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## Lock and Dam #1, Asian carp barrier alternatives analysis; the known unknowns

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# **Lock and Dam #1 Fish Deterrence Barrier Alternatives Analysis**

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Barr Engineering Company

2014 International Engineering Ecohydraulics  
and Fish Passage Conference

# Original Project Scope

Contract with MNDNR August 2012

## **Phase 1**

Alternatives Evaluation Report

## **Phase 2**

IEPR review assistance

Design

Permitting

USACE Section 408 EA and approval

Construction Plans

## **Phase 3**

Bid and Award

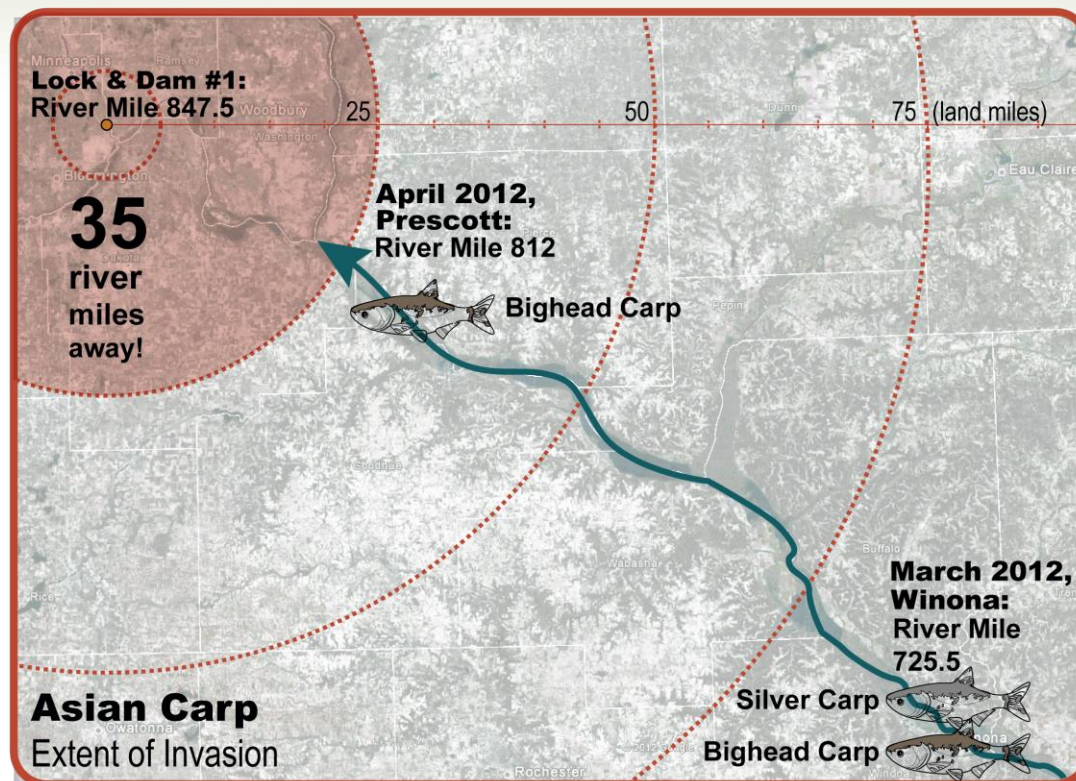
