LEWIS & CLARK LAKE SEDIMENT MANAGEMENT PLAN STUDY SECTION 22

Welcome and Introductions

Jennifer Gitt
Greg Johnson

19 May 2023

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PROJECT BACKGROUND

The study is being conducted in three phases with a 50:50 federal and sponsor cost share.

Phase 1: Scoping Effort
- Collaborate to develop the study objectives, constraints, and study scope for Phases 2 and 3
- Output: Project Management Plan with Phase 2 Tasks, Schedule, and Budget, and Phase 3 Framework.
- Budget: Federal Contribution $12,000; Sponsor (MSAC & Partners) Contribution $7,000 cash and Work-in-kind (WIK) $3,680

Phase 2:
- Focus on leveraging existing sediment management studies coupled with the application of economic models to consider the costs and benefits associated with sediment management.
- Developed trend analysis for future impacts
- Hosted Solutions Workshop in June 2021
- Budget: Fed. $107,834; Sponsor $84,434 cash and WIK $24,720

Phase 3:
- Expand the technical analysis to consider emerging technologies
- Integrate the economic and environmental benefits and impacts
- Develop a Sediment Management Plan for Lewis and Clark Lake
- Budget to be developed with scope

PREDICTION OF FUTURE CONDITIONS

- The USACE team used historical sedimentation rates and aerial imagery to develop estimates on the progression of the visible delta face on the Missouri and Niobrara River.

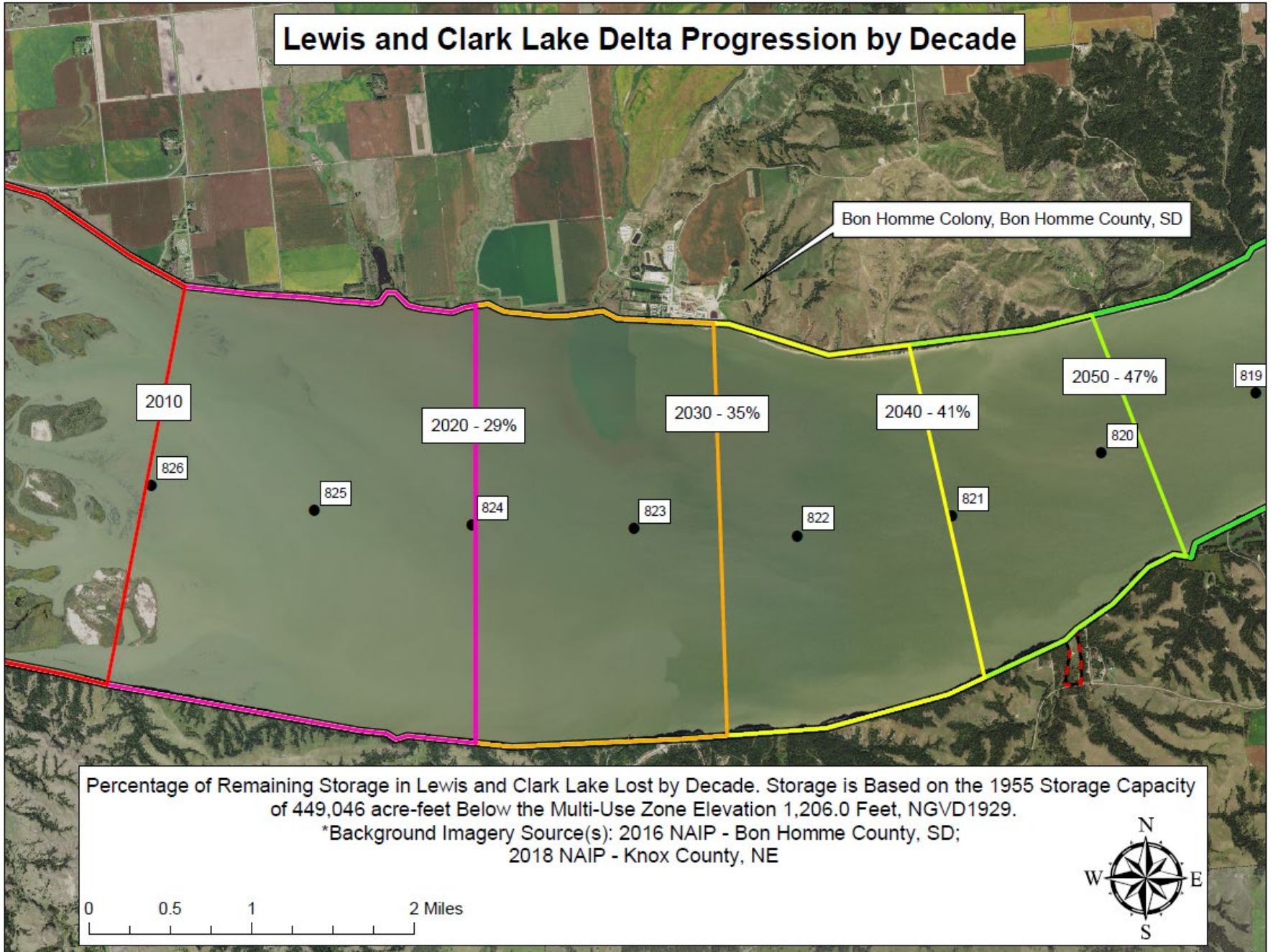
- NOTE: These estimates are not done with a numerical model, but with basic calculations of volume change and annual measured distance of delta progression.

- Based on these estimates, continued loss of benefits will be chronic until approximately 70 years into the future, when hydropower may start to be significantly impacted by sedimentation. (relevant to Economic Analysis).

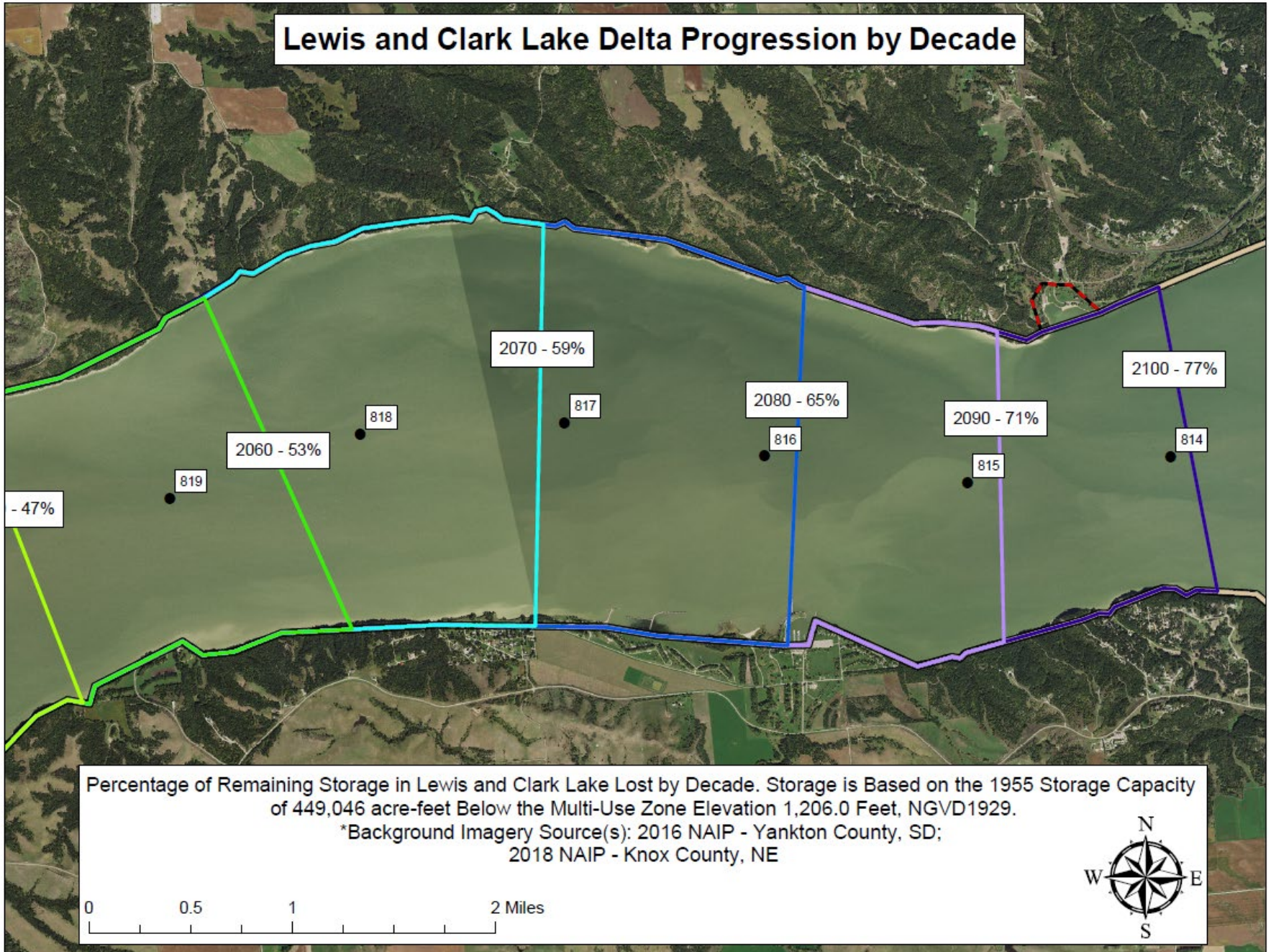
- The Multipurpose and Carryover pool will be full, with sediment being transported through the spillway gates in approximately 120-150 years (at current rates)

- The Flood Control pool is not often filled, and deposition is minimal. Even when the multipurpose pool is 'full', much of the Flood Control pool will remain.

