe at its current locations could increase or decrease owing to natural population fluctuations or interactions with other species such as round goby (Bowen & Goehle 2011).

T_{25}: See T_{10}.

T_{50}: See T_{10}.

e. ***Distance from Pathway***

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to limit the movement of the ruffe outside of its current distribution.

T_{10}: See T_0. Ruffe could become 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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Given time to naturally disperse, the species may be able to reach the pathway over a 50-year period. The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake

Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains 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 Lakefront 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 ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point for the ruffe at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe 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 Lakefront 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 Lakefront 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 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. There is recreational but not commercial vessel traffic to the BSBH from Lake Michigan (USACE 2011a,b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront 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.

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 Lakefront 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
Lakefront 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 Lakefront 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 ruffe through the aquatic pathway. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that the ruffe and vessels potentially transporting the species in ballast and bilge water would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of the ruffe passing through the aquatic pathway. 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
Lakefront Hydrologic Separation Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: Nonstructural measures alone are not expected to control the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Lakefront 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 the passage of ruffe through the CAWS 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}: 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.5.2.4.3 Tubenose Goby (*Proterorhinus semilunaris*)

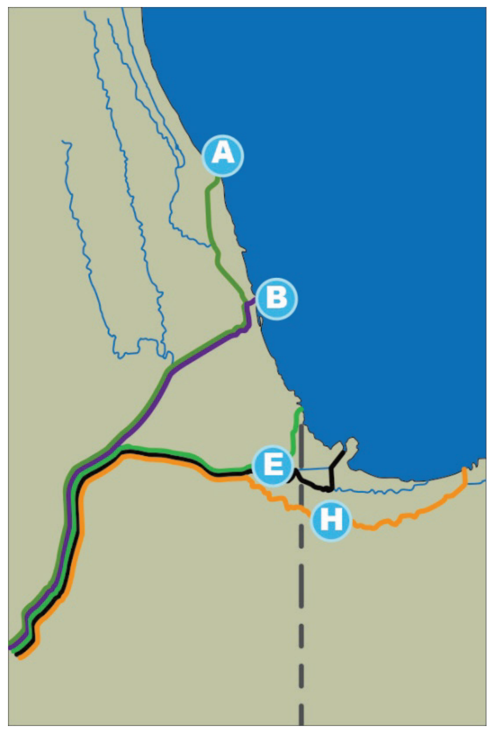
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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) 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}).

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

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



PATHWAY 1

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

LAKEFRONT 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.

Lakefront 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 WPS and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby from natural dispersal 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 for a discussion on how nonstructural measures may affect human-mediated transport.
The Lakefront 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 Lakefront 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 (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently

established in deep water environments in which implementation of such a control is not feasible. Because of 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 of the tubenose goby at the CAWS pathway.
T_{10}: See T_0.
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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and an ANSTP at the WPS in Wilmette, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the distance of tubenose goby from the pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures, such as ballast/bilge-water exchange programs, which may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge-water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.

T_{10}: See T_0. Tubenose goby could become closer to the WPS by vessel transport or natural dispersion to southern Lake Michigan. The species may be able to occupy shallow waters of all five Great Lakes (EPA 2008). Nonstructural measures, such as ballast/bilge-water exchange programs, may increase the time the tubenose goby takes to arrive at the CAWS pathway.
T_{25}: See T_{10}.
T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

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

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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
Lakefront 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 Lakefront 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 for the tubenose goby to arrive at the pathway.

The Lakefront 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 Lakefront 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. 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 tubenose goby is located approximately 4828 km (3000 river miles) from the pathway entrance. The species can be transported in ballast water (Dopazo et al. 2008, Jude et al. 1992), which likely provides a faster mechanism than natural dispersion of the species.

