A solution for invasive carp in Minnesota

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ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

mn DNR

Outline

- Today's question
- Lessons learned about Common Carp
- Bigheaded carp
- A feasible option to stop the Bigheaded Carp invasion
- Summary
- Questions and answers

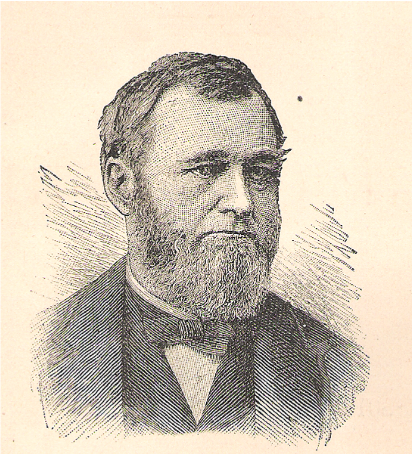
Silver Carp: the invasive carp of greatest interest

Today’s Question:

Does Minnesota want to stop invasive carp, or not?

A lesson from the past: Common Carp:

On October 22, 1880, common carp were introduced into Minnesota waters by the MN Fish Commission.



PROF. SPENCER F. BAIRD,
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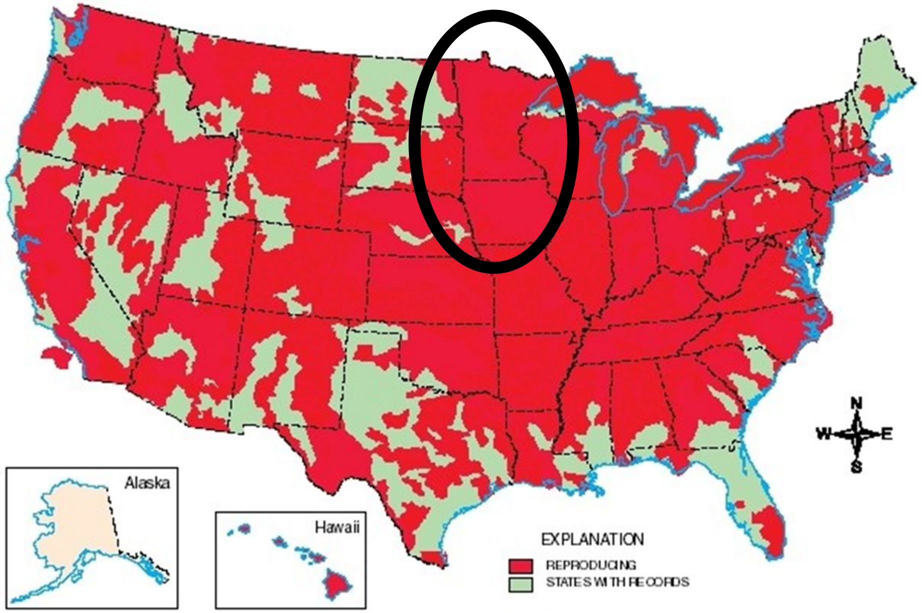
Common carp were soon everywhere and causing enormous damage, and then removal efforts began which by and large have failed except sometimes control is possible when coupled with other approaches.



Minnesota:

- 100,000 of acres of wetland infested and many permanently degraded
- 1,000s of lakes and rivers also infested
- 100s of millions of dollars have been spent on control in MN alone
- Still no good way to remediate and control
- Life will never be the same.

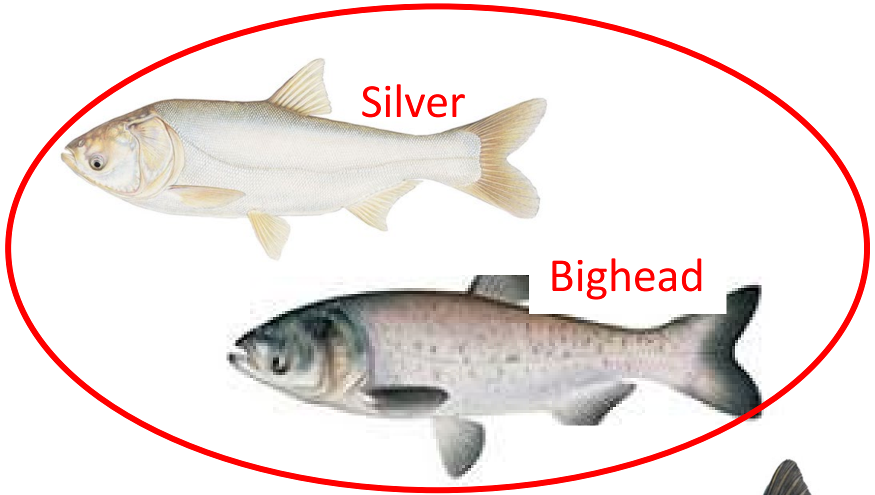
Lessons

1. <u>Preventing</u> establishment (reproduction) is the <u>only</u> reasonable approach
2. It is critical to act at the onset of an invasion
3. Success does not require 100% efficiency (just a high number)
4. Multiple control measures needed, removal alone does <u>not</u> work
5. Adaptive control is best
6. Some locations are amenable to control and some are not
7. **Failing to act decisively is a choice.**

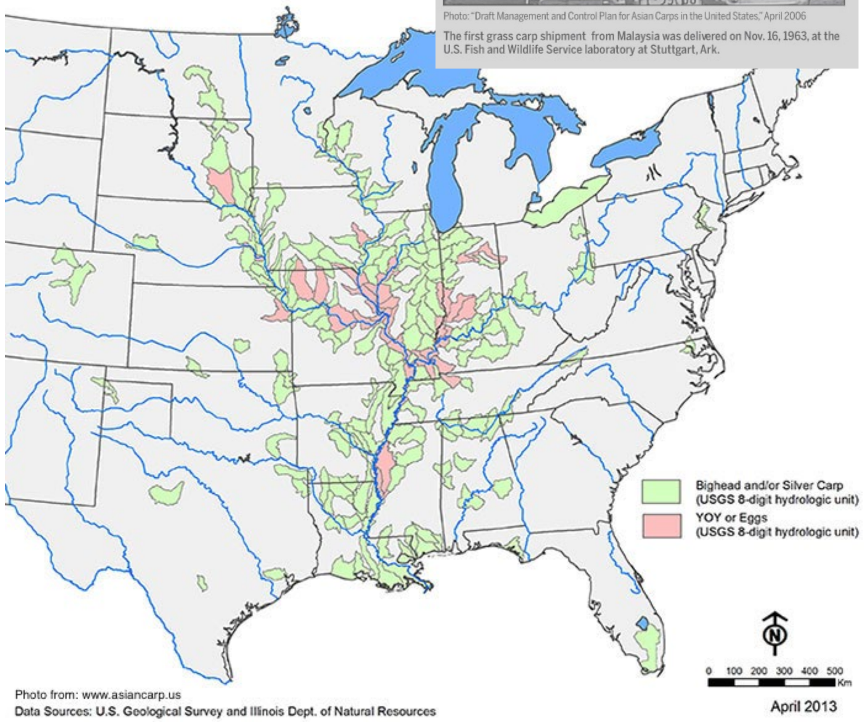
140 years later another test: Bigheaded (Invasive) Carp

- 4 species of carp from Asia: Bighead, Silver (or Bighead**ed**), Black, and Grass
- Repeatedly introduced in Arkansas by government agencies in the 1960s
- NOW: spreading north and establishing—breeding and producing young
- Now what?

Photo: "Draft Management and Control Plan for Asian Carps in the United States," April 2006



2 species of Bigheaded carp



40 years of study show that as with common carp, Bighead are damaging fisheries and waters – 6 effects

1. **Driven a 50% reduction in native gamefishes** in rivers (Chick et al. 2020 *J Biol Inv*).

2. **Driven 10-25% reduction in the size of native planktivorous fish** (ex. bigmouth buffalo; Irons et al. 2007. *J. Fish Biol*).

3. Driven a **90% reduction in macroplankton species richness (biodiversity)** and abundance (Sass et al. 2014; *J Great Lakes Res*; DeBoerer, 2018. *Freshw Biol*).

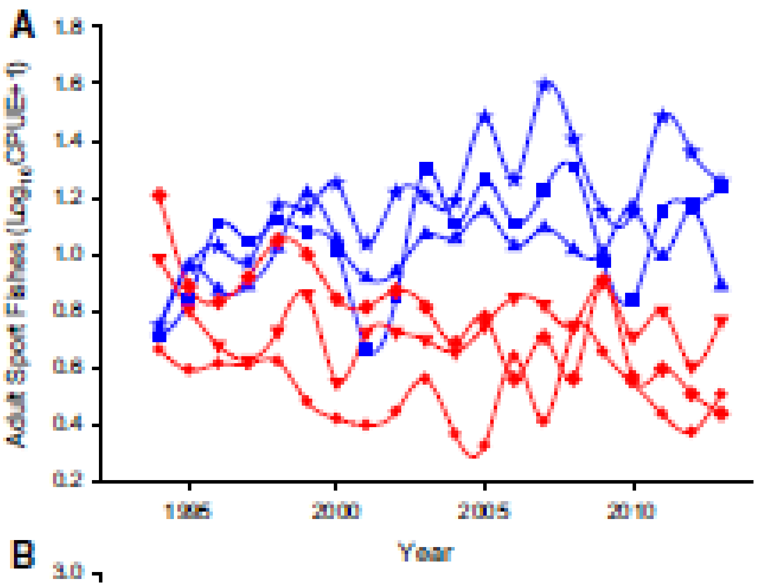
4. **Reduced the size (57-87%) of larval fish** and zooplankton (Fletcher et al. 2019).

