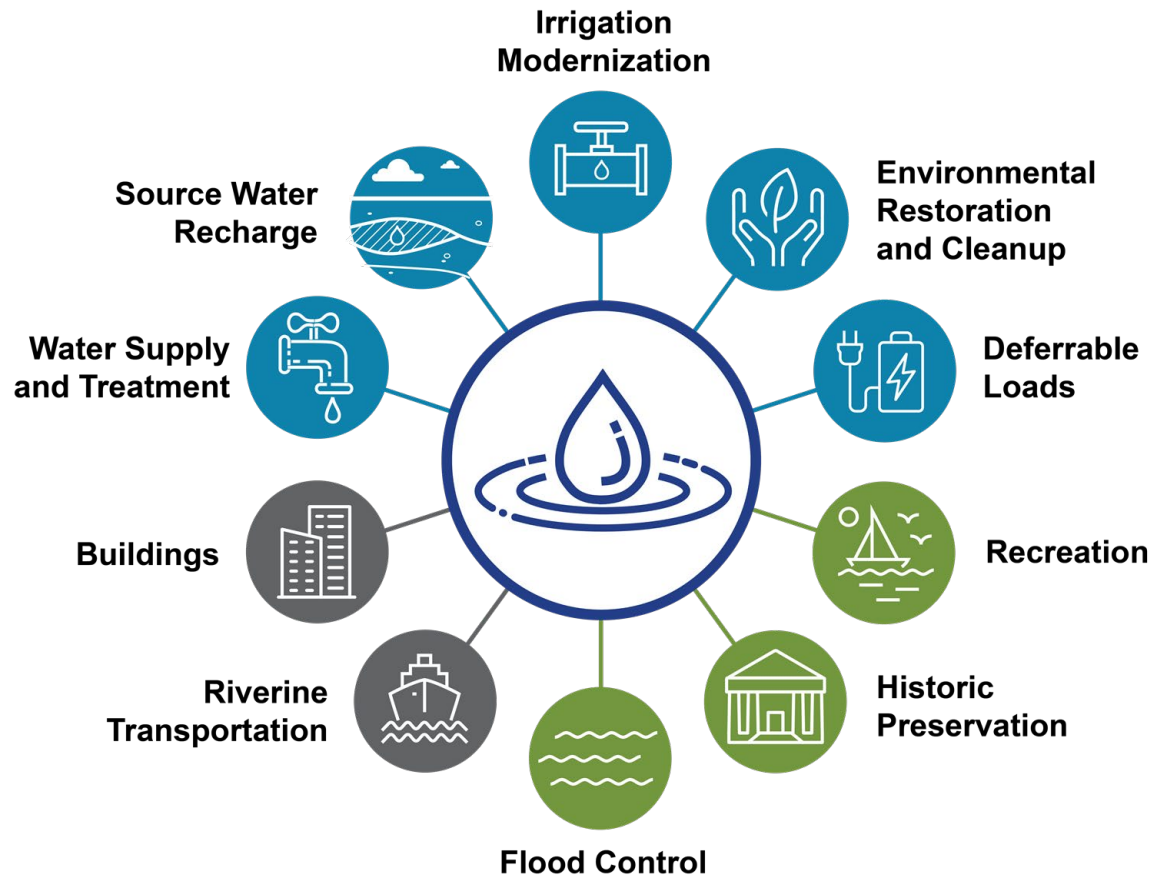


1.1.1.102 – Alternative Opportunities for Hydropower



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Project Overview

Project Summary

- Adoption of new technologies and strategies could leverage both energy and non-energy drivers in new business models that enable growth of additional hydropower capacity. Within the water-energy nexus, hydropower can be integrated in projects that sustain water supplies, improve environmental outcomes, and increase facility and community resilience using new, untapped value streams. Project benefits, associated beneficiaries, and value streams that deliver benefits are identified through extensive stakeholder outreach. Potential new projects are