The Lakefront 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 for the tubenose goby to arrive at the pathway. The Lakefront Hydrologic Separation Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by human-mediated transport. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. There is no commercial vessel transport to the WPS, and the implementation of nonstructural measures, such as a ballast/bilge-water exchange program, is expected to increase the time for the tubenose goby to arrive at the aquatic pathway. However, over time, the likelihood of the tubenose goby having time to disperse to the WPS by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the WPS increases. Therefore, its probability of arrival remains medium.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

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

The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

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

The Lakefront 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}. 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the WPS 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 this aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 and ultraviolet radiation (UV) 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 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 5.0 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) would be able to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to ultraviolet (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. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the human-mediated transport of the species 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 Lakefront 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 Lake Michigan water for the tubenose goby 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, 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 Lakefront 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 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 Lakefront 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 Lake Michigan water for the tubenose goby prior to discharge into the CAWS.
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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS, 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 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 Lake Michigan water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront 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
Lakefront 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}: The Lakefront Hydrologic Separation Alternative includes structural measures that 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. 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 would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Therefore, 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

LAKEFRONT 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.

Lakefront 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 CRCW and the Brandon Road Lock and Dam over the next 50 years. The Lakefront Hydrologic Separation Alternative does not affect the pathway for tubenose goby.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for the tubenose goby from natural dispersal 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 affect human-mediated transport.
The Lakefront 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 Lakefront 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 (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently established in deep water environments in which implementation of such a control is

not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to affect the arrival of the tubenose goby at the CAWS pathway.

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

d. *Existing Physical Human/Natural Barriers*

T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).
T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the distance of tubenose goby from the pathway.

The Lakefront 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. Tubenose goby could become closer to the CRCW by vessel transport or natural dispersion to southern Lake Michigan. The species may be able to occupy shallow waters of all five Great Lakes (EPA 2008). 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}. 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 Lakefront 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
Lakefront 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 Lakefront 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 through aquatic pathways at the CAWS. The implementation of a ballast/bilge-water exchange program is expected to increase the time for the tubenose goby to arrive at the pathway.

The Lakefront 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 Lakefront 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. See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. The implementation of a ballast/bilge-water exchange program is expected to increase the time for the tubenose goby to arrive at the pathway. The Lakefront 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}. There is commercial vessel transport to the CRCW from ports where the tubenose goby is located (section 2b*, Human-Mediated Transport through Aquatic Pathways*).

The Lakefront 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 because 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
The Lakefront 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_0. 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 Lakefront 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 this aquatic pathway.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at the CRCW 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 ANS from Lake Michigan 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 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 tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with a body width less than 0.75 in. (19.05 mm) are expected to be able 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. Based on water quality data, UV treatment of Lake Michigan Water at the CRCW control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 Lake Michigan water for the tubenose goby 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 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 Lakefront 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 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 Lakefront 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 it in ballast and bilge water would be unable to traverse the physical barrier. The ANSTP would treat Lake Michigan water for the tubenose goby prior to discharge into the CAWS.

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 Lakefront Hydrologic Separation Alternative is not expected to affect habitat suitability for 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW 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 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 Lake Michigan water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish.

Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront 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
Lakefront 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}: The Lakefront Hydrologic Separation Alternative includes structural measures that 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. 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 would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Therefore, 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for tubenose goby.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront 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 affect human-mediated transport.

The Lakefront 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 Lakefront 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 (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently

established in deep water environments in which implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to affect the arrival of the tubenose goby at the CAWS pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. *Existing Physical Human/Natural Barriers*

T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).
T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the distance of tubenose goby from the aquatic pathway.

The Lakefront 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. See the Nonstructural Risk Assessment for this species. Nonstructural measures, such as ballast/bilge-water exchange programs, are expected to increase the time for the tubenose goby to arrive at the CAWS pathway.
T_{25}: See T_{10}.
T_{50}: 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 Lakefront 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
Lakefront 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 Lakefront 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 for the tubenose goby to arrive at the pathway.

The Lakefront 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 Lakefront 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. See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. The implementation of a ballast/bilge-water exchange program is expected to increase the time for the tubenose goby to arrive at the pathway. The Lakefront 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 Lakefront 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 because the species would have time to disperse by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the Calumet Harbor. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

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

The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

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

The Lakefront 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_0. 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

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

The physical barrier would be constructed in the channel at Calumet City, 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 tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from Little Calumet River water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening 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 tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to be able 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. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 this 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 Lakefront 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 Little Calumet River water for the tubenose goby 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 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 Lakefront 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 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 Lakefront 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 Little Calumet River water for the tubenose goby prior to discharge into the CAWS.

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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 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 passage of this species through this aquatic pathway.

