A Long Hard Road to Nowhere:

Arctic Grayling Restoration in Upper Red Rock Lake, Montana

MONTANA LAKES CONFERENCE

K. Flynn | October 20, 2023

Preliminaries

1. Professional disclaimer

- The views and opinions expressed in this presentation are those of the speaker and do not reflect the positions of agencies or entities represented in the past, present, or future.

2. AHA disclaimer

- No grayling were harmed in the making of this presentation

Outline

- Introduction & Background
- Feasibility Study
- Environmental Assessment
- Recent Events

Introduction & Background

Arctic Grayling Restoration in Upper Red Rock Lake, Montana

Red Rock Lakes National Wildlife Refuge

Upper Red Rock Lake (URRL)

- Elevation = 2,080 m AMSL
- Surface Area = 8.93 km^2 (893 ha)
- Volume = 0.0128 km^3
- Depth = 1.4 m (mean) | 2.0 m (max)
- HRT = 143 days
- Polymictic & eutrophic/hypereutrophic
- Home to grayling spending nonbreeding portions of the year in URRL

Davis et al. (2019), Flynn et al. (2022)

Grayling Population Decline & Significance

- Estimated number of grayling declined from >2,000 to 73 spawners in 2022
- Far below the 1,000 fish recovery goal in the CV Arctic Grayling AMP
- Only 2 arctic grayling populations in lower 48
- Separated from grayling that exist in the northern latitudes

https://www.youtube.com/watch?v=G3KG0wn_TqE

Hypothesis Tests on Grayling Population

- Over 80 years, 3 prevailing hypothesis put forward as to the decline in grayling population
  1. Competition from hybrid rainbow-cutthroat trout
  2. Poor spawning habitat in the tributaries
  3. Winter habitat limitations
     - Fish migrate upstream to spawn and then back to URRL to overwinter (i.e., adfluvial)
     - Anoxic/hypoxic overwinter conditions
- Information to support and refute each hypothesis

Hypothesis 1 - Competition from non-native hybrid rainbow-cutthroat trout

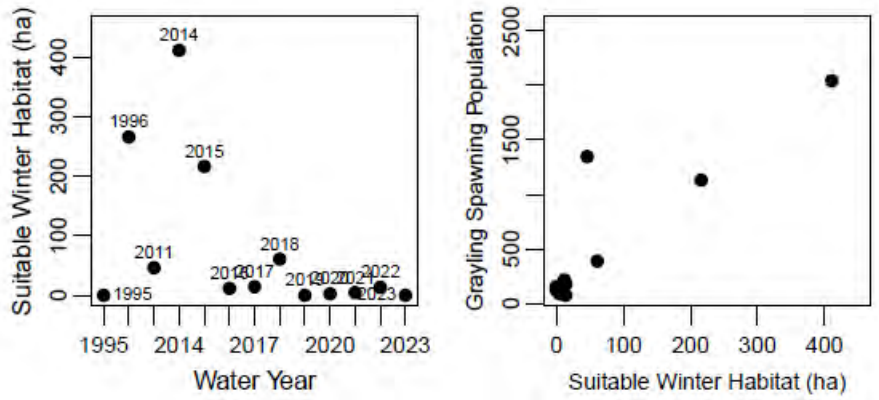
- Implemented population suppression
  - Increase angling pressure by liberalizing fishing regulations to 20 cutthroat trout per day
    - Dozens of people coming to fish catching 10-20 fish > 3lbs
    - 7,150 cutthroat trout removed from RRC 2013-2017
  - Euthanizing fish as they came through fish weir during spawning run

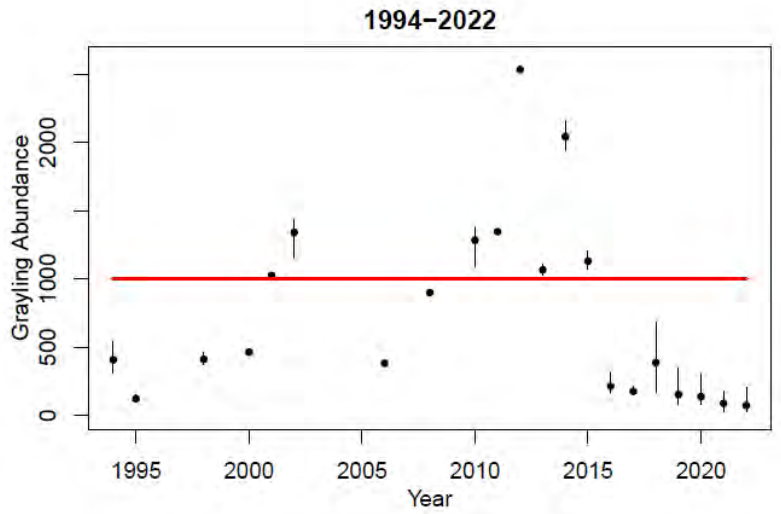
Hypothesis 2 - Stream Habitat

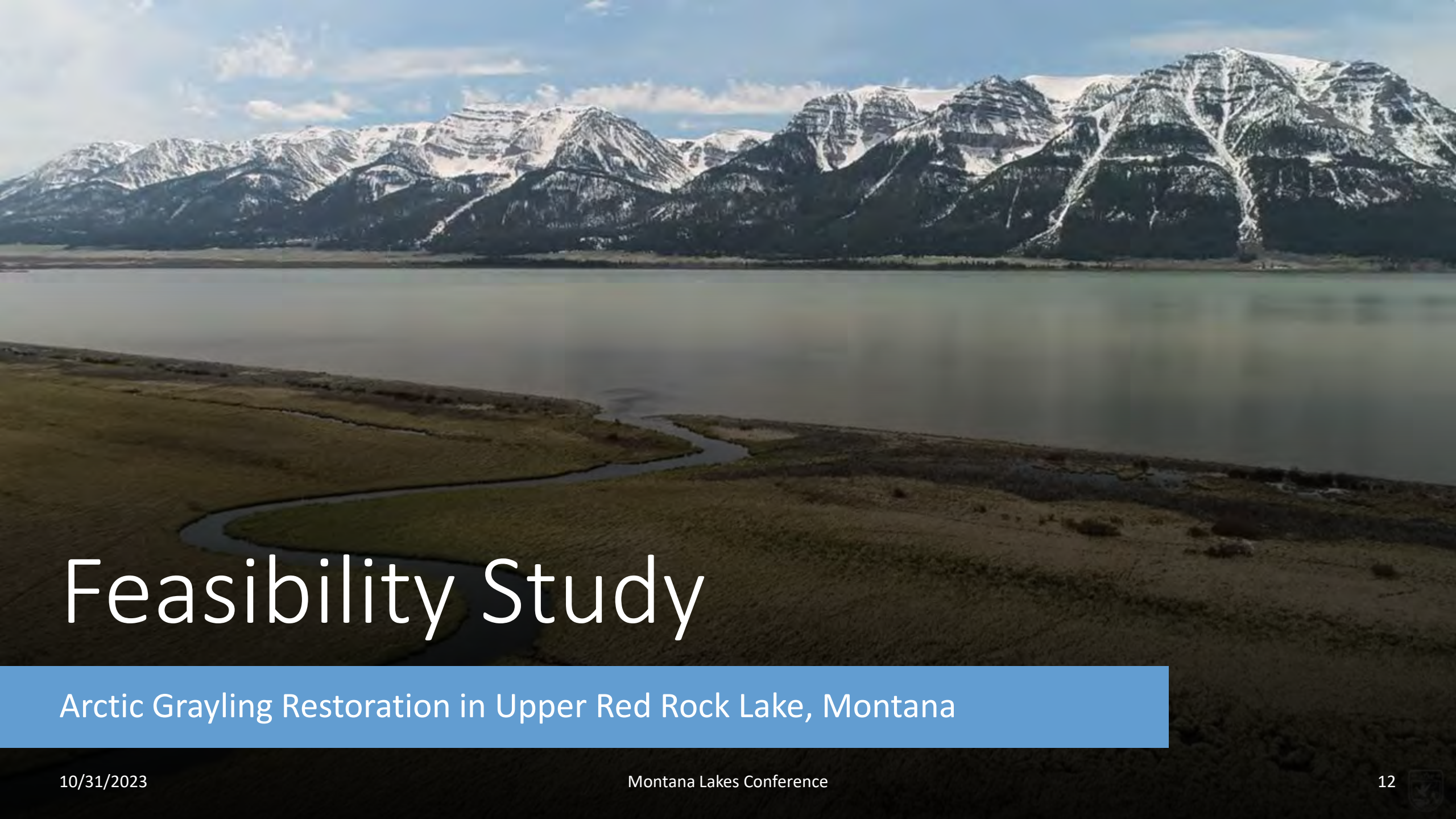
- Habitat impeded by natural fragmentation via beaver dams
  - Partially notched beaver dams to make more miles of spawning habitat available to fish from 2017-2020
- Elk Springs Creek channel restoration and spawning habitat restoration
  - Restored through explosives