MISSOURI RIVER DELTA AT LEWIS AND CLARK LAKE



MISSOURI RIVER DELTA AT LEWIS AND CLARK LAKE



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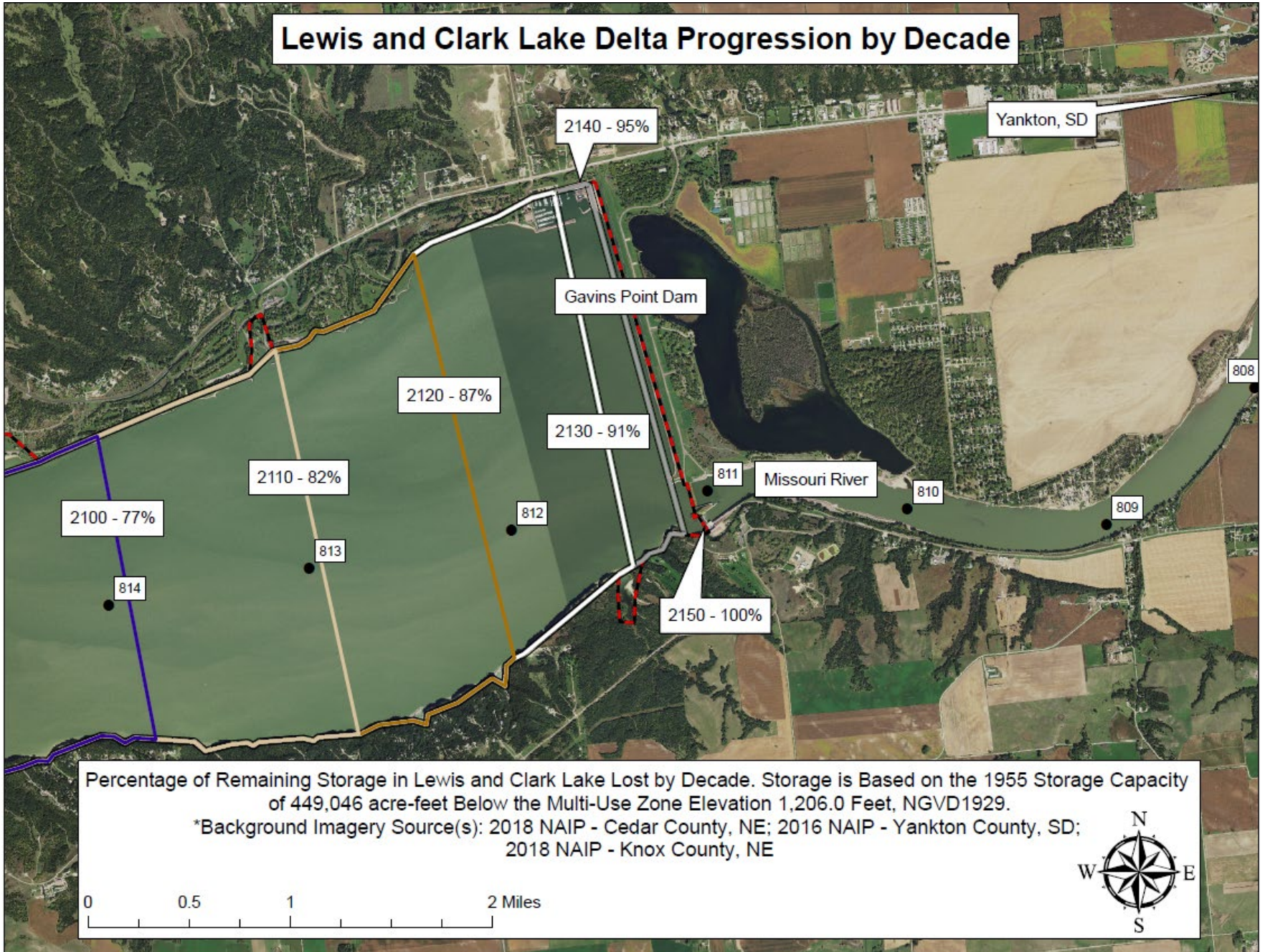
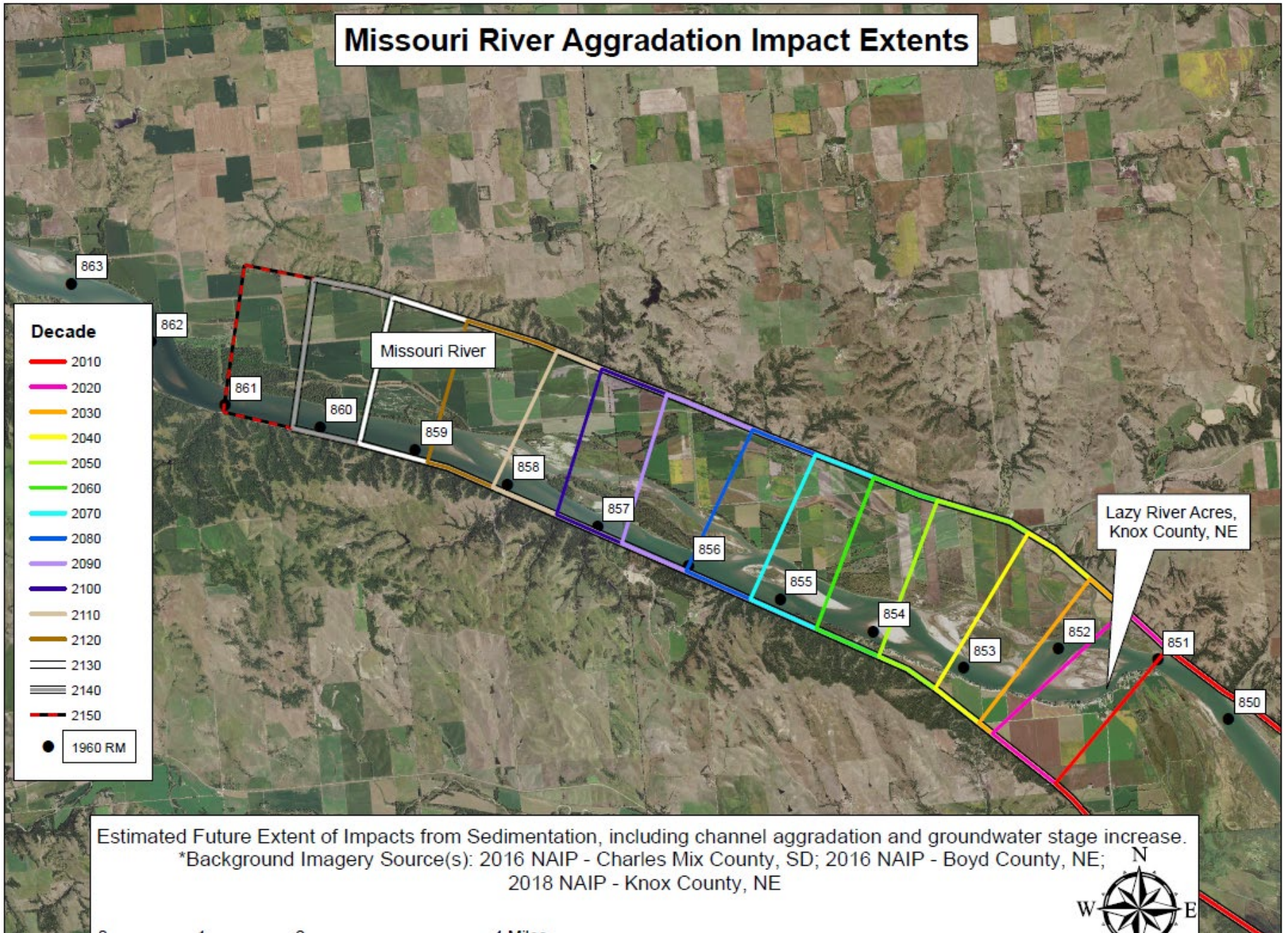
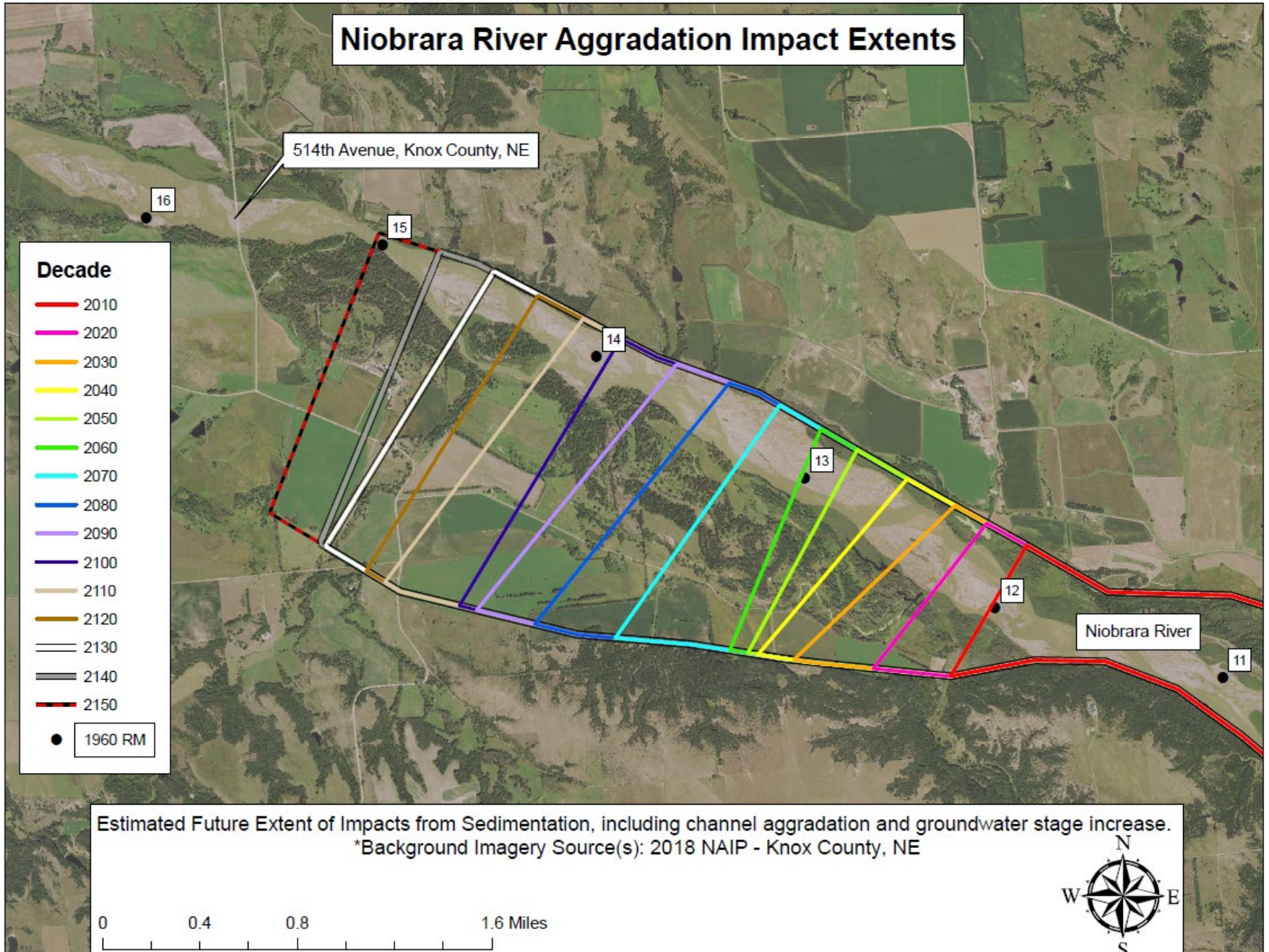