5. **Reduced the size of freshwater mussels** (Tristano et al. 2019. *Aqu Conserv*)

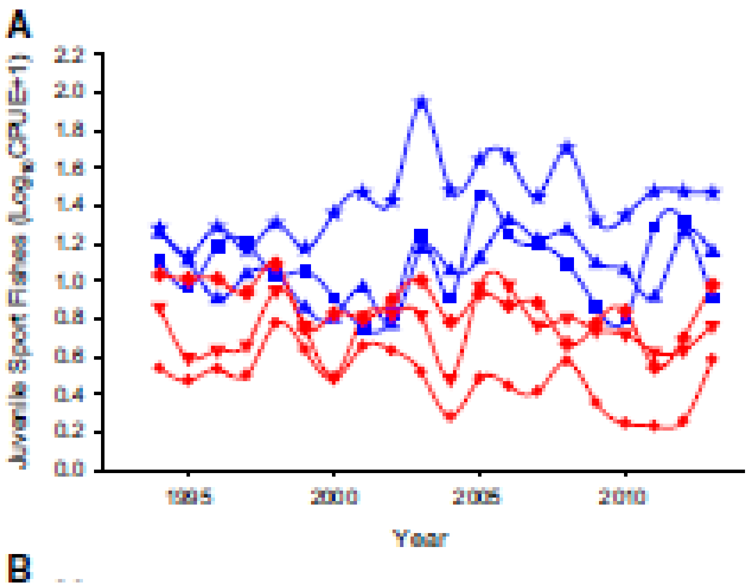
6. Caused **eutrophication of the benthic environment** (feces and bacteria) (Kolb et al. 2019)

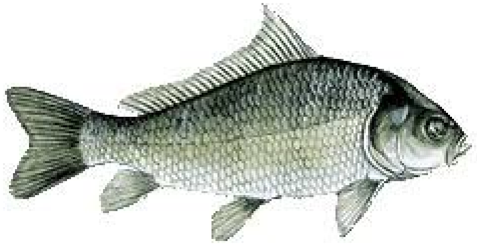
For example, Sport fisheries in Illinois have dropped by half, no reason not to expect the same in Minnesota

Adult gamefish abundance



Juvenile gamefish abundance





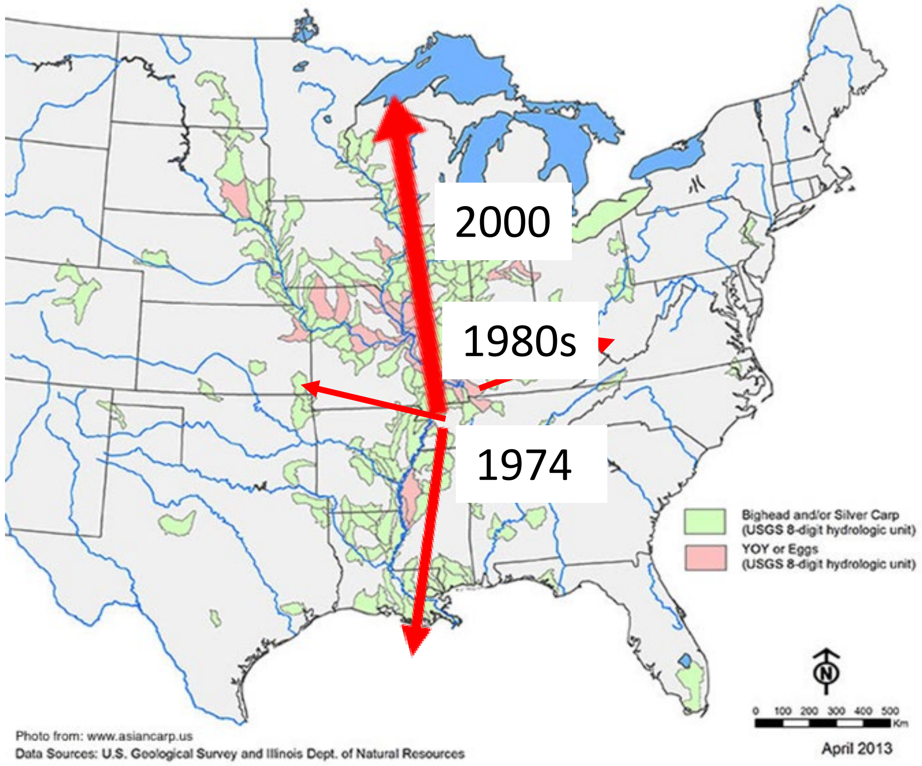
Blue= Carp-free water

Red= Water invaded by Bigheaded carps

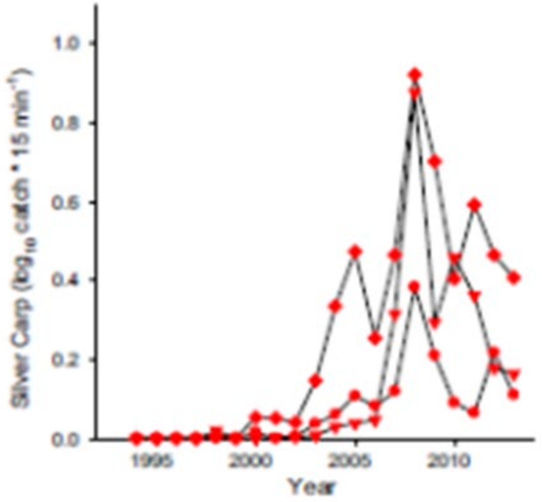
1. Chick et al. 2020 *J Biol Inv*).

Further, Silver carp jump 9 feet in the air, posing danger to boaters and taking all the fun away

Silver carp have been moving away from their point of introduction since 1970s and then reproducing: establishment in MN is inevitable in unless something is done



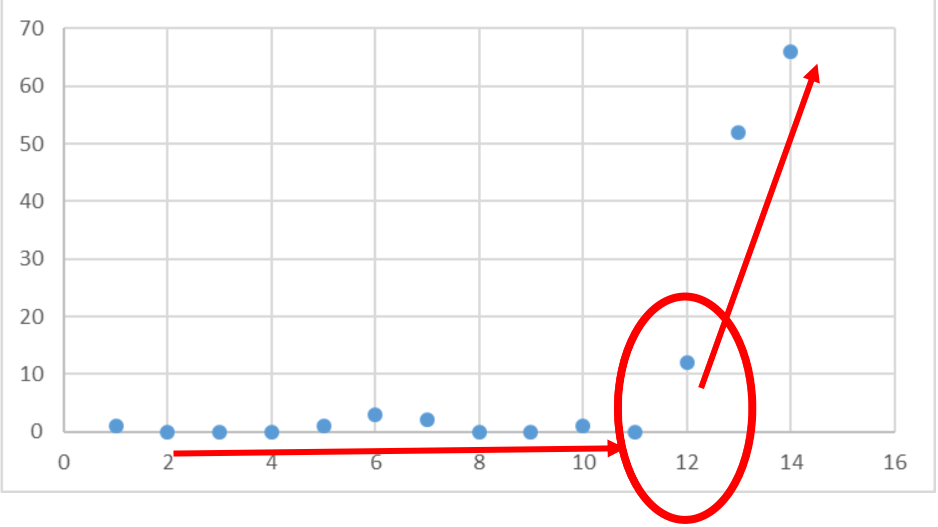
Silver carp now problematic in 12 states
- a quarter of the USA!
Budget for control is about 30 million$



<u>Locally, Increases have been rapid</u>: In Illinois after years of no change: sudden, explosive growth (Sass et al)

Adult silver carp are presently invading Minnesota waters

MN captures (all sources reported to the MN DNR



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Adult Silver carp captures are now increasing dramatically in MN - nearly doubling each year, after years of no change

ONLY QUESTION: WHEN WILL THEY REPRODUCE?