In addition, the ANSTP would treat Little Calumet River water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront 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
Lakefront Hydrologic Separation Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures. 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}: The Lakefront Hydrologic Separation Alternative includes structural measures that 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. 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 would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Therefore, 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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for tubenose goby.
T_{10}: See T_0.
T_{25} The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby from natural dispersion at the CAWS 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 affect the human-mediated transport.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival for 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 Lakefront 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 (water drawdown) is not expected to be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Due to the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to affect the arrival of the tubenose goby at the CAWS pathway.

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

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, Illinois. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the distance of the tubenose goby from the pathway.
The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the distance of the tubenose goby 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. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

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

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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
Lakefront 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 Lakefront 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 for the tubenose goby to arrive at the pathway.

The Lakefront 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 Lakefront 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 Lakefront 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 for the tubenose goby to arrive at the pathway. The Lakefront 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}. There is commercial vessel transport to Indiana Harbor from ports where the tubenose goby is located (section 2b, *Human-Mediated Transport through Aquatic Pathways*).

The Lakefront 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 because the species would have time to disperse by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to Indiana Harbor. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
The Lakefront 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}. 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that could be implemented immediately T_0. Nonstructural measures alone are not expected to affect 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from Little Calumet River 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 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 greater than 0.75 in. (19.05 mm). It is expected that adult tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with a body width less than 0.75 in. (19.05 mm) are expected to be able 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. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is anticipated to be effective. 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 Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 Little Calumet River water for the tubenose goby 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 Lakefront 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 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 Lakefront 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 physical barrier is expected to control the 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 Little Calumet River water for the tubenose goby prior to discharge into the CAWS.

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 Lakefront Hydrologic Separation Alternative is not expected to affect habitat suitability for 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 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 Little Calumet River water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish 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 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. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Lakefront 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	Medium	Medium	Low	Low
Lakefront Hydrologic Separation Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures. 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}: The Lakefront Hydrologic Separation Alternative includes structural measures that 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. 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 would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Therefore, 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

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

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of the tubenose goby from natural dispersion through aquatic pathways to 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 affect human-mediated transport.

The Lakefront 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 Lakefront 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 (water drawdown) is not expected to be an effective control measure for the tubenose goby as the species is currently established in deep water environments where implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective measures for controlling 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 Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. However, the physical barrier is not expected to control the arrival of the tubenose goby at the CAWS. Tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_0.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may affect the distance of tubenose goby from the aquatic pathway.

The Lakefront Hydrologic Separation Alternative includes nonstructural measures that are expected to affect the distance of the tubenose goby from the aquatic 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 for the tubenose goby to arrive at the CAWS pathway.

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

T_{25}: See T_0.

T_{50}: See T_0. 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 Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. The implementation of a ballast/bilge-water exchange program is expected to increase the time for the tubenose goby to arrive at the pathway.

The Lakefront 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 Lakefront 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 the Nonstructural Risk Assessment for this species.

The Lakefront 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 for the tubenose goby to arrive at the pathway. The Lakefront 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 the Nonstructural Risk Assessment for this species.

The Lakefront 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 because 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
Lakefront Hydrologic Separation Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

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

The Lakefront 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 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 Lakefront 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 $T_{25:}$ 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 Lakefront 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 this aquatic pathway.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_0. This alternative would create a control point for the tubenose goby at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of 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 Lakefront 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 this 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 Lakefront 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 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. There is recreational but not commercial vessel traffic to the BSBH from Lake Michigan (USACE 2011a,b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront 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.

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 Lakefront Hydrologic Separation Alternative is not expected to affect habitat suitability for 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
Lakefront Hydrologic Separation Rating[a]	High	High	***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 Lakefront 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 Lakefront 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 Assessments.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that the tubenose goby and vessels potentially transporting the species in ballast water would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of tubenose goby passing through the aquatic pathway. 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
Lakefront 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 Lakefront 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 the passage of the tubenose goby through the CAWS up to 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}: 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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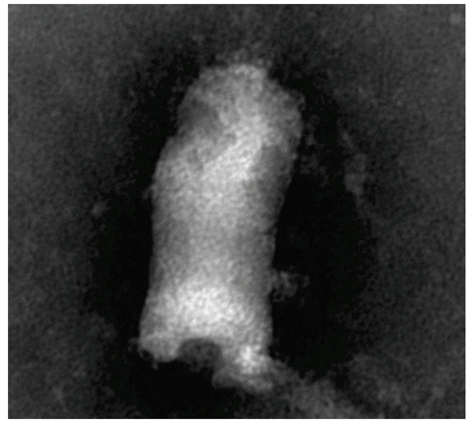
E.5.2.5 Virus

E.5.2.5.1 Viral Hemorrhagic Septicemia (*Novirhabdovirus* sp.)