MISSOURI RIVER DELTA ABOVE THE NIOBRARA RIVER



NIOBRARA RIVER DELTA



LEWIS & CLARK LAKE SEDIMENT MANAGEMENT PLAN STUDY SECTION 22

Reservoir Sediment Management Alternatives (workshop and more)

Paul Boyd

19 May 2023

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JUNE 2021 RESERVOIR MANAGEMENT WORKSHOP

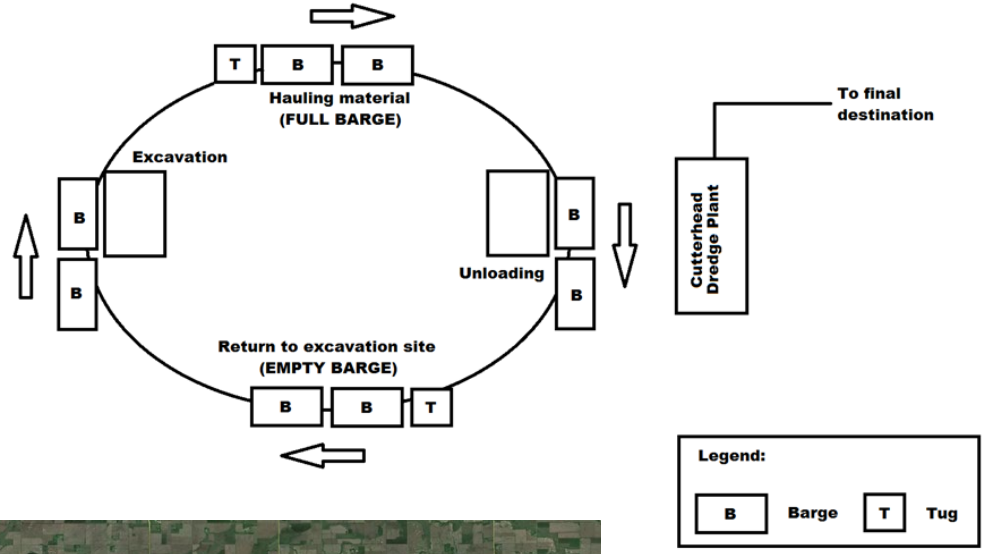
- Dr. Greg Morris
- Dr. John Shelley
- Ms. Meg Jonas
- Mr. Tim Welp
- Provided input on possible reservoir management actions

WORKSHOP OUTCOME - CONVENTIONAL DREDGING

USACE Developed Plan – Updated in 2021 to move sediment from the delta for downstream delivery

Multiple Options include:

– Mechanical Excavation and barges



– Single Dredge with Boosters

– Staged Dredges

WORKSHOP OUTCOME - RESERVOIR SLUICING WITH AUGMENTATION

Sluicing is the process of lowering the reservoir pool to a run-of-river condition to allow scour of deposited sediments and transport downstream

- Works best in short reservoirs with steep slopes (which is not Lewis and Clark)
- Works best with low level outlets (which is not Lewis and Clark)
- Works best with fine sediments (which is only partially Lewis and Clark)

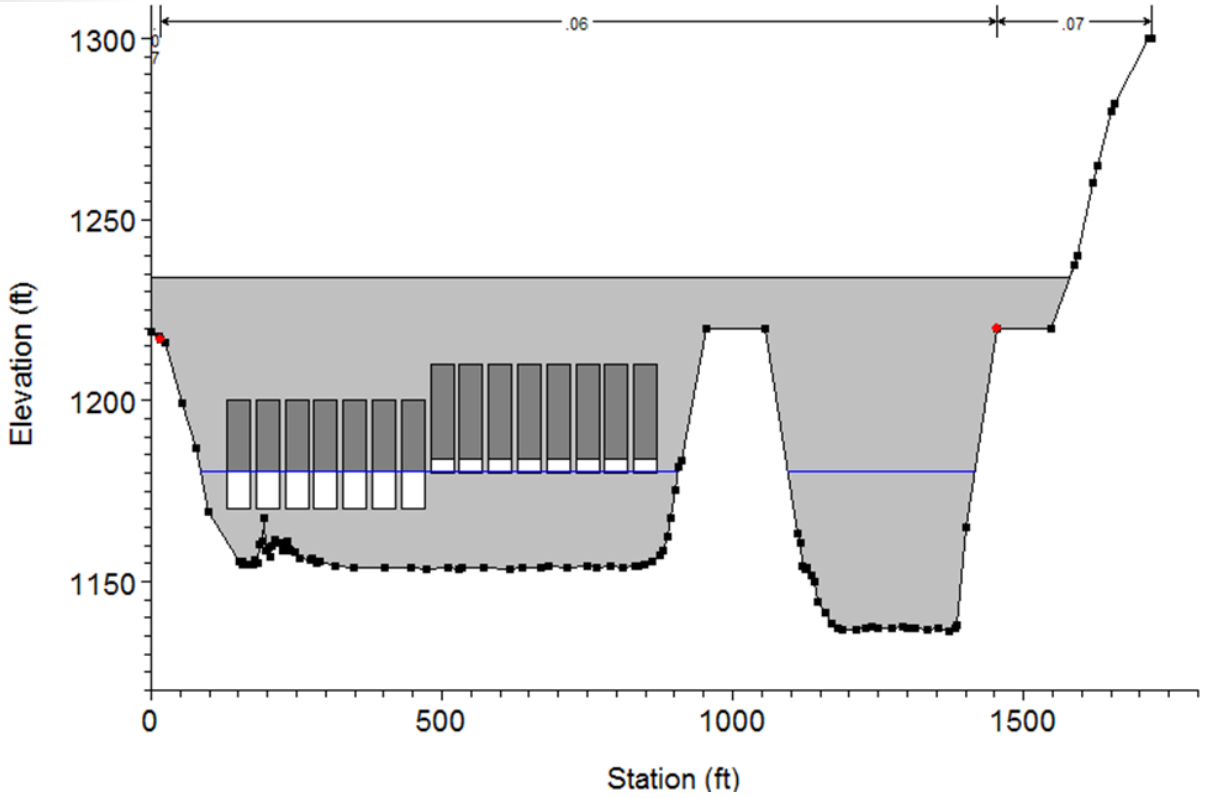
But.....

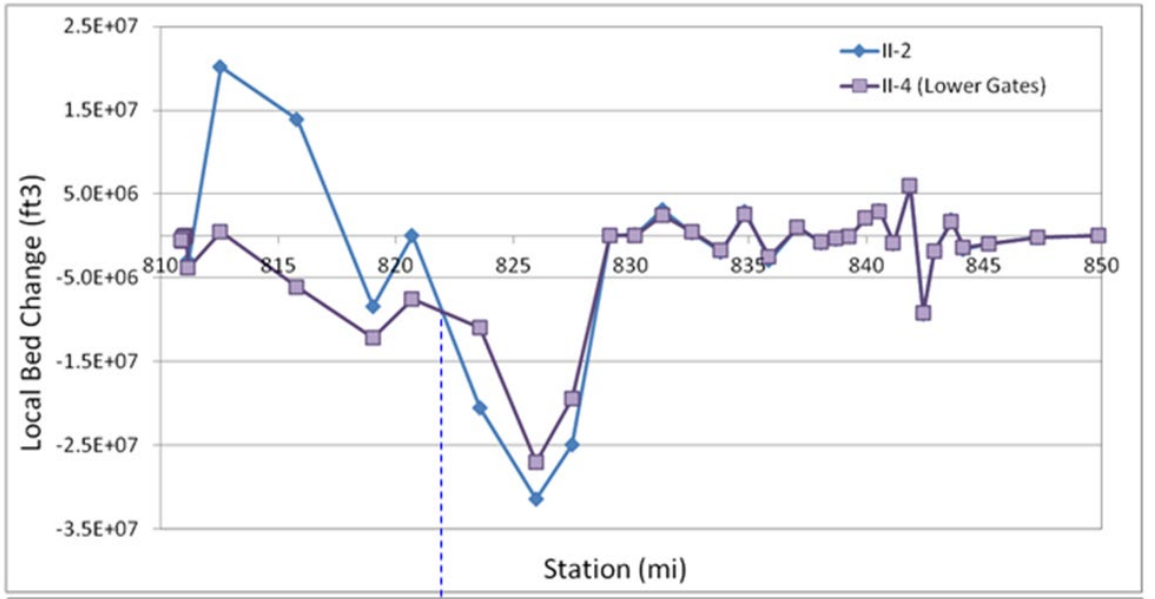
- Combined with Augmentation, which could be dredging, channelization, mechanical addition of sediment, or physical modification of the dam gates, it may provide the most nearly financially viable management action.

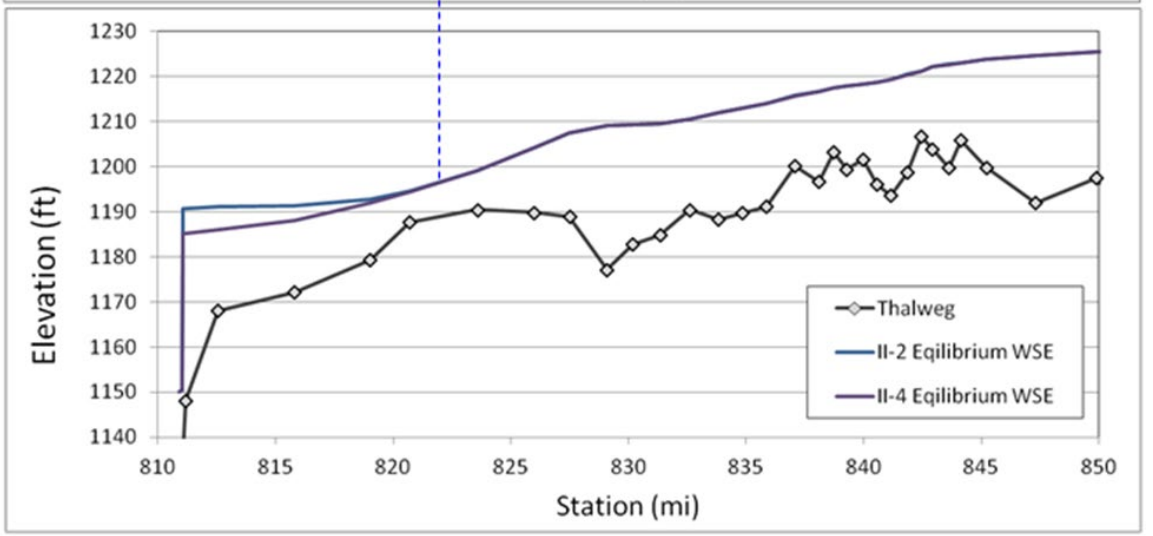
- USACE is updating a numerical flushing model first developed in 2015 with new 2022 reservoir geometry. The efficiency of a sluice action will increase as the delta moves closer to the outlet.