Construction Admin and oversight

Completion of construction by April 15, 2014

O&M manual

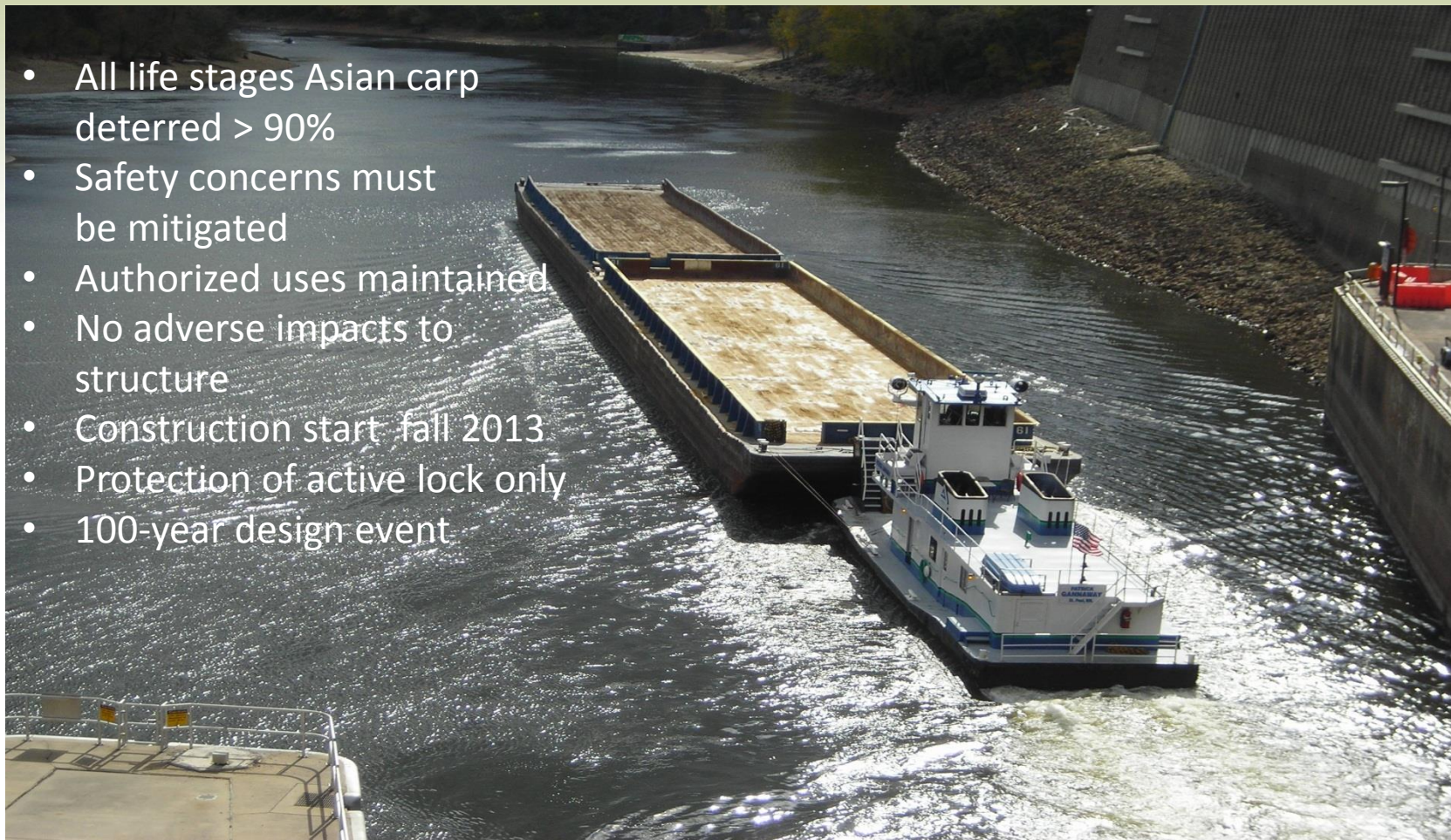
# Lock and Dam #1 Fish Barrier Alternatives Analysis

It is the goal of the MNDNR to design and construct a safe and effective fish deterrence barrier at Lock and Dam #1.



# Barrier Alternatives Evaluation Criteria

- All life stages Asian carp deterred > 90%
- Safety concerns must be mitigated
- Authorized uses maintained
- No adverse impacts to structure
- Construction start fall 2013
- Protection of active lock only
- 100-year design event



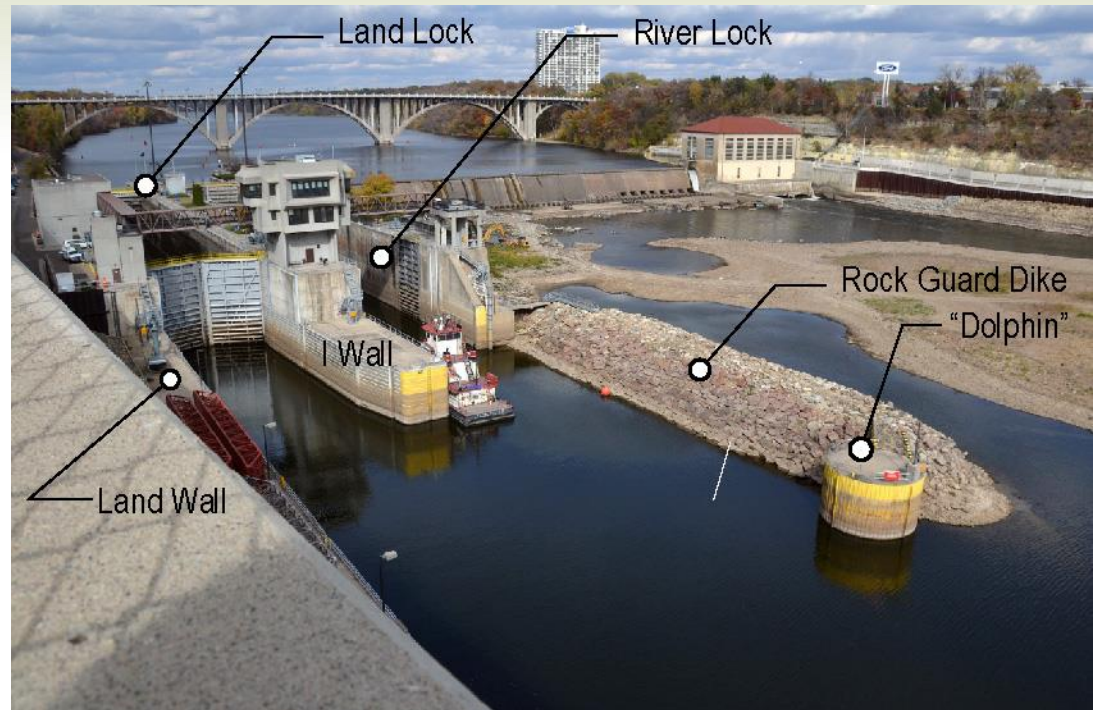
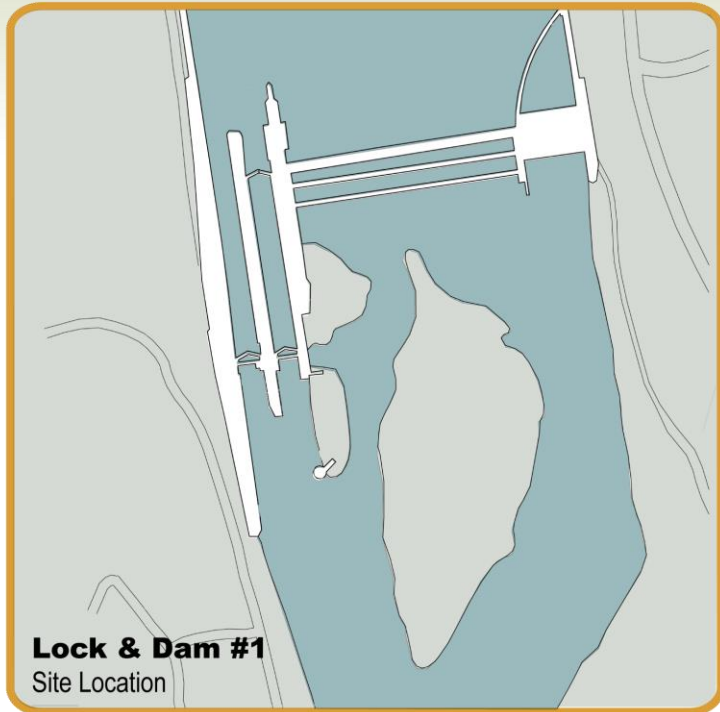
# Project Site and Uses