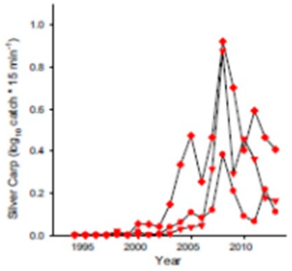
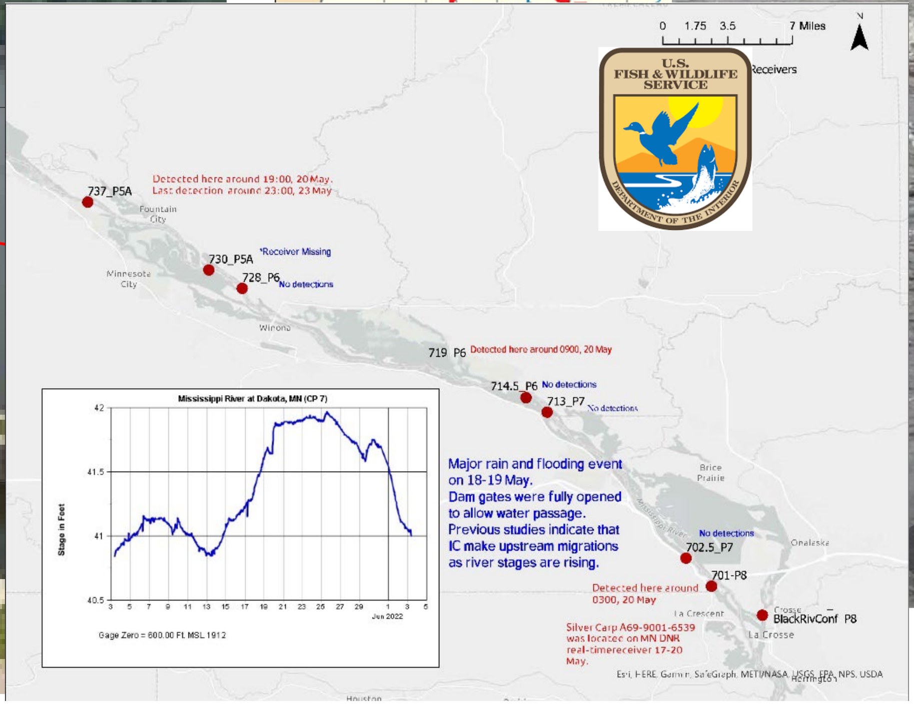
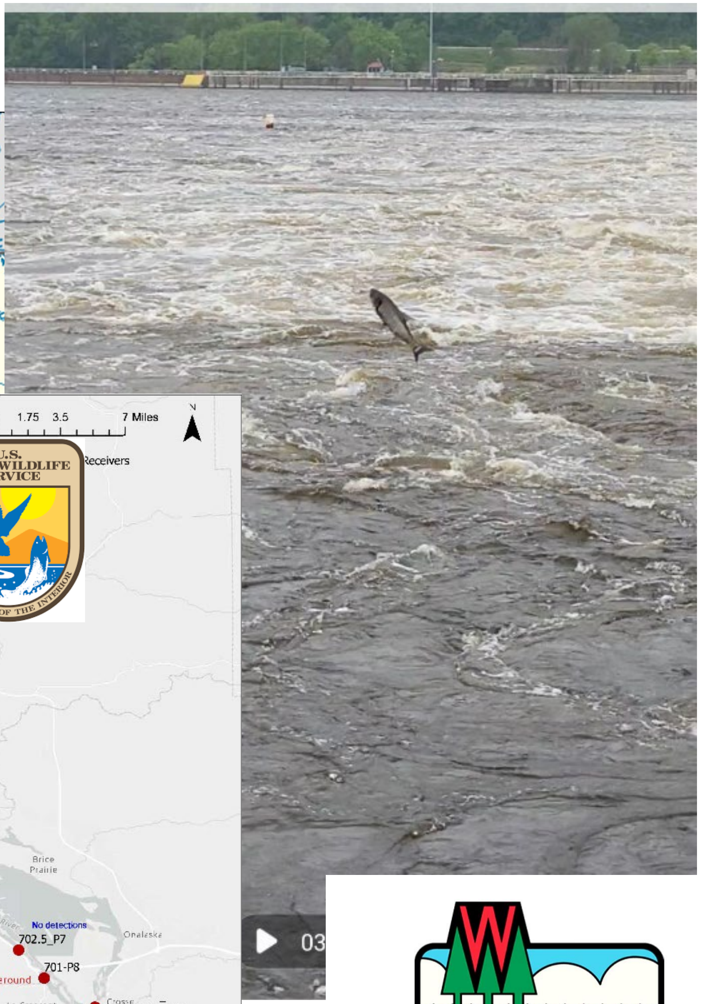


Fig. 2 Catch per unit effort ($\log_{10}$ catch * 15^{-1} min electrofishing) of silver carp in the three invaded reaches [Pool 26 (red inverted triangle), Open River (red circle), La Grange (red diamond)] from 1994 to 2013

Silver Carp are now routinely observed in Pool5A (Winona), immediately below Lock & Dam #5 in the summer!





- Many Public sightings
- Confirmed by USFWS and UofMN:
  1 of 2 tagged silver carp in Pool 8 tracked here

- Confirmed by Brian Brecks and Bob Jumber, WI DNR (June 6 and 8: “ *jumping at a rate of once a min below the spillway*”)

This is a VERY serious situation

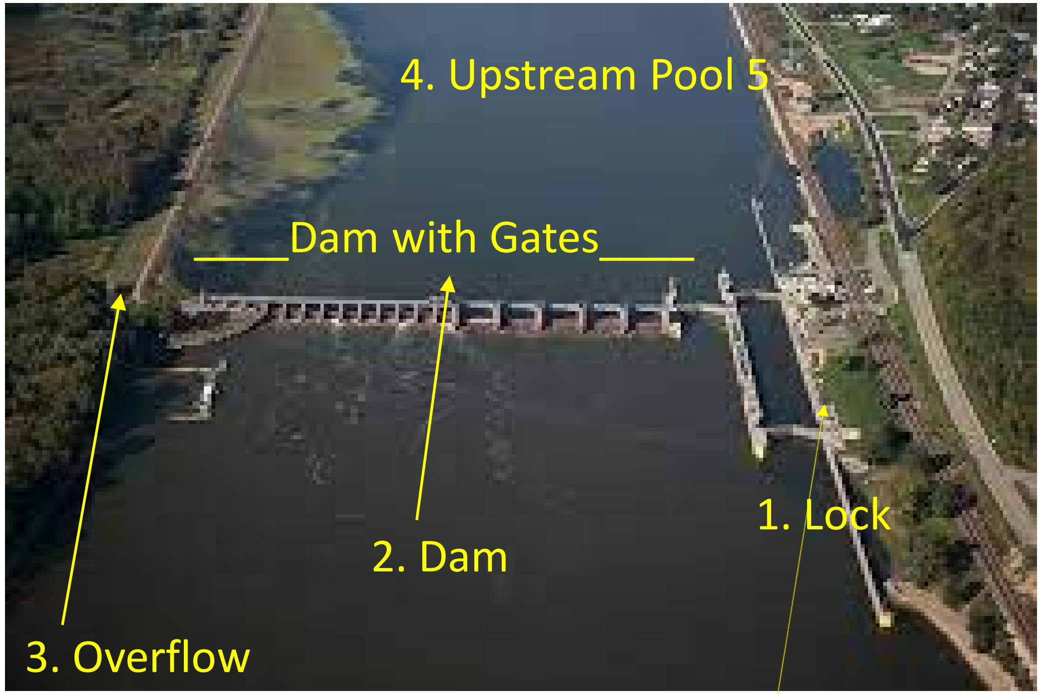
1) Lock and Dam 5 (LD5) is **the last place to stop these carp** south of the Twin Cities.
2) **As few as 20 female carp** can be expected with 75% certainty to reproduce and create a viable population within as little as 10 years! (Cuddington et al. 2014).
3) **Once carp reproduce, prevention is not even possible,** only management (as with common carp).

Today, I describe a plan that could save the state from bigheaded carp

- **Developed by UMN experts with $5 million LCCMR funding, project now complete**
- **Predicted to stop 97-99% of all invasive carp**
- **Would save the entire state from Lock and Dam 5 north (Lake Pepin and north)**
- **Would also help native fishes**
- **Reasonable** (multiple component with options, adaptive)
- **Validated** by the scientific community (8 peer-reviewed publications)
- **Doable** (validated by Barr Engineering Co. Feasibility and cost analysis)
- **Reasonable Cost:** about $11 million—if not implemented, state will pay $2 million/year for carp control
- Must be **implemented now** (2023) to have a good chance of working
- **Specific to Locks and Dams (LDs) and <u>Lock and Dam 5 in particular</u>**
- Agencies not yet on board

First, what are Locks and Dams (LDs)?

- 29 Locks and Dams (LDs) span the Mississippi River to regulate water depth for navigation.
- All fish swimming upstream must pass through them. **Some LDs already stop 50-85% of all fish including carp at no cost.**
- **It's simply a matter of improving on these numbers…**

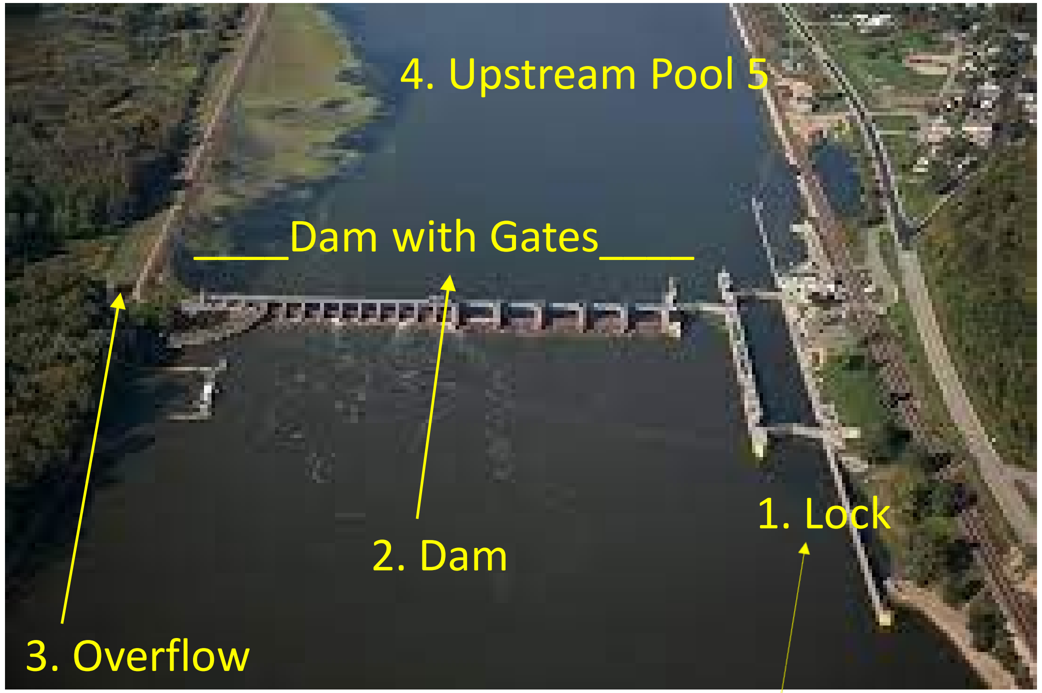


Only 3 ways to pass a LD

How might the ability of LDs to impede invasive carp be enhanced?