Scenario	Flushing Flow	Flushing Duration	Other
II-1	None	None	No Action – 53 year projection to determine delta progression through 2064
II-2	60,000 cfs	7 days	Base alternative – single drawdown flushing event
II-3	60,000 cfs	7 days	Scenario II-2 with 2064 geometry
II-4	60,000 cfs	7 days	Seven spillway gate inverts lowered to 1,170 ft
II-5	30,000 cfs	7 days	Half magnitude version of II-2
II-6a	60,000 cfs	7 days	Low Elevation Tunnels (invert 1,157 ft)
II-6b	30,000 cfs	7 days	Low Elevation Tunnels (invert 1,157 ft)
II-7a	180,000 cfs	~8 days	Repeat of Scenario I-1 from Phase I
II-7b	88,000 cfs	~10 days	Repeat of Scenario I-2 from Phase I
II-8	30,000 cfs	7 day repeating	Annual flushing event through 2064
II-9	30,000 cfs	7 day repeating	Annual flushing event with longitudinal revetment through 2064
II-10	30,000 cfs	7 days	Annual flushing event with dredging 675 tons per day during flush through 2064

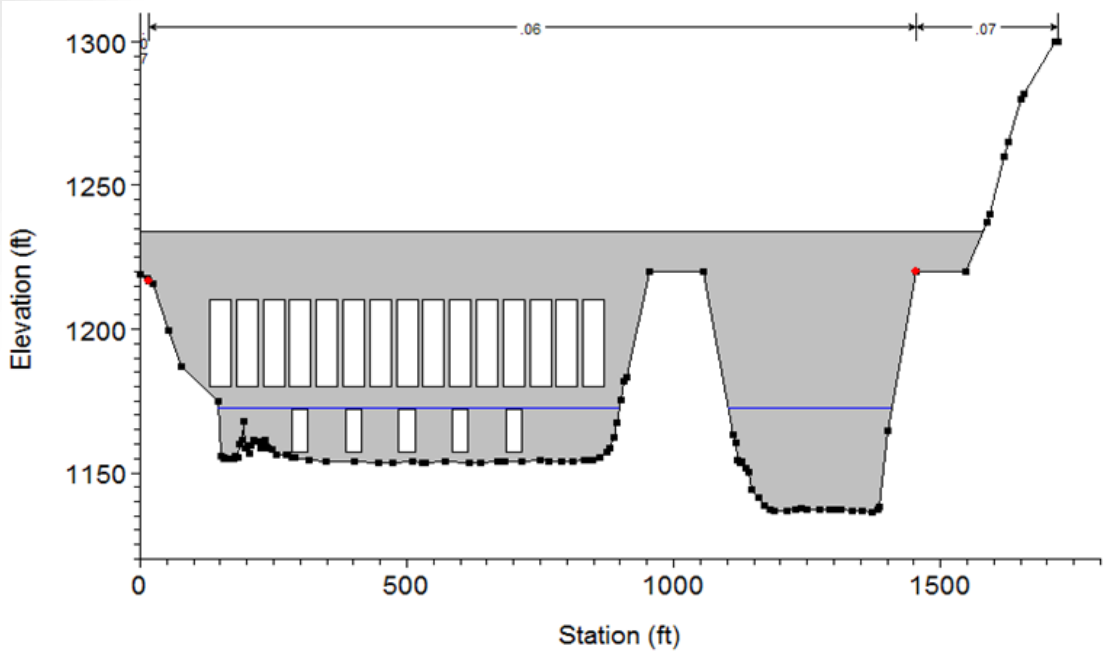
GAVINS POINT DAM GATE MODIFICATION (LOWER GATES BY 10FT)

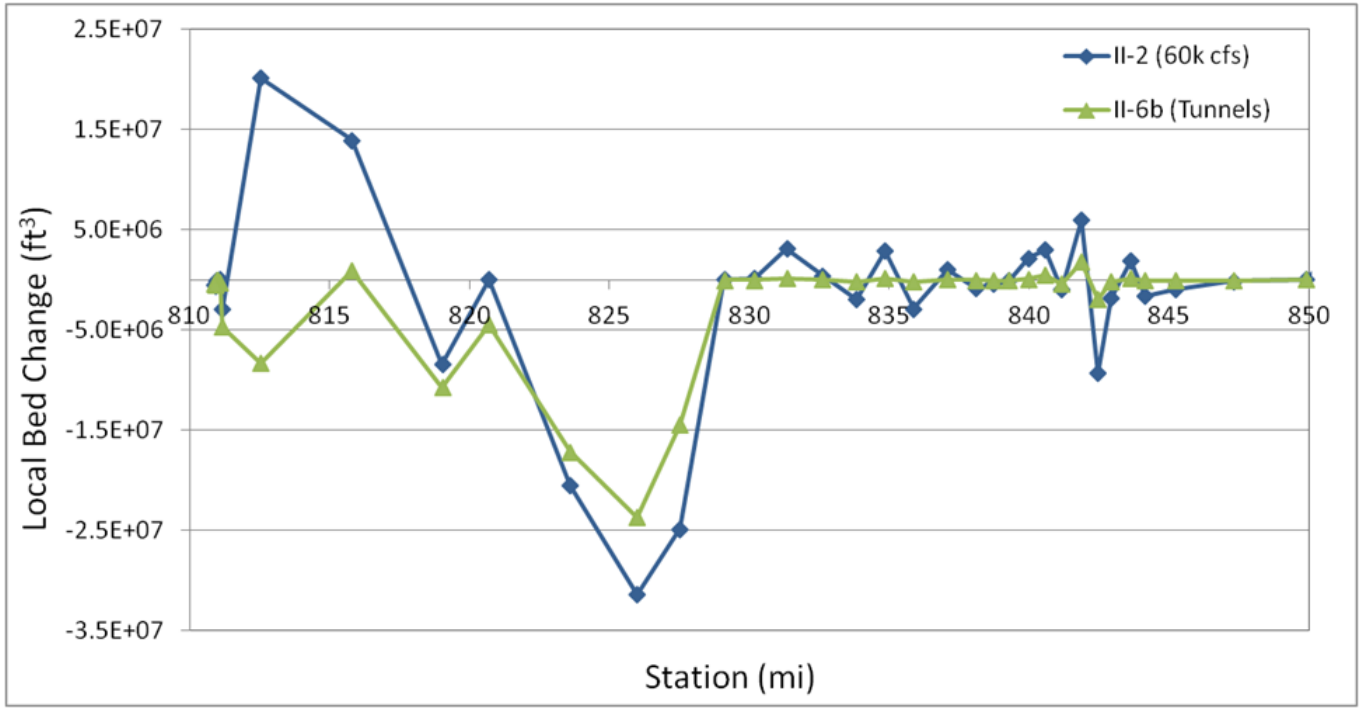




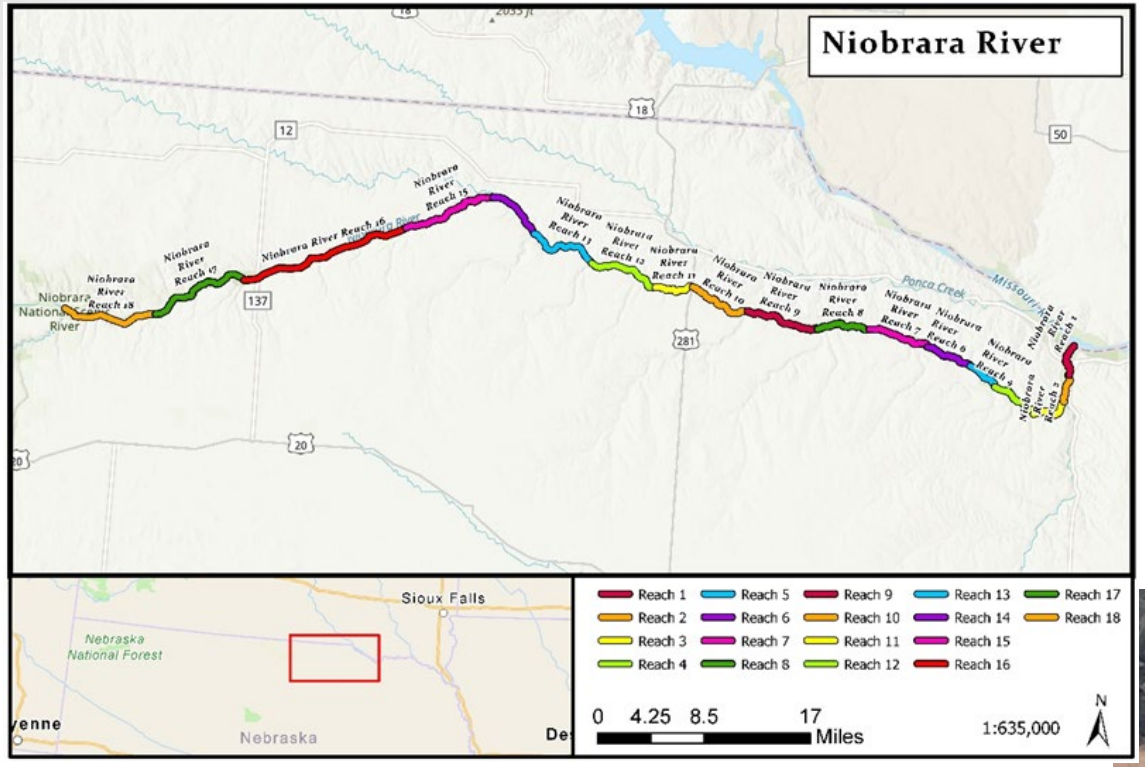


GAVINS POINT DAM MODIFICATION (SLUICING TUNNELS)