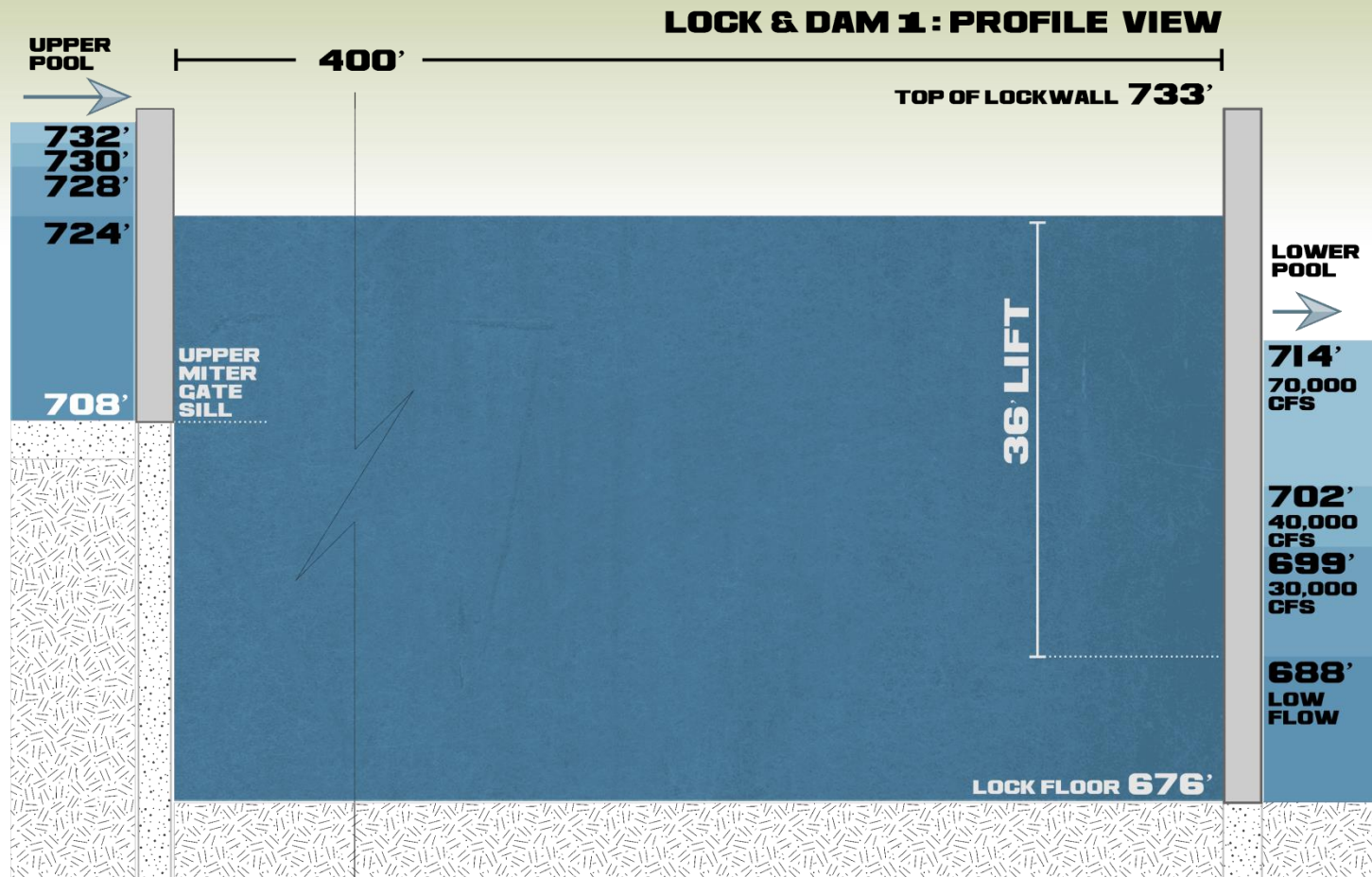
2,000,000 annual park visitors  
2,495 3-yr avg. # lockages



