Innovations for Sustainability Workshop: Water Quality

Thursday, February 1, 2024
12:00 – 2:00 p.m. ET / 9:00 – 11:00 a.m. PT

Uncommon Dialogue on Hydropower, River Restoration, and Public Safety

Working Group 1 (Technology)
Working Group 4 (Valuation)

How to Participate

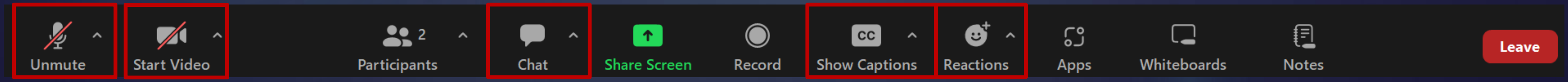
Ground Rules

- Commit to a good faith effort.
- Participate actively and respectfully.
- Honor the agenda.
- Be brief and prepared.
- Speak in order; facilitator will mind the queue.
- Provide your name and affiliation when you speak.

Zoom Guidelines

- “Rename” yourself to include your name and organization (e.g., “Shannon Ames, LIHI”).
- Use the “raise hand” feature under “Reactions” to join the speaker’s list.
- Speak in order; facilitator will mind the queue.
- Mute your audio when not speaking.
- If you are participating by phone, raise your hand by dialing *9.
- This meeting will be recorded.

For technical assistance, please chat Morgan Nachman directly or email her at mnachman@kearnswest.com.



INTRODUCTIONS

Please use the chat feature to state your name and affiliation

Introductions: Workshop Planning Team

Uncommon Dialogue WG1 Co-Chairs (Technology)

- Jose Zayas, American Council on Renewable Energy (zayas@acore.org)
- Maryalice Fischer, Low Impact Hydropower Institute (mfischer@lowimpacthydro.org)
- Chris Hayes, National Hydropower Association (chris@hydro.org)
- Miles Hall, Natel Energy (miles.hall@natelenergy.com)

Uncommon Dialogue WG4 Co-Chairs (Valuation)

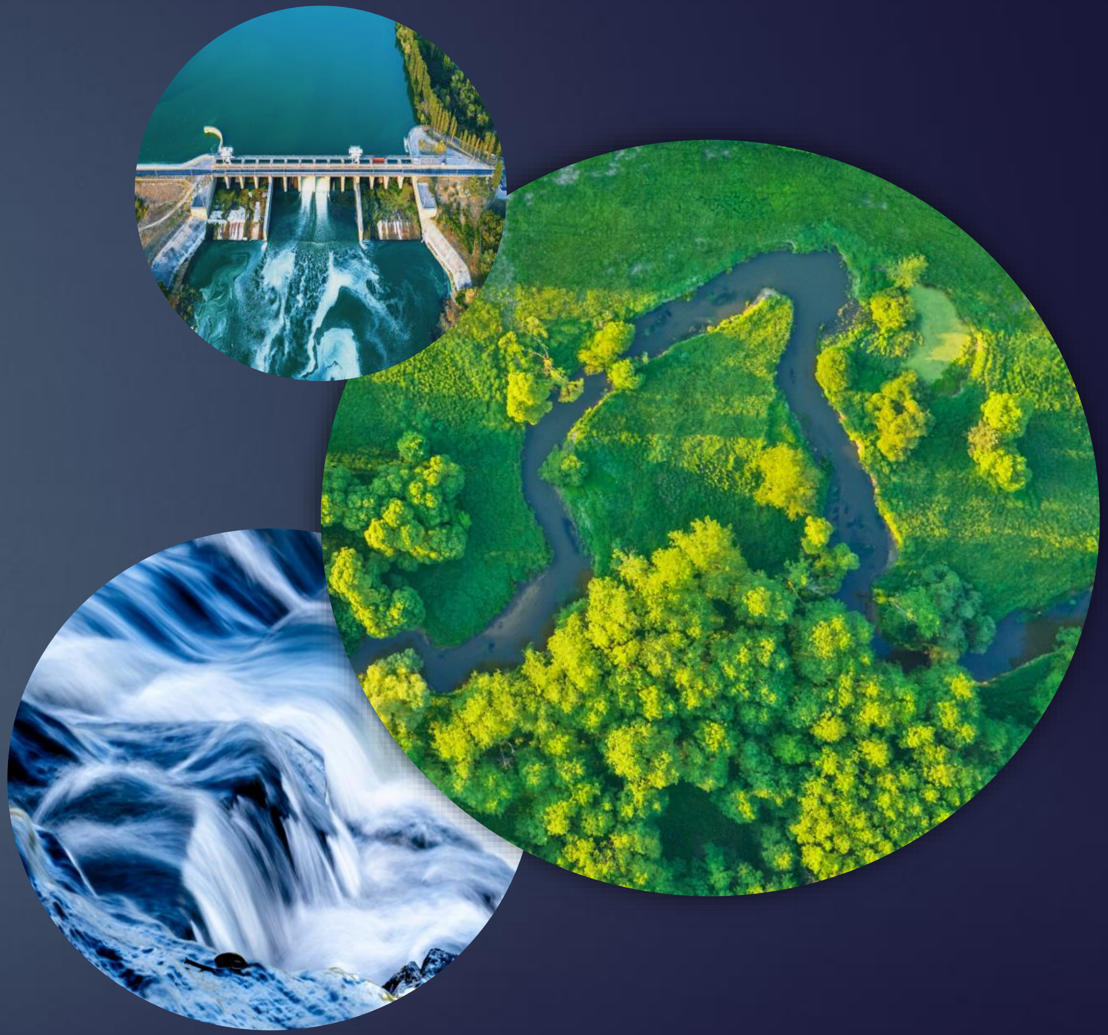
- Shannon Ames, Low Impact Hydropower Institute (sames@lowimpacthydro.org)
- Michael Purdie, National Hydropower Association (michael@hydro.org)

Facilitation Team

- Anna West, Kearns & West, Facilitator (awest@kearnswest.com)
- Brittani Bohlke, Kearns & West, Co-Facilitator & Notetaker (bbohlke@kearnswest.com)
- Morgan Nachman, Kearns & West, Technology Support (mnachman@kearnswest.com)

Objectives

- Learn about ways to achieve sustainable hydropower and river restoration, focusing on water quality.
- Explore different water quality technologies and innovations.
- Consider recommendations to advance river restoration and hydropower sustainability, particularly water quality.
- Guage interest in continuing the conversation in future workshops and a white paper.



Agenda Review

I. Welcome, Introductions, and Agenda Review

II. Uncommon Dialogue: An Overview

III. Water Quality: An Overview (Maryalice Fisher)

IV. Presentations

  a) *Real-Time and Autonomous Hydropower Water Quality Monitoring Systems* (Daniel Deng, PNNL)

  b) *Dissolved Oxygen Technologies – High Rock Project*(Neal Simmons, Eagle Creek Renewable Energy)

  c) *Environmentally Acceptable Lubricants* (Jeffrey DiMaio, VBASE Oil Company)

V. Discussion on Future Water Quality Needs

VI. Wrap Up and Next Steps

PollEverywhere Participation

Three ways to participate:

BY COMPUTER
Go to **pollev.com/ucdhydro353** on your internet browser.

BY SMART PHONE
Go to **pollev.com/ucdhydro353** on your internet browser.

BY TEXT MESSAGE
Text the contact number '22333' the phrase '**ucdhydro353**' on your mobile phone.

WAYS TO PARTICIPATE

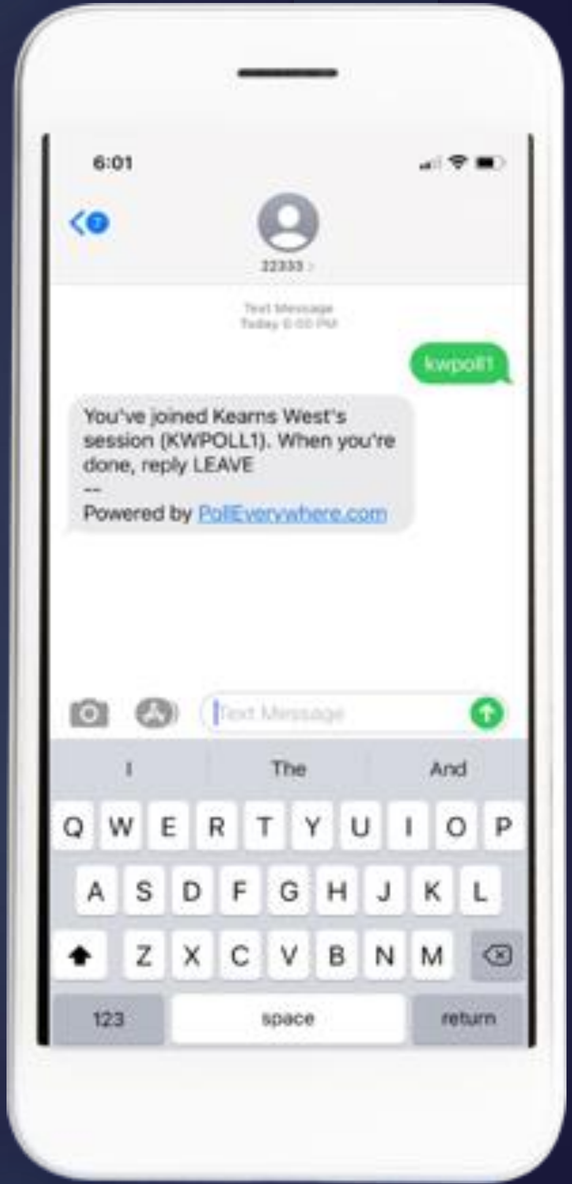
TEXT MESSAGE

BY TEXT MESSAGE

Text **ucdhydro353** to **22333** on your mobile device.

Text 22333

Type & Send: ucdhydro353



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SMARTPHONE BROWSER

BY SMARTPHONE

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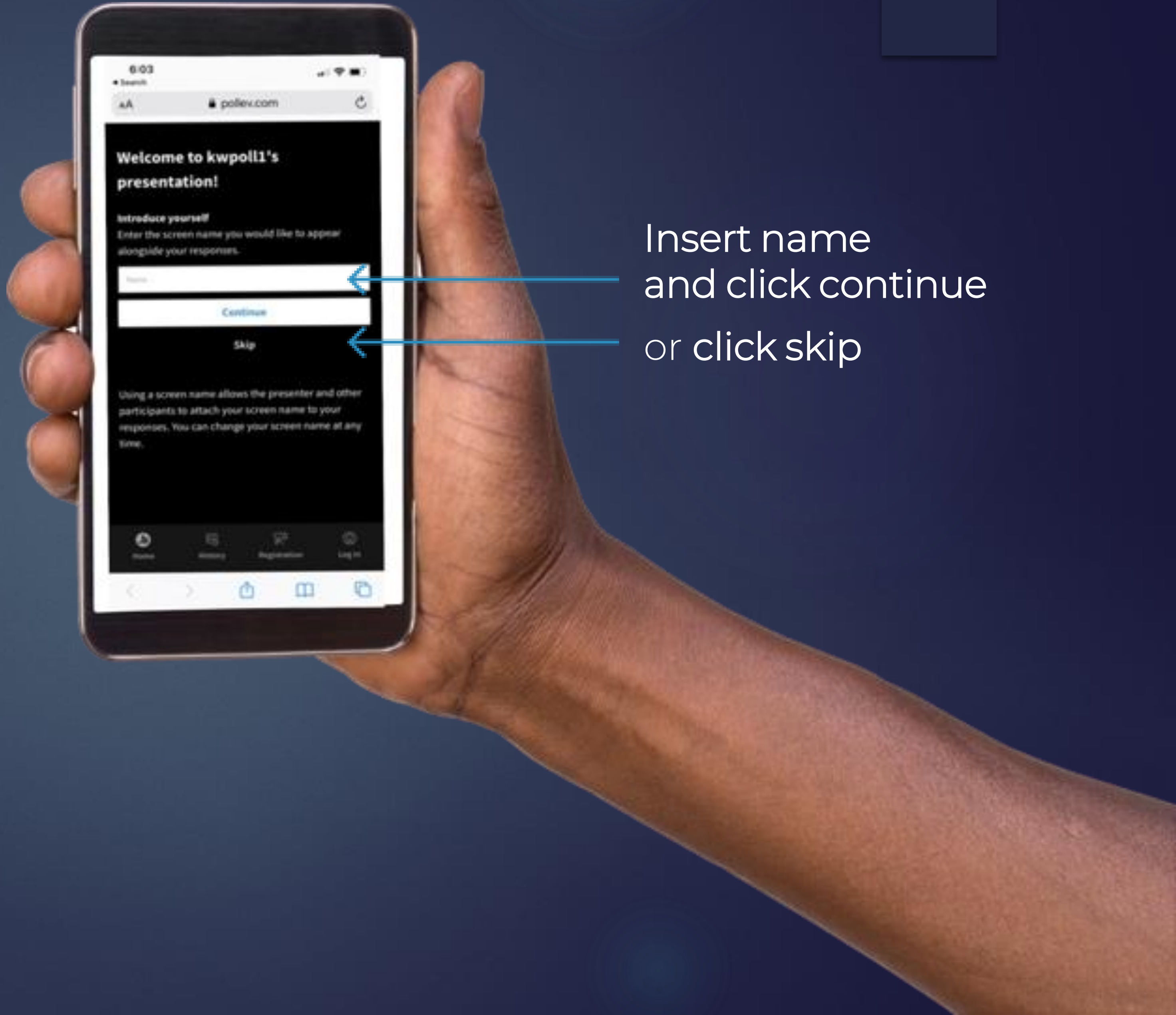