Hypothesis 3 - Winter Habitat Model

- Going into winter 2015-2016:
  - 4 years of cutthroat removal, habitat improvement, and competition model predicting fantastic spawning run in 2016
  - Spawning habitat improved over the same period
  - Winter habitat model predicted population crash
  - Grayling population decline fivefold







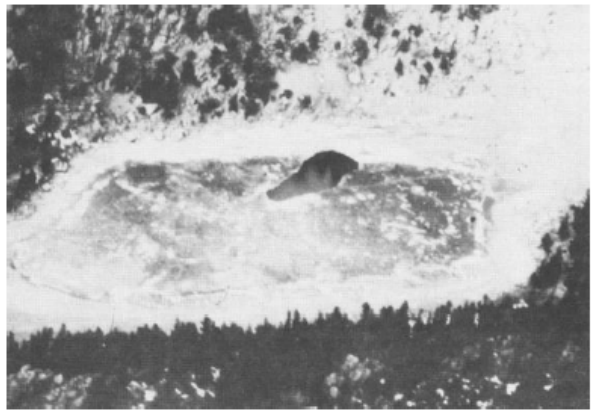
Feasibility Study

Arctic Grayling Restoration in Upper Red Rock Lake, Montana

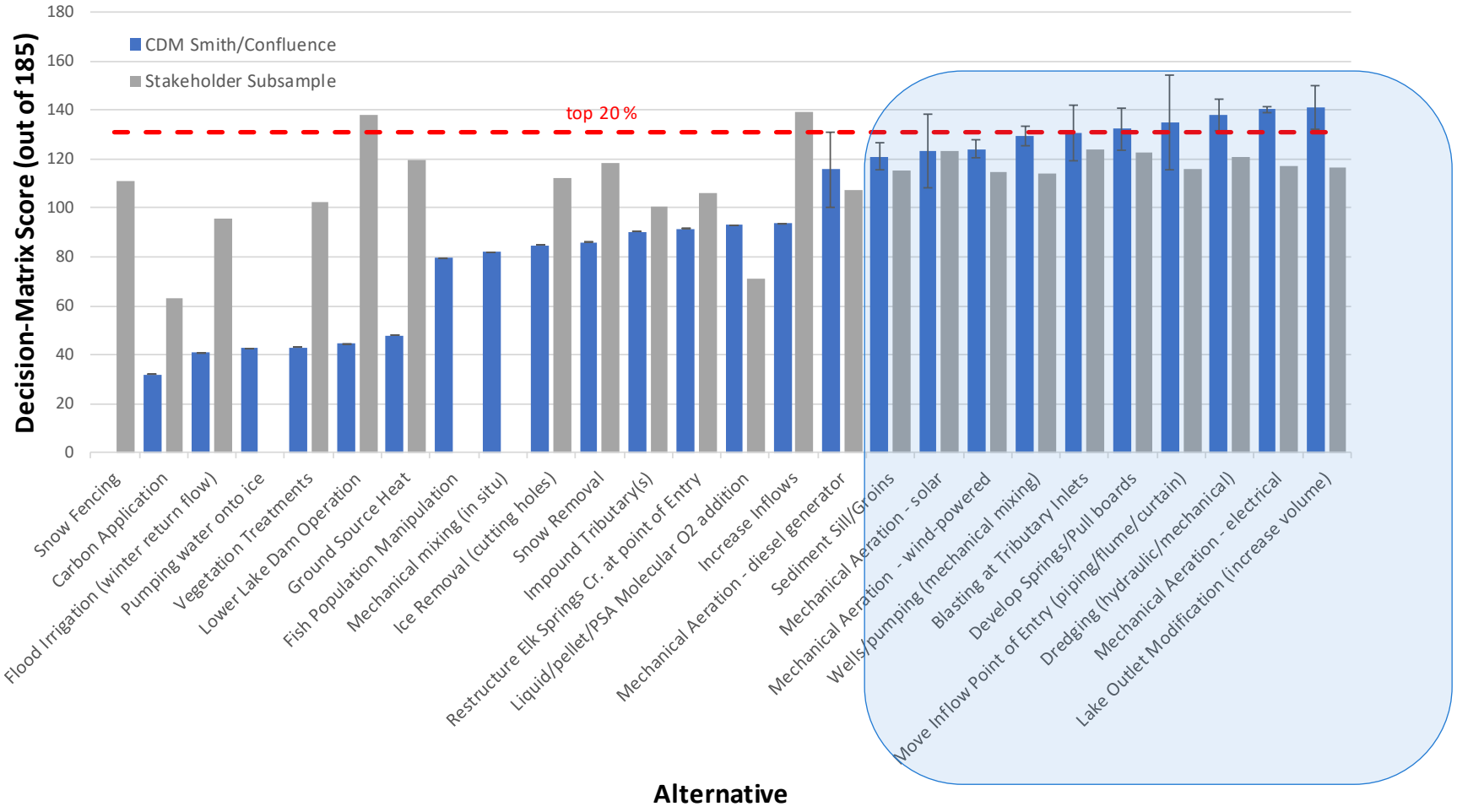
Winterkill Mitigation Options

Many authors: Fast 1994; McCord 1999/2000; Ellis & Stefan 1989; Ashley and Nordin 1999; Miller and Mackay; 2003

Type	Alternative
Mechanical Aeration	Diesel/propane, Electrical, Wind, Solar
	Mechanical mixing/circulation
Physical Treatments	Snow removal/carbon application
	Snow fencing
	Vegetation treatments
	Carbon application
	Ground source heat
	Molecular O_2 addition (liquid/pellet)
	Ice removal (cutting holes)
	Pumping water onto ice
	Fish population manipulation
Bathymetry Modification	Dredging
	Blasting at tributary inlets
	Lake outlet modification
	Lower lake dam operation
	Sediment sill/groins
Circulation	Increase inflow (groundwater/surface water)
	Move tributary point of entry (POI)
	Restructure Elk Springs Creek at POI
	Develop springs/pull boards
	Impound tributaries
	Flood irrigation