# Site Description



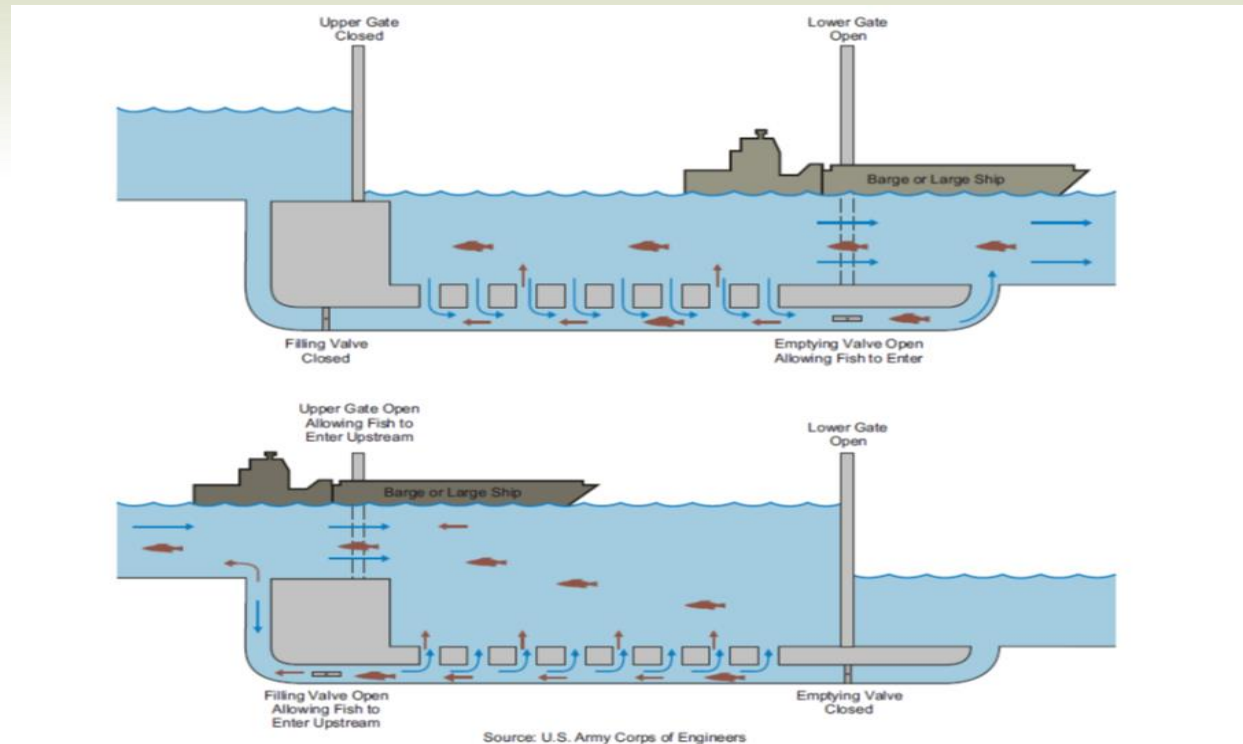
# Important Water Elevations at the Lock and Dam





# Lock and Dam #1 Fish Passage Routes

- Drain tubes/discharge manifold manifold
- Miter gates
- Water levels



# Known and Unknown

## Known

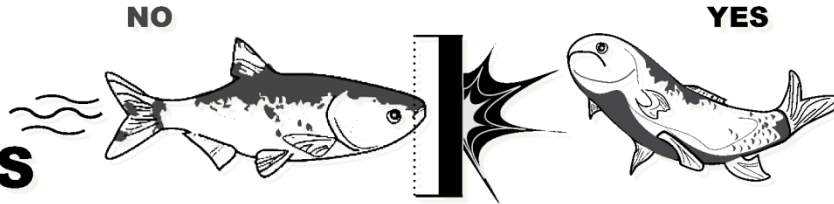
- Tight timeline
- High use area at/near lock
- 100-yr flood risk
- Multiple passage pathways
- USACE facility