<u>**3 components - 3 ways with location being the key.**</u>
All LDs have 3 components that determine fish passage and each provide excellent options for carp control but only at specific locations because individual LDs differ:

1. A **dam with spillway gates** that open/close to maintain depth in lock (usually 90% of structure).
2. A **navigation lock** that open for boats (10% of structure, allows fish to pass when opened).
3. Embankments (sometimes with overflows and culverts)

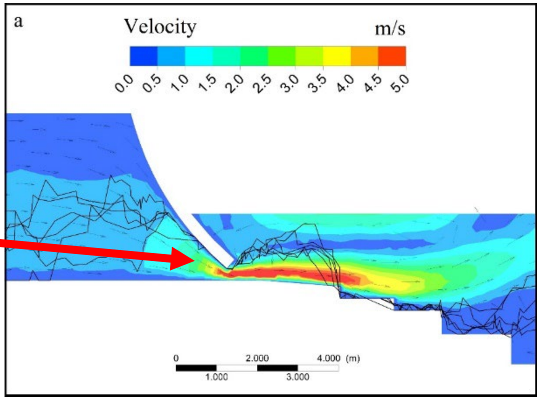


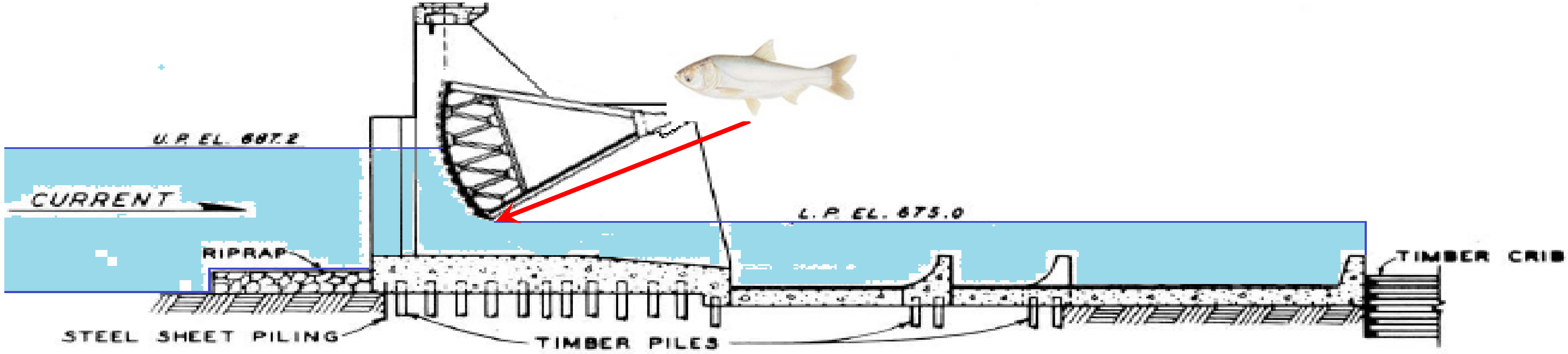
Only 3 ways to pass

1. Component 1: Dams with spillway gates - what to do.

Background:

- What are they: Dam with spillway gates
- Spillway gates are raised/lowered daily according to river flow/depth, accelerating flows beneath them as they close.
  - However, fish can only swim so far so fast!
    - This means fish including carp often cannot swim below them - We now know this relationship for invasive carp, but it is LD-specific, being a factor of LD design and hydraulics.

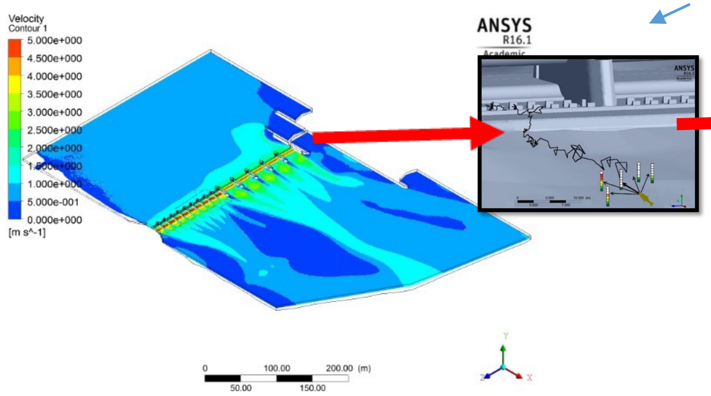


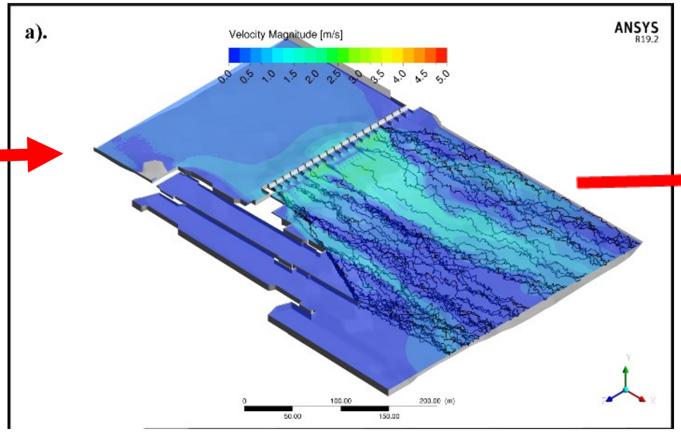


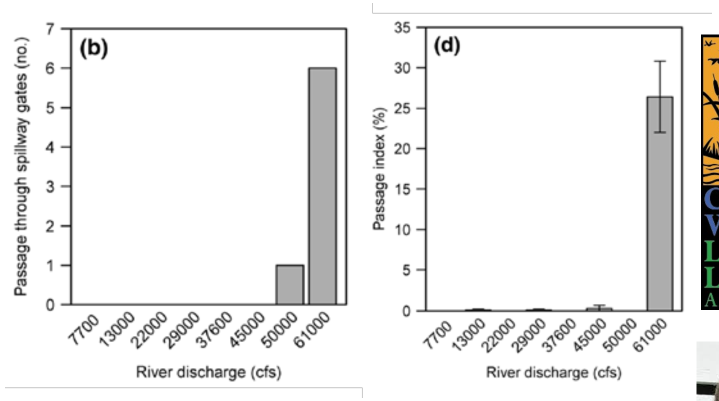
For example, Lock and Dam 2 (a study funded by the DNR with LSOHC funds)

- We determined how fast and how far adult bigheaded carp can swim against velocity (Hoover et al. 2006)
- We determined the relationship between spillway gate opening, river flow and water velocity – and thus ability of adult carp to pass beneath (Zielinski et al. 2018).
- We tested the ability of wild carp and other fish to actually pass LD2 (Finger et al., 2020) and found that as predicted they only passed with gate almost fully open.

Lock and Dam 2







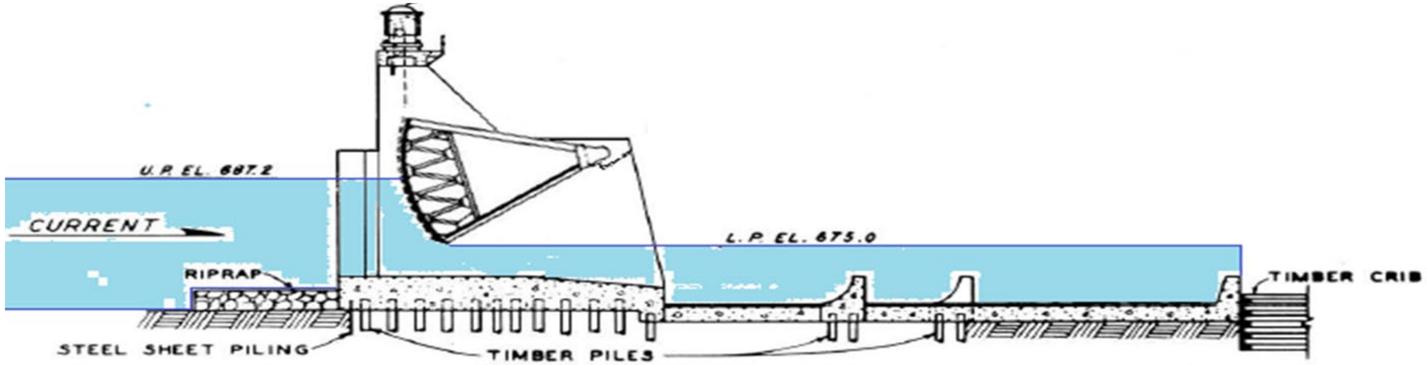
CLEAN WATER LAND & LEGACY AMENDMENT

Carp passage at LD2 was predicted to occur only when gates were lifted out of the water

From: Finger et al. 2020. *River Res Applications*

The Next Step and Take-home Message

- We used this relationship between passage and hydraulics to build a numeric model that predicts the ability of individual LDs to pass carp across the year under realistic flows conditions (Zielinski and Sorensen 2021).
- We found that only those few LDs whose have spillway gates rarely open rarely pass adult carp. **LD5 is very promising (gates only open 2% of the year)!**
- We also found that spillway gates can be adjusted to reduce this rate (Zielinski et al. 2018).
- **Focus all efforts on LD5, ignore other locations**



2. Navigation locks: what to do

- ~10% of surface area of most LDs
- Miter gates are usually closed—only open for river traffic
- Noisy, and that seems to deter fish: Low carp passage rates that could decreased further if a deterrent is added.
- Locks are already good blocks, so enhance this property at LDs where spillways are not passable

Enhancing blocking ability of locks: Lock deterrent systems for carp

Three options:

1) electrical

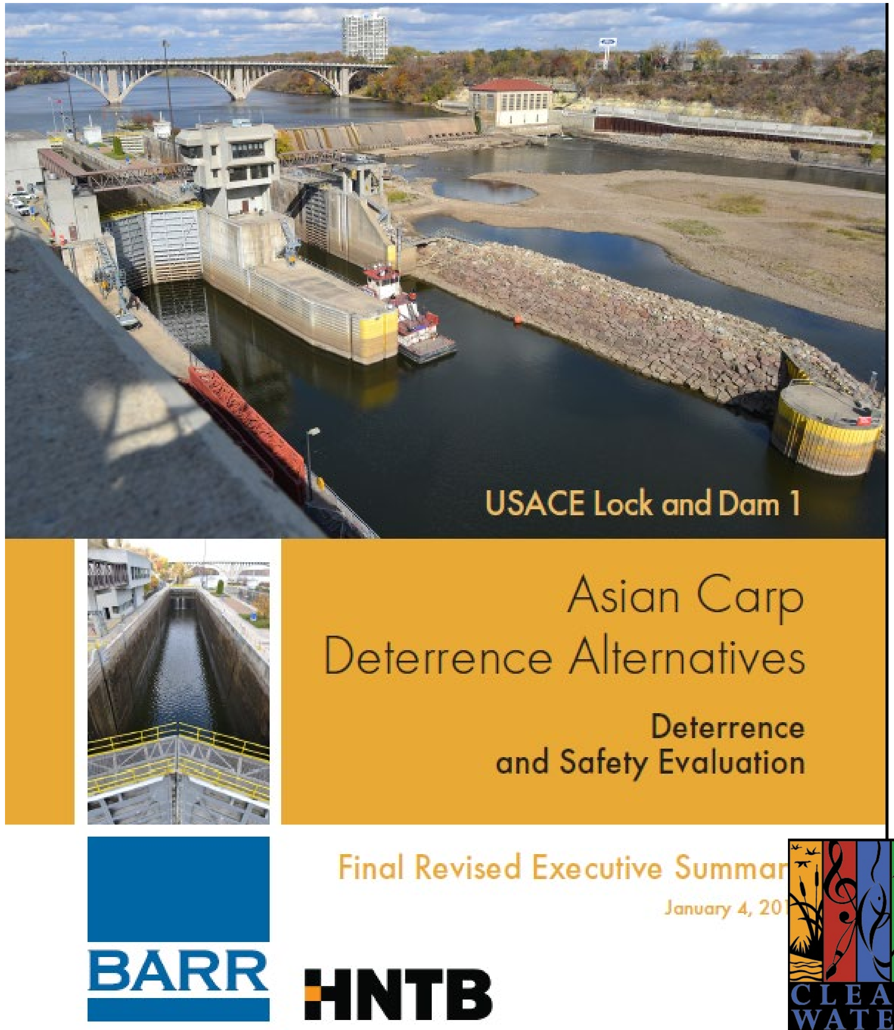
2) sound

3) multi-modal (

Asian Carp Deterrent Report (2013, LSOHC funded)

“We recommend the acoustic/air bubble curtain/ strobe light” (Bioacoustic Fish Fence or BAFF), a multi-modal system

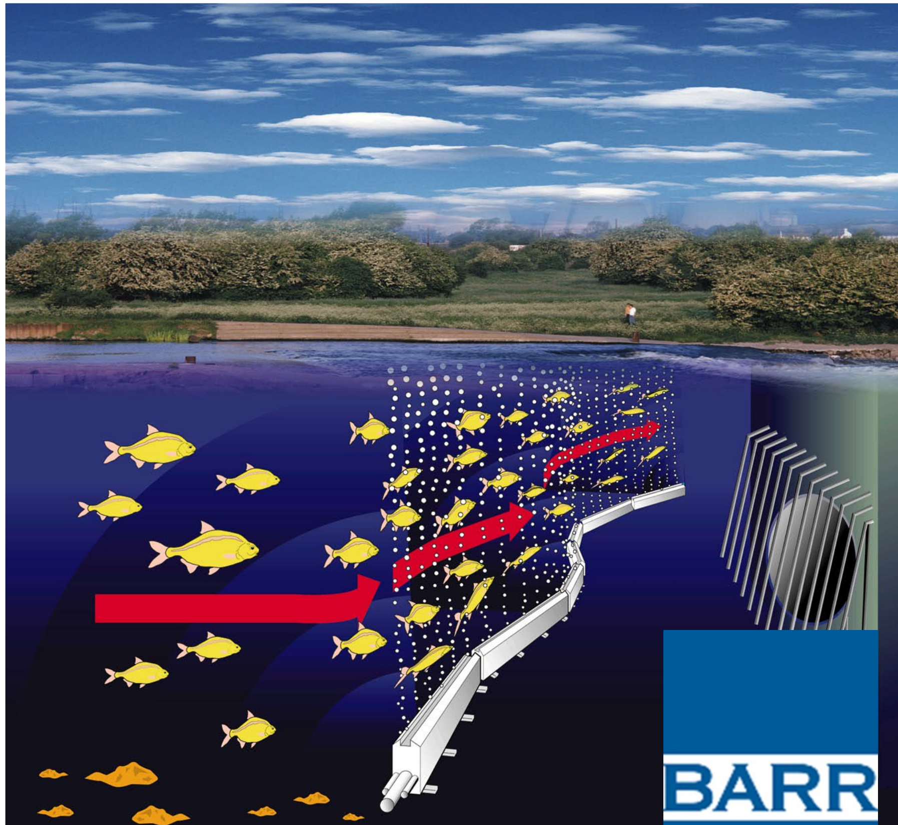
- Safety
- Efficacy
- Cost



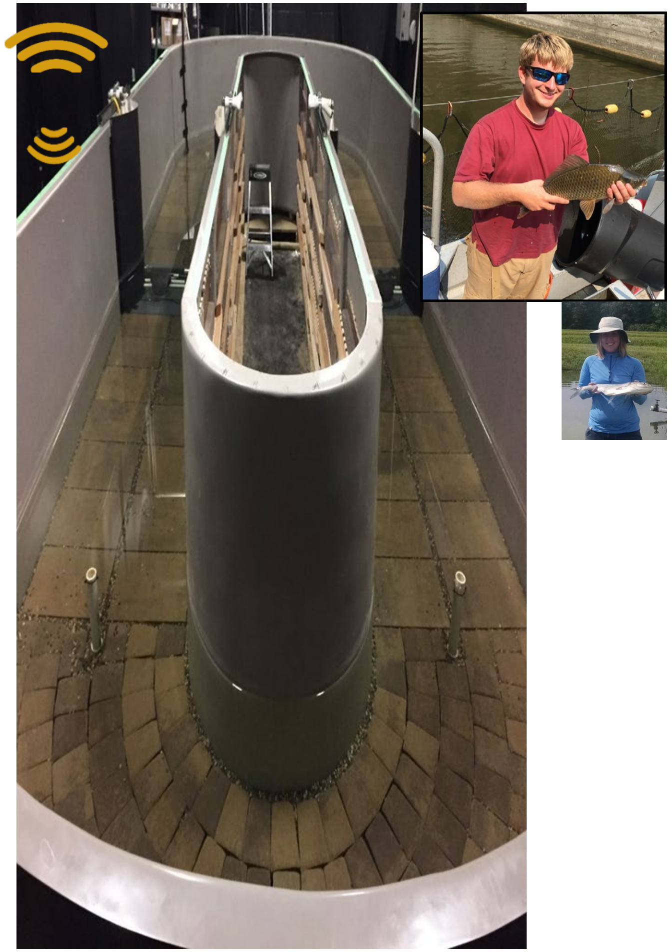
CLEAN WATER LAND & LEGACY AMENDMENT

What is a Bioacoustic Fish Fence (BAFF)?

- Combines acoustic signal with a bubble curtain to create a wall of sound (multimodal)
- Effective carp deterrent (lab and field, ambient sound levels are not a problem)
- Feasible, affordable
- Safe

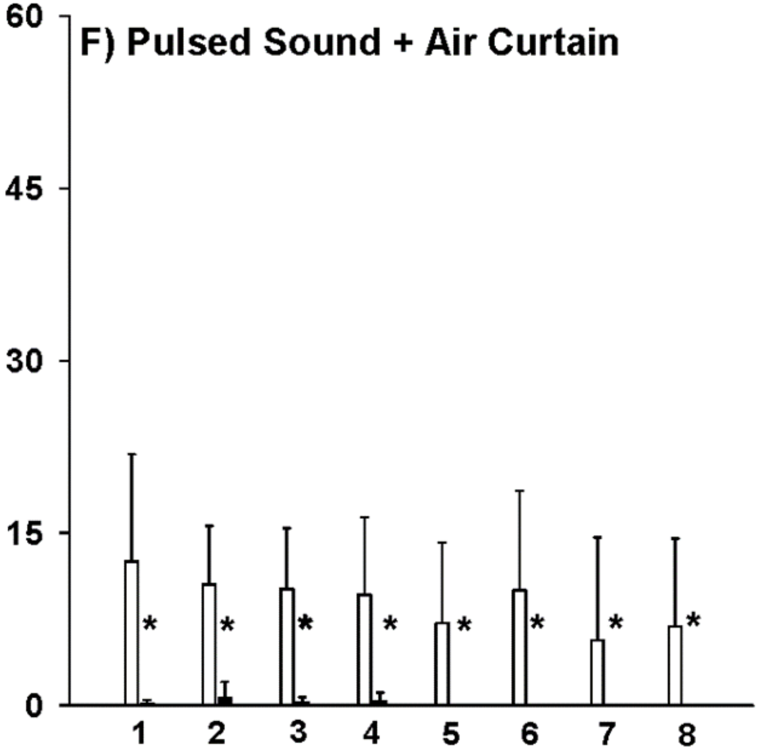


BAFF blocks 97% of invasive carp in published lab test



Air coupled with sound (Bioacoustic Fish Fence or BAFF)