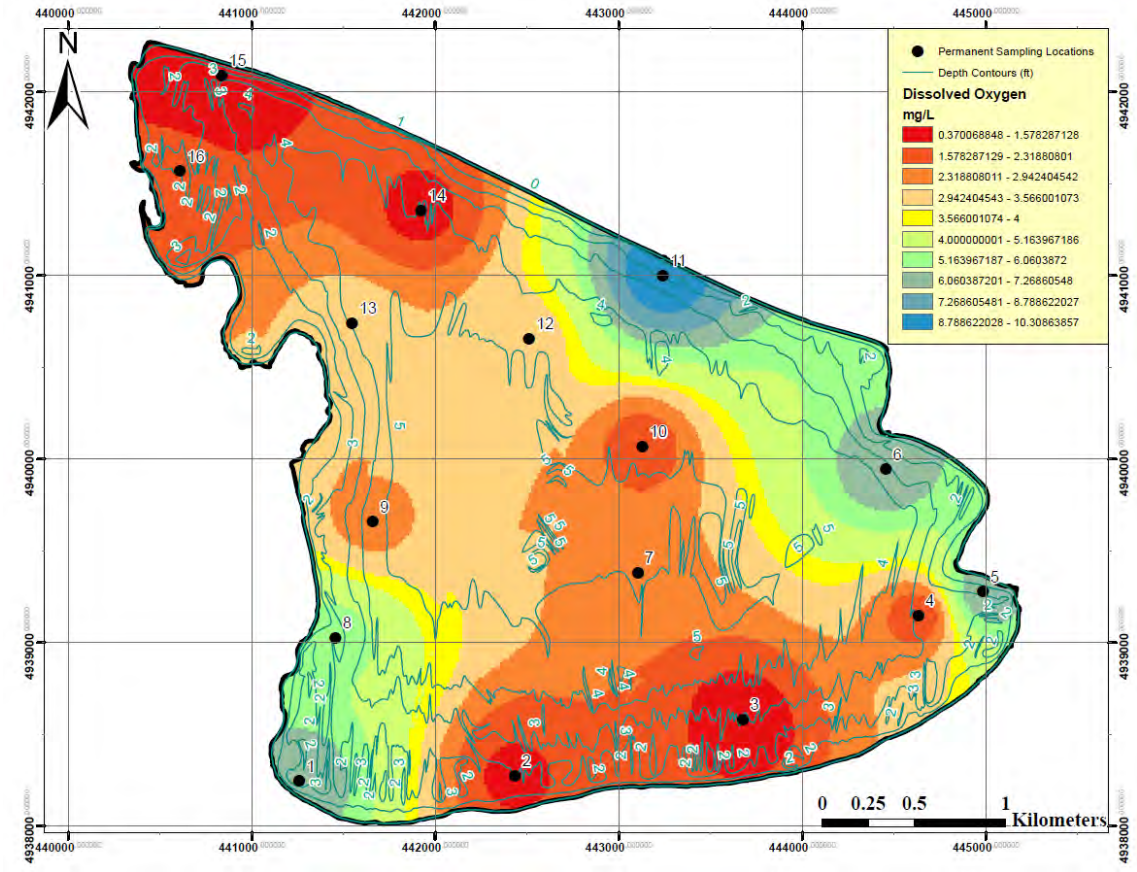
Alternatives Screening



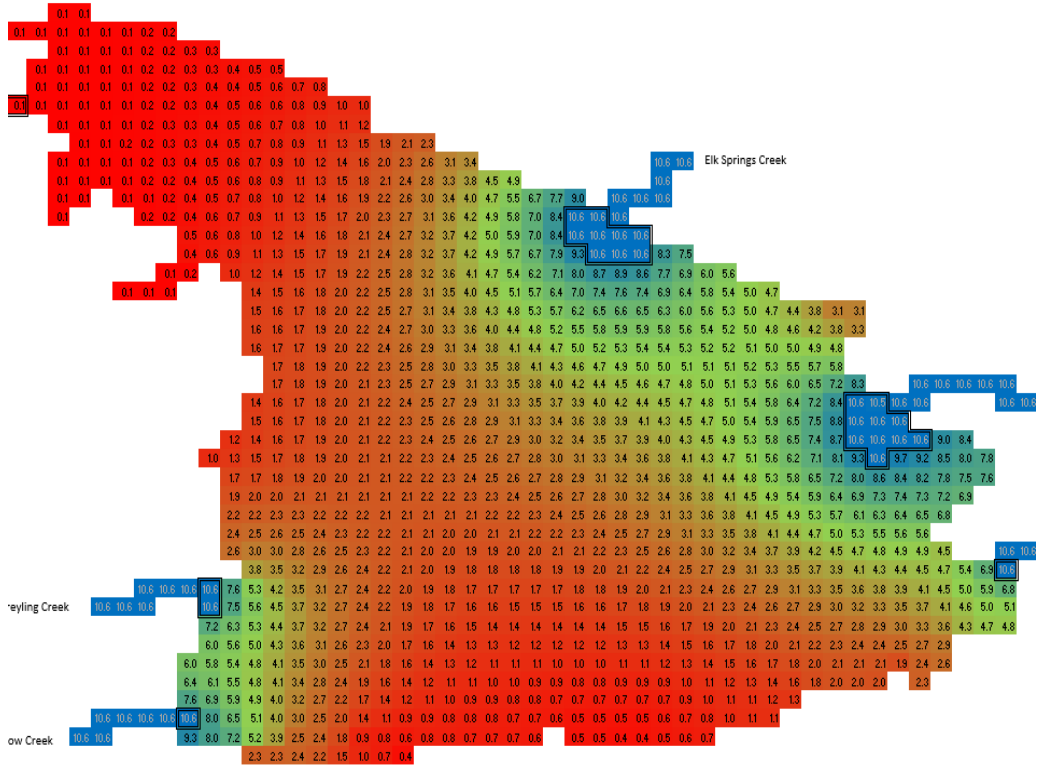
Further Evaluation

Simple 2D Modeling

January 2019 (K. Cutting)