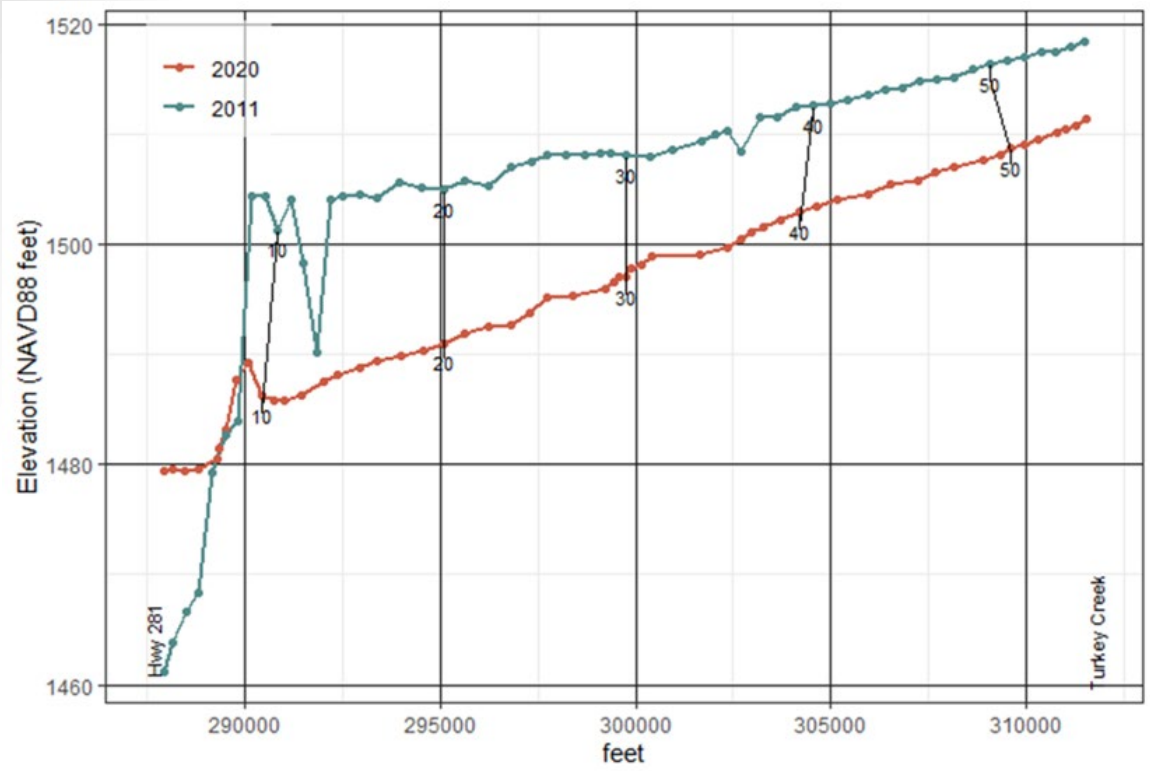


WORKSHOP OUTCOME - NIOBRARA RIVER WATERSHED TREATMENT

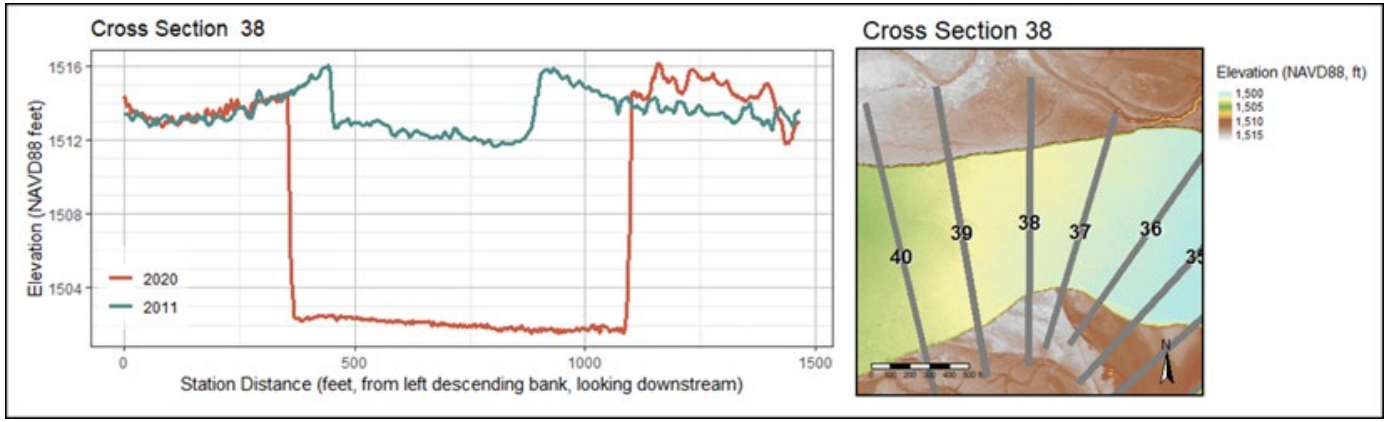


- Initial assessment done as part of a Water Operations Technical Support (WOTS) request
- Many reaches of the Niobrara are actively supplying large amounts of sediment
- Expanded assessment needed to determine what level of sediment reduction could be achieved

CONTRIBUTION FROM SPENCER DAM FAILURE

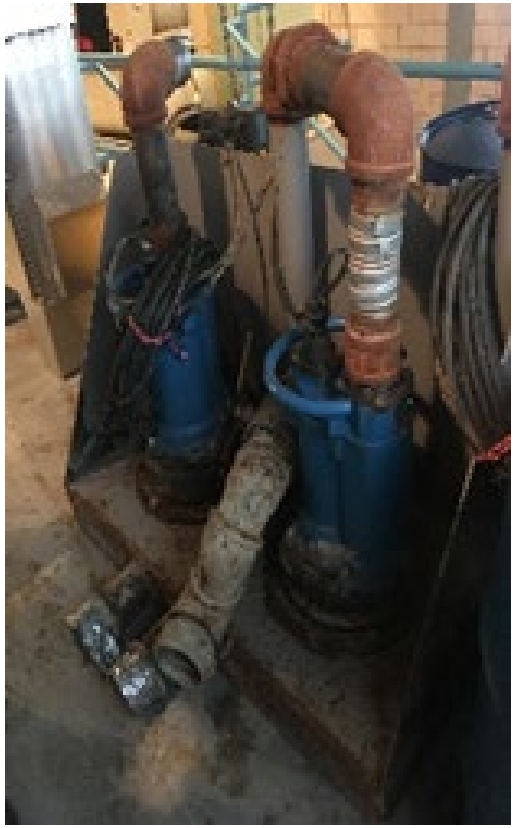


- Initial assessment done as part of a Water Operations Technical Support (WOTS) request
- Volume of sediment above the annual load has not been quantified

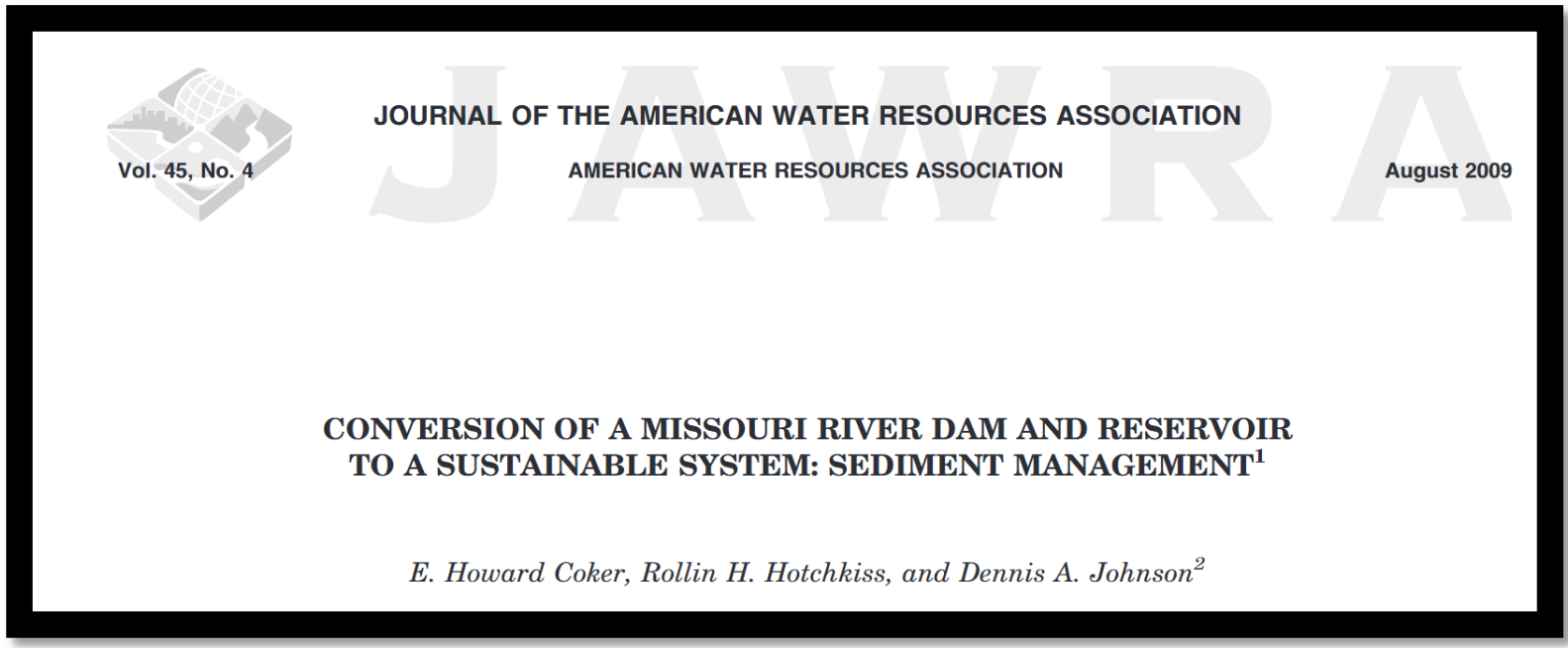


NIOBRARA RIVER SEDIMENT COLLECTION

- The Niobrara River produces over 50% of the supply to the Missouri River and Delta
- A significant reduction in delivery from the Niobrara could have a positive impact on reservoir life



THE COKER PLAN



JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

Vol. 45, No. 4 AMERICAN WATER RESOURCES ASSOCIATION August 2009

CONVERSION OF A MISSOURI RIVER DAM AND RESERVOIR TO A SUSTAINABLE SYSTEM: SEDIMENT MANAGEMENT[1]

E. Howard Coker, Rollin H. Hotchkiss, and Dennis A. Johnson[2]

The proposed project involves four phases:
(1) moving and storing deltaic sand upon the present upstream delta at a rate that will lower the riverbed,
(2) maintaining the reduced bed elevation by adding to the stored sand,
(3) topping the relocated sand with dredged silts and clay while beginning the transport of sand downstream past the dam, and
(4) moving all future sediments past the dam.