## Unknown

- Technologies available
- Technology effectiveness for bigheaded carp
- Viable ways to protect lock
- Scope of safety mitigation
- Lock infrastructure affected

# LEVEL 1 SCREENING: IS FISH DETERRENCE > 90%?

## THE CONTENDERS



### Downstream

- D1:** Electric
- D1a:** Sweeping
- D1b:** Suspended Electrodes
- D1c:** Graduated Field (GFFB)
- D2:** Strobe Lights
- D3:** Air Bubble Curtain (BAFF)
- D4:** Sound Projection Array (SPA)
- D5:** Acoustic Air Bubble Curtain (SPA/BAFF)
- D6:** Combination: Sweeping Electric & Non-electric
- D7:** Combination: Graduated Field & Non-electric
- D8:** Combination: Suspended Electrodes & Non-electric
- D9:** Chemical Treatment

### In-lock

- I1:** Electric
- I1a:** Sweeping
- I1b:** Suspended Electrodes
- I1c:** Graduated Field (GFFB)
- I2:** Strobe Lights
- I3:** Air Bubble Curtain (BAFF)
- I4:** Sound Projection Array (SPA)
- I5:** Acoustic Air Bubble Curtain (SPA/BAFF)
- I6:** Combination: Sweeping Electric & Non-electric
- I7:** Combination: Graduated Field & Non-electric
- I8:** Combination: Suspended Electrodes & Non-electric
- I9:** Cease Operation of the Lock
- I10:** Chemical Treatment

### Downstream

- D2: Strobe Lights
- D3: Air Bubble Curtain (BAFF)
- D4: Sound Projection Array (SPA)

D9: Chemical Treatment

### In-lock

- D2: Strobe Lights
- D3: Air Bubble Curtain (BAFF)
- D4: Sound Projection Array (SPA)

I10: Chemical Treatment

### Downstream

- D1**
- D1a**
- D1b**
- D1c**

- D5**
- D6**
- D7**
- D8**

### In-lock

- I1**
- I1a**
- I1b**
- I1c**

- I5**
- I6**
- I7**
- I8**
- I9**

**MOVING ON.  
FURTHER CONSIDERATION...**

# Technology effectiveness

Literature review of non-physical deterrence barriers

Decision to use only Bighead and Silver carp specific research

<u>Barrier Type</u>	<u>Species</u>	<u>*Deterrence Effectiveness</u>	<u>Factors influencing effectiveness</u>	<u>Limitations</u>	<u>Reference Studies</u>
GFFB	Chinook salmon	84.7%	Water conductivity, size of fish, attenuation of electric field or placement of electrodes	Power outages, maintenance issues, human error, size-selective effectiveness	Palmisano and Burger 1988; Maceina et al. 1999a,b; Holliman 2011
	Grass carp	98.7%			
	Silver carp, bighead carp	63% - 99%			
SPA/BAFF	Silver carp, bighead carp	60-99.7%	Ambient light and turbidity (strobe portion)	Lack of Asian-carp-specific testing on large scale	Taylor et al. 2005; Ruebush et al. 2012; Pegg and Chick 2004
Sweeping	Goldfish	Unknown	Unknown	Unknown	Unpublished data Smith-Root
Suspended electrodes	Bleak, asp, common carp, rainbow trout, catfish	93-98%	Water conductivity, size of fish	Water velocity; only downstream applications to date	Unpublished and mostly Polish journals
Air Bubble Curtain	Gizzard shad, alewife, rainbow smelt	70-95%	Turbidity, water velocity, bottom geography, light penetration	Not easily noticed from a distance	Patrick et al. 1985; McIninch and Hocutt 1987
SPA	Alewife, Atlantic herring, European sprat, river lamprey, flat fish	60-96%	Bottom morphology, hydrology, angle of sound waves	Sound waves are less effective in shallow waters and across hard substrates	Ross et al. 1993; Maes et al. 2004
Strobe Lights	Rainbow smelt, Atlantic menhaden, spot, white perch	8-100%	Turbidity, ambient light	Reduced effectiveness during daylight hours and in high-turbidity conditions	Sager et al. 1987; Hamel et al. 2008
BAFF	European silver eels, alewife, silver carp, bighead carp	57-99%	Bottom morphology, hydrology, angle of sound waves	Less effective in shallow waters and across hard substrates	Haymes and Patrick 1986; Sand et al. 1999; Pegg and Chick 2004

# Bighead and Silver carp specific peer reviewed studies 2012

- Holliman, F. M.. 2011. Operational protocols for electric barriers on the Chicago Sanitary and Ship Canal; Influence of electrical characteristics, water conductivity, fish behavior, and water velocity on risk to breach by small silver and bighead carp. Final Report CELRD-DE to US Army Corps of Engineers.
- Ruebush, B.C. et al. 2012. In-situ tests of sound-bubble-strobe light technologies to prevent range expansions of Asian carp. *Aquatic Invasions* 7(1): 37-48
- Taylor, R. M. et al. 2003. Some observations on the effectiveness of two behavioral fish guidance systems for preventing the spread of bighead carp to the Great Lakes. *Aquatic Invaders* 14:1-5.
- Taylor, R.M et al. 2005. Response of bighead carp to a bioacoustics behavioral fish guidance system. *Fisheries Management and Ecology*, 12, 283-286