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or click skip

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INTERNET BROWSER

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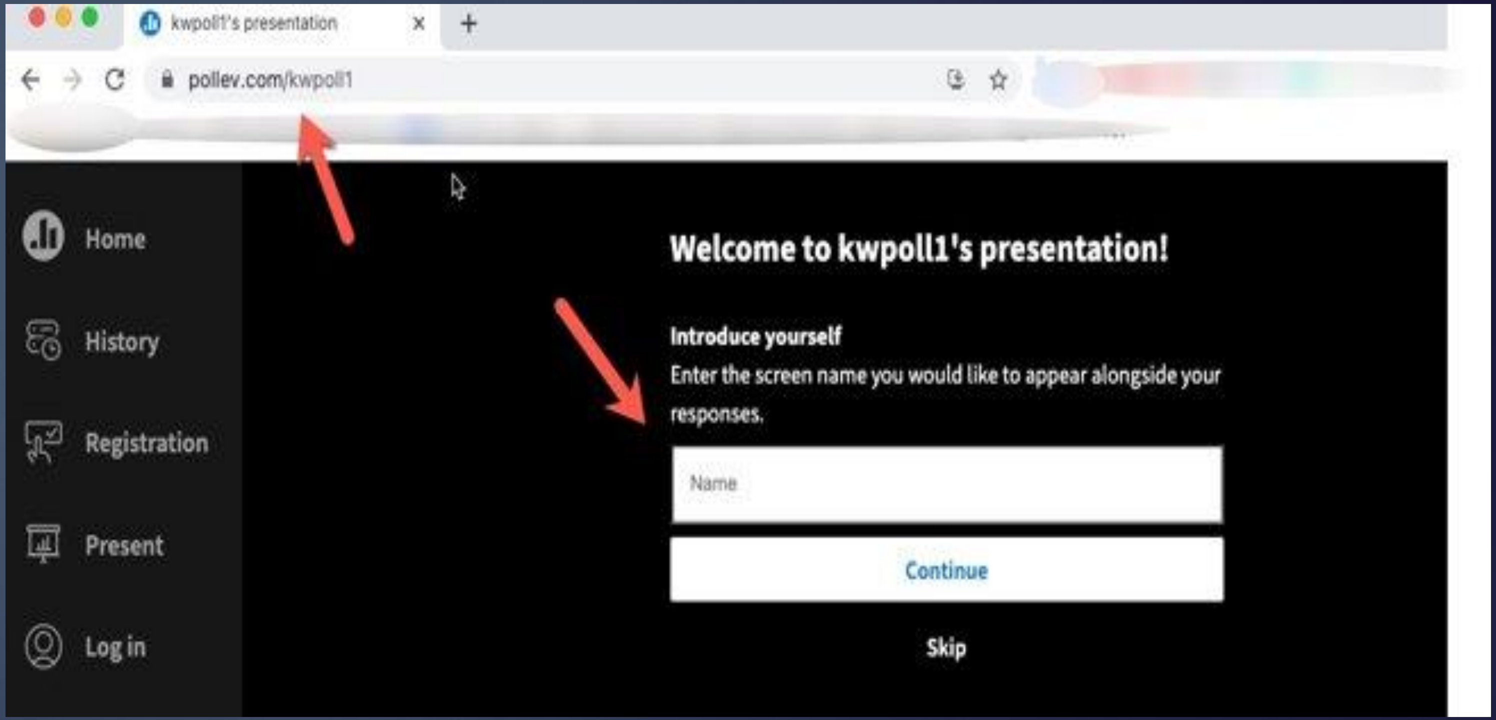
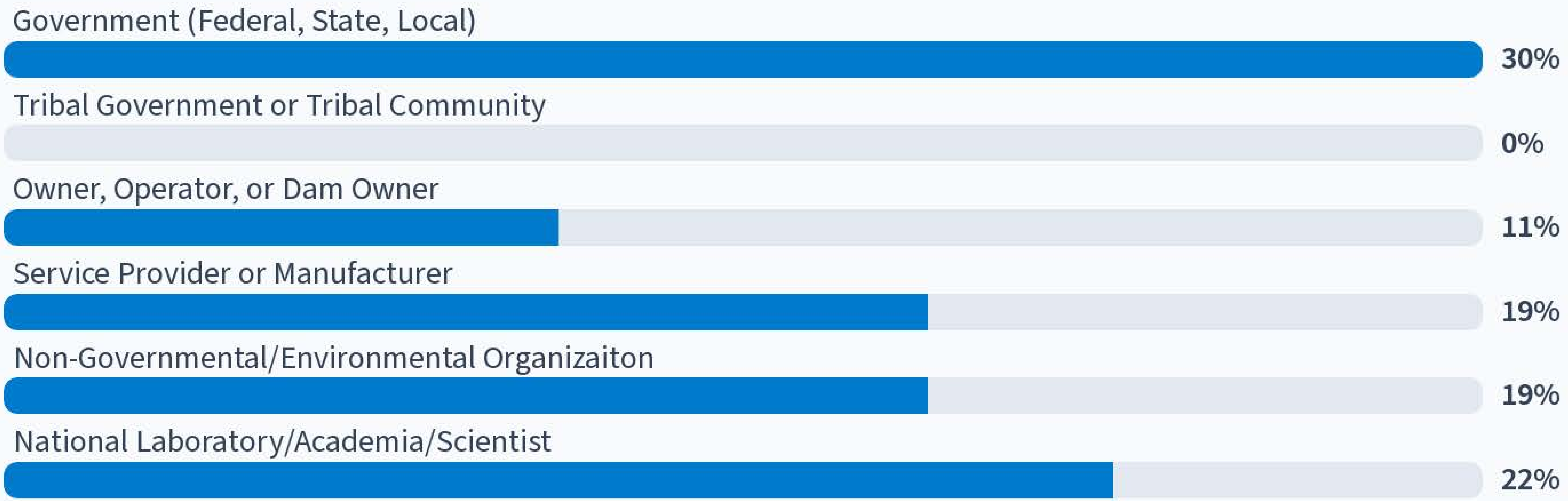


Introductory PollEverywhere Questions

- What sector do you represent?
- When you think about hydropower, sustainability/river restoration, and water quality, what is one word that comes to mind?

What sector do you represent?



When you think about hydropower, sustainability/river restoration, and water quality, what is one word that comes to mind?

Upcoming Speaker Discussion Questions

- How could we advance, adopt, or scale the use of these technologies?

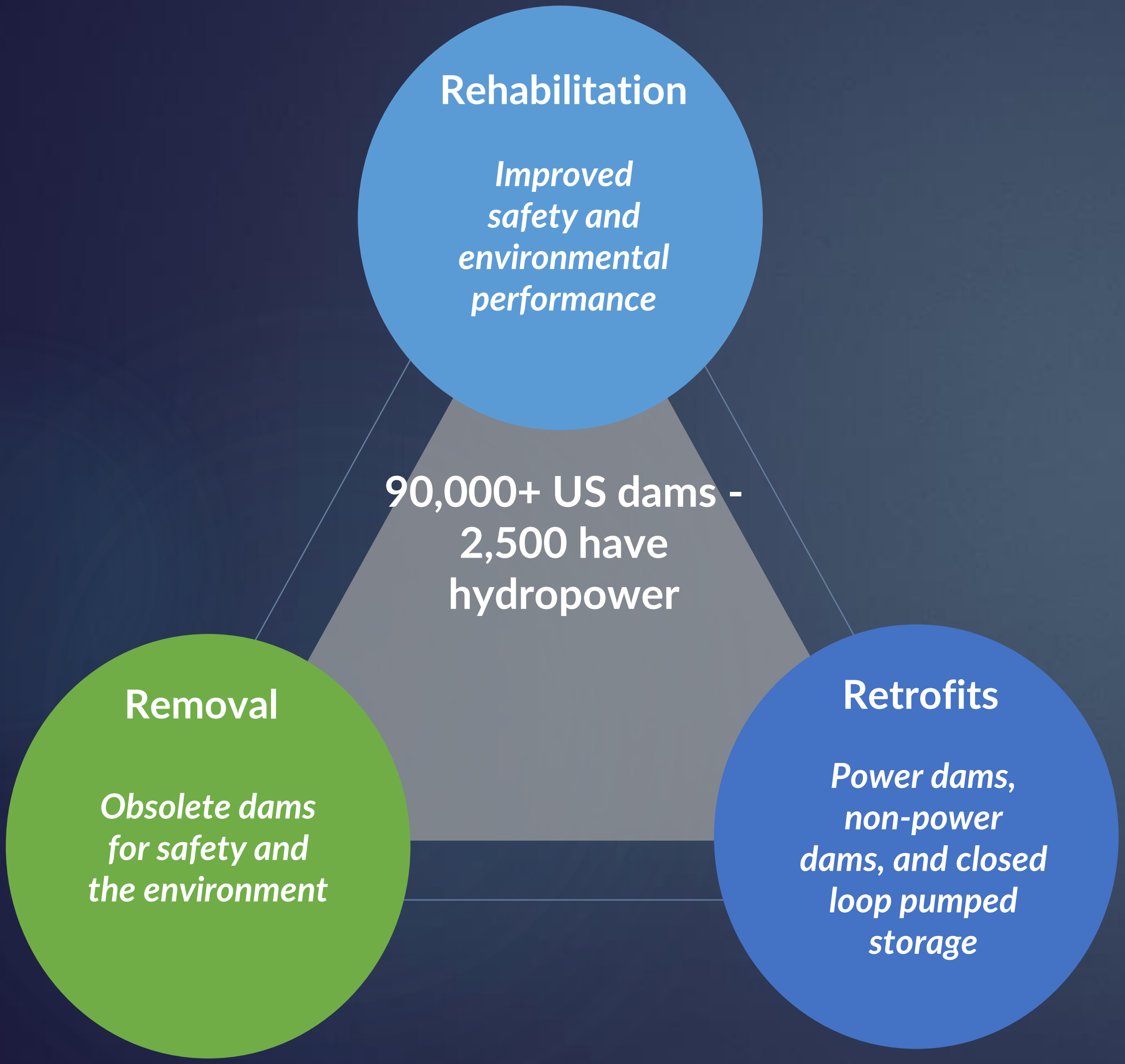
- What are the obstacles/barriers for these types of innovations?

Overview Presentation

Uncommon Dialogue on Hydropower, River Restoration, and Public Safety

Anna West, Founder & Principal, Kearns & West

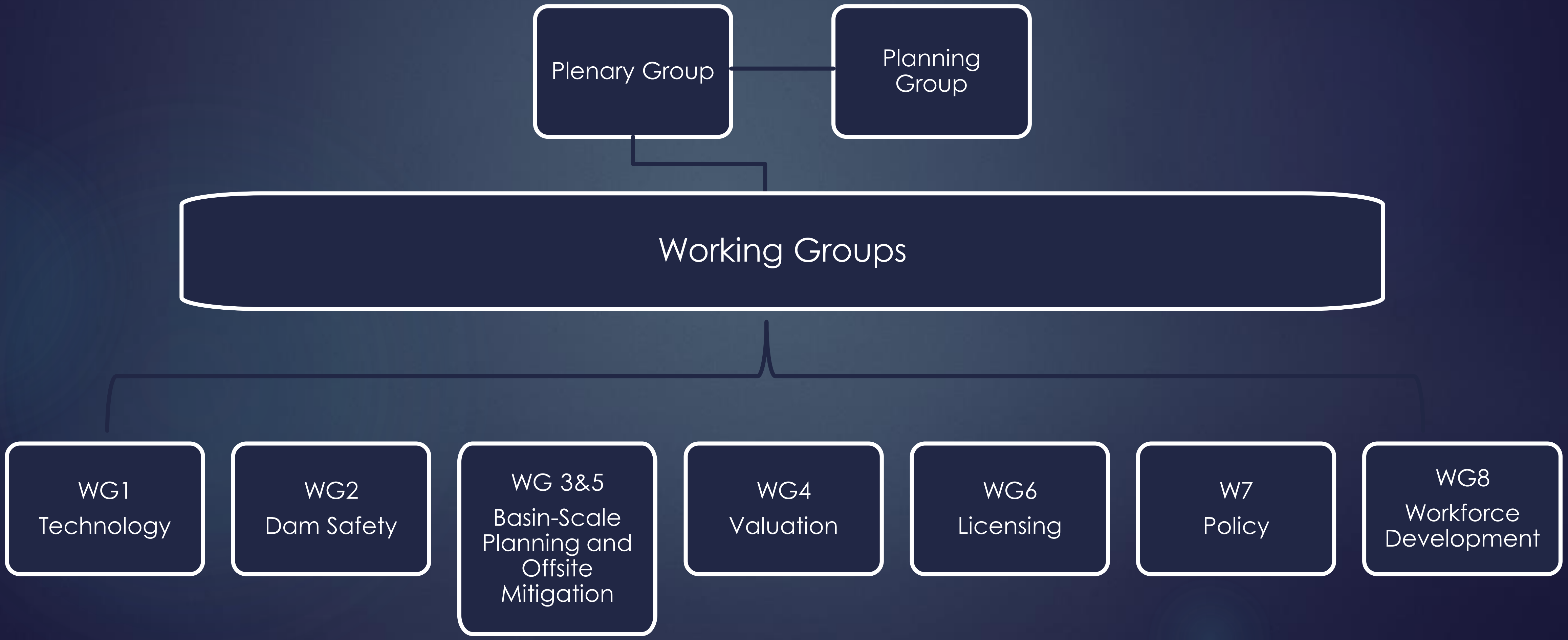
Uncommon Dialogue Background



- **Broad Goal:** To better address climate change – and protect rivers – through a smarter approach to hydropower river restoration and public safety in the United States.

- **Specific Objectives:** A 2020 Joint Statement between the U.S. hydropower industry and river conservation/environmental NGOs identified three opportunities to advance the renewable energy and storage benefits of hydropower and the environmental and economic benefits of healthy rivers – the "3Rs."

Uncommon Dialogue: Working Groups Organization



Uncommon Dialogue: Recent Accomplishments

Participation and Engagement

- Continued to expand membership and bring in new and varied perspectives.
- Three workshops for outreach and input on basin-scale planning.
- Op-Ed on dam safety and the 3Rs in The Hill.
- Launched new Working Group on Workforce Development and DEIA.

Products

- Advancing the Enhanced Environmental Performance Definitions Document.
- Published article on the hydropower flexibility valuation tool.
- Revising white paper on basin-scale planning.

The Uncommon Dialogue developed proposals and ideas that are gaining acceptance:

- Licensing Reform
- Dam Safety
- Tax Credits and Other 3Rs Ideas
- Implementation of IIJA Programs

Overview Presentation

Water Quality Background

Maryalice Fischer, Low Impact Hydropower Institute

Dams and Hydropower - Water Quality Effects

Receive, concentrate, transform:

Nutrients, Organics
Pathogens
Suspended Solids
Heavy metals
Toxics

Directly add:

Petroleum and other chemicals

Recreation pollution

Powerhouse wastewater

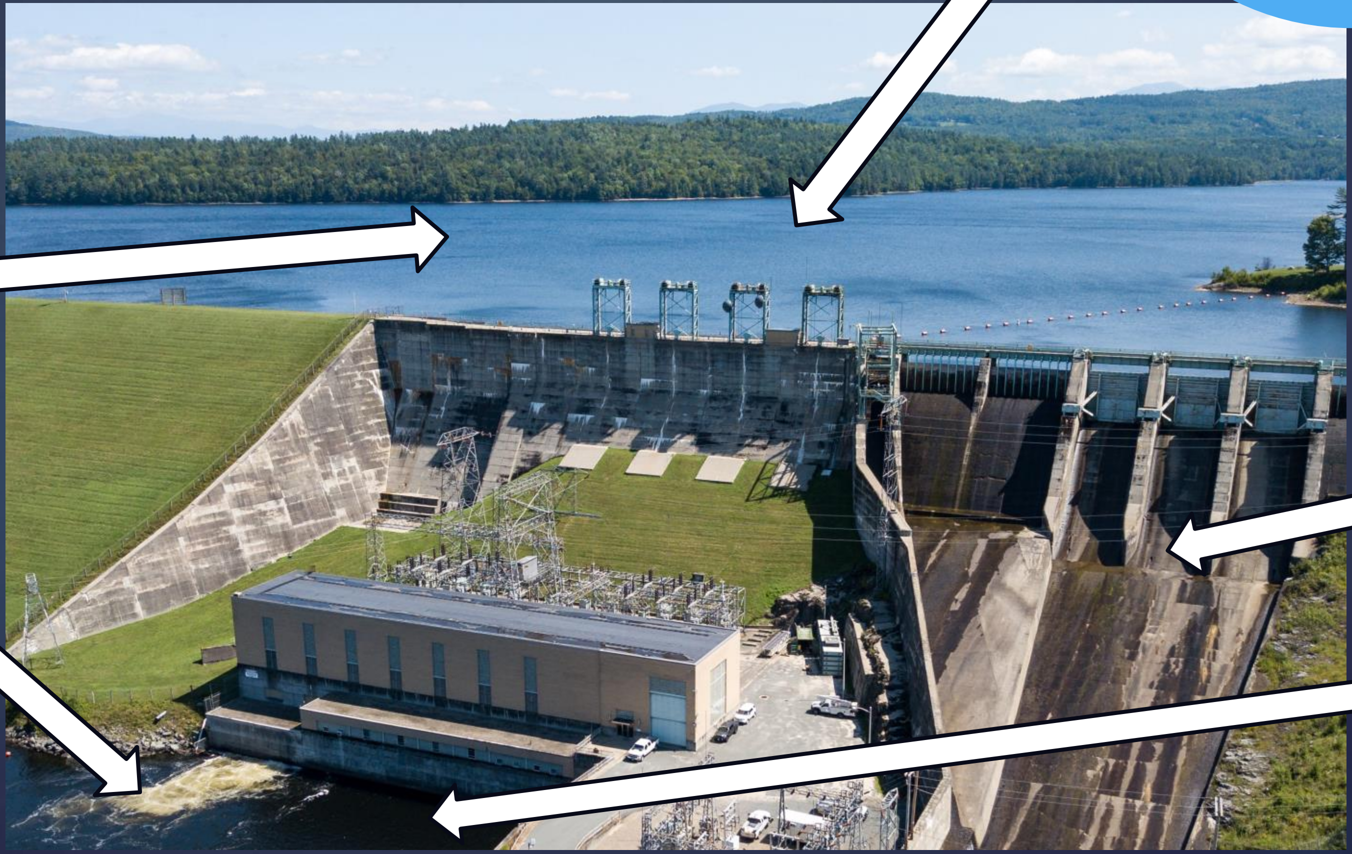


Image courtesy of Great River Hydro, LLC

Alter:

Dissolved Oxygen
Temperature
pH
Turbidity
Total Dissolved Gas

Today's Presentations

1. Real-time water quality monitoring leads to better understanding of operational impacts and sustainable management opportunities
2. Sustainable management is adaptive and responsive to data and incorporates long-term solutions
3. Operational best management practices can further reduce day-to-day impacts

Today's Speakers

1. Daniel Deng, Pacific Northwest National Laboratory, Laboratory Fellow and Director of Bio-Acoustics and Flow Laboratory
2. Neal Simmons, Eagle Creek Renewable Energy, CEO and President
3. Jeff DiMaio, VBASE Oil Company, CEO

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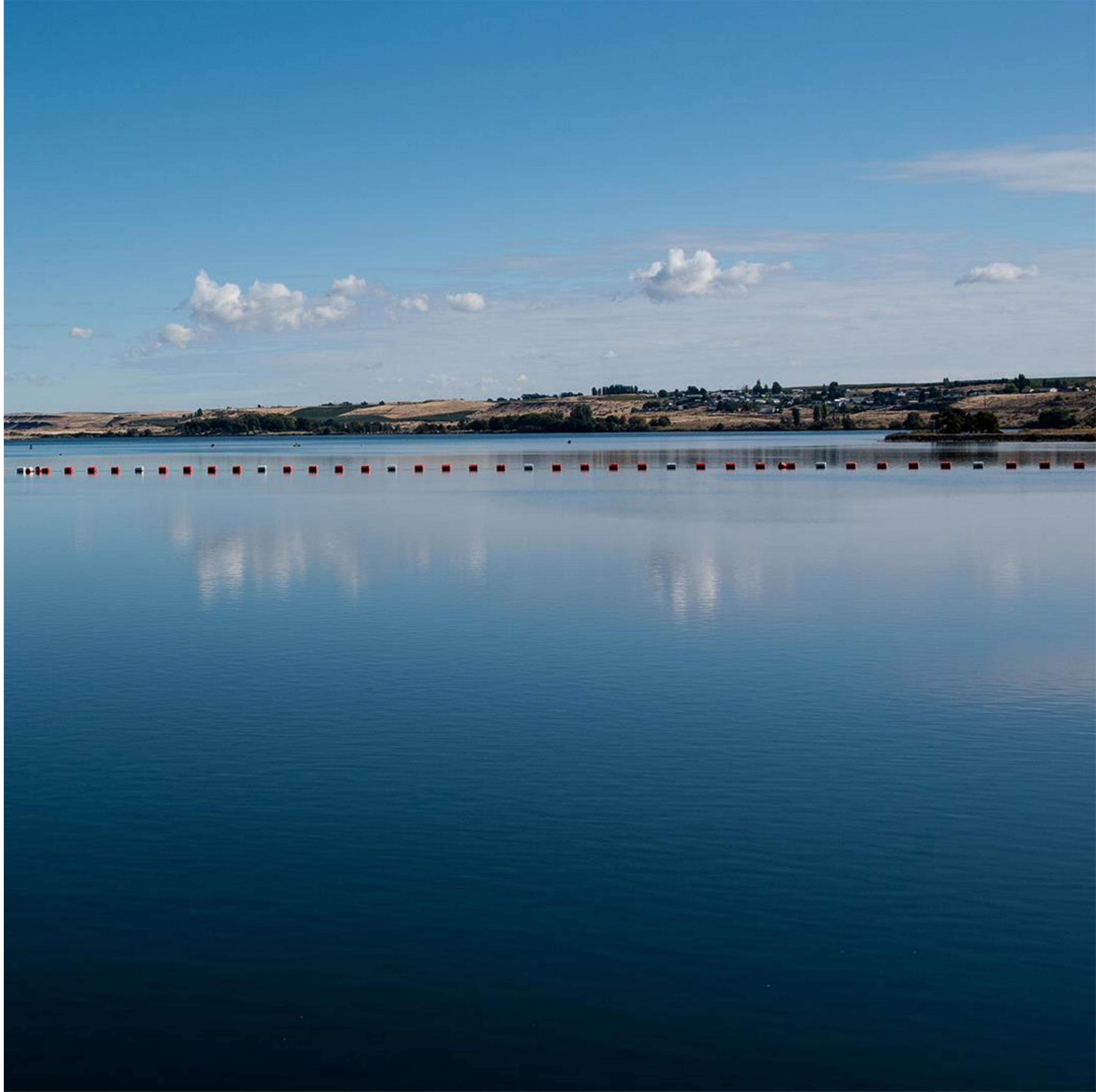
Autonomous Real-time Water Monitoring System

Daniel Deng, Aljon Salalila, Jayson Martinez,

Robbert Elsinghorst, Hongfei Hou

February 1, 2024

Uncommon Dialogue-Innovations for Sustainability Workshop: Water Quality

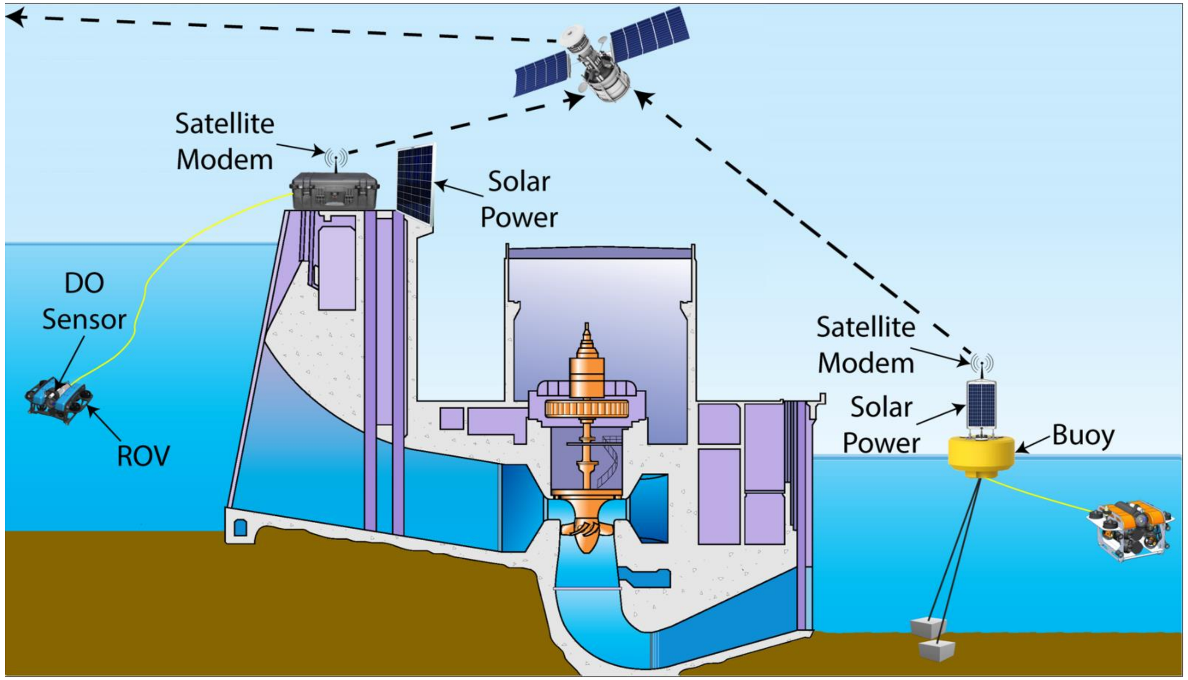


Project Objectives

- Objective
  - Develop a real-time and autonomous sensing system that can provide high-resolution, multi-position, multi-depth water quality measurements
- Goals
  - Enable safe, timely, and comprehensive water quality data collection
  - Reduce FERC and state water quality monitoring costs for compliance
  - Maximize power generation revenue with improved operational control
- Applications
  - Intended for operation in challenging water environments near hydropower facilities such as intake and tailrace

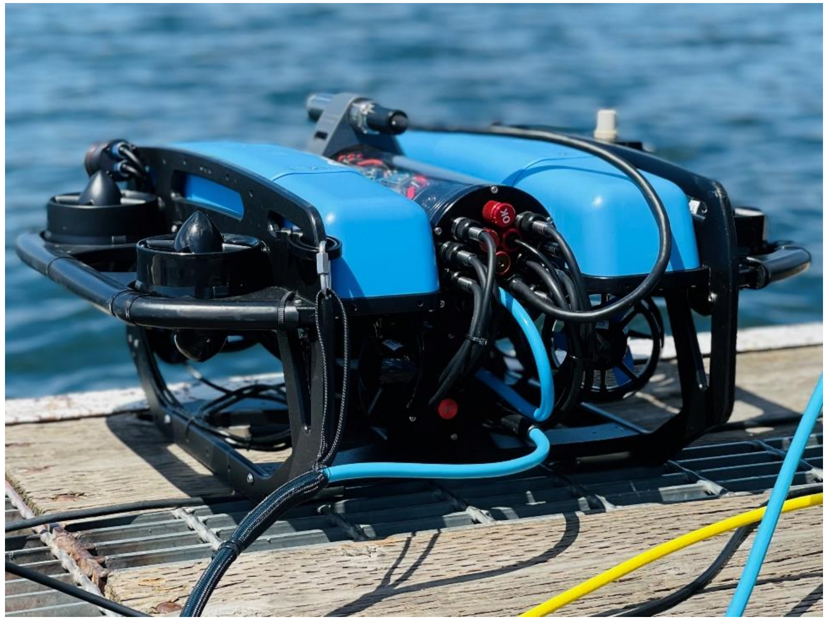
System Overview

Autonomous comprehensive measurements	Takes pre-programed measurements at multiple locations to provide sufficient temporal and spatial resolution
Self-powered	Harvests solar energy to support long duration autonomous operation
Wireless real-time communication	Transmits measurements to a web-based software interface
Modular and expandable	Carries various combinations of sensors (DO, TDG, temperature, etc.) via a modular mount configuration
Remote monitoring of sensor	Monitors onboard sensors through real-time camera images to detect biofouling or other potential issues
Worker safety	Travels to shore--away from the dangerous water environment where it is deployed-- for maintenance
Alternative configurations	Two versions of the system were developed, a dam structure-based version and a buoy-based version



Dam Structure-Based Version

- Remotely operated vehicle (ROV) is deployed from the forebay deck and tethered to equipment above the water surface
- System can be powered using 110-V AC power or solar power
- ROV can operate at distances of up to 300 m from the deployment location
- Useful for gathering upstream data for modelling the effect of the hydropower operations

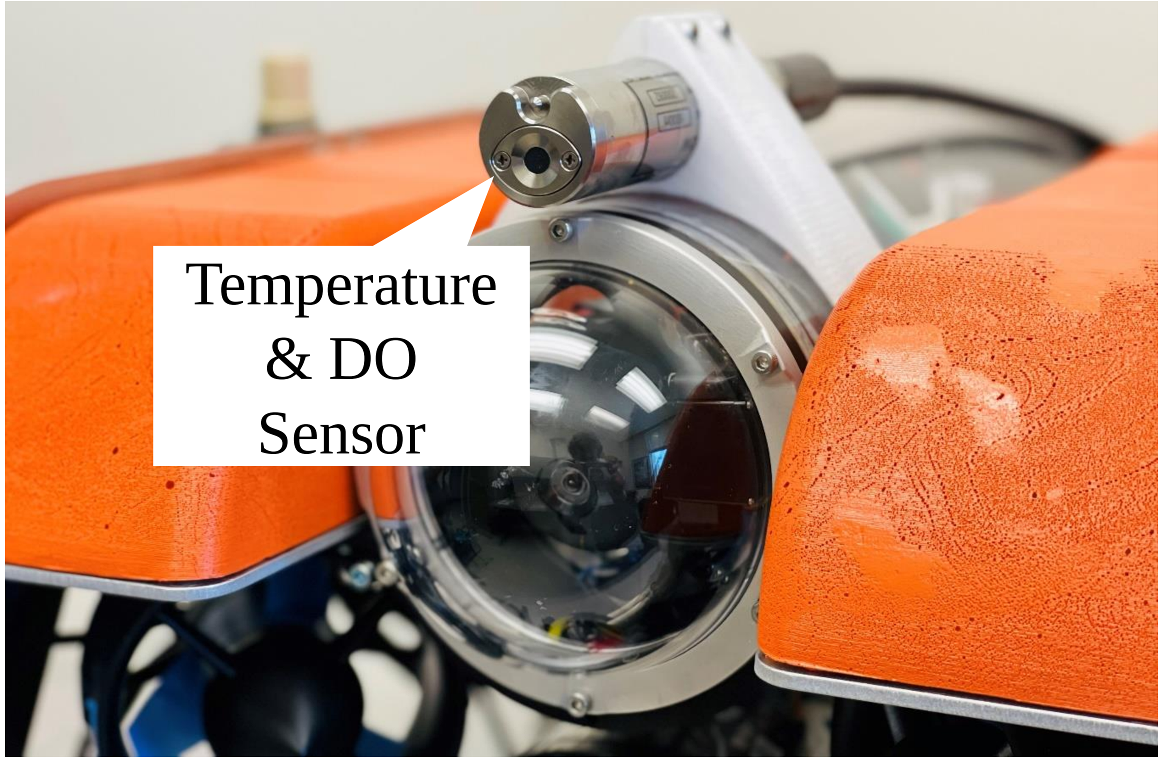


Buoy-Based Version

- ROV is deployed from a floating platform at locations either downstream or further upstream than the dam structure-based version
- Platform includes a solar power system
- ROV can operate at distances of up to 300 m from the platform
- Useful for gathering upstream data for modelling the effect of the hydropower operations or downstream data for monitoring the operation’s effects on water quality

Modular Design

Adaptable for a variety of water quality sensors



RBR*coda*^{3} T.ODO Temperature & Dissolved Oxygen (DO) Sensor

Hydrolab MS5 Multiparameter
Mini Sonde (w/ total dissolved gas [TDG] sensor)

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Underwater Positioning System