Sand and Silt Loaders would be an R&D effort – considerably more detail is need to assess the viability and economics of the plan

GUARDIANS OF THE RESERVOIR PRIZE COMPETITION

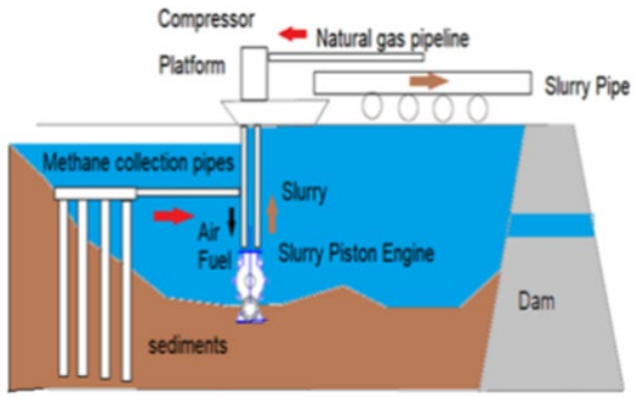
Sponsored by the US Bureau of Reclamation
From 2020-2022, 50+ submitted ideas were judged and progressed through three award phases

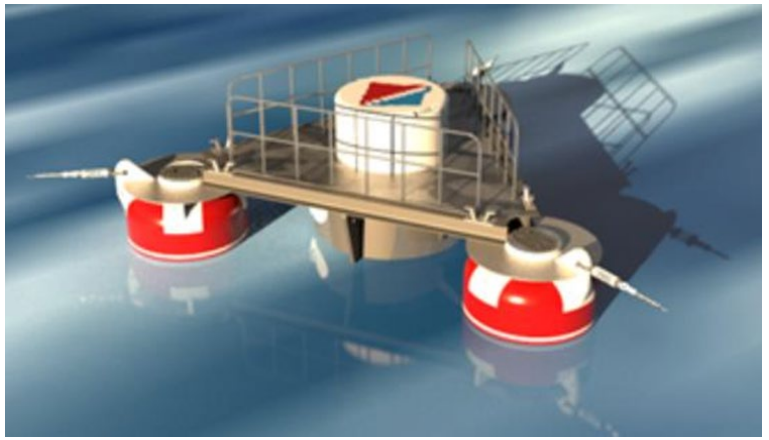
Finalists:

– Mazdak International – Sediment Compression Piston Pump

– 3D Dredger – partially autonomous dredging system with multiple collection tools

– D-Sediment – autonomous vacuum dredge system





COLORADO SCHOOL OF MINES CAPSTONE PROJECT

- Suggested by USACE-Omaha

- CSM Team: *Wyatt Evans, Irene Truitt,*
- *Zachary Kriethe, Jonathan Cattan*

- Initial 'conceptual' analysis of what an active project would entail on Lewis and Clark Lake using GoR finalists' technology

- Designed to manage 1M CY per year (not full sustainability – 25% of annual)

- Team proposed a single D-Sediment remote autonomous dredge and transport of sediment downstream to Missouri River

COLORADO SCHOOL OF MINES CAPSTONE PROJECT

Economic analysis done by CSM team

- NOT USACE standard or reviewed,
- BUT long-term estimate of $5+ per cubic yard may justify further analysis in Phase 3

Table 2: Ten -Year Pilot Lifespan Cost Estimations at 4% inflation and 30% Contingency (Preliminary Solution #1)

Year	Cumulative Cubic Yards Removed	O&M Cost	Capital Cost	Cumulative Cost per Cubic Yard of Sediment Removed
1	1 MM	$1,480,000	$21,060,000	$22.54
2	2 MM	$1,540,000	-	$12.04
3	3 MM	$1,600,000	-	$8.56
4	4 MM	$8,010,000	-	$8.42
5	5 MM	$1,730,000	-	$7.08
6	6 MM	$1,800,000	-	$6.20
7	7 MM	$1,870,000	-	$5.58
8	8 MM	$9,380,000	-	$6.06
9	9 MM	$2,020,000	-	$5.61
10	10 MM	$2,100,000	-	$5.26
Cumulative Cost $52,590,000 at $5.26 per Cubic Yard of Sediment				

Gavin's Point Dam Delta Spillway Approach Project

F22-25. Wyatt Evans, Irene Truitt, Jonathan Cattan, Zachary Kriethe
Client: USACE, Christine Cieslik, Paul Boyd. **PA:** Laura Crisman.

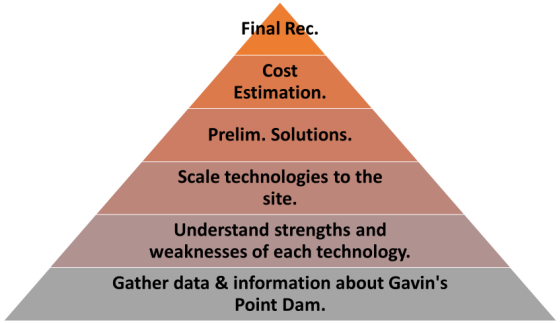
MINES | Capstone Design

Problem Statement

- Lewis & Clark Lake upstream of Gavin's Point Dam (NE) is currently facing a sedimentation crisis
- Since completion in 1957, the Lake has lost >25% of storage due to sedimentation from the Niobrara River
- At current rates, Lewis & Clark Lake will fill with sediment in less than 150 years

Project Direction & Progression

- Federally funded Guardians of the Reservoir Sedimentation Removal Challenge announced 3 new dredging technology winners in September 2022
- Winners included D-Sediment, Prometheus Innovations & Mazdak International



Technology Analysis Requirements

- Target Removal = 1 million cy/year
- Target Price <$10.00 per cy removed over lifespan of project
- Mitigate environmental impacts
- Mitigate Noise/Recreational Disturbances
- Increase lifespan of Lewis & Clark Lake

D-Sediment SediMovers

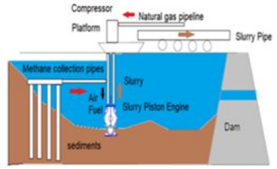
- Operational Depth: 2 ft – 4 ft
- Optimal Location: Delta Mouth (15.5 miles upstream of Gavin's Point Dam)
- Autonomous Dredging System
- 3 units needed (340,000 cy/year per unit)
- Multiple in-field pilot tests completed

Prometheus Innovations 3D-Dredger

- Operational Depth: 20 ft – 40 ft
- Optimal Location: Deepest Portions of Lewis & Clark Lake (5 miles from Gavin's Point Dam)
- Autonomous Dredging System
- 1 unit needed with suction head (1million cy/year per unit)
- Multiple lab tests completed; pilot tests in progress

Mazdak's Submersible Slurry Pump Dredger

- Operational Depth: Deepest Portions of Lewis & Clark Lake
- Preliminary lab tests and computer simulations have been performed



Concept of Mazdak Pump Dredger Unit

Reservoir Flushing

- Currently nonviable due to lake geometry in certain regions
- Recognized as the optimal long-term solution for de-sedimentation
- Continual studies and modeling are being completed by USACE and partners to determine flow rate and cy of sediment removed

Preliminary Solutions

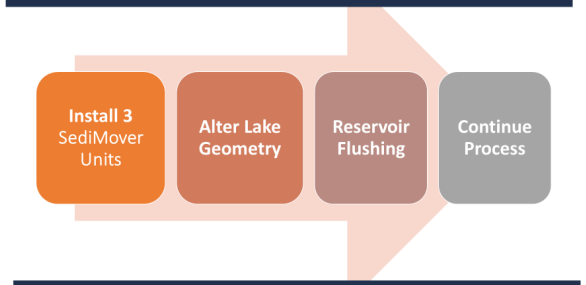
1. SediMovers & 3D-Dredger
   1. Three SediMover Units deployed at delta mouth
   2. Three booster pumps will move sediment 10 miles downstream
   3. One 3D-Dredger unit with suction head deployed at the deepest section of the lake
   4. One additional booster pump will move sediment 5 miles downstream
   5. Apply reservoir flushing when feasible
2. SediMovers Only
   1. Three SediMover Units deployed at delta mouth
   2. Four booster pumps will move sediment 15 miles downstream
   3. One unit will be placed downstream IF NEEDED
   4. Apply reservoir flushing when feasible

Rough Order of Magnitude Cost Estimations

1	Initial Capital: $24 million	Yearly O&M: $3 million	Yearly O&M w/ Pipe Replacement: $9 million
2	Initial Capital: $21 million	Yearly O&M: $1.5 million	Yearly O&M w/ Pipe Replacement: $8 million

- Solution #2 will save $23.7MM over a 10-year lifespan

Final Recommendation



Next Steps

- Updated USACE reservoir flushing modeling
- Analyze points of interest for ideal lake geometry
- Secure funding for pilot program

ECONOMIC OPPORTUNITIES FOR SEDIMENT

Road Sand

Construction Aggregate

Recreation

Mining/Hydraulic Fracturing

Ash Grove Cement – exploring Circular Economy Concepts with Sediment

- Working with Omaha cement plant, considering sourcing of sediment from Minnesota
- Investigate if L&C sediment would be suitable
- Possible transport pilot project

LEWIS & CLARK LAKE SEDIMENT MANAGEMENT PLAN STUDY SECTION 22

Economics Presentation

Justin Brewer
Jeff Cavanaugh

19 May 2023

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HISTORIC COSTS

- Movement of Highway 12: $340,000,000
- Movement of the Town of Niobrara: $12,443,000
- Movement of Springfield's Water Intake Facility: $10,300,000

PERIOD OF ANALYSIS

- Traditional USACE Studies look at a 50-year period of analysis
- This study utilizes a 150-year period of analysis
- The 150-year period allows us to look at the “big picture” of Lewis and Clark Lake and the benefits it provides
- This is based on prior research (i.e., Annadale & Morris) that suggests looking at a longer period of analysis

FUTURE WITHOUT PROJECT (FWOP)

- This “baseline” condition is for finding out how much can be spent on sedimentation reduction products

- This assumes there is no action taken as Lewis and Clark Lake slowly fills in with sediment

- The Corps will have to decide the future of the hydropower facility by about year 2100. Power consumption, rehabilitation costs, and alternate power sources will affect any decision on continuing or decommissioning hydropower.