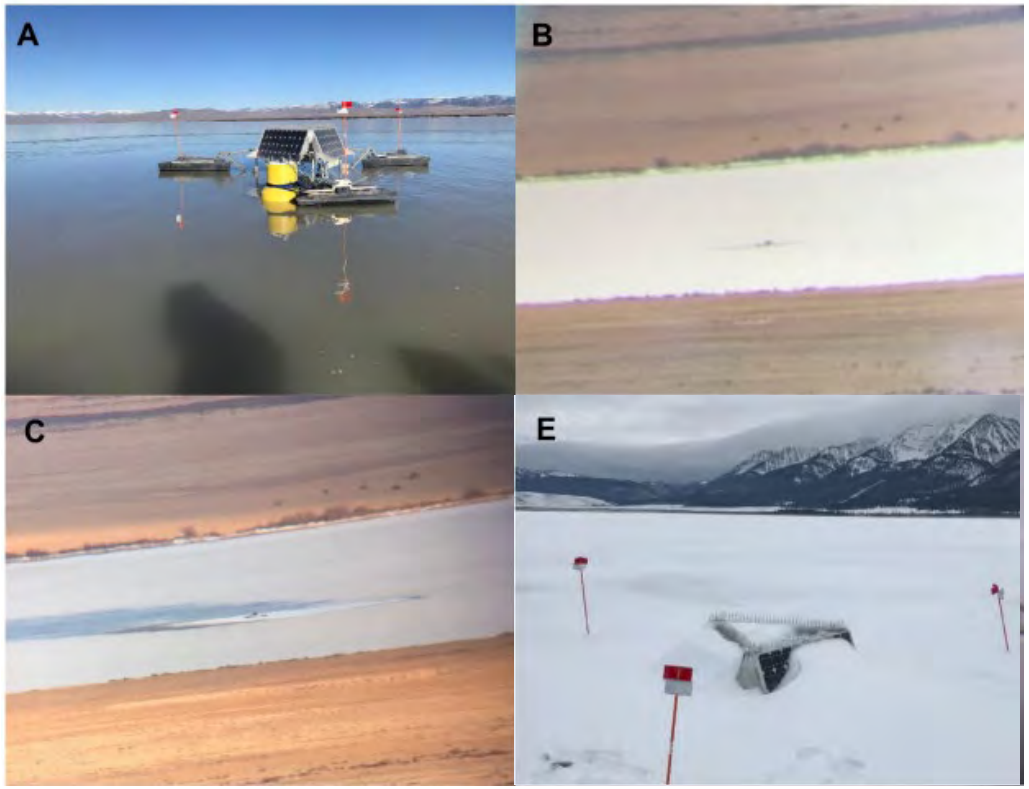


Laplacian Difference 2D diffusion



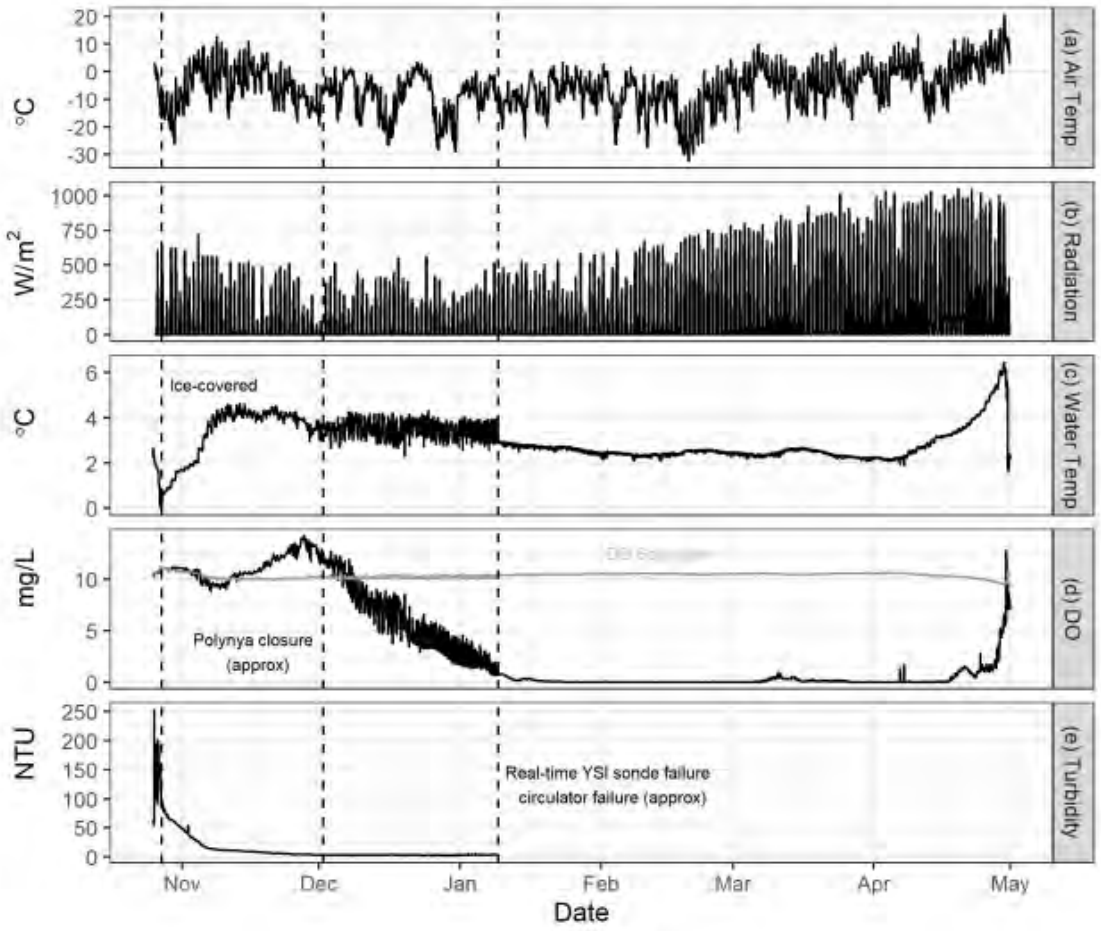
Pilot Studies

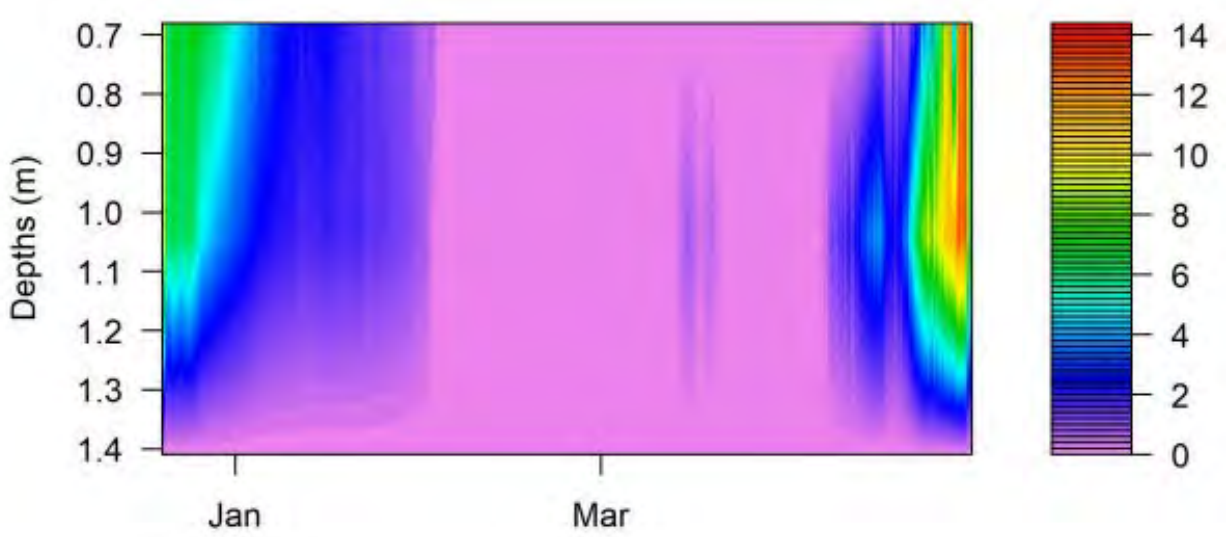
Solar Aerator

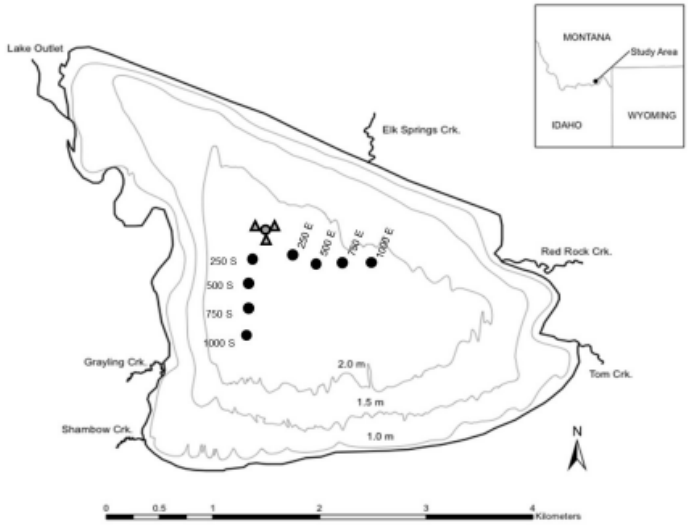


Bubble Diffuser

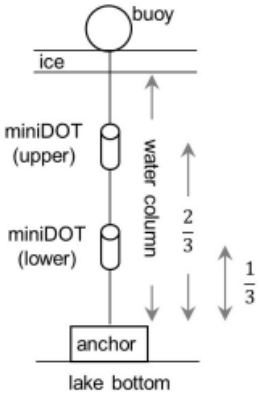
Pilot Studies





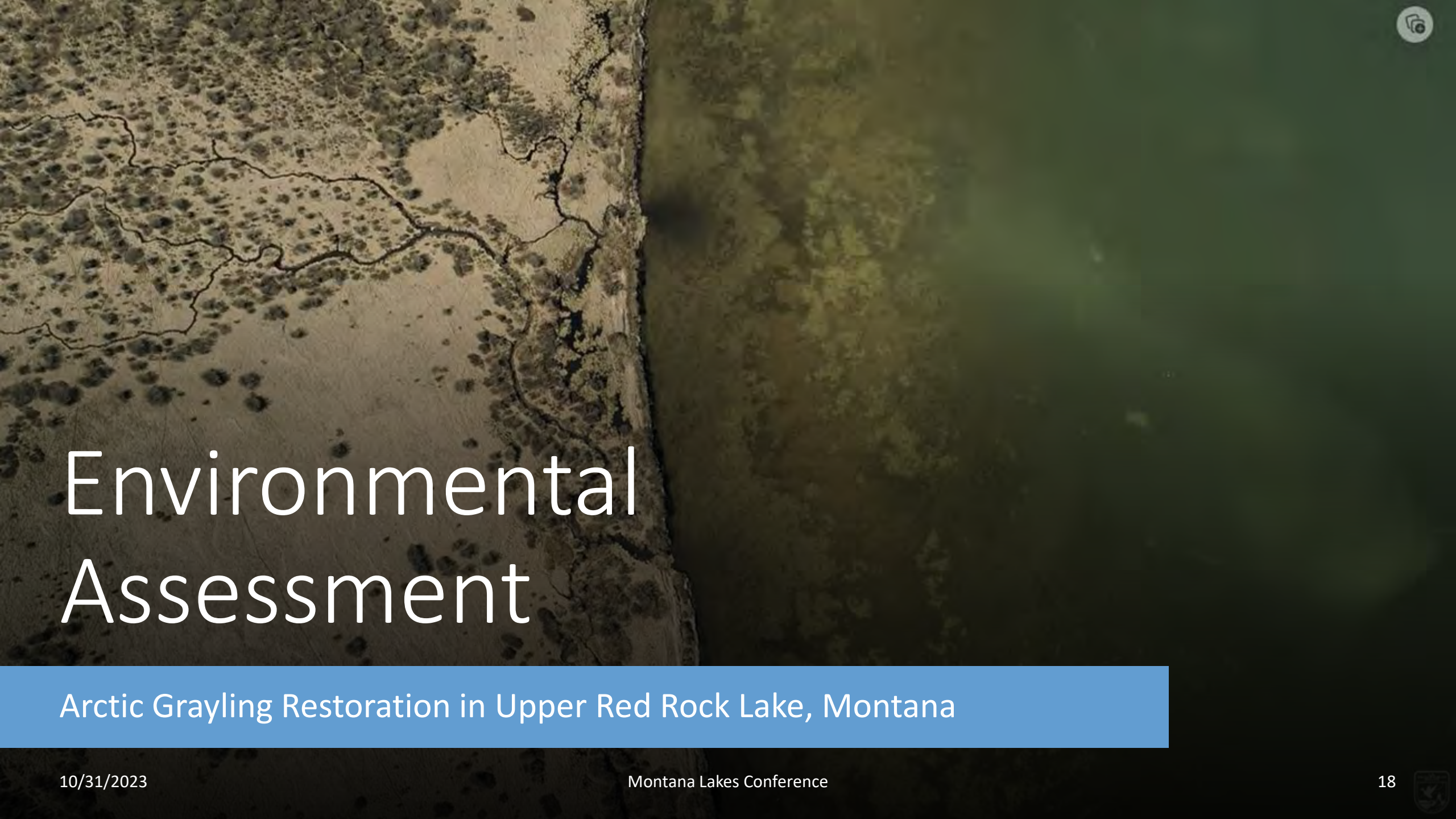


Plan view



Side view

Flynn et al. (2022)