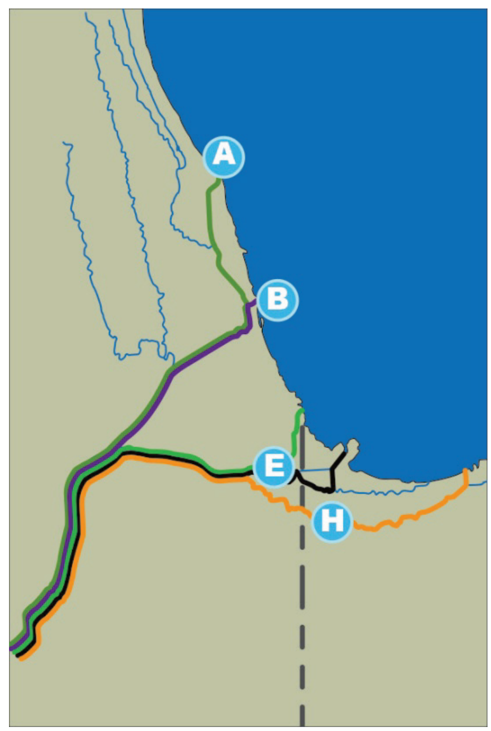
LAKEFRONT HYDROLOGIC SEPARATION ALTERNATIVE

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) 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}).

Lakefront Hydrologic Separation Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Physical Barrier
		ANS Treatment Plant
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	Physical Barrier
		ANS Treatment Plant
Calumet Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Indiana Harbor	Nonstructural Measures[a]	
	Calumet City, IL (E)	Physical Barrier
		ANS Treatment Plant
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier

[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

LAKEFRONT 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.

Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the pathway for viral hemorrhagic septicemia (VHSv).
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the North Shore Channel at the WPS. 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

f. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Lakefront Hydrologic Separation Alternative is not expected to affect the arrival for VHSv 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 Lakefront 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 Lakefront 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 spread or virulence of this species.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at WPS in Wilmette, 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 Lakefront 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 Lakefront Hydrologic Separation Alternative is not expected to affect 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
Lakefront Hydrologic Separation Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan.

The Lakefront 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
Lakefront 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 for this species). Its ability to spread rapidly in the Great Lakes has been documented.

The Lakefront 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.
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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at WPS in Wilmette, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at WPS 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 through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species (ANS) from Lake Michigan 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 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) in size. 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. Based on water quality data, UV treatment of Lake Michigan Water at the WPS control point is anticipated to be effective. 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 Lakefront 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 Lakefront 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 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 Lakefront 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 Lake Michigan water for VHSv prior to discharge into the CAWS. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway; 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 Lakefront 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 Lakefront 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 Lake Michigan water for VHSv prior to discharge into the CAWS.

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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the WPS in Wilmette, 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 Lake Michigan water for VHSv prior to discharge into the CAWS. 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. 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, and length of UV radiation exposure and to establish whether an additional treatment process would be needed to control passage of VHSv through the ANSTP.

Overall, the Lakefront 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
Lakefront 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 Lakefront Hydrologic Separation Alternative are not expected to control the natural dispersion or 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. 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 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

LAKEFRONT 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.

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

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Chicago River at the CRCW. 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront 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 spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at the CRCW in Chicago, 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 Lakefront 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 Lakefront 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
Lakefront 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 Lakefront 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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.

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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at CRCW 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 through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan 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 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. Based on water quality data, UV treatment of Lake Michigan water at the CRCW control point is expected to be effective. 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 Lakefront 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 Lakefront 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 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 Lakefront 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 Lake Michigan water for VHSv 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 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 Lakefront 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 Lakefront 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 physical barrier. The ANSTP would treat Lake Michigan water for VHSv prior to discharge into the CAWS.