# Level 2 Screening: Site-Specific Considerations

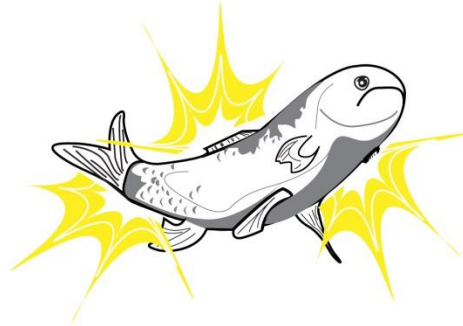
- Lock structure modifications
- Lock and dam operational modifications
- Public and operator safety
- Ice and cold weather
- Flood flows
- Damage by commercial vessels
- Fish behavior
- Recreational traffic impacts
- Sedimentation and/or scour



# Electrical Effects on Fish and Humans

- CSSC operations
- NAVSEA report

**Voltage known  
to deter Asian Carp  
of any life stage:**



**2.3 Volts/inch**

**Voltage level that can  
cause fibrillation and  
involuntary loss of  
muscular control in  
humans:**



**0.08 Volts/inch**

# LEVEL 2 SCREENING: SITE SPECIFIC CONSIDERATIONS

## THE SEMI-FINALISTS

### Downstream

- D1:** Electric
- D1a:** Sweeping
- D1b:** Suspended Electrodes
- D1c:** Graduated Field (GFFB)
- D5:** Acoustic Air Bubble Curtain (SPA/BAFF)
- D6:** Combination: Sweeping Electric & Non-electric
- D7:** Combination: Graduated Field & Non-electric
- D8:** Combination: Suspended Electrodes & Non-electric

### In-lock

- I1:** Electric
- I1a:** Sweeping
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- I8:** Combination: Suspended Electrodes & Non-electric
- I9:** Cease Operation of the Lock

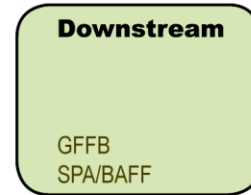
- D1a: (High Potential, but not ready to implement)
- D1b: (potential for entanglement)
- D6: (should be evaluated separately)
- D7: (should be evaluated separately)
- D8: (should be evaluated separately)

- I1a: (not recommended)
- I1b: (not applicable)
- I1c: (not recommended)
- I5: (not recommended)
- I6: (should be evaluated separately)
- I7: (should be evaluated separately)
- I8: (should be evaluated separately)
- I9: (public decision process required)

FAIL

PASS

### Downstream



### In-lock





# Known and Unknown

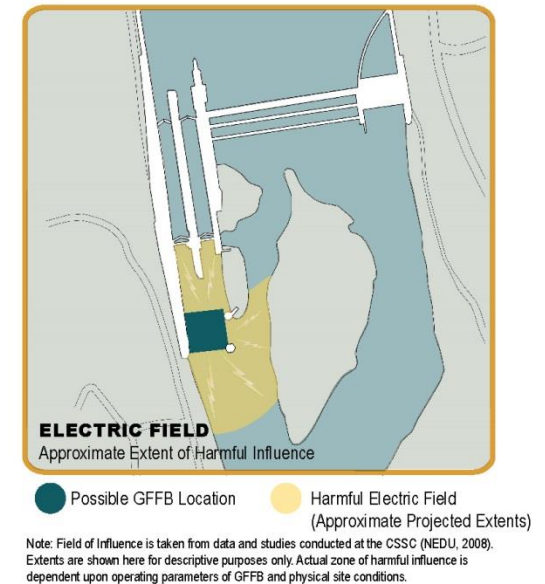
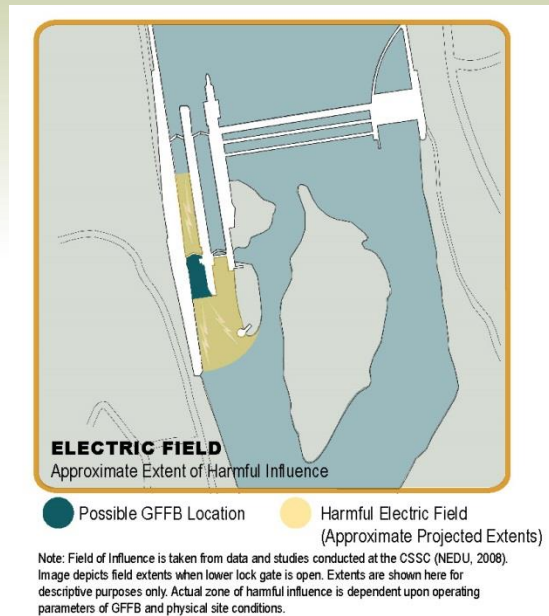
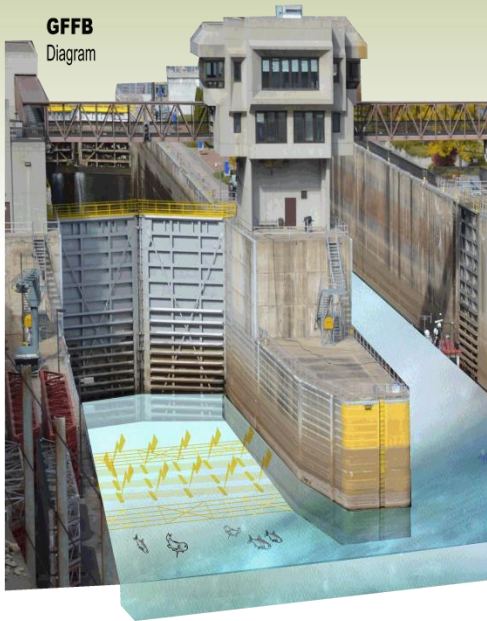
## Known