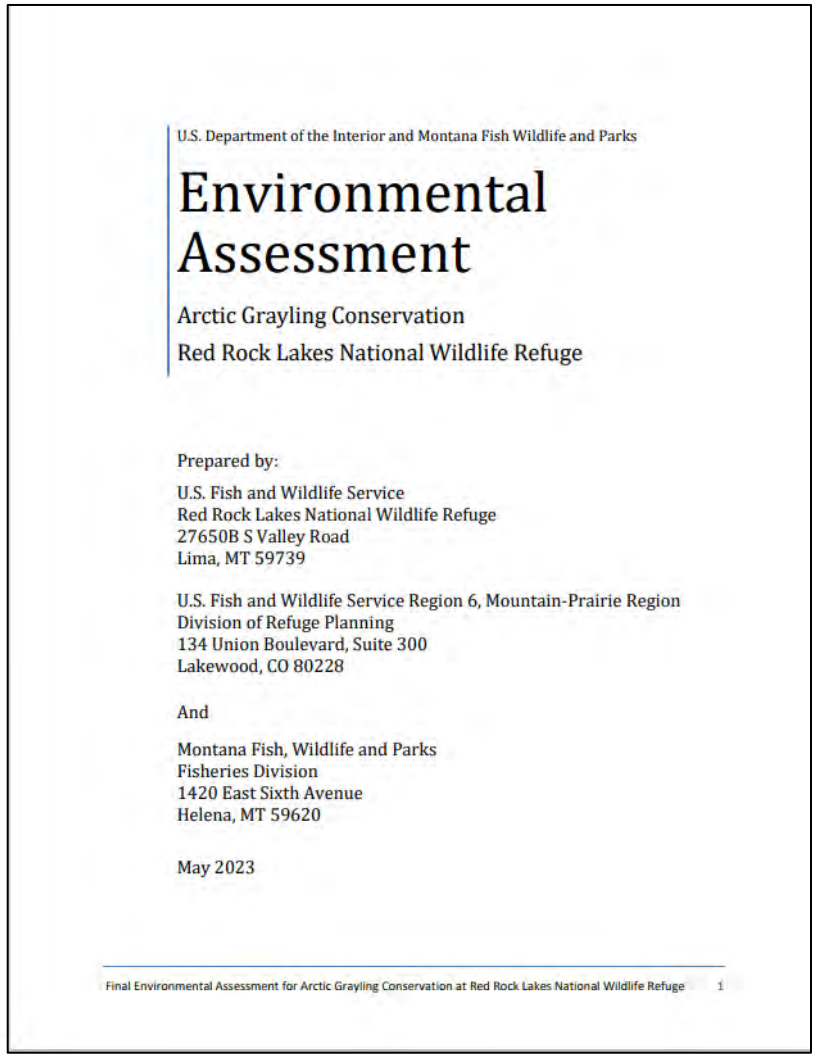


Environmental Assessment

Arctic Grayling Restoration in Upper Red Rock Lake, Montana

Environmental Assessment (EA)

- June 5, 2023 - U.S. Fish and Wildlife Service published a Final EA and Findings of No Significant Impact (FONSI) to improve winter oxygen levels for the conservation of Arctic grayling (*Thymallus arcticus*) in Upper Red Rock Lake (URRL) within Red Rock Lakes National Wildlife Refuge.



U.S. Department of the Interior and Montana Fish Wildlife and Parks

Environmental Assessment

Arctic Grayling Conservation

Red Rock Lakes National Wildlife Refuge

Prepared by:

U.S. Fish and Wildlife Service
Red Rock Lakes National Wildlife Refuge
27650B S Valley Road
Lima, MT 59739

U.S. Fish and Wildlife Service Region 6, Mountain-Prairie Region
Division of Refuge Planning
134 Union Boulevard, Suite 300
Lakewood, CO 80228

And

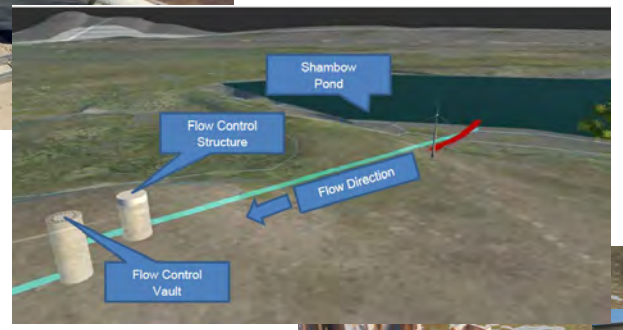
Montana Fish, Wildlife and Parks
Fisheries Division
1420 East Sixth Avenue
Helena, MT 59620

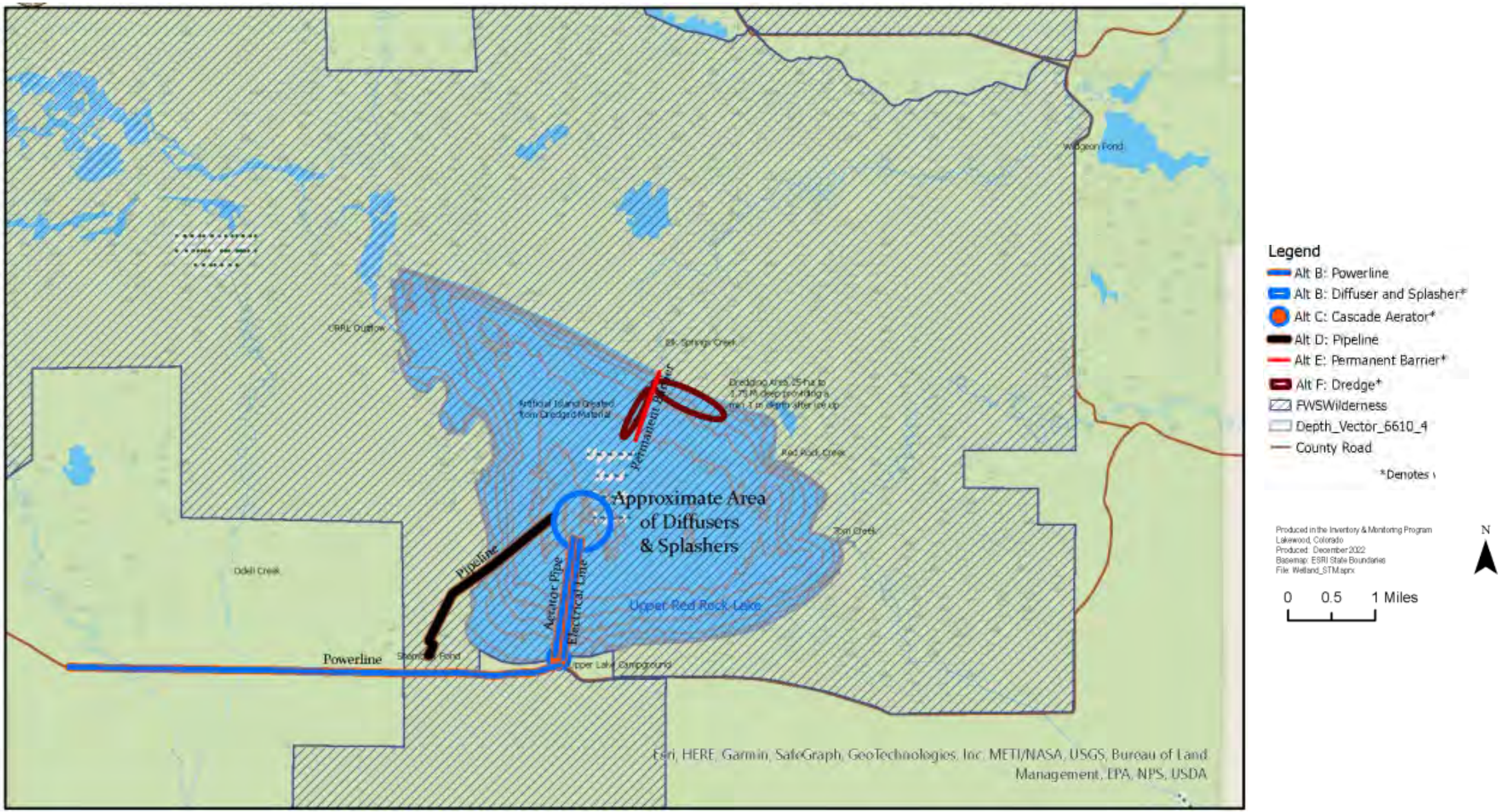
May 2023

Final Environmental Assessment for Arctic Grayling Conservation at Red Rock Lakes National Wildlife Refuge 1