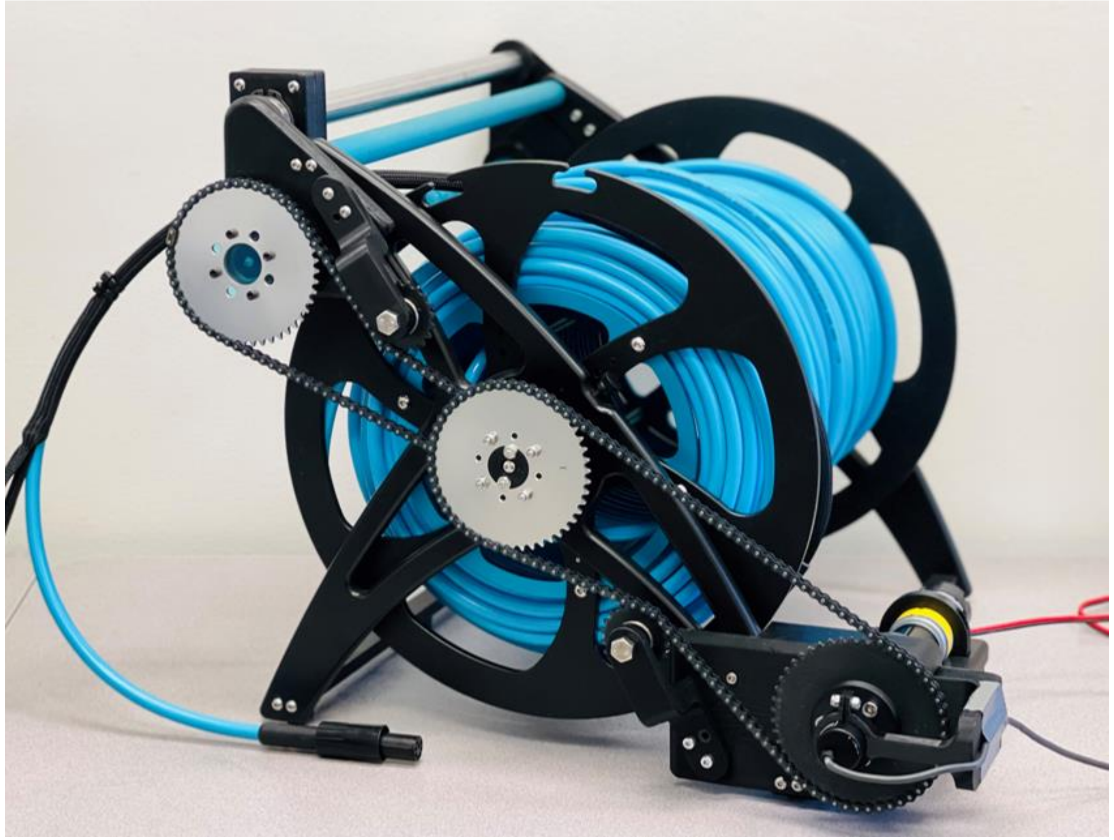
- Enables autonomous functionality by providing absolute position of the ROV while underwater
- Short Baseline (SBL) underwater acoustic positioning system
- Utilizes:
  - Acoustic locator beacon on the ROV
  - Hydrophones (x4) at fixed locations
- Range up to 300 m and an accuracy of <1% of distance

Surface Electronics w/ GPS

Acoustic Locator Beacon

Hydrophone (x4)

Automatic Tether Management System



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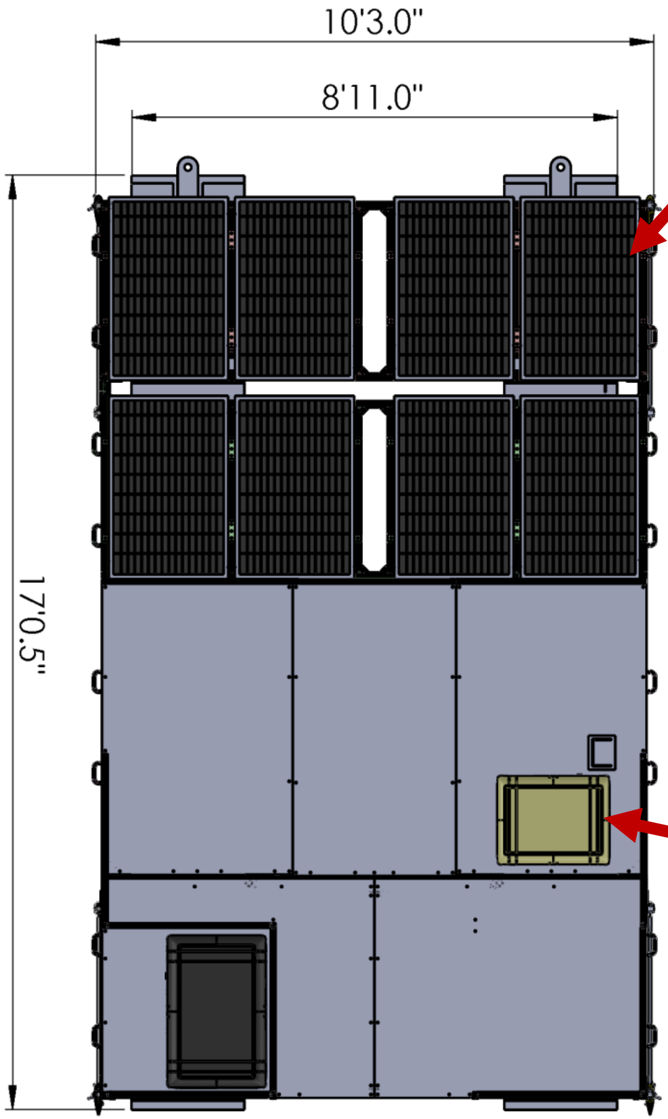
Surface Power Unit

- Provides the ability to power the ROV from the surface, which enables the use of a solar power system
- Allows system to operate for extended periods since there is no battery in the ROV
- Surface Power Unit integrated provides 500-W of power to the ROV
  - Provides sufficient power for the BlueROV2 Heavy Configuration
  - More powerful unit can be used for providing power for the T12 ROV

Surface Power Unit

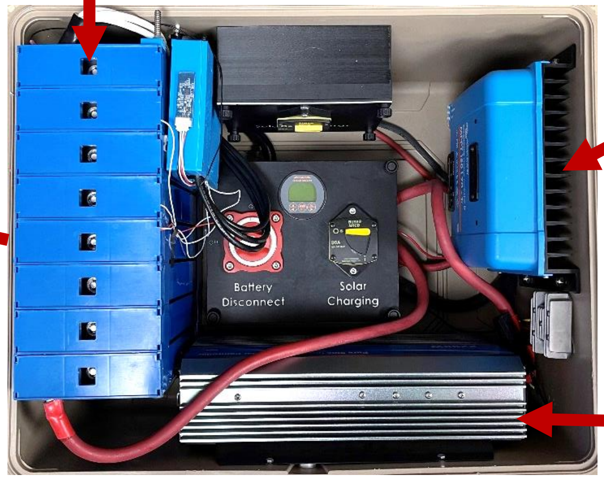
Vehicle Power Unit

Floating Platform Deployment System



100 W
Solar Panel
(x8)

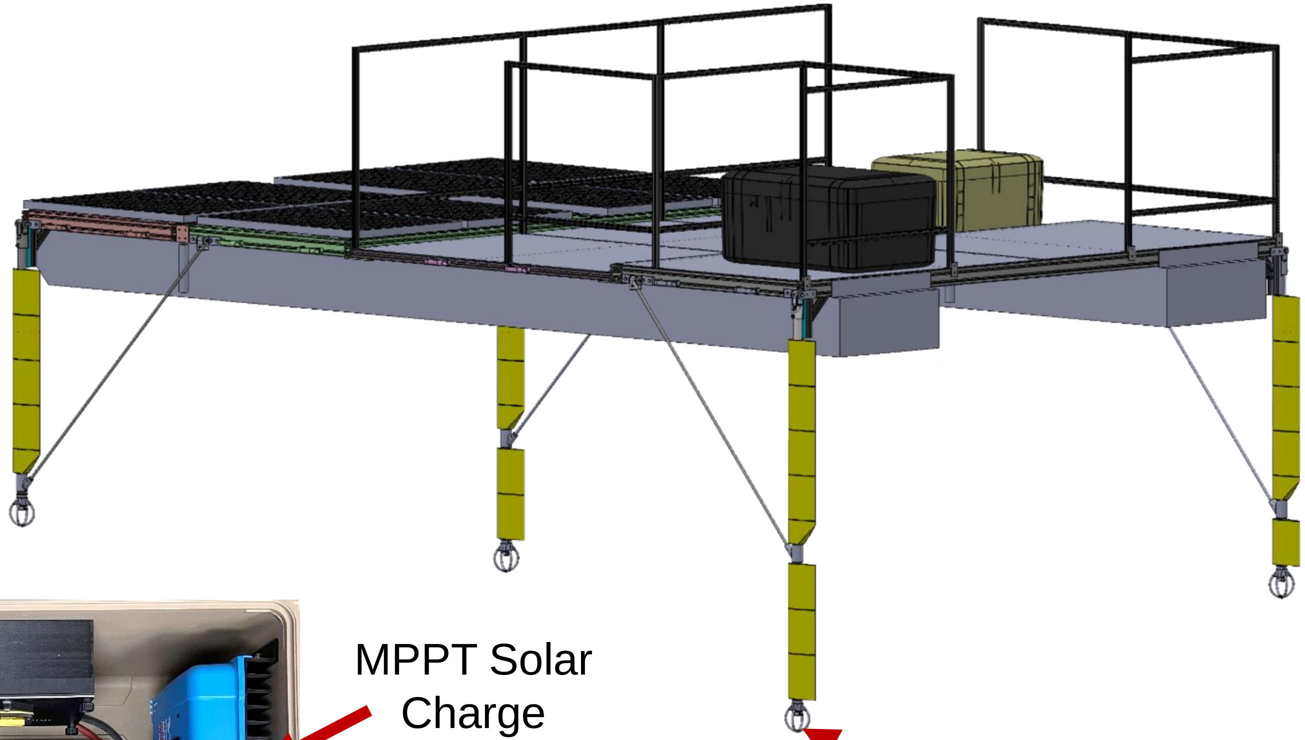
12 V 200 Ah
$LiFePO_4$ Battery



Power Management Electronics

MPPT Solar
Charge
Controller

2000 W Inverter



Hydrophone for
positioning
system (x4)

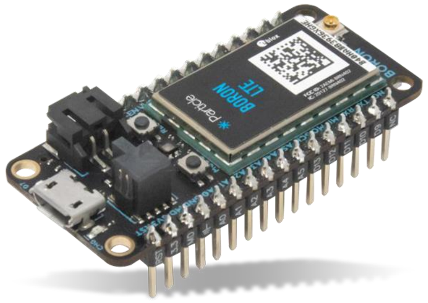
Floating Platform Deployment System

- Platform designed to be modular to facilitate shipping
  - Two pontoons
  - Four aluminum framed panels

Data Communication

- Variety of communication methods implemented to provide different options:
  - Direct connection to internet Wi-Fi/Ethernet
    - ✓ Best option if already present
  - Satellite telemetry using Iridium network
    - ✓ Pros: Works anywhere, relatively low power needs
    - ✓ Cons: Most expensive option, not feasible/possible to upload images
  - Cellular telemetry
    - ✓ Pros: Low power needs, relatively low cost
    - ✓ Cons: Only works at sites with cell coverage, uploading images possible but not readily implementable
  - Starlink internet service
    - ✓ Pros: Provides direct connection to internet from anywhere
    - ✓ Cons: High power needs