- The Lake will become 100% full of sediment by approximately year 2150

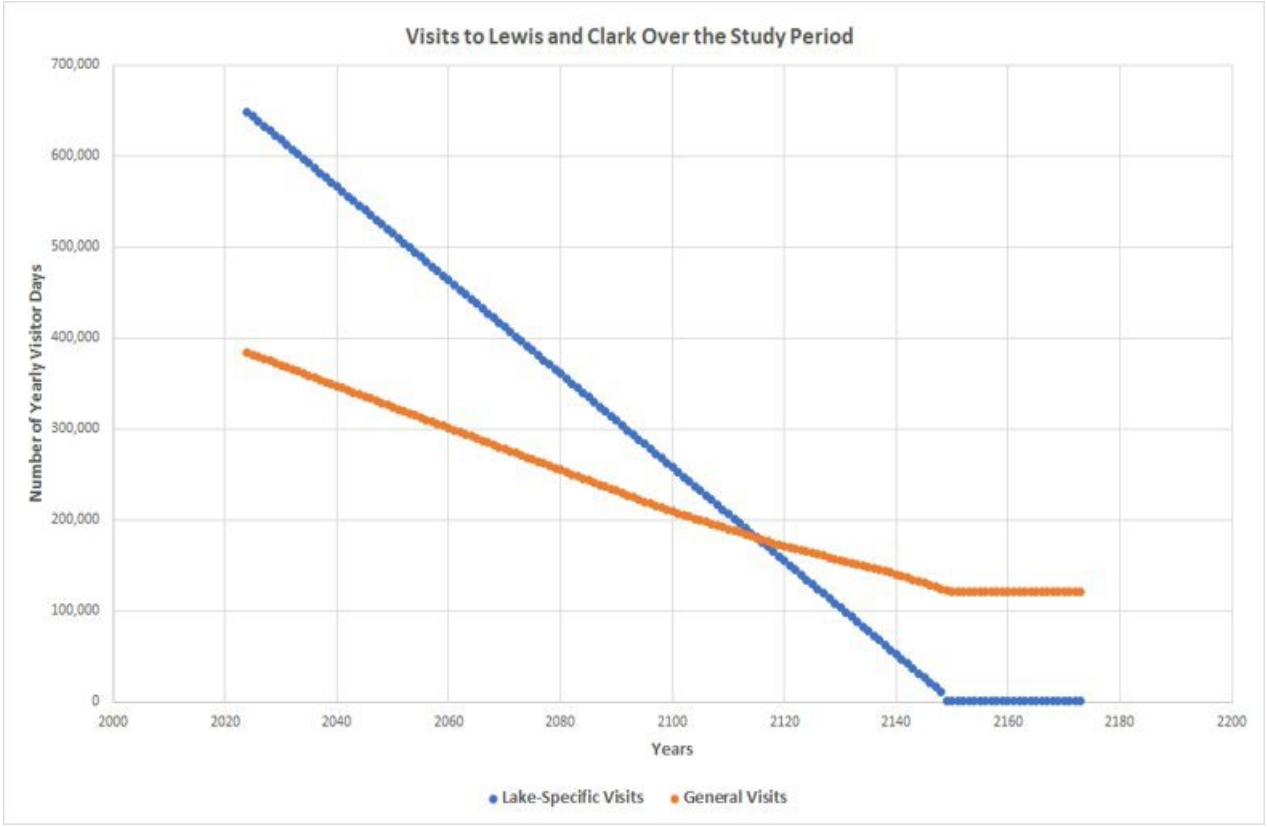
LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - RECREATION

- Two types of recreation: Water-specific and General
- Water-specific recreation will likely be more sensitive to sedimentation than General recreation
- When sediment increases fewer visitors will be attracted for both recreation categories

Table 17: Visits by General versus Water-Specific		
Water-Specific		
Activity	**Percent**	**Total Number of Visitors**
Boating	7.3%	75,415
Skiing	2.1%	21,695
Swimming	9.5%	98,142
Fishing	9.1%	94,010
Sightseeing	34.8%	359,511
Total	62.8%	648,774
General		
Activity	**Percent**	**Total Number of Visitors**
Camping	4.3%	44,422
Picnicking	3.0%	30,992
Hunting	0.9%	9,298
Sightseeing	11.6%	119,837
Other	17.4%	179,756
Total	37.2%	384,305

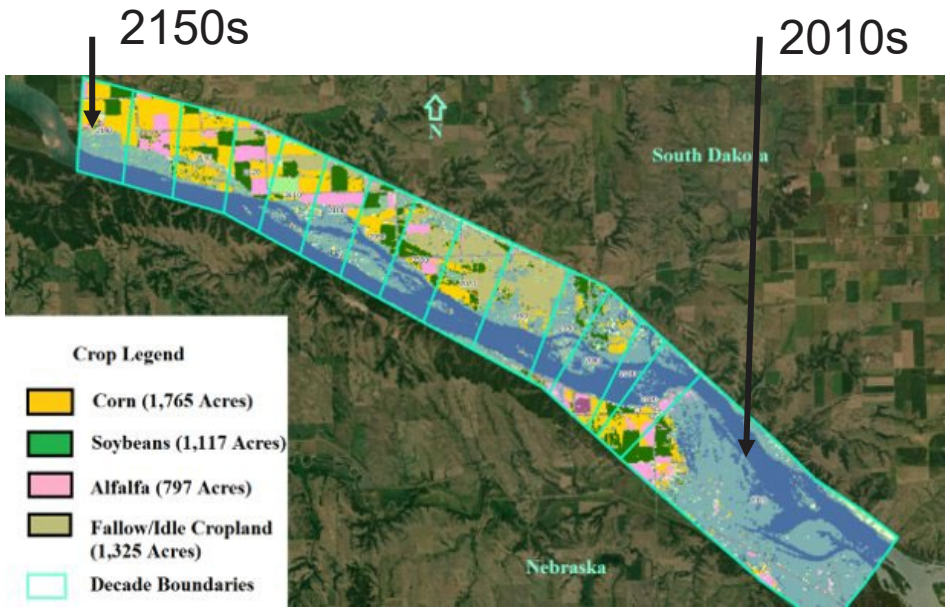
LOOKING AHEAD: 150 YEARS OF SEDIMENTATION – RECREATION (FWOP)

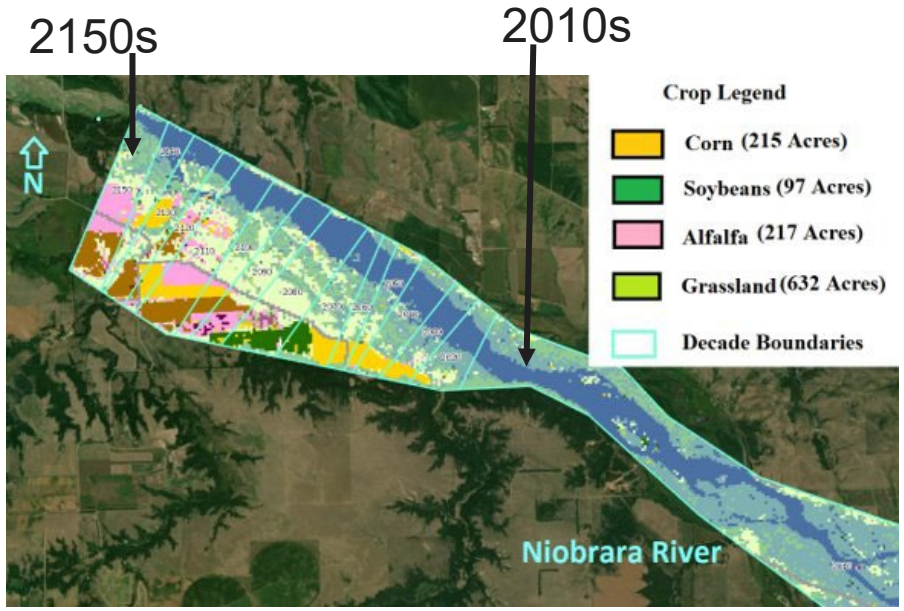
- In the future, without any action, visitations may decline as shown in the graph
- When the lake is 100% full, there will be no more water recreation
- The lake currently provides around $8,680,000 in recreation benefits a year
- After the lake is filled in, it will provide around $1,026,000 in recreation benefits a year



LOOKING AHEAD: 150 YEARS OF SEDIMENTATION – AGRICULTURAL BUYOUTS (FWOP)

- Without action, many acres upstream of the lake would need to be bought out
- This occurs because the fields become flooded and marshy
- Note these are future projections and do not represent any planned Federal action
- This data on crop usage comes from the USDA National Agricultural Statistics Service
- South Dakota's State Landowners Website provides information on price per acre
- This assumes each acre is valued at $3,814
- This results in 5,620 acres on the Missouri and 1,160 acres on the Niobrara for a total of $25,859,000 in lost benefits

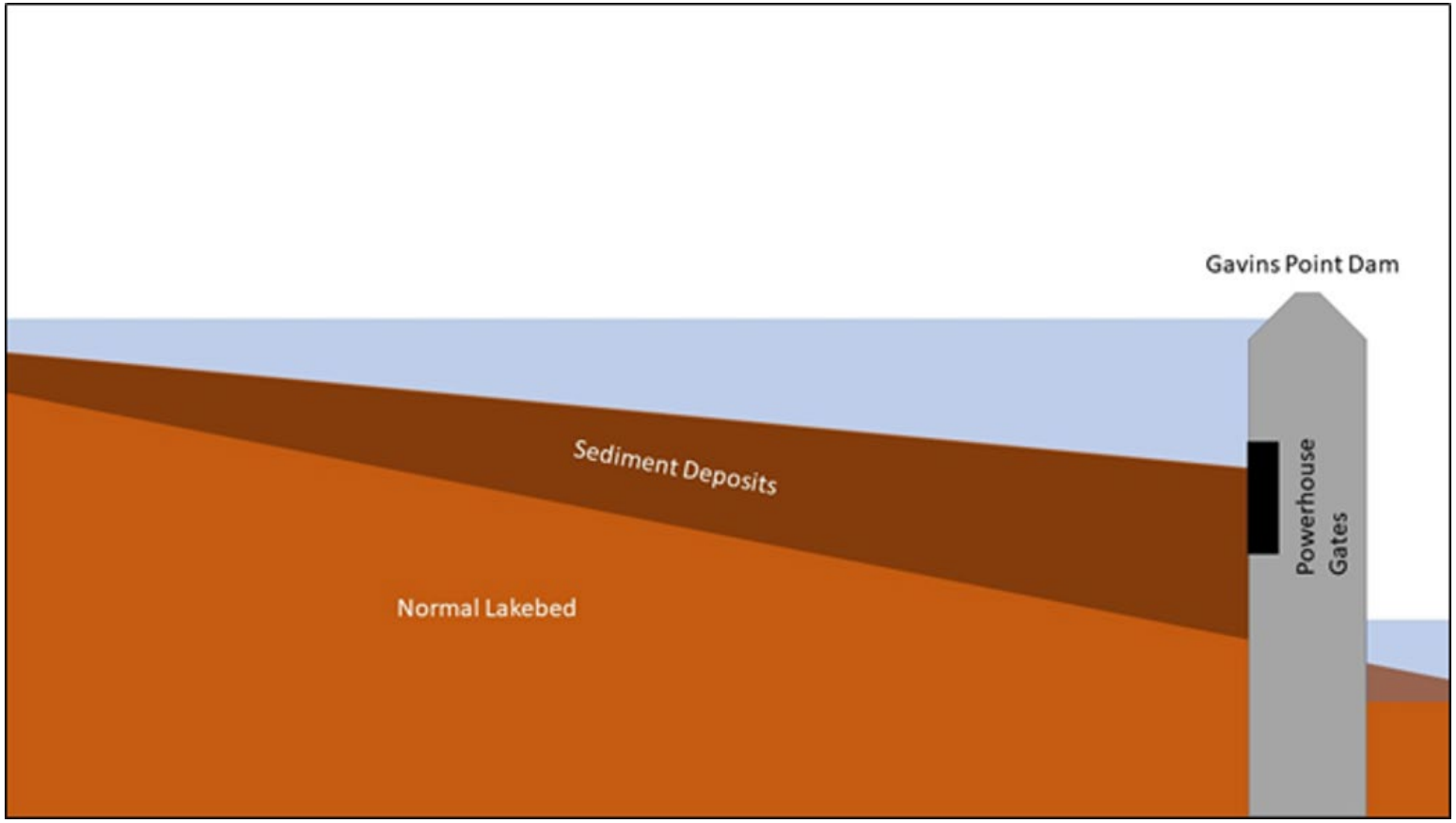




LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - STRUCTURAL BUYOUTS (FWOP)