97% BLOCK



Published: Dennis et al. 2019 . Journal of Biol. Invasions

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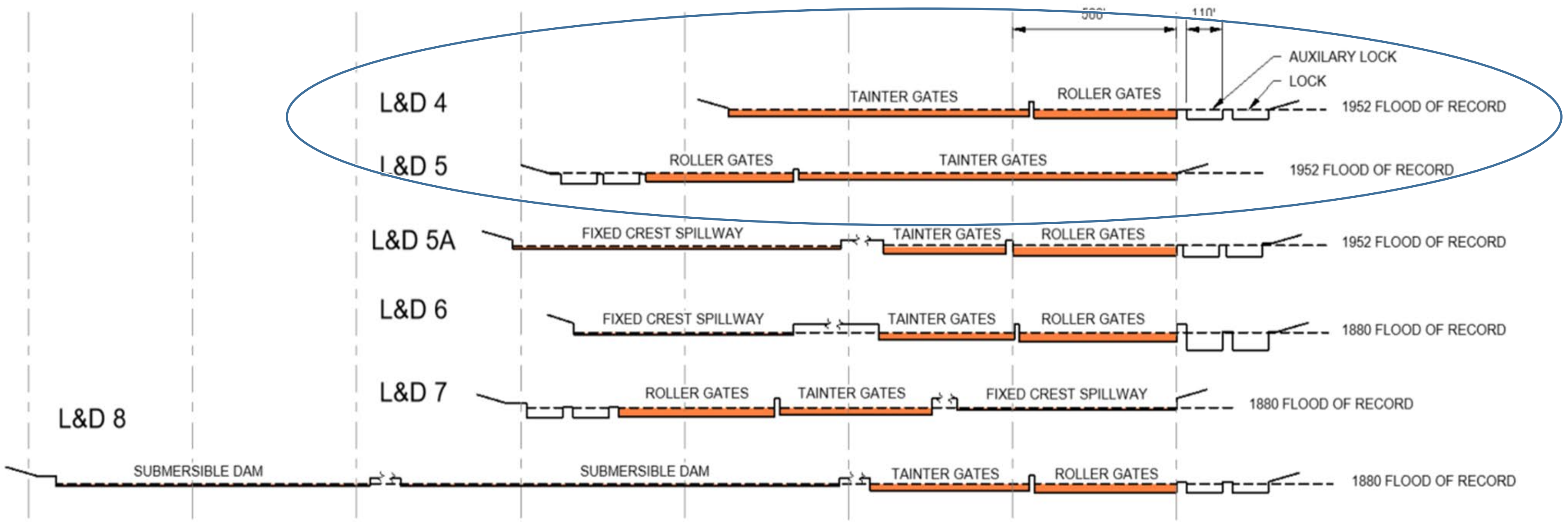
BAFF presently being tested by USFWS at Barkley Lock, KY (an operating lock with high boat traffic) with very favorable results

~71% effective to date (easily enough to work very well in LD5; Zielinski & Sorensen 2020))

3. Embankments

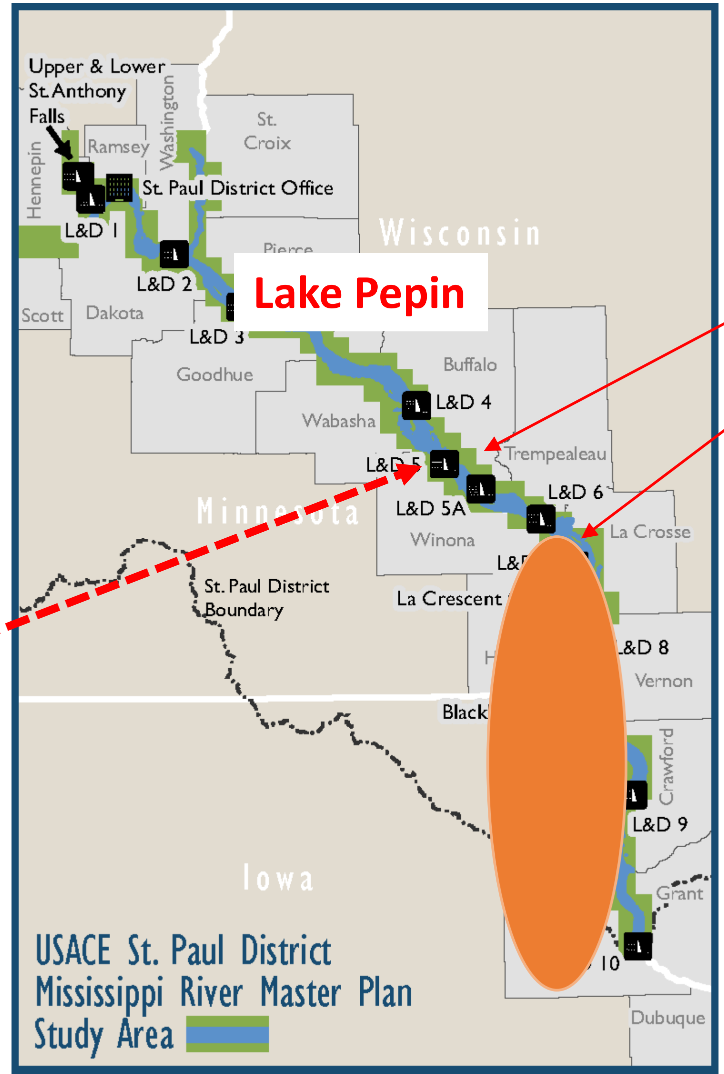
- Locks and Dams have embankments, some of which have overflows and culverts that can bypass carp, but some do not!
- <u>It is critical to select a LD for carp control that does not have such bypasses</u>



So, is there a Lock and Dam(s) in southern MN that would work well for carp control? (i.e. spillway gates rarely open, can accommodate BAFF, no overflows)

(Six LDs between the "invasion front" at Pool 5A and Lake Pepin)

LD5



Silver carp now being seen (2022)

51 adult invasive carp caught in 2019

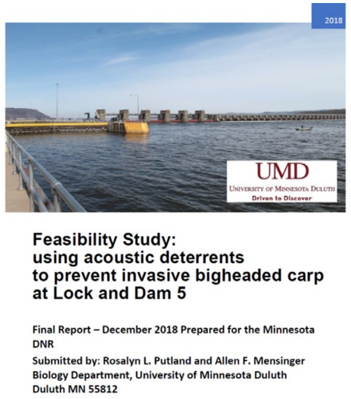
Adult invasive carp relatively abundant

YES! By all criteria, LD5 is just such a place (if we act now)

LD	% Time Spillway Gates passable	Lock can house BAFF	Lacks overflow spillways	Upstream Pool (miles)**
4	7.8%	Y	Y	43.9
5	**2.5%**	**Y**	**Y***	**14.9**
5A	18.5%	Y	N	9.6
6	12.7%	Y	N	14.4
7	8.0%	Y	N	11.6
8	8.8%	Y	N	23.3

*4 4-ft culverts in 18,000 ft embankment at LD5 must be blocked using electrified culverts

** Short pools can be fished and also prevent successful carp reproduction


2018

UMD
University of Minnesota Duluth
Driven to Discover

Feasibility Study:
using acoustic deterrents
to prevent invasive bigheaded carp
at Lock and Dam 5

Final Report – December 2018 Prepared for the Minnesota DNR
Submitted by: Rosalyn L. Putland and Allen F. Mensinger
Biology Department, University of Minnesota Duluth
Duluth MN 55812

A helpful supplementary technique: Carp Removal in Pool 5 (above LD5 and below LD4): integrated management

Two options:

1. Contracted Commercial fishing

2. Modified Unified Method (MUM)
   - $1-2 million/year in IL
   - Summed efficiency might be between 5-50% depending on site
   - MN DNR already testing at Pool 8 with mixed results

Exactly how good is LD5 for Integrated Carp Control?

Presently, It is excellent!
Numeric simulation shows that if these 4 strategies were pursued, **LD5 will stop 99+% of all carp**. *(This number is so high that any carp that might still pass will die of old age before reproducing)*.

Ex. 3 of 108 options considered:

1. 66% efficient Deterrent at LD5, no gate modification, no removal: ~**98.8 ±0.05 % blocked**
2. 66% efficient Deterrent at LD5, gates modified, 0% removal: ~**98.9 ± 0.03% blocked**
3. 66% efficient BAFF at LD5, gates modified, 10% removal: ~**99.6 ± 0.03% blocked**

Zielinski & Sorensen 2021

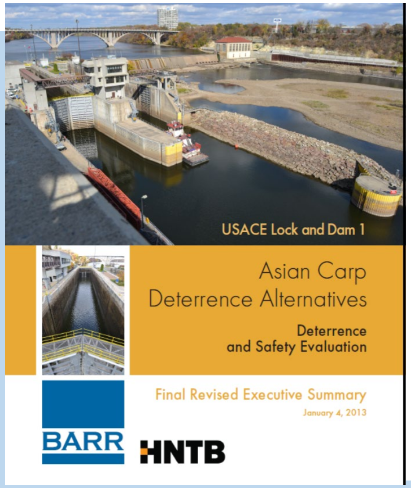
(50% exceedance)

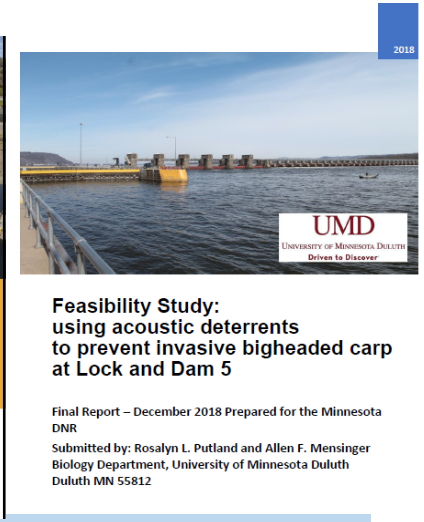
2022: UMN asked Barr Engineering Co.: **Could this plan (including a carp deterrent) be deployed at LD5, and in time to stop the carp?**

"An Engineering Assessment of the Feasibility and Estimated Cost of Installing a State-of-the-art BAFF Carp Deterrent at Mississippi Lock and Dam 5"

9 Tasks addressed in the contract and resulting report:

1. Review and Update 2013 and 2018 assessments.
2. Confirm that LD5 location is best
3. Confirm that a BAFF is best
4. Confirm that an effective deterrent system be installed at LD5?
5. Could a nature fish way be installed at LD5 to help native fish?
6. Could the state get permits for this deterrent?
7. Can questions (culverts, sound) expressed by earlier study (Putland &Mensinger 2018) addressable?
8. How much would it cost?
9. Can a BAFF be installed in time?