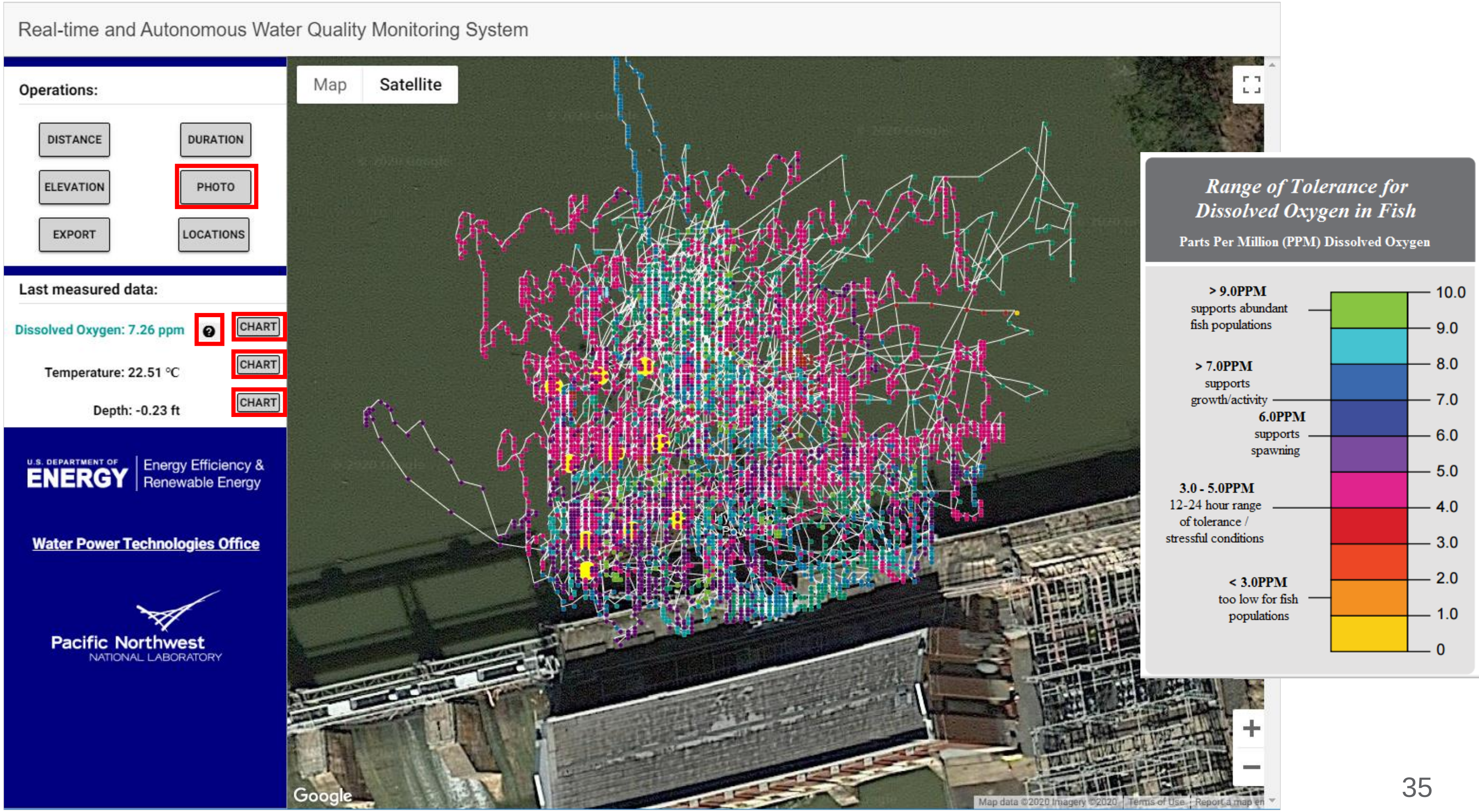
Satellite Telemetry Module



Cellular Telemetry Module

Starlink Dish

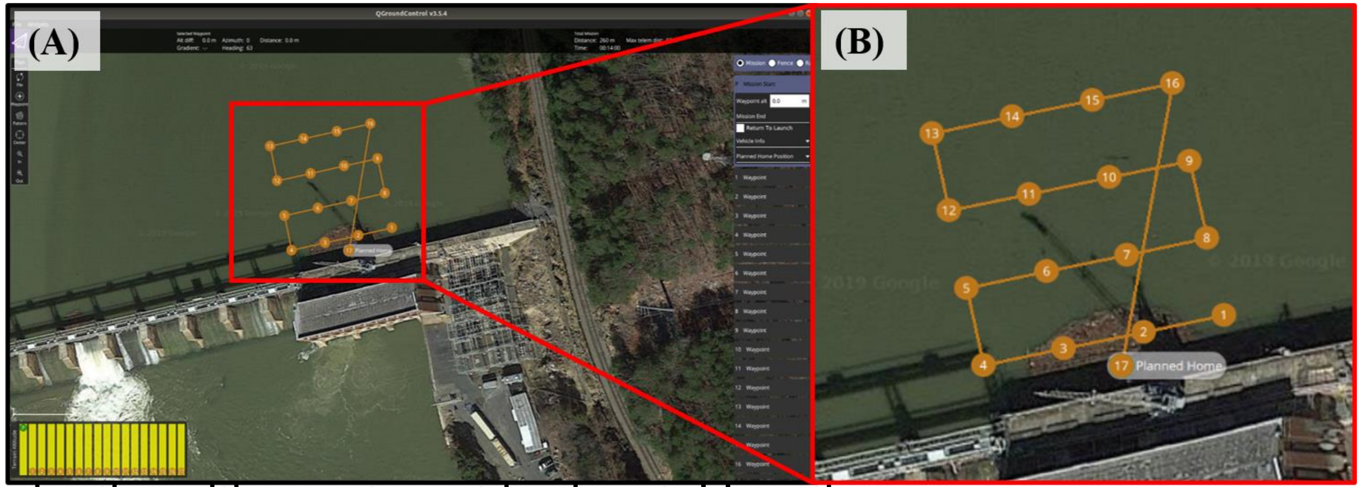
Web-Based User Interface



Mission Types

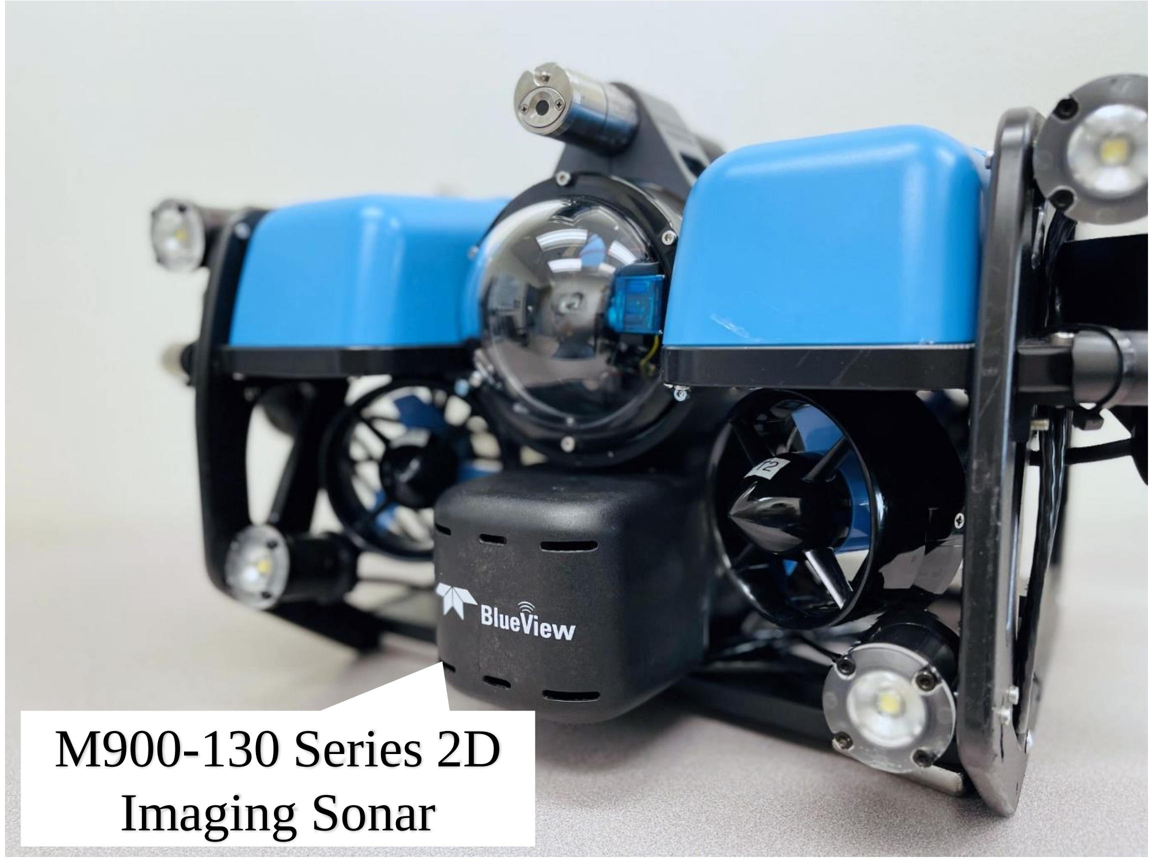
To simplify data collection and analysis, missions are categorized into two groups as follows:

- Multi-Location Mission
  - Route consisting of multiple pre-determined horizontal locations with one target depth.
  - Enables measurements to capture contour over a specified area.

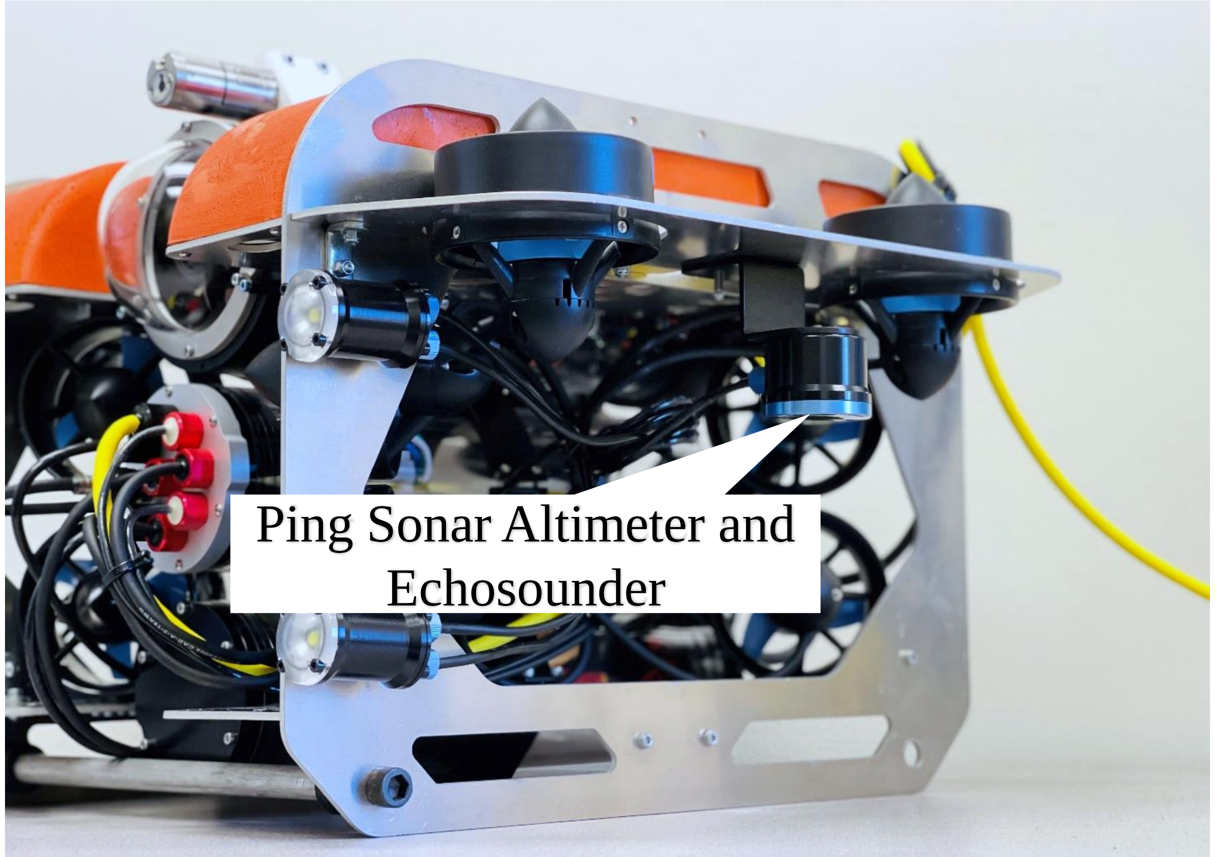


- Multi-Depth Mission
  - Route consisting of multiple predetermined depths with one target horizontal location.
  - Enables measurements to capture stratification with depth.

Active Acoustic Sensing Devices



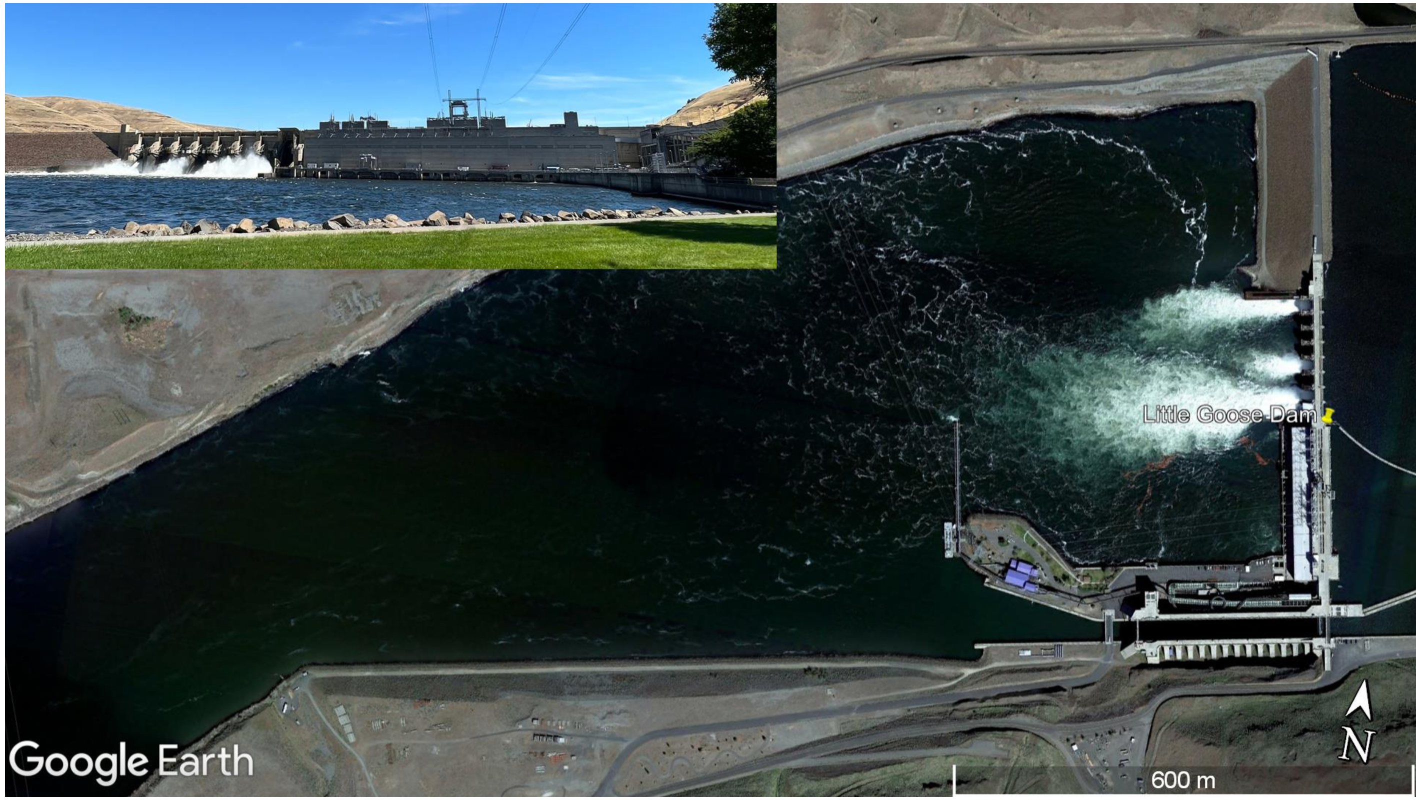
Forward-looking multi-beam imagining sonar



Down-looking single-beam echosounder

Pilot Study Site: Little Goose Dam, Washington

- Little Goose Dam is located on the Snake River in the Columbia River Basin (CRB)
- During high flow periods in the CRB it can often be necessary to spill more than is necessary to safely pass fish downstream
- High spill can increase dissolved gas levels in the water
- When Total Dissolved Gas (TDG) levels are high it can cause gas bubble disease in fish



Pilot Study Site: Little Goose Dam, Washington

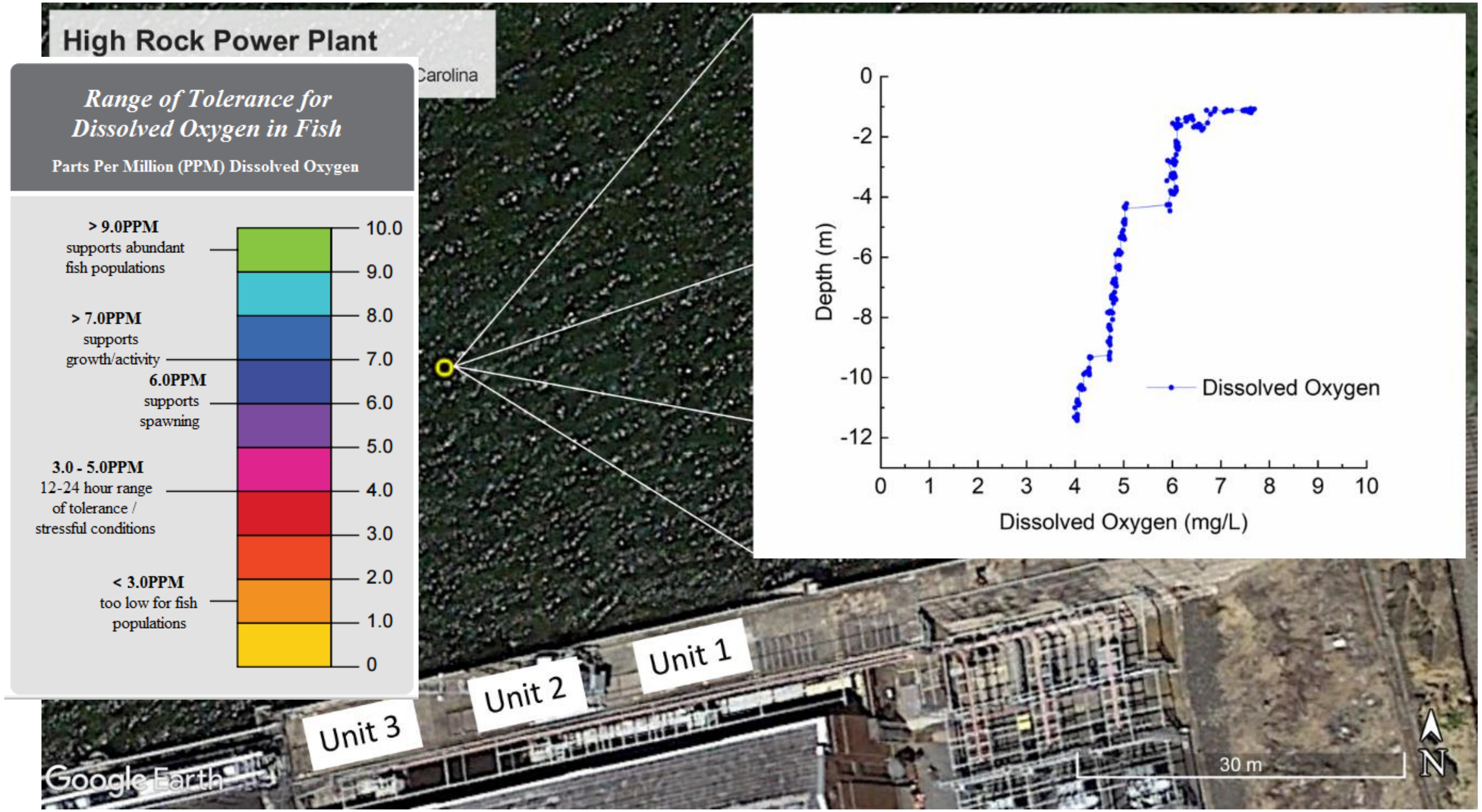
- Buoy-based version of the system was deployed to demonstrate the ability to monitor TDG across the river in the tailrace ~1.2 km downstream
- Used BlueROV2 w/ surface power unit and solar power system
- Tailrace flow was near the limit for the BlueROV2
- Even with ROV operating constantly near max thrust was able to be powered entirely from the solar power