- Structures that sit near the banks of the Missouri and Niobrara Rivers could potentially be bought out if sedimentation continues
- In the without action scenario, sediment will increase flood frequency to many structures
- There are approximately 484 structures on the Missouri and 8 on the Niobrara
- The combined structure value is $68,014,000

LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - HYDROPOWER



LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - HYDROPOWER

- If sedimentation continues under the no action condition, the powerhouse will not be able to generate power past the year 2090
- Sediment passing through the turbines would cause damage, and it could be replaced with alternate energy-generation choices
- This would result in an annual loss of $19,239,606 in energy to the national economy

LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - HYDROPOWER

- Under FWOP the powerhouse could no longer be safely operated
- The powerhouse would sit unused and potentially require decommissioning
- Based on the Columbia River Systems Operations EIS, separate powerhouse decommissioning would cost $40 million over two years

LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - PUBLIC WATER SUPPLY

- The four main water intakes included for NED analysis are two B-Y RWD intakes, and two Cedar-Knox County intakes
- B-Y provides water to South Dakota, Cedar-Knox provides water to Nebraska
- To keep these projects operating, they must be modified to either utilize a different water source or so they can reach further into the new channel under FWOP
- It will cost $411,672 to extend the B-Y water intakes.
- It would cost $237,915 to extend the Cedar-Knox County Intakes

LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - IRRIGATION

- While these permit owners could extend their intake pumps further out from the existing shore to accommodate the shrinking channel, they could also receive water from a well
- ER-1105-2-100 requires researching the least-cost alternative for other sources that meet the same needs as existing sources for water resources
- Under the FWOP condition, many nearby irrigators would need to dig wells
- Wells in this area are assumed to be 150' deep and $95 per foot: costing $14,250
- This will irrigate a 133 acres using a standard center-pivot system
- Based on the number of irrigated acres that draw from this area, the total cost would be $714,000, spent equally across each decade until the lake is full for the no action, as heavy sediment loads would limit intake power

LOOKING AHEAD: 150 YEARS OF SEDIMENTATION

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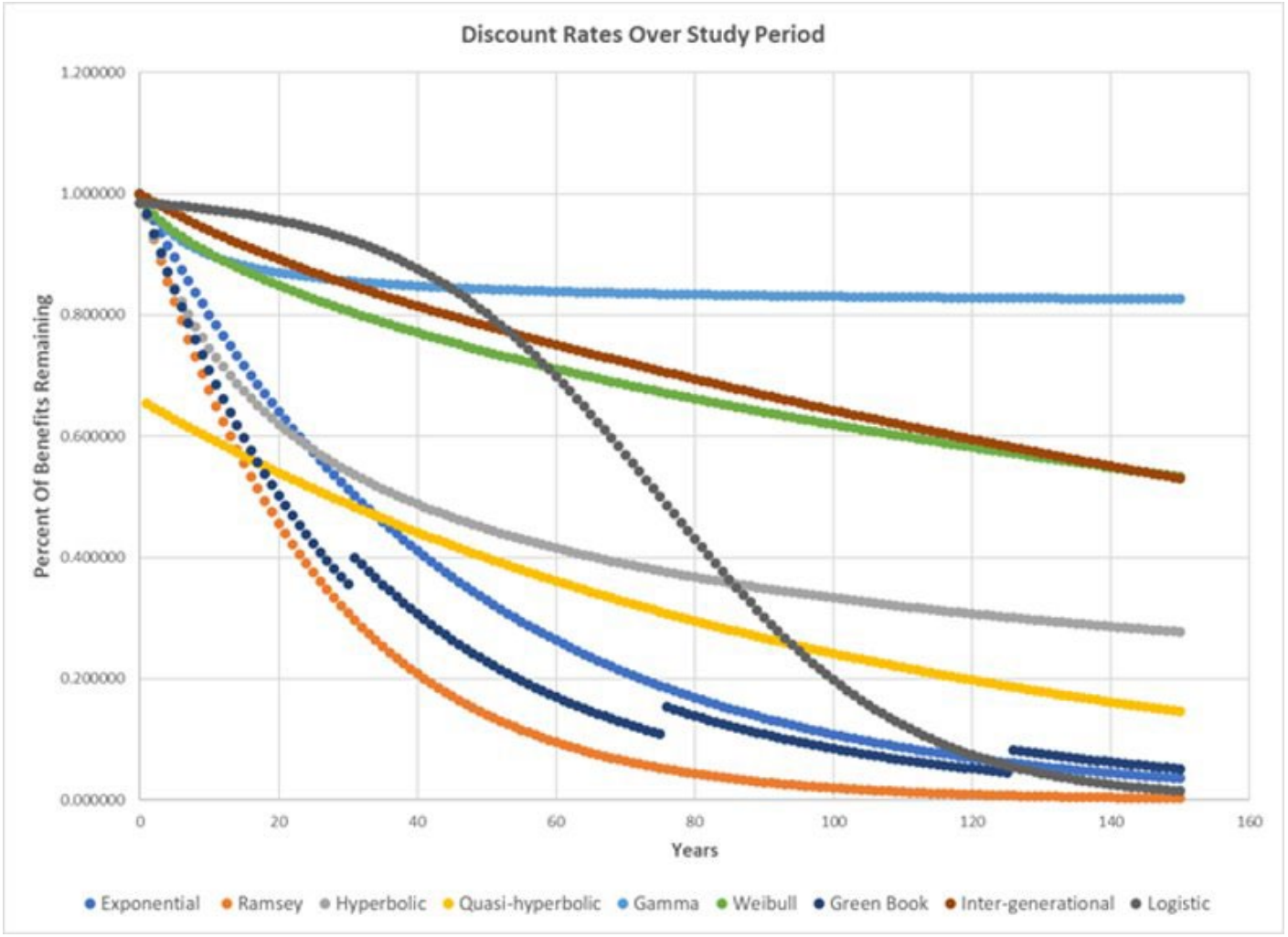
This study looks at 9 total discount rates:

Method	Equation
Exponential (Classic)	$D_n = \frac{1}{(1+r)^n}$
Ramsey	$D = \delta + \eta g$
Hyperbolic[1]	$D = \frac{1}{(1+r)^{\frac{\beta}{\alpha}}}$
Quasi-hyperbolic	$D = \beta(\delta^n)$
Gamma[2]	$D = \frac{1}{\beta^\alpha \tau(\alpha)} x^{\alpha-1}$
Weibull	$D = \left(\frac{1}{(1+r)}\right)^{\frac{1}{n^s}}$
Green Book[3]	*Changing formula based on t, where: rt_1=0,1,...30; rt_2=31,32,...75; rt_3=75,76,...125; rt_4=126,127,...150*
Intergenerational[4]	*Changing formula based on t, r, G, and delta of t*
Logistic	$D = \frac{1}{1+r^{-n}}$



Harpman, David A. *Discounting for Long-Lived Water Resource Investments.* Bureau of Reclamation Technical Memorandum Number S&T-2014-X3574 and Manuals and Standards Report M&S-2014-G4129. U.S. Department of the Interior, Bureau of Reclamation. Denver, Colorado. April 17, 2014. 55 pages.

LOOKING AHEAD: 150 YEARS OF SEDIMENTATION - TOTALS

METHOD	TOTAL	ANNUALIZED
Combined Damages (not present valued)	$2,081,286,173	$13,875,241
Exponential	$274,847,392	$1,832,316
Ramsey	$92,939,706	$619,598
Hyperbolic	$714,459,202	$4,763,061
Quasi-hyperbolic	$511,897,658	$3,412,651
Gamma	$1,733,030,083	$11,553,534
Weibull	$1,290,701,199	$8,604,675
Green Book	$225,916,080	$1,506,107
Inter-generational	$1,332,246,529	$8,881,644
Logistic	$516,846,087	$3,445,641

LEWIS & CLARK LAKE SEDIMENT MANAGEMENT PLAN STUDY SECTION 22

Phase 3 Scoping
Other Studies
Research and Pilot Opportunities
Future Funding Streams

Paul Boyd
Greg Johnson
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19 May 2023

U.S. ARMY

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LEWIS AND CLARK SEDIMENT MANAGEMENT PLAN
PHASE 3 SCOPING

Considered for Inclusion:

- Engineering analysis of technologies – dredging methods, flushing, bed collector, watershed improvement
- Pilot of bedload collector
- Environmental benefits
- Advanced Economic Analysis - Comprehensive benefit analysis (regional economic development)
- Environmental Justice considerations

RELATED STUDIES

- Ponca Creek Section 208
- Lewis and Clark Lake Hydrographic Surveys and Analysis
- Updated HEC-RAS numerical model for Reservoir Sluicing
- Missouri River Flow Frequency (June 23) and Stage Frequency
- Upper Missouri River Basin Flow Frequency – Silver Jackets proposal for FY24
- Missouri River System Plan
- Highway NE12 Update
- Other Planning Studies in Upper Basin

RESEARCH AND PILOT OPPORTUNITIES

- Niobrara River Bedload Collector Pilot – Grant Application or Phase 3

- Tuttle Creek Water Injection Dredging
  - State of KS funding support paired with USACE budget line to get $3M for pilot in 2024

- ERDC request for $10M/5yr Reservoir Sedimentation Work Unit to fund research and pilots

- D-Sediment and 3D Dredger (Guardians of the Reservoir Finalists) interested in pilot partnerships

FUTURE FUNDING STREAMS

- Phase 3 under Section 22
- WOTS support for Niobrara Sediment Delivery Assessment
- Regional Sediment Management Program
- ERDC Research Unit
- Future funding request for Section 1179a start