USACE Lock and Dam 1
Asian Carp Deterrence Alternatives
Deterrence and Safety Evaluation
Final Revised Executive Summary
January 4, 2013
BARR
HNTB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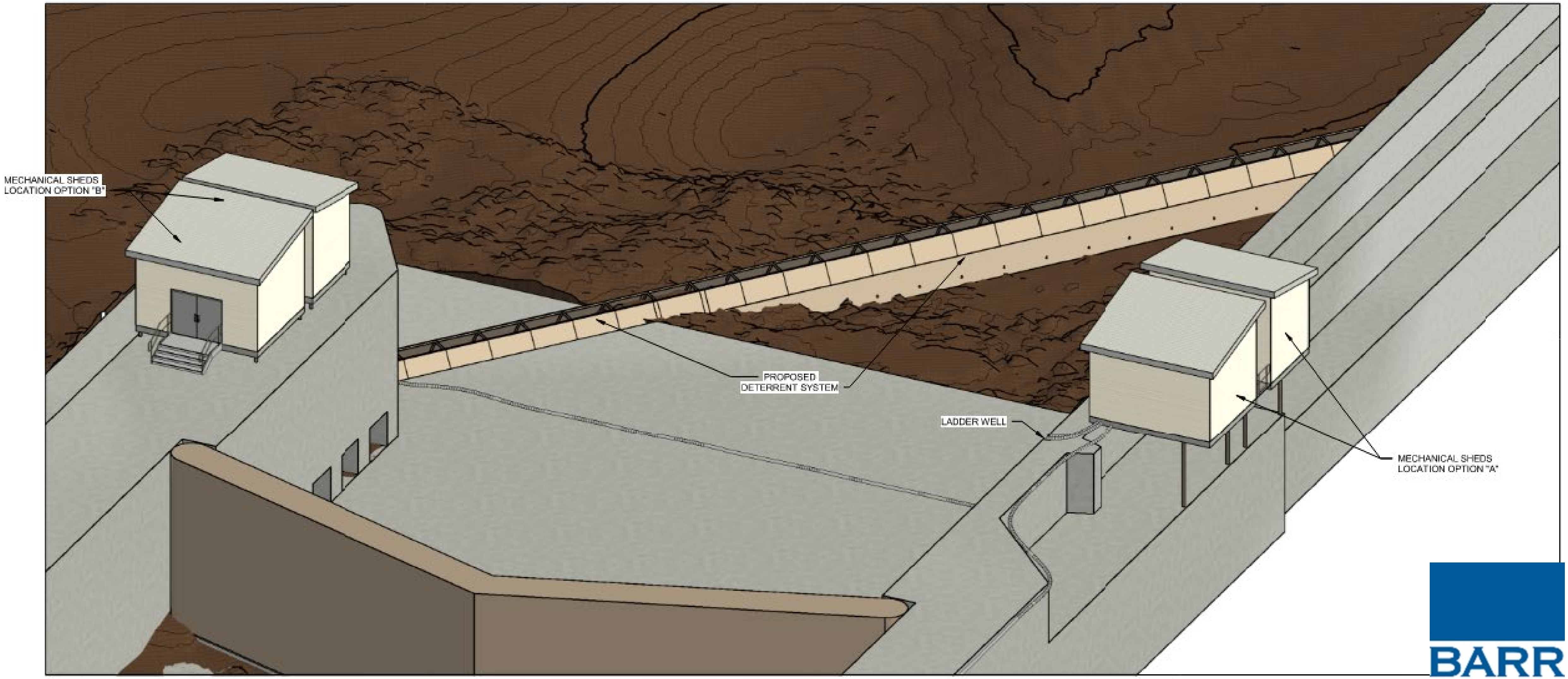
Barr Engineering Co. study confirmed that UMN plan is reasonable and feasible at LD5 – but time is of the essence!

1. Spillway gates only open 2% of the time
2. A Bioacoustic Fish fence (BAFF) deterrent is best and LD5's lock will accommodate it
3. Sound levels where BAFF would be situated do not pose a problem
4. No overtopping fixed crest spillways/submersible dams at LD5. (Only 4 small upstream culverts and they will stop all carp if managed correctly and electrified)
5. Carp can be effectively removed from Pool 5 (with L&D 4 as a redundant upstream deterrent)
6. All flaws identified by Putland & Mensinger (2018) report easily addressable.
7. A fish pass for native fish can be added to LD5

Barr found that a BAFF deterrent could be added at LD5, while creating a 10% design layout



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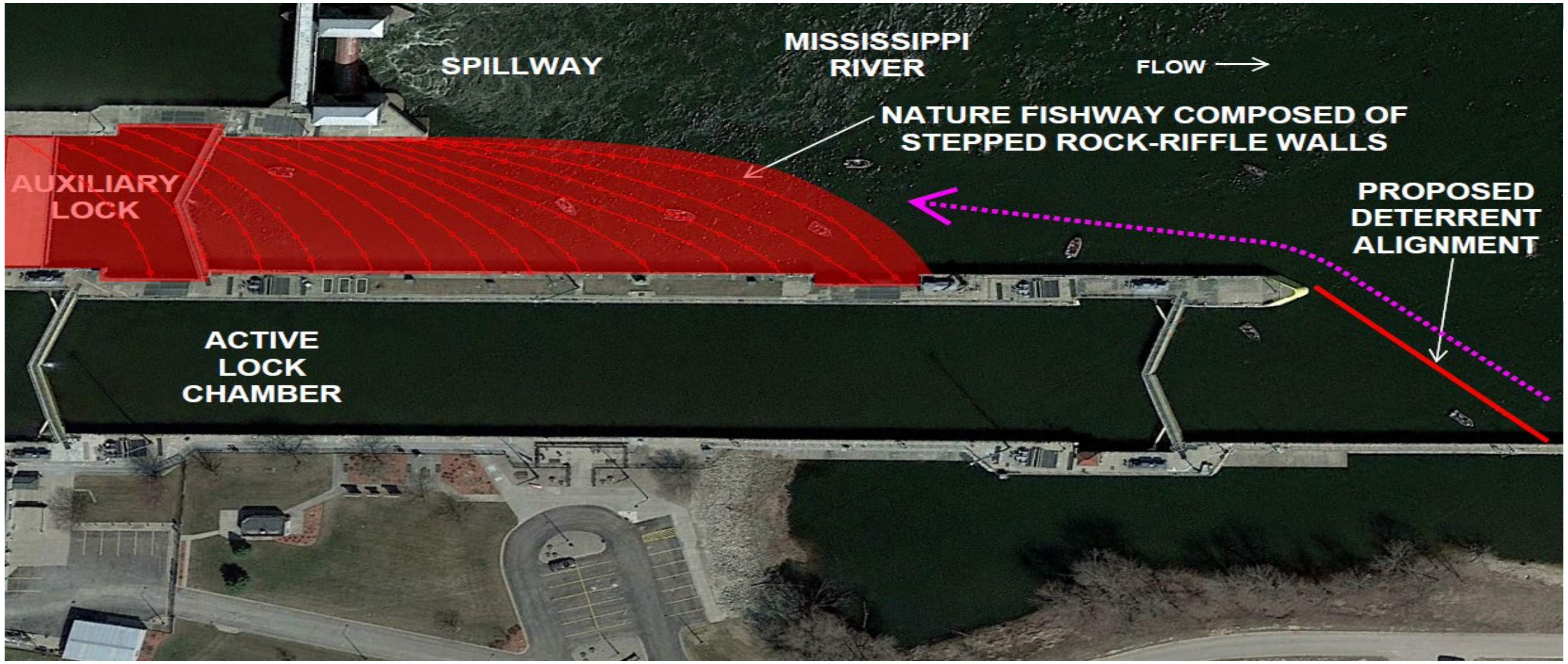
Additionally, to help native fish: a nature-like fishway can be installed



Fishway with sorting chamber for natives in auxiliary lock

Barr found that permits for a BAFF can be obtained relatively quickly

Agency	Authorization	Estimated Agency Review Timeframe
USACE	Clean Water Act (CWA) Section 404 and Rivers and Harbors Act Section 10 authorization	3 months to 1 year
USACE	Section 408 of the Rivers and Harbors Act of 1899 authorization	4 months to 1 year
USFWS	USACE consultation under Section 7 of the Endangered Species Act	Concurrent with USACE review
SHPO	USACE consultation under Section 106 of the National Historic Preservation Act	Concurrent with USACE review
MPCA	CWA 401 Water Quality Certification (WQC)	Not applicable for Nationwide or Regional General Permits 1 year for an individual WQC for a Standard Permit
MPCA	Dredge Materials Management SDS Permit	6 months to 1 year
DNR	Public Waters Work Permit	3 to 6 months
DNR	NHIS Review and Takings Permit for Threatened/Endangered Species	2 months