Pilot Study Site: High Rock Dam, North Carolina

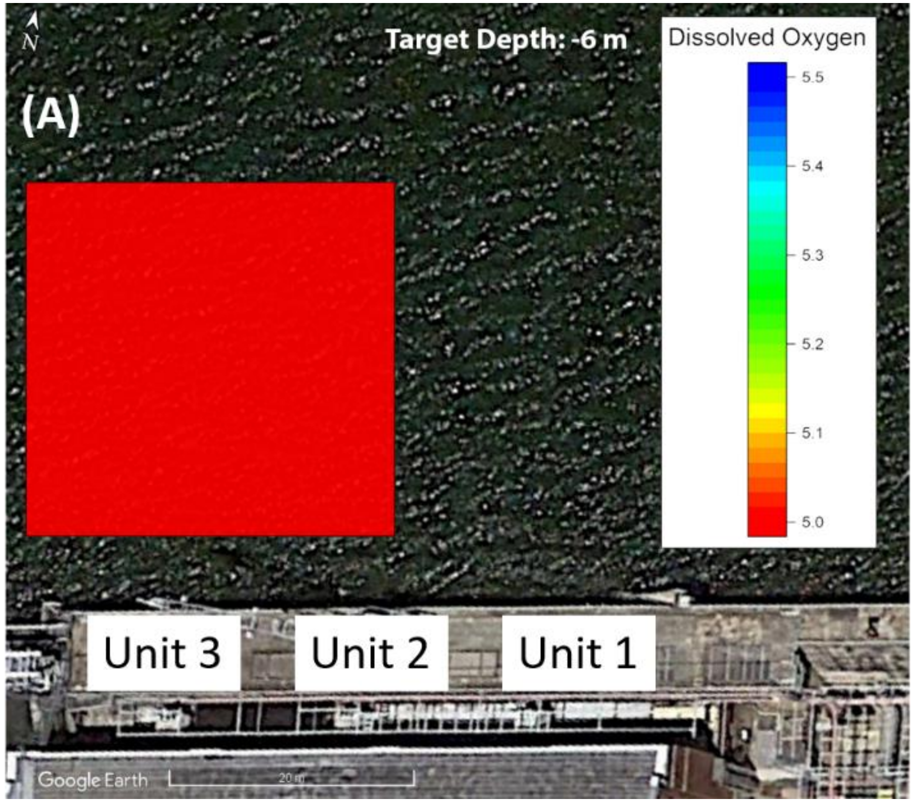
- High Rock Dam is in North Carolina on the Yadkin River
- High Rock Dam had experienced difficulties maintaining minimum levels of dissolved oxygen, so Eagle Creek developed and deployed two mitigations measures:
    - Adapting an existing spill gate to aerate spill
    - Installing GE’s new aerating Francis turbine

Pilot Study Site: High Rock Dam, North Carolina

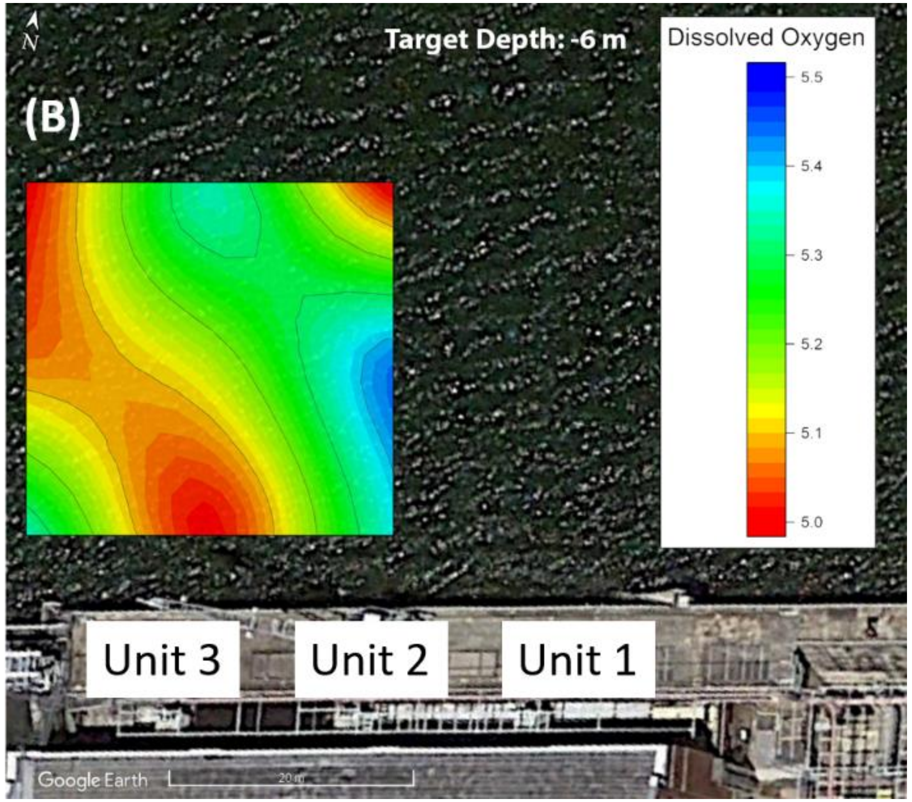
- Multi-depth missions demonstrated a clear stratification of DO
- Measurements between 1-12 m depth at 0.5 m increments
- In this example, as the ROV descended there were distinct drops in DO at ~4.5 m and ~9.5 m



Pilot Study Site: High Rock Dam, North Carolina



No power generation



Power generation at Unit 1

- Multi-location missions demonstrated the effect of power generation
- In this example at 6 m depth, DO was a uniform ~5 mg/L with no generation and non-uniform average of ~5.3 mg/L when Unit 1 was generating

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Project Summary

- Enables improved measurements in challenging locations
- Reduces risks to workers
- Provides greater spatial coverage of measurements
- Improves communication between the sensor and dam operators
- Can help identify and better understand complex issues such as when to implement mitigations
- Provide more accurate data for water quality models that inform compliance
- Enables real-time operational changes to reduce impacts, and potentially increase generation or system flexibility

We are looking for more partnerships to improve, optimize, and demonstrate the technology to move toward commercialization.

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Acknowledgements

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Water Power Technologies Office

Funding

- U.S. Department of Energy Water Power Technologies Office

Project Partners

- BlueRobotics
- Charles Stuart University
- Columbia River Inter-Tribal Fish Commission (CRITFC)
- Eagle Creek Renewable Energy
- Sapere Consulting
- Southern Company
- U.S. Army Corps of Engineers

Thank you

Zhiqun.deng@pnnl.gov
http://JSATS.pnnl.gov/

PollEverywhere: How could we advance, adopt, or scale the use of this technology?

- Increase database size by integrating USGS data (available to public) with more detailed data. Not all hydropower plants have publicly available water quality or stream data.
- There is obviously more work in developing this system. Not sure if it would be cost prohibitive but cost is always a hurdle to overcome. Could this system be more automated. It has already come up that having standard locations/depths would be a key. I would doubt that standards could be accomplished without more testing. This system presents some differences in current technologies so it needs more work in the field. (Current tech usually deploys where it can be accessed and not necessarily in the best location.
- Depending on sensor availability this could be useful for many water quality monitoring applications outside of hydro power
- can you review by regions and begin to see similarities between which could be then extended? which conditions can be applied across water systems?
- Apply data to ecosystem service valuation methodologies to ensure BMPs are supporting economic cases for adopting sustainable practices.
- consider measuring methane in water related to reservoir greenhouse gas emission (not water quality)
- Provide initial and ongoing costs and compare to other WQ monitoring methods.
- More testing and demonstration projects; collaborative funding between DOE and Owner & Operators for demonstration projects;
- This could help with adaptive project management.
- more demonstrations for different applications
- A standard or normalized measurement plan will be essential. Daniel and team's data is great and can help determine operating plans and characteristics. How do we take this level of data acquisition and reduce it for everyday use?
- Modulize it as standard and test on variety site for verification
- collect much more data across the many variables which should help to demonstrate if patterns, understandings begin to appear.
- Deploy it in multiple, different environments to determine where it is suitable; compare data obtained from this system to more conventional monitoring and compare.
- Lakes and Reservoirs:
  Guidelines for Study Design and Sampling USGS publication
- Have a clear regulatory framework to define when & where measurements should be taken
- Collaboration
- use it to update: https://pubs.usgs.gov/tm/09/a10/tm9a10.pdf

PollEverywhere: What are obstacles/barriers for these types of innovations?

- Need standard approaches for planning and deploying the tech
- Institutional turf ("this is how we've always done it ")
- The data stream would complex (but impossible) to analyze. Time series with depth and lat lon.
- As Anna said, the definition of how to regulate measurement: what/where/how. It is hard to hit a moving target.
- Scaling up
- Maintenance cost(when it goes to commercialization)
- How to utilize the outputs of these devices to change operations of a plant to improve on the conditions.
- Early stage system development costs.

High Rock Dam on the Yadkin River in North Carolina

Improving Dissolved Oxygen Levels at High Rock Dam

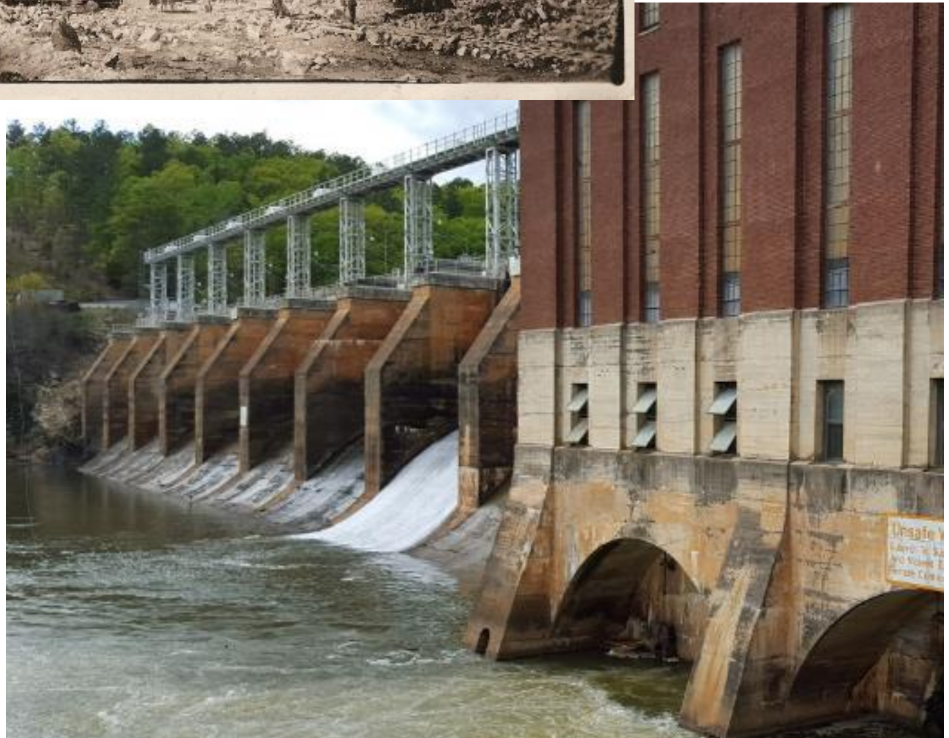
W. Neal Simmons, *President and CEO*

February 1, 2024

EAGLE CREEK
— RENEWABLE ENERGY —

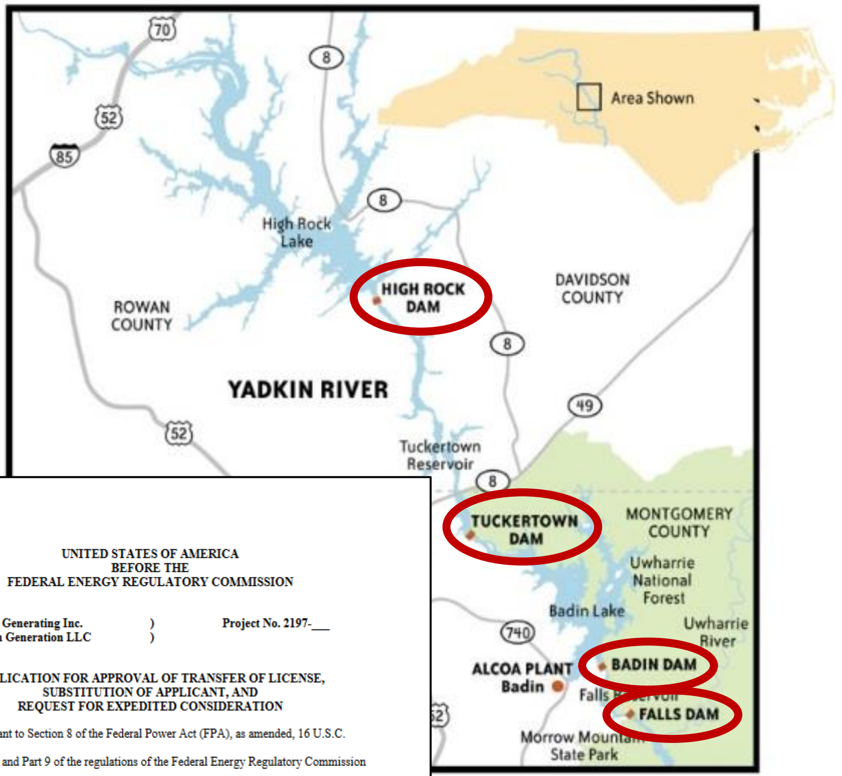
High Rock Dam

- Year Completed: 1927
- High Rock Lake
  - Drainage Area: 3,973 Sq Miles
  - Lake Surface Area: 15,180 Acres
  - Available Storage: 234,100 Acre-ft
- High Rock Dam 936 Ft. long
  - Concrete Gravity
  - Gated Spillway
  - Max head: 59 Feet
  - Hydraulic capacity: 11,040 CFS
- High Rock Powerhouse
  - 3 Units X 13.2 MW-I, Vertical Francis Turbines
  - Total Licensed Capacity: 39.6 MW



Cube’s Yadkin River Portfolio

- Cube acquired Yadkin Hydropower assets from Alcoa in 2017
  - High Rock: 39.6 MW
  - Tuckertown: 38.04 MW
  - Narrows: 110.4 MW
  - Falls: 31.1 MW
- Yadkin Re-licensing requires improvements in Dissolved Oxygen (DO) to improve river health
  - Instantaneous: 4.0 mg/L
  - Daily Average: 5.0 mg/L
- DO Solutions needed for generating and non-generating periods
  - Aerating turbine
  - Howell-Bunger valve



UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Alcoa Power Generating Inc.	)	Project No. 2197-___
Cube Yadkin Generation LLC	)	