Alternatives Evaluated

A. No Action
B. Mechanical Aeration
C. Pumped Aeration
D. Pipeline/Aeration
E. Hydraulic Barrier
F. Dredge/Berm

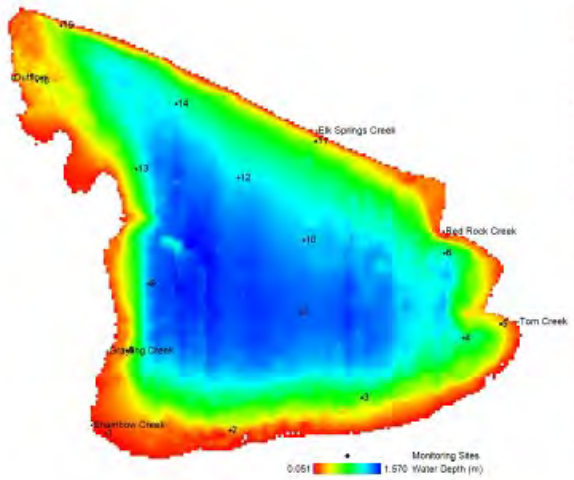


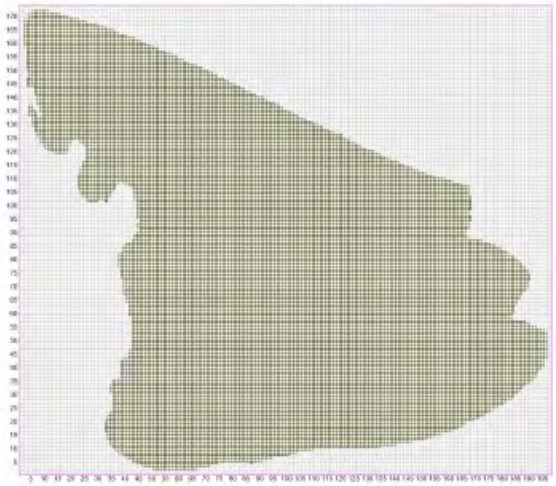

Legend
Alt B: Powerline
Alt B: Diffuser and Splasher*
Alt C: Cascade Aerator*
Alt D: Pipeline
Alt E: Permanent Barrier*
Alt F: Dredge*
FWSWilderness
Depth_Vector_6610_4
County Road
*Denotes
Produced in the Inventory & Monitoring Program
Lakewood, Colorado
Produced: December 2022
Basemap: ESRI State Boundaries
File: Wetland_STM.aprx
N
0 0.5 1 Miles
Approximate Area of Diffusers & Splashers
Upper Red Rock Lake
Pipeline
Aerator Pipe
Electrical Line
Powerline
Permanent Barrier
Artificial Island Created from Dredged Material
Dredging Area 25 ha to 1.75 m deep providing a min 1 m depth after ice up
Odell Creek
Red Rock Creek
Upper Lake Campground
Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

Evaluation Process

1. Simulate habitat created by each alternative in 2D EFDC hydrodynamic water-quality model

   >4 ppm DO and >1 m depth





2. Evaluate effects of alternatives on grayling through habitat projection model
3. Compute probability of persistence

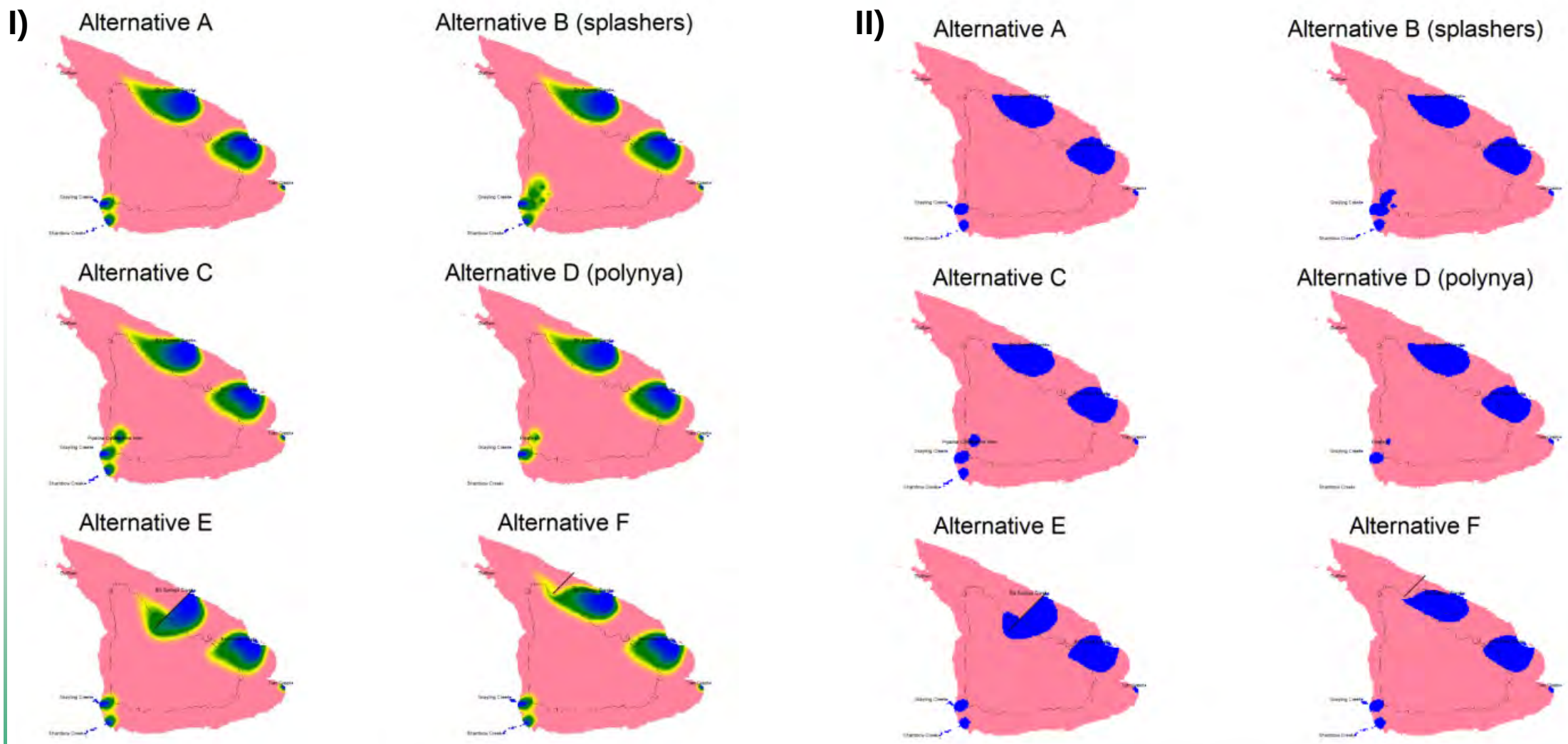
$$N_{t+1} = N_t s_t p_t + F_{t-2}\alpha_{t-2}\gamma_{t-2}(\delta_{t-2}p_{t-2})(\varepsilon_{t-1}p_{t-1})(\theta_t p_t) \quad (4)$$

where,

N_t	is the number of spawning CV grayling in year t,
F_{t-2}	is the number of adult females in the spawning run in year t-2,
s_t	is the maximum annual survival of adult grayling (aged 3+) in year t,
p_t	is the proportional change in the maximum winter or annual survival as a function of overwinter habitat in year t (described below),
α_{t-2}	is the length specific fecundity rate,
β_{t-2}	is the probability of an egg being fertilized and hatching in year t-2,
γ_{t-2}	is the age-0 fish in-stream survival (emergence to September 1st),
δ_{t-2}	is the age-0 fish maximum winter survival (September 2st – May 15th),
ϵ_{t-1}	is the age-1 fish maximum annual survival (May 16th – May 15th),
θ_t	is the age-2 fish maximum annual survival (May 16th – May 15th).