- Limited technologies applicable
- USACE concerns about structural changes to lock
- Safety mitigation for electric required
- Very limited species specific research
- Limited understanding of how research results apply in operational use

## Unknown

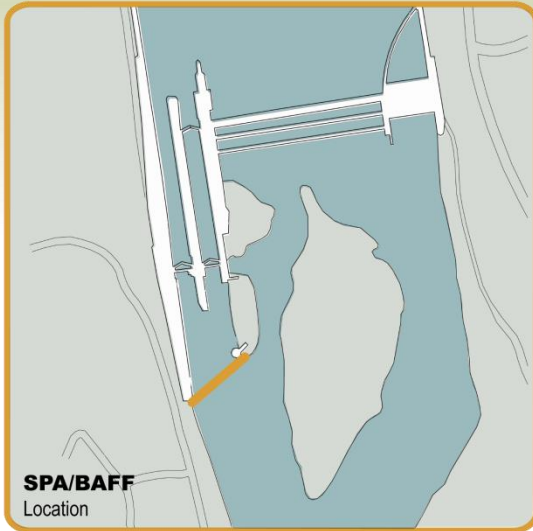


# GFFB Locations and Specific Site Issues

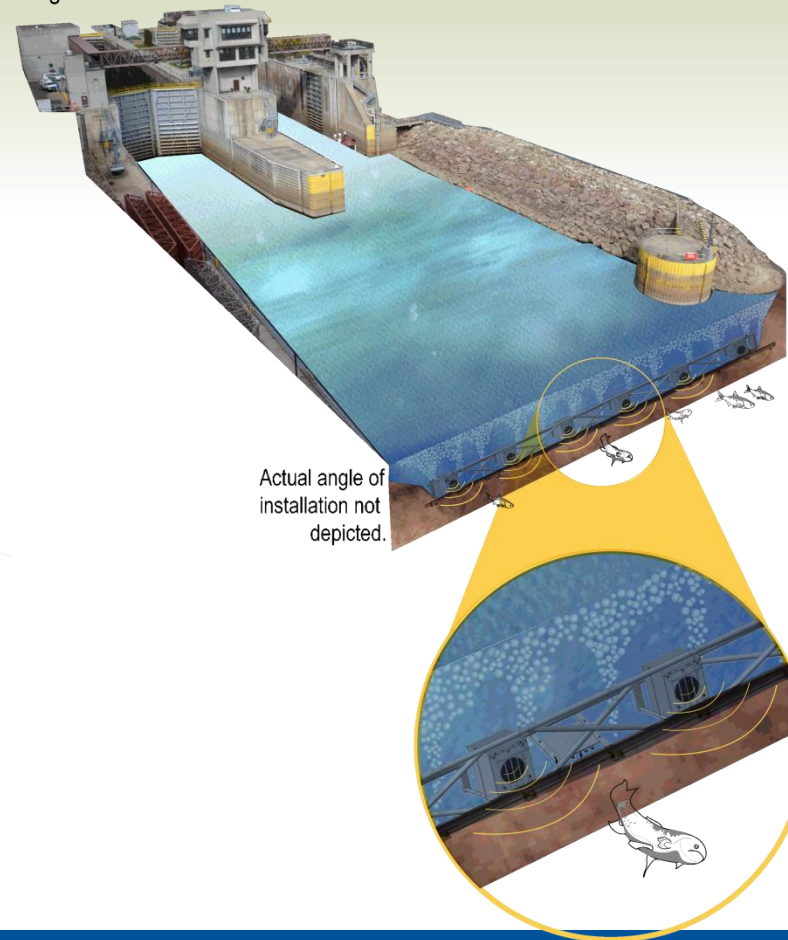


- Short and long-term structural impacts
- Construction methods
- Construction schedule
- Operational changes