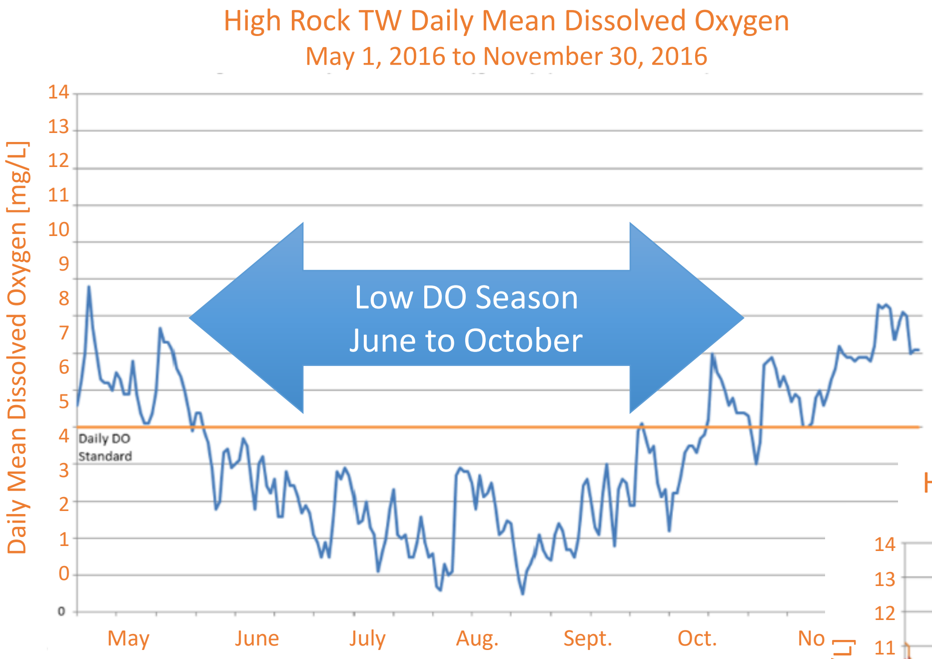
APPLICATION FOR APPROVAL OF TRANSFER OF LICENSE,
SUBSTITUTION OF APPLICANT, AND
REQUEST FOR EXPEDITED CONSIDERATION

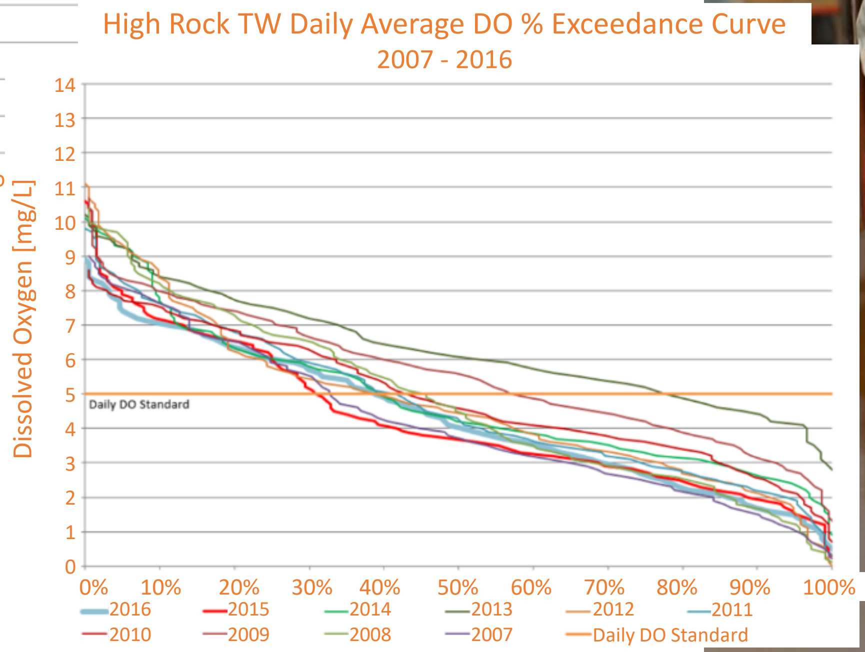
Pursuant to Section 8 of the Federal Power Act (FPA), as amended, 16 U.S.C. § 801 (2012), and Part 9 of the regulations of the Federal Energy Regulatory Commission (Commission or FERC), 18 C.F.R. Part 9 (2016), Alcoa Power Generating Inc. (APGI), licensee for the Yadkin Project, FERC Project No. 2197 (Yadkin Project or Project), and Cube Yadkin Generation LLC (Cube Yadkin, and together with APGI, Applicants), hereby jointly and severally submit this Application for Approval of Transfer of License (Application) from APGI to Cube Yadkin. As discussed below, Applicants also request expedited consideration of this Application to meet the closing date set forth in the acquisition agreement.

The Yadkin Project is an approximately 212 MW hydroelectric project located on the Yadkin River in Stanly, Montgomery, Davidson, and Rowan Counties, North Carolina. It consists of four individual developments, each with a dam and reservoir: Falls, Narrows, Tuckertown, and High Rock, located at river miles 234, 237, 244, and 253, respectively. The Commission originally granted the Yadkin Project a 50-year license in 1958.[1] On April 25, 2006, APGI filed an application for a new license for the Project. APGI filed a comprehensive Relicensing Settlement Agreement on May 7,

[1] *Carolina Aluminum Co.*, 19 FPC 704 (1958).

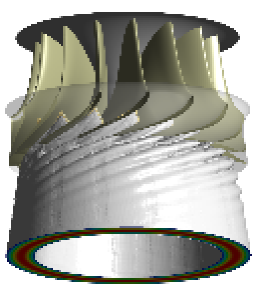
High Rock: Historical DO levels





Improving Dissolved Oxygen on the Yadkin

- DO levels in High Rock and Tuckertown tailwaters periodically fall below the State standards during the summer and fall (May – November)
- Cube Yadkin understands the importance of meeting water quality standards, including DO
- Investing in R&D and technology to meet standards:
  - Direct oxygen injection in penstock and scroll cases
  - Central aeration
  - Howell-Bunger Valves
  - Draft tube aeration
  - Distributed aeration (GE)
  - Linear Aerating Valves
  - Advanced controls, measurement, and prediction



Request NCDEQ to modify condition 12c in the 401 to replace the requirement of the Howell-Bunger valve with the use of the Linear Cone Valve.

Traditional Solution

Howell-Bunger Valve

Advantages:

- Proven technology

Challenges:

- Reduced dam integrity
- Impact to NRHP eligible facility
- Boat/Fishing safety
- Impacts recreation
- Fatigue failure from jet dynamics
- Long installation time
- Portion of water has limited exposure to atmosphere, limiting oxygen pickup.

Alternative Solution (Linear Aerating Valve)

Advantages:

- Breaks flow into droplets for exposure to atmosphere in same manner as a Howell-Bunger type valve, but provides greater aeration
- Easily installed on existing spillway gates and utilizes gate motion and hydrodynamic forces to adjust valve setting
- Valve can be configured to self-regulate flow or vary oxygenation
- 20X reduction in installation time
- Safer for downstream recreation
- Maintains integrity of dam
- Preserves historic attributes of facility

Challenges:

- New solution with limited field experience
- Limited to facilities with spillways, such as the facilities on the Yadkin river

Linear Cone Valve on Gate 1 at Tuckertown

Currently installed at High Rock and Tuckertown facilities

GE's New Aerating Inter-Blade Turbine

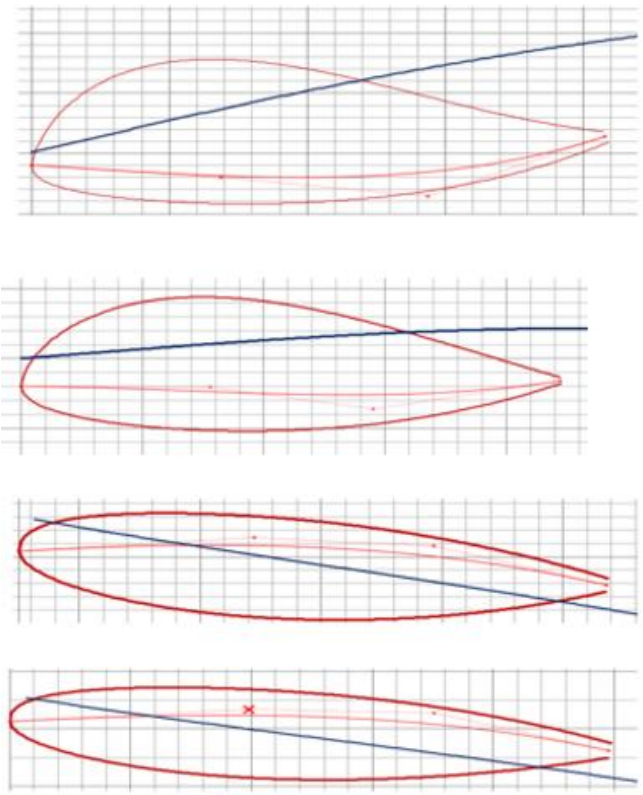
- First deployment of GE's state-of-the-art aerating turbine technology provides key environmental benefits while improving water quality at all times when combined with proprietary linear aerating valves
- Turbines, generator, balance-of-plant, station systems and building services all being upgraded
- Significant Cost savings from original pre-acquisition estimates

Installation of Coils on Unit #1 Rotor

High Rock Unit #1 (GE's Aerating Turbine)

Flexible Design of Inter-Blade Profile Optimized using High Fidelity Modeling

Customizable aerating profile between adjacent blades



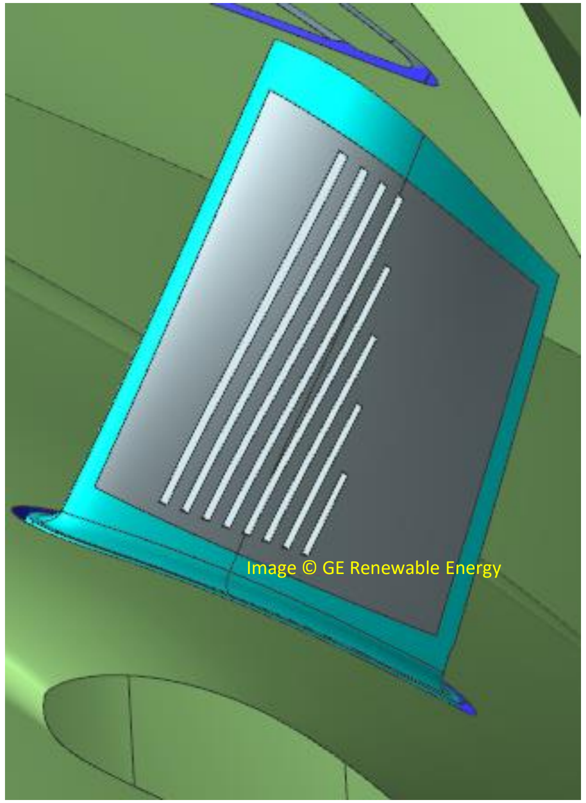


Image © GE Renewable Energy

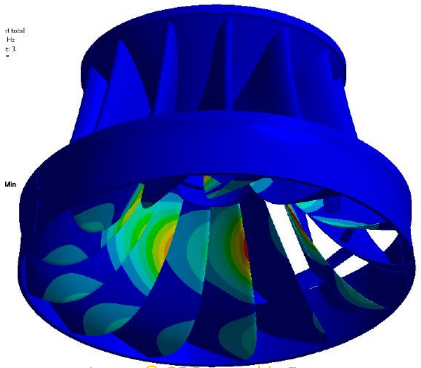


Image © GE Renewable Energy

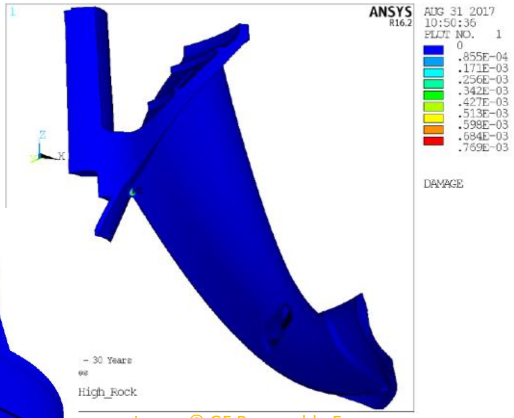


Image © GE Renewable Energy

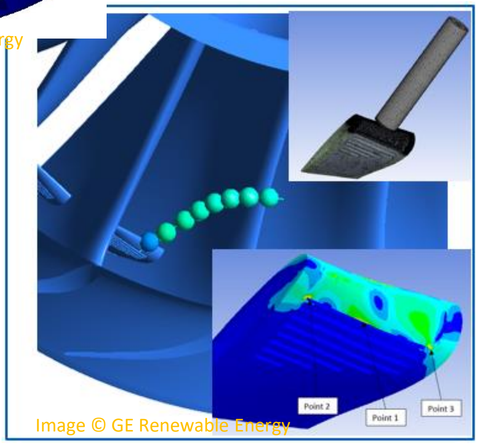


Image © GE Renewable Energy

GE's aerating turbine solution: Inter-blade profiles

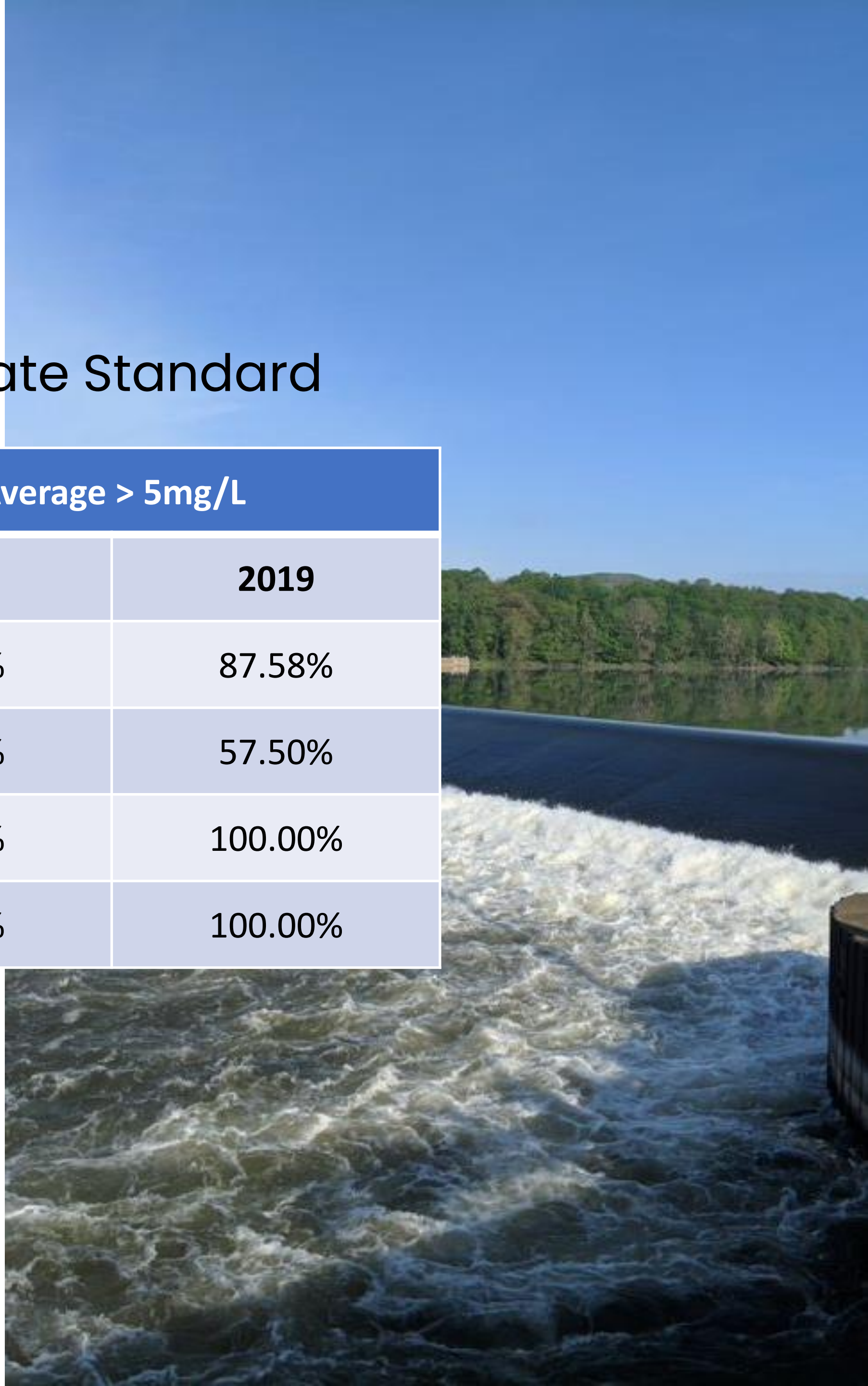
- Distributed aeration runner with inter-blade profiles for air injection
  - Design methodology applied to Wateree
  - High Rock site testing: DO > 5mg/L
  - Inter-blade profile:
  - Best DO performance
  - Maximum unit efficiency
  - Profile optimized for your turbine operating conditions

High Rock Linear Cone Valve and Monitoring Setup

Significant Improvement in Yadkin Water Quality

- Percentage of time water quality exceeds State Standard

	Instantaneous > 4mg/L		Average > 5mg/L	
Facility	**2018**	**2019**	**2018**	**2019**
High Rock	57.41%	95.30%	41.10%	87.58%
Tuckertown	66.00%	81.98%	41.79%	57.50%
Narrows	96.28%	99.47%	91.03%	100.00%
Falls	98.72%	99.37%	94.44%	100.00%



Innovation is Critical to Hydropower's Success

PollEverywhere: How could we advance, adopt, or scale the use of this technology?