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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at the CRCW in Chicago, 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 Lake Michigan water for VHSv prior to discharge into the CAWS. 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. 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 Lakefront 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
Lakefront 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 Lakefront 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. 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 would be needed to control passage of VHSv through the ANSTP. 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}: 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

LAKEFRONT 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.

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

T_{25}: The Lakefront Hydrologic Separation Alternative includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront 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 Lakefront 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 Lakefront 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 spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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 Lakefront 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 Lakefront 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 viral hemorrhagic septicemia.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Lakefront 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 Lakefront 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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, 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.
The physical barrier would be constructed in the channel at Calumet City, 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 VHSv through the aquatic pathway to Brandon Road Lock and Dam.
The purpose of the ANSTP is to remove aquatic nuisance species from Little Calumet River 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. 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 is expected to be able to pass through the screens where they would subsequently be 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. Based on water quality data, UV treatment of Little Calumet River water at Calumet City (Illinois) control point is anticipated to be effective. 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 Lakefront 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 Lakefront 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 Lakefront 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 Little Calumet River water for VHSv 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 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 Lakefront 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 Lakefront 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 Little Calumet River water for VHSv prior to discharge into the CAWS.

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 Lakefront 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
Lakefront 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 Lakefront 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 and human-mediated transport. Therefore, the Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 ANTSP would treat Lake Michigan water for VHSv prior to discharge into the CAWS. 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 UVC irradiation, achieving a 3-log reduction of infective virus in freshwater at a UVC 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 Lakefront 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
Lakefront 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 Lakefront 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. 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 would be needed to control passage of VHSv through the ANSTP. 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}: 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

LAKEFRONT 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.

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

T_{25}: The Lakefront Hydrologic Separation includes an ANSTP and a physical barrier in the Little Calumet River at Calumet City, 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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Lakefront 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 Lakefront 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 spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier and ANSTP at Calumet City, 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 Lakefront 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 Lakefront 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
Lakefront 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 Lakefront 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront 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, 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Calumet City, 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 VHSv through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Little Calumet River 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 and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. 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 be able 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. Based on water quality data, UV treatment of Little Calumet River water at the Calumet City, Illinois, control point is anticipated to be effective. 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 Lakefront 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 Lakefront 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 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 Lakefront 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 Little Calumet River water for VHSv 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 Lakefront 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 Lakefront 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 Little Calumet River water for VHSv prior to discharge into the CAWS.

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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Calumet City, 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 Little Calumet River water for VHSv prior to discharge into the CAWS. 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 Lakefront 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
Lakefront 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 Lakefront 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. 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 would be needed to control passage of VHSv through the ANSTP. 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}: 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

LAKEFRONT HYDROLOGIC SEPARATION: Nonstructural Measures and Physical Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	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.

Lakefront 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	***Low***	***Low***	***Low***	***Low***
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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront Hydrologic Separation Rating	High	High	***Low***	***Low***

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

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes a physical barrier in the channel near Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Lakefront Hydrologic Separation Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, the barrier and associated flood risk management features would be designed to control overtopping of the banks only up to a 0.2% ACE event. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Lakefront Hydrologic Separation Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.

The Lakefront 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 Lakefront 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 spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Lakefront Hydrologic Separation Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 Lakefront 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 Lakefront 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, spread, or abundance of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Lakefront 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 Lakefront 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
Lakefront Hydrologic Separation Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Lakefront 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, 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 Lakefront 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 Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Lakefront Hydrologic Separation Alternative is expected to control the natural dispersion of VHSv 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 Lakefront 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 Lakefront 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 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. There is recreational, but not commercial, vessel traffic to the BSBH from Lake Michigan (USACE 2011a,b).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Lakefront Hydrologic Separation Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of 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 Lakefront 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.
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 Lakefront 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
Lakefront 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 Lakefront 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 Lakefront Hydrologic Separation Alternative does not affect the high rating designated for this time step in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Hammond, Indiana, with the construction of a physical barrier.
The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The physical barrier reduces the likelihood that VHSv and vessels potentially transporting the species in ballast and bilge water or via hull-fouling would pass through the aquatic pathway.

Overall, the Lakefront Hydrologic Separation Alternative reduces the likelihood of VHSv passing through the aquatic pathway. 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
Lakefront 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 Lakefront 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. 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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