# SPA/BAFF Location and Site-Specific Issues



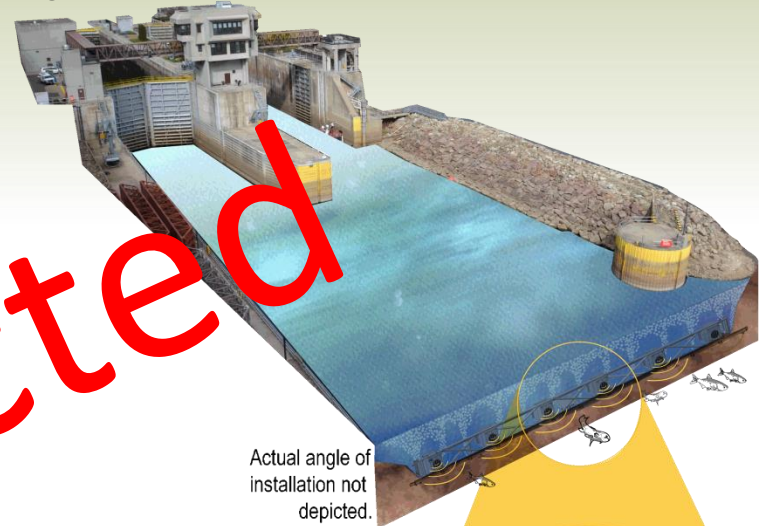
SPA/BAFF Diagram



- Operational changes
- Construction methods

# SPA/BAFF was the Recommended Alternative

SPA/BAFF  
Diagram



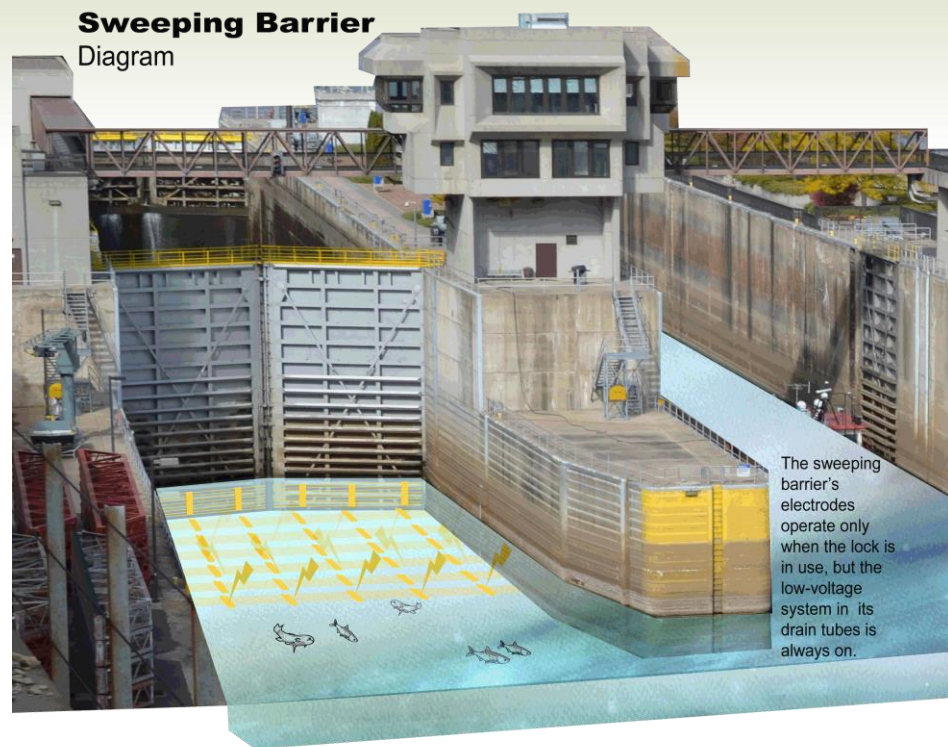
Actual angle of installation not depicted.

- Potentially up to 99+% effective for all life stages of Asian carp
- No lock operational changes
- Meets public safety needs
- Location may enhance effectiveness

Rejected

# Sweeping Barrier Concept and Location

- SRI design contract
- Electrical parameter validation study May 2014



# WRDA 2014

Upper St. Anthony Falls to be closed within one year of signature of the legislation.

# Questions



resourceful. naturally.



# Barrier Overview

## Sweeping Field/Diffuser/Terminal

No installations of these combined technologies at this time anywhere.

May 2014 validation study to provide guidance on parameter settings required for Asian carp.

Barrier Type	Voltage Gradient at Surface**	Voltage Gradient near electrodes at (12' water depth)**	Pulse Rate/Frequency**	NAVSEA report max safe voltage gradient humans	CSSC canal electric barrier operational parameters (surface)
Diffusers	.004V/in-.014V/in	1.6-1.7V/in	3Hz/2ms	≤0.05V/in	NA
Sweeping	≥1.08V/in	<2.0V/in	3Hz/2ms	≤0.05V/in	NA
Terminal	≥1.08V/in	6.0V/in	3Hz/2ms	≤0.05V/in	2.3V/in,30Hz, 4ms

\*\* hypothetical optimums Smith Root 99% design report 2014  
NAVSEA Report 2008