- Standard deployment patterns should help scale
- more installations and document the testing and benefits/risks
- how do you publicize this work? who is aware of it? can we help to tell your story to bigger population?

PollEverywhere: What are obstacles/barriers for these types of innovations?

- DO is a very site specific issue so we would need to show that this turbine technology would work in various applications.
- Costs
- cost, especially for smaller projects

Innovations for Sustainability:
Environmentally Acceptable Lubricants (EALs) in Hydropower

Jeff DiMaio, PhD
CEO, VBASE Oil Company

vbase®

2/1/2024

Innovations in EALs

Environmentally Acceptable Lubricants

Limitations of Natural Oils and Fats

Environmentally Friendly, Limited Performance

Thermal Stability:
High temperatures cause oxidation
Cold temperature cause crystallization

Hydrolytic Stability: breaks down in presence of water

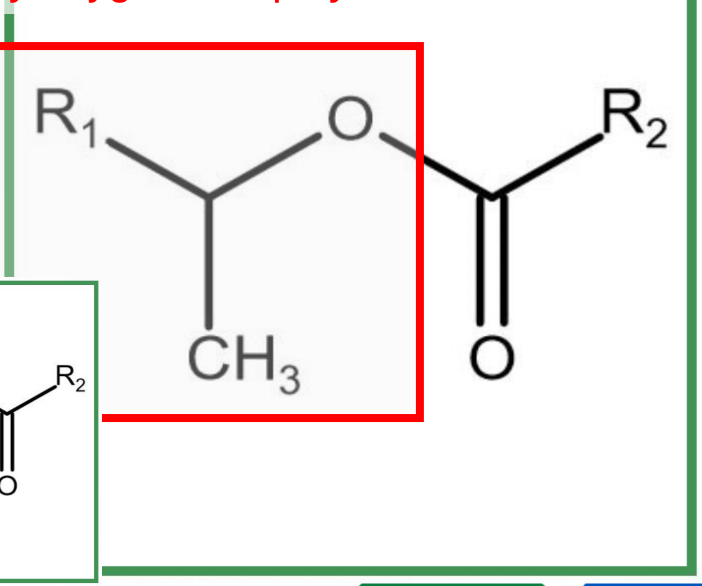
Viscosities: limited to 32 cps (think vegetable oil)

Lifetime: varnishing

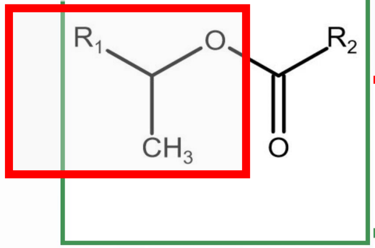
VBASE Secondary Polyol Ester^{TM} Chemistry

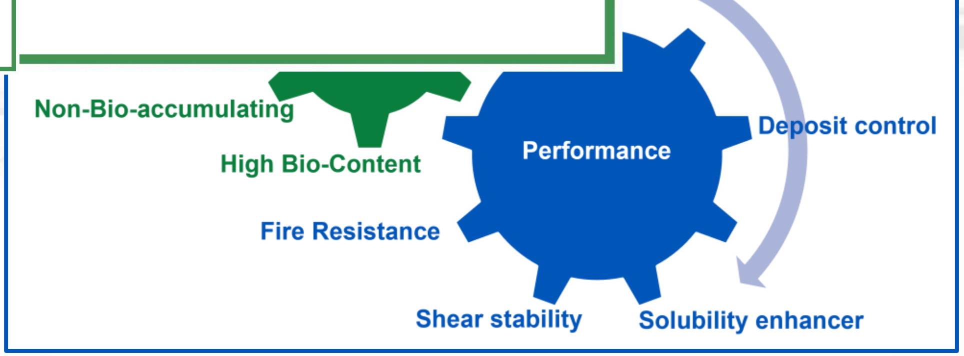
High Performance AND Environmentally Friendly

Proprietary oxygen rich polyols



Proprietary oxygen rich polyols





VBASE Oil development funded by:

U.S. DEPARTMENT OF ENERGY

DE-SC0018751

USDA

2019-33610-30170

VBASE Hydro T-EL™

Fully Formulated Turbine EAL

Hydro T-EL™ development funded by:

U.S. DEPARTMENT OF ENERGY

DE-SC0018751

PERFORMANCE REQUIREMENTS: Meets and exceeds the performance of traditional hydropower oils to protect equipment and ensure reliable energy generation.

ENVIRONMENTAL PERFORMANCE: Meets EPA standards for Environmentally Acceptable Lubricants (EALs) under VGP (Vessel General Permit) and VIDA (Vessel Incidental Discharge Act).

Hydro T-EL™ is built with high-performing, proprietary VBASE base oil that is certified:

- ✓ **Biobased**
- ✓ **Readily Biodegradable**
- ✓ **Non-Toxic**
- ✓ **Non-Bioaccumulating**

USDA CERTIFIED BIOBASED PRODUCT PRODUCT 50%

NSF

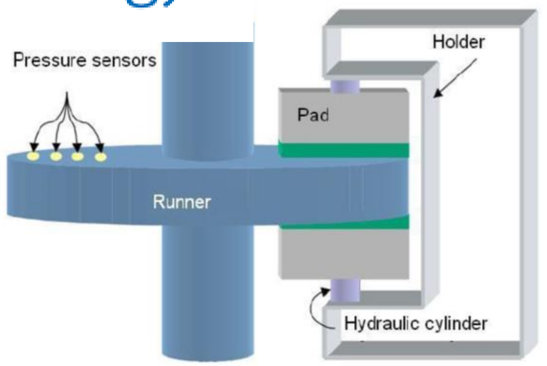
European Ecolabel LuSC-list

Lab Validation of Turbine Oil

GE Renewable Energy

Rig Testing

- ✓ No Damage to bearing pad with high load test
- ✓ No failure of fluid film
- ✓ Recommended for U9



BUT great results do not guarantee technology adoption

De-risking must address:

1) Performance in full scale equipment
2) Seal and Gasket Compatibility
3) Oil Changeover Procedures
4) EH&S

Operators must have some incentive to consider switching to EALs.

Because doing the same thing is perceived as the safest thing.

Field Installations

NATEL ENERGY

Sauerbrunn Hydro Project in Austria

VBASE Hydro T-EL™ is in service in Natel Energy's fully-submersible Restoration Hydro Turbines (RHT) installed in fall 2022.

VATTENFALL

Installed in combined thrust guide bearing on U9 turbine at the Porjus Hydroelectric Power Station in Sweden Jan 2024.

Facility operated by Porjus Hydropower Centre Foundation, a joint collaboration between **Andritz**, **GE Renewable Energy**, and **Vattenfall**.

Adoption of EALs in Hydro

Barriers to EAL Turbine Oil Adoption

- No regulatory differentiation of EALs vs. traditional
- No reduction in fines; No *de minimis* for spill volumes
- EALs cost up to 2X traditional lubricants

Stakeholder Perspectives

Environmental Groups	Any spill is too much
EPA	A spill is a spill
Hydropower Operators	We don't spill

A Baby Step for Operators...
EAL Hydraulic Fluids & Greases

This is a natural extension of the Hydro T-EL™ turbine oil technology, and easier for operators to adopt because:

Greater Perceived Need for EAL – Greases/hydraulics are more likely to contact water

Easier Switch - Less of a financial commitment and more frequent fills

Lower risk – Used in less expensive equipment

Thank you!

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PollEverywhere: How could we advance, adopt, or scale the use of this technology?

- As said on one slide: doing the same thing is perceived as the safest thing. The industry is very conservative, so incentives are required to ensure that everybody can meet targets and improve environmental performance.
- long-term reliability testing or accelerated lab test given the long expected life span of hydro turbines
- Raise awareness/ reduce cost/ need a better case for change
- Standards applicable to hydropower (vs EPA standards for vessels) from which to environmentally judge the performance of these lubricants. Agencies really don't have any measure from which to judge the risks to the river environments. These exist in the periphery, but not directly at this time.

PollEverywhere: What are obstacles/barriers for these types of innovations?

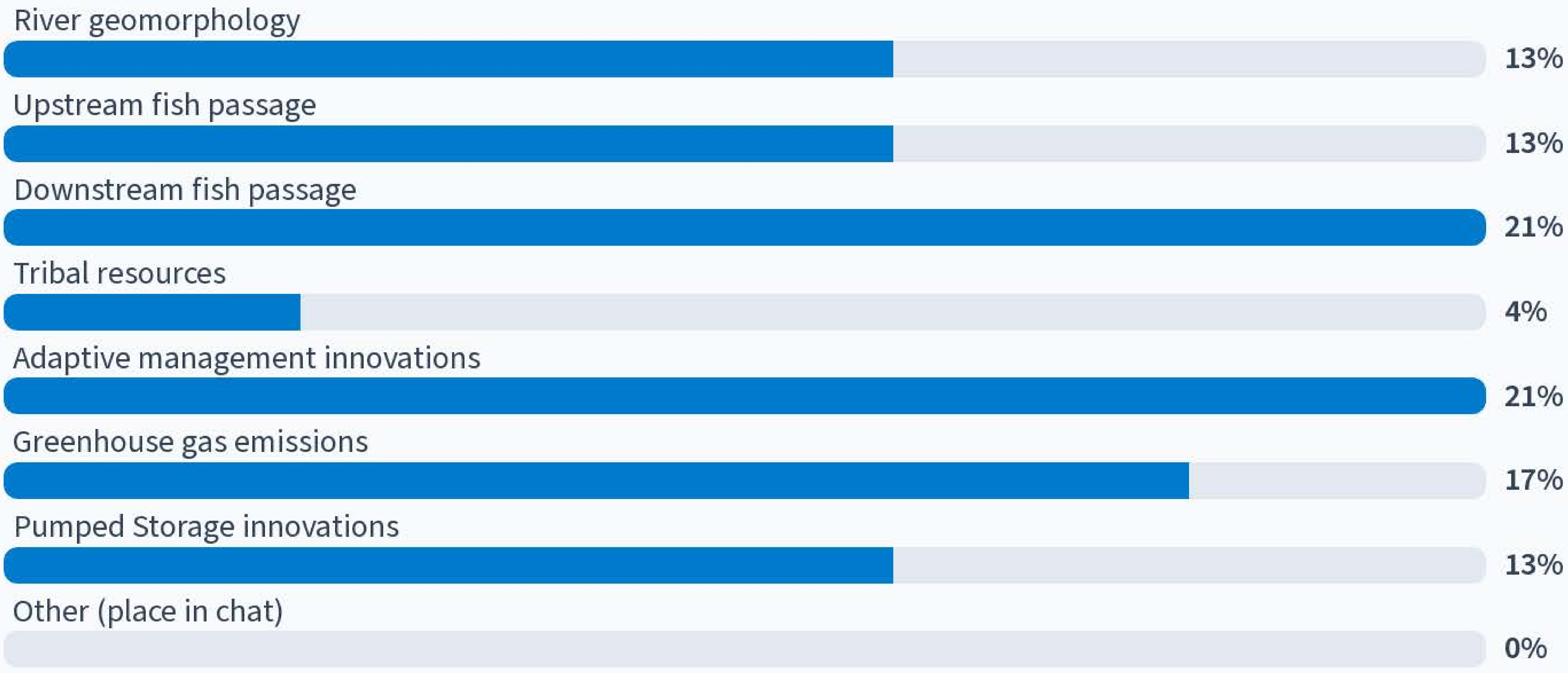
- No PollEverywhere responses for this question. Discussion highlights will be shared via the meeting summary.

Workshop Discussion
Water Quality & Sustainability Needs

PollEverywhere: What's missing when it comes to improving water quality for hydropower and river restoration? What is not being addressed that should be? What are the gaps/opportunities?

- oil-free turbines can be an option for Kaplan turbines
- Compiling all available data in as few locations as possible to make review, analysis, and discussion efficient and comprehensive.
- Second sediment transport. Especially for existing projects that were not designed to pass designed down stream.
- TDG abatement, sediment, changing flow characteristics,
- Fish-friendly vs WQ improving turbines
- Differentiating between effects related to and affected by the hydropower facility versus those that would occur at the impoundment without the hydropower facility.
- Addressing impacts from climate change
- sediment transport
- Revenue streams that could be possible for removing other human contaminants in our river systems: pharmaceutical products, other industrial/agricultural products and whether revenue streams can be created to remove these at hydro facilities
- Methods for water temperature conditioning.

What topics are you interested in for future workshops related to hydropower technologies for sustainability?



Next Steps

- Meeting summary and recording.
- Evaluation Form
- Future workshops!
- White paper
  - Interested in being involved?!
    - Send your name and email directly to Morgan Nachman at K&W in the chat.

Contact: Workshop Planning Team

Uncommon Dialogue WG1 Co-Chairs (Technology)

- Jose Zayas, American Council on Renewable Energy (zayas@acore.org)
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- Chris Hayes, National Hydropower Association (chris@hydro.org)
- Miles Hall, Natel Energy (miles.hall@natelenergy.com)

Uncommon Dialogue WG4 Co-Chairs (Valuation)

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- Michael Purdie, National Hydropower Association (michael@hydro.org)

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Contact: Speakers

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2. Neal Simmons, Eagle Creek Renewable Energy, CEO and President (Neal.Simmons@eaglecreekre.com)
3. Jeff DiMaio, VBASE Oil Company, CEO (dimaio@vbaseoil.com)


THANK YOU