Simulated I) DO and II) Habitat

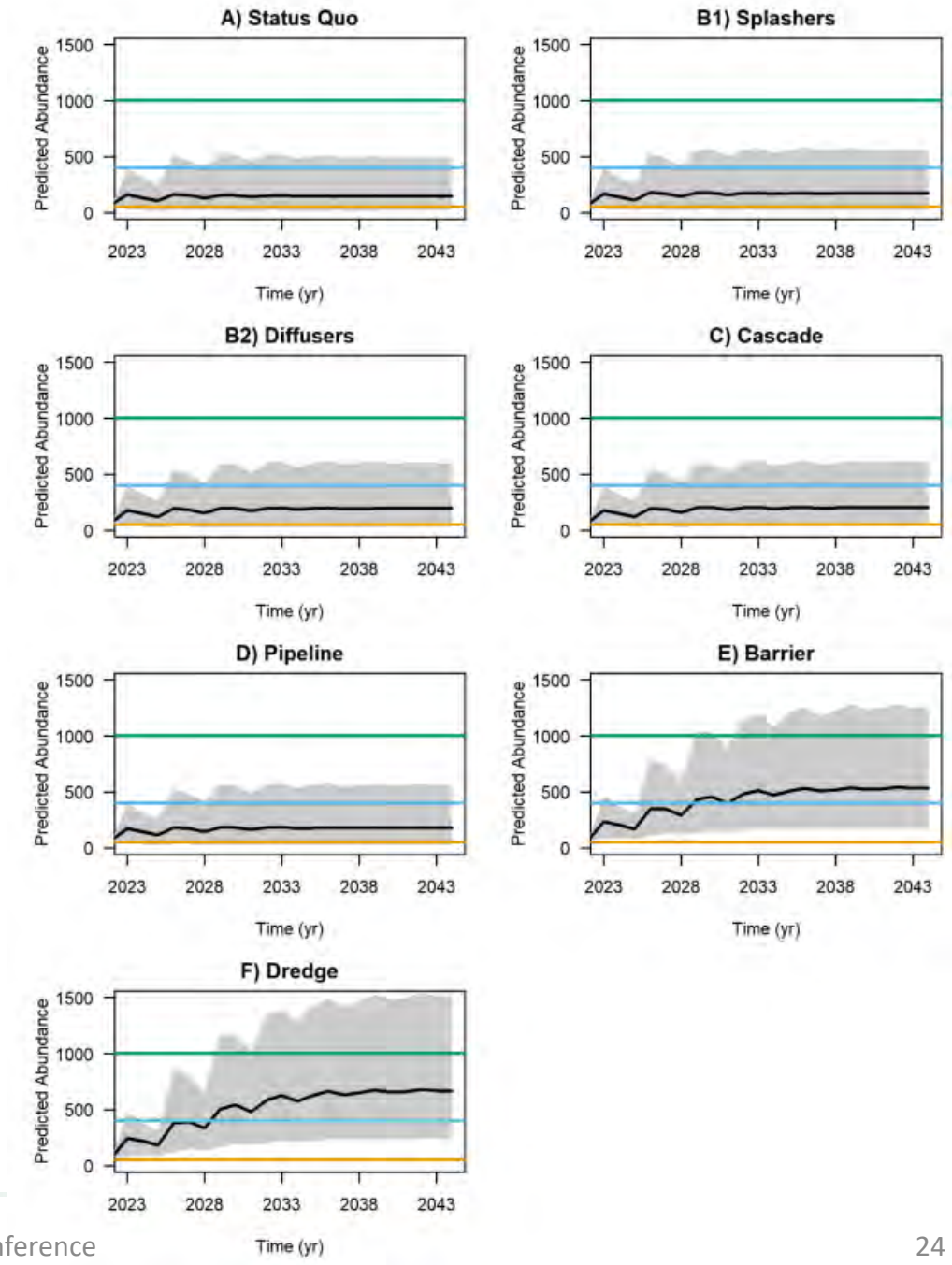
Cook et al. (2023)



Habitat Created & Probability of Extinction and Recovery

Alternative		(URRL Habitat Created)	1A1: CV Grayling Extinction			1A2: CV Grayling Recovery
		(Created habitat area [hectares])	Pr(extinction) <25 individuals in a single year	Pr(extinction) <50 individuals across 3 yrs.	Pr(extinction) both thresholds	Freq(CV grayling greater than 400)
		Maximize	**Minimize**	**Minimize**	**Minimize**	**Maximize**
A	Status quo	0.0	0.41	0.31	0.46	0.05
B_1	Splashers	1.5	0.30	0.22	0.33	0.07
B_2	Diffusers	2.6	0.17	0.11	0.19	0.09
C	Cascade	2.7	0.11	0.06	0.13	0.09
D	Pipeline	1.5	0.18	0.11	0.21	0.07
E	Barrier	26.9	<0.01	<0.01	<0.01	0.62
F	Dredge/ Berm	37.3	<0.01	<0.01	<0.01	0.80

Cook et al. (2023)



Structured Decision Making

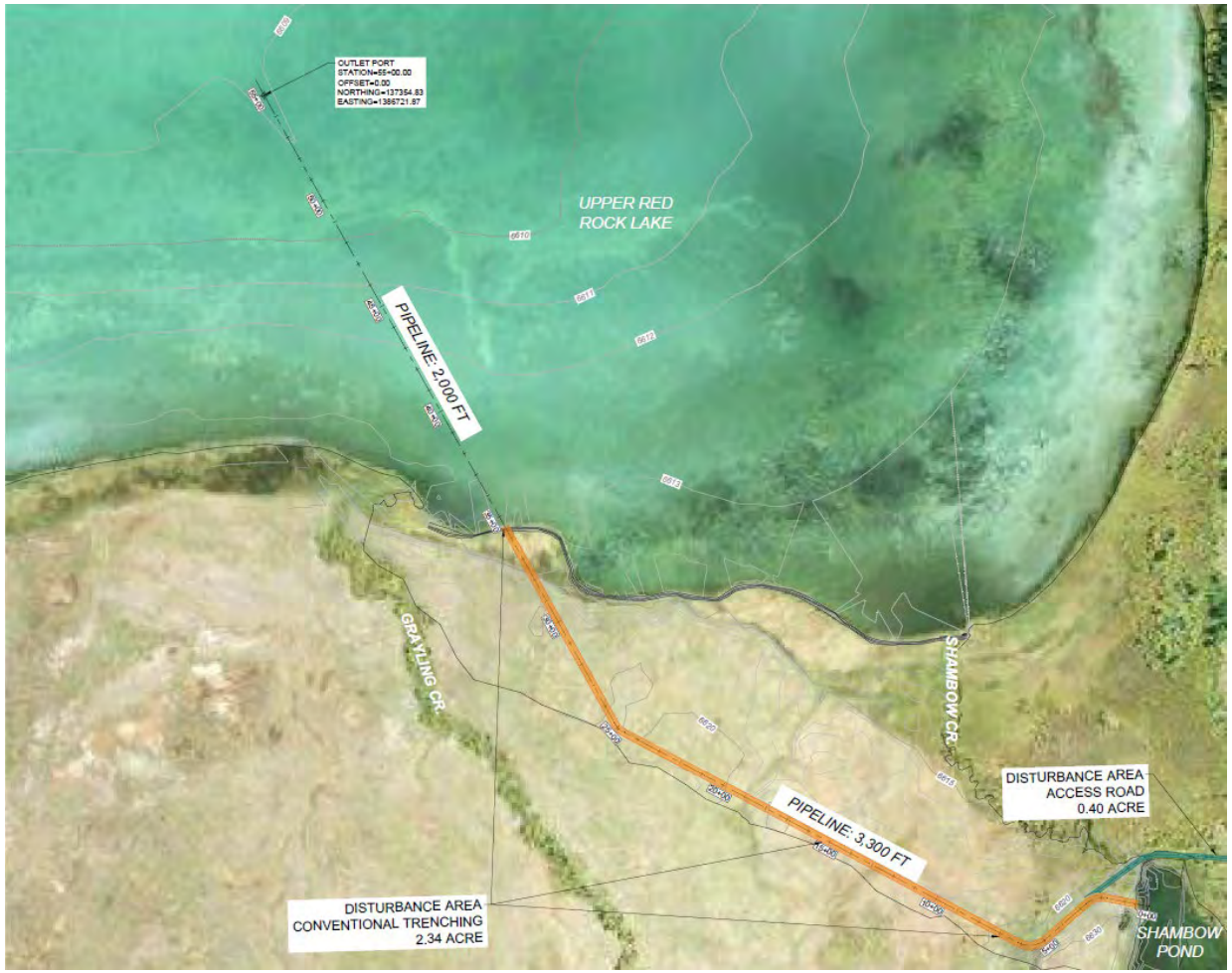
- Maximize grayling probability of persistence over 25 years
- Preserve wilderness character
- Preserve/enhance stakeholder values
- Incorporate costs/consequences