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Barr's study shows BAFF cost will be between $8-16 million

(accuracy still being improved)

	Item	Estimate of Probable Construction Cost	Notes
1	Engineering	$468,000	8% of items 2-8 (excluding BAFF furnished cost); includes engineering, survey, geotech investigation, and construction observation
2	Mobilization and Demobilization	$800,000	Includes mobilization of contractor, dive crew, barges and crane
3	BAFF Components & Initial Installation	$7,242,000	BAFF enclosure and foundation, wiring to BAFF system, compressed air lines
4	Compressor Shed	$290,000	Pre-engineered building, compressor, HVAC, finishes
5	Electrical Shed	$141,000	Pre-engineered building, electrical panels, HVAC, finishes
6	Utilities and Power	$235,000	Transformer, generator, propane, electrical service
7	Contractor Overhead	$871,000	10% of items 2-6
8	Contingency	$1,741,000	20% of items 2-6
	Total:	$11,788,000	
	Lower Range (-30%)	**$8,252,000**	
	Upper Range (+40%)	**$16,503,000**	

Notes:
1) **Cost estimate based on AACE (17R-97, Class 4, -30%/+40%)**
2) **Costs are based on conceptual 10% level of design**
3) **Budgetary quotes were supplied for the FGS BAFF system, compressor and shed enclosure**
4) **All numbers rounded to nearest thousand**

BARR

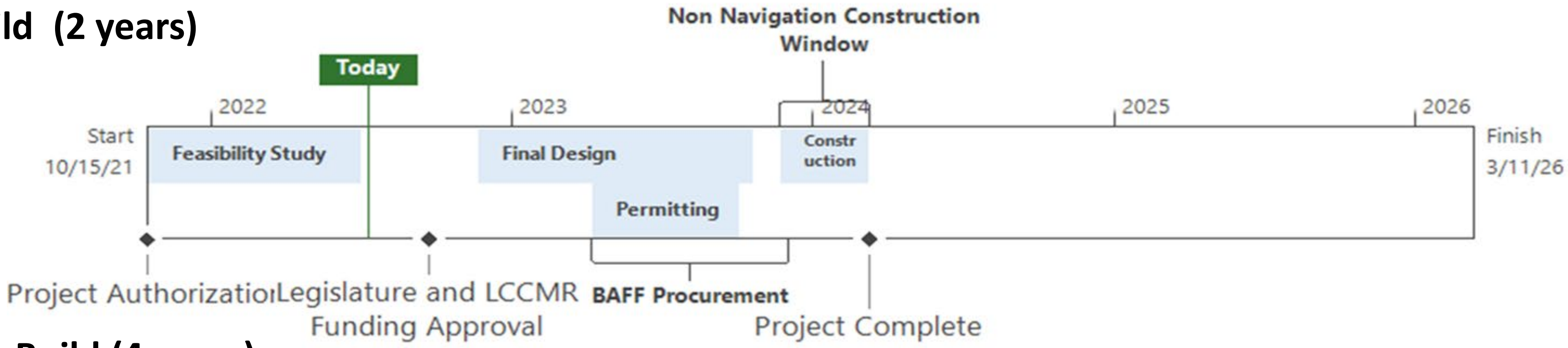
BUT time is of the essence:

Barr’s study shows it will take 2-5 years to install a BAFF

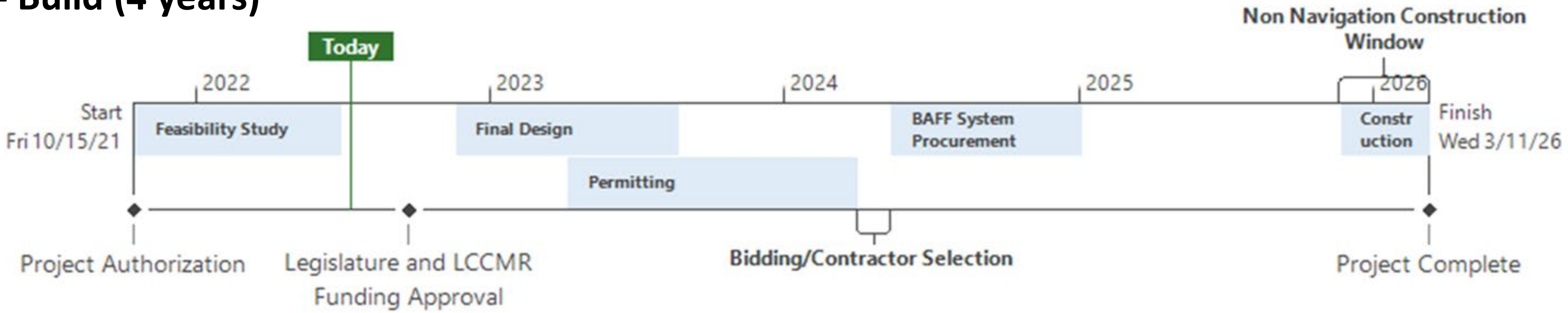
-5 years is just enough time based on carp passage rates and experience at LD19

-The legislature and MN DNR must make a decision in 2023 to be sure of success

Design- Build (2 years)



Bid-Design- Build (4 years)



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Summary

- Invasive carp are now in MN and could reproduce anytime – its **now or never**.
- Using a **combination of 4** available techniques at LD5 we could **stop over 99% of Bigheaded Carp** passage right now, sparing Lake Pepin, and the St Croix and Upper Mississippi Rivers – and the common carp catastrophe!
- **No single technique, many options—but a BAFF lock deterrent is key.**
- Carp control can be achieved with **little effect on native game fishes** in the river, in fact it **may even allow improvement if a fishway is installed.**
- **A decision needed ASAP to start in 2023**

- **Recommended Next Step:**
  - Get the BAFF and DNR funding into 2023 biannual budget, complete 60% design, then build and run while monitoring and adapting.

Over a dozen published peer-reviewed studies (5 Million$) support this solution for carp in Minnesota as well as 3 engineering assessments:

- Dennis, C. E., Zielinski, D., & Sorensen, P. W. (2019). A complex sound coupled with an air curtain blocks invasive carp passage without habituation in a laboratory flume. *Biological Invasions*, *21*(9), 2837-2855.
- Eichmiller, J. J., Miller, L. M., & Sorensen, P. W. (2016). Optimizing techniques to capture and extract environmental DNA for detection and quantification of fish. *Molecular ecology resources*, *16*(1), 56-68.
- Feely, J. R. (2020). *The ability of a cyclic sound on its own, and when coupled with an air curtain, to block ten species of fish including carp in a laboratory flume* (Doctoral dissertation, University of Minnesota).
- Finger, J. S., Riesgraf, A. T., Zielinski, D. P., & Sorensen, P. W. (2020). Monitoring upstream fish passage through a Mississippi River lock and dam reveals species differences in lock chamber usage and supports a fish passage model which describes velocity-dependent passage through spillway gates. *River Research and Applications*, *36*(1), 36-46.
- Ghosal, R., Coulter, A. A., & Sorensen, P. W. (2022). Proof-of-Concept Studies Demonstrate That Food and Pheromone Stimuli Can Be Used to Attract Invasive Carp So Their Presence Can Be Readily Measured Using Environmental DNA. *Fishes*, *7*(4), 176.
- Gilmanov, A., Zielinski, D., Voller, V., & Sorensen, P. (2019). The effect of modifying a CFD-AB approach on fish passage through a model hydraulic dam. *Water*, *11*(9), 1776.
- Hoover, J. J., Zielinski, D. P., & Sorensen, P. W. (2017). Swimming performance of adult bighead carp Hypophthalmichthys nobilis (Richardson, 1845) and silver carp H. molitrix (Valenciennes, 1844). *Journal of Applied Ichthyology*, *33*(1), 54-62.
- Riesgraf, A., Finger, J., Zielinski, D., Dennis III, C., Whitty, J., & Sorensen, P. (2022). Evaluation of a broadband sound projected from the gates of a navigation lock in the Mississippi River shows it to be a weak deterrent for common carp and unable to block passage.
- Whitty, J. M., Riesgraf, A. T., Zielinski, D. P., & Sorensen, P. W. (2022). Movements of a model fish, the common carp, through a generic Mississippi River lock and dam demonstrate how fish swimming performance, behavior, and discharge-driven flow-fields determine fish passage rates in ways that can be predicted and modified using fish passage models. *River Research and Applications*, *38*(4), 670-683.
- Zielinski, D. P., & Sorensen, P. W. (2016). Bubble curtain deflection screen diverts the movement of both Asian and common carp. *North American Journal of Fisheries Management*, *36*(2), 267-276.
- Zielinski, D. P., & Sorensen, P. W. (2017). Silver, bighead, and common carp orient to acoustic particle motion when avoiding a complex sound. *PLoS One*, *12*(6), e0180110.
- Zielinski, D. P., Voller, V. R., Svendsen, J. C., Hondzo, M., Mensinger, A. F., & Sorensen, P. (2014). Laboratory experiments demonstrate that bubble curtains can effectively inhibit movement of common carp. *Ecological engineering*, *67*, 95-103.
- Zielinski, D. P., Voller, V. R., & Sorensen, P. W. (2018). A physiologically inspired agent-based approach to model upstream passage of invasive fish at a lock-and-dam. *Ecological Modelling*, *382*, 18-32.

- Barr Engineering Co. 2022. Preliminary Engineering Assessment of the Feasibility and Estimated Cost of Installing a State-of-the-Art BAFF Carp Deterrent at Mississippi Lock and Dam 5. DRAFT
- Barr Engineering C0. 2013. Asian carp deterrence alternatives.
- Pultand RL, Mensinger AF 2018. Feasibility study: using acoustic deterrents to prevent bigheaded carp at Lock and Dam 5

Thank You!

QUESTIONS?