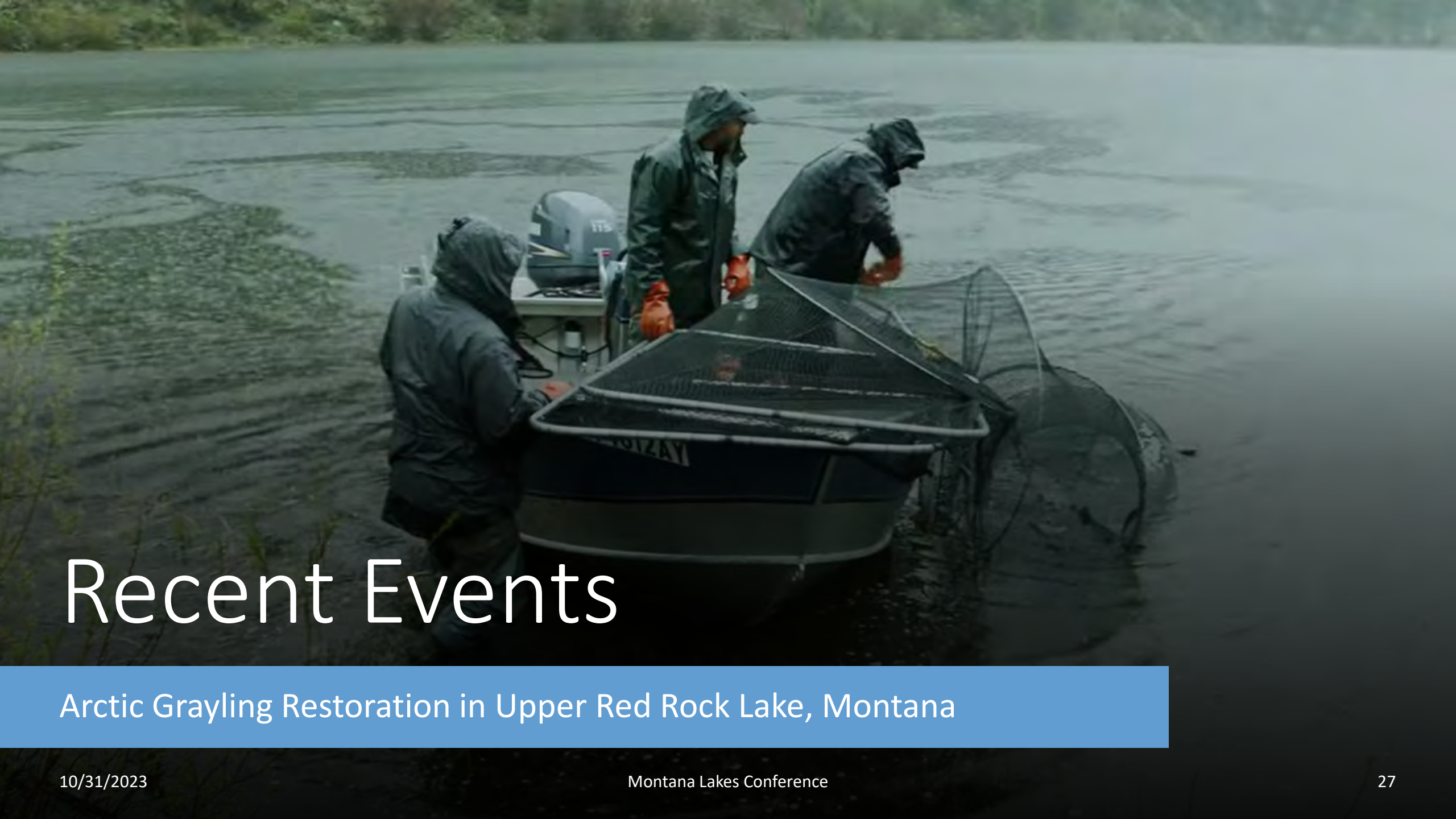
Alternative		3A1: General Refuge Users	3A2: Hunters	3A3: Downstream water users	4A1: Construction costs†	4A2: Operational costs†
		Days/overlap	Days/overlap	Reduction in cubic meters per second	U.S. Dollars	U.S. Dollars
		Min	**Min**	**Min**	**Min**	**Min**
A	Status quo	0.0	0.0	0.0	$0.00	$0.00
B_1	Splashers	74.0	0.0	0.0	$509,750	$25,250
B_2	Diffusers	74.0	0.0	0.0	$371,000	$20,000
C	Cascade	115.0	0.0	0.0	$774,000	$81,000
D	Pipeline	91.0	0.0	0.0	$657,000	$0.00
E	Barrier	40.0	0.0	0.0	$3,160,000	$0.00
F	Dredge and Berm	435.0	60.0	0.006	$7,370,000	$0.00

†Costs are not for bid or construction (Association for the Advancement of Cost Engineering 2005) Level 5 estimate at best)

Preferred Alternative

- Alternative D – Pipeline w/ aeration; balancing habitat gained with overall wilderness impact and costs





Recent Events

Arctic Grayling Restoration in Upper Red Rock Lake, Montana

EA Status

- June 26, 2023 – several organizations filed complaint for declaratory and injunctive relief, raising claims under the Wilderness Act.
- August 3, 2023 – after brief oral arguments, the U.S. District Court issued injunction prohibiting the Service for engaging in any construction activities within the Wilderness Area.

Status Quo

- Grayling in URRL are likely imperiled
- Future hydrologic and climatic conditions will likely predicate their future

Questions & Discussion

- Open

References

- Cook, J.D., Flynn K.F., Bell, D., Jaeger, M., Warren, J., Kreiner, R., Payne, J. Andrews, J., Brummond, A., Campbell Grant, E.V., Sells, S. 2023. Decision-making for Centennial Valley Arctic Grayling (*Thymuallus arcticus*) Conservation on Red Rocks Lake National Wildlife Refuge. https://fwp.mt.gov/binaries/content/assets/fwp/conservation/fisheries-management/arctic-grayling/upper-red-rock-lake-grayling-technical-report.pdf
- Davis et al. 2019. Winter Survival, Habitat Use, and Hypoxia Tolerance of Montana Arctic Grayling in a Winterkill-Prone Lake. Transactions of the American Fisheries Society 148:843–856.
- Flynn, K.F., Johnson, T.J., Parker, W.S., Lovell, J. 2019. Upper Red Rock Lake, MT: Preliminary Engineering and Feasibility Analysis to Improve Winter Habitat for Arctic Grayling. CDM Smith, Inc., Helena, MT.
- Flynn et al. 2022. Solar circulator to restore dissolved oxygen in a hypoxic ice-covered lake. PLOS Water. https://doi.org/10.1371/journal.pwat.0000012
- U.S. Fish and Wildlife Service & FWP. 2023. Environmental Assessment. Arctic Grayling Conservation & FONSI https://www.fws.gov/sites/default/files/documents/EA_URRL_Final.pdf https://www.fws.gov/sites/default/files/documents/FONSI_URRL_EA_20230524.pdf
- U.S. Fish and Wildlife Service. 2023. Withdrawal of FONSI. https://www.fws.gov/sites/default/files/documents/RRL%20Withdrawal_Decision-Notice.pdf
- Warren, J., Jaeger, M., Kreiner, R., Bateman, L., Gander, T. and T. Paterson. 2022. Centennial Valley Arctic Grayling Adaptive Management Project Annual Report. 19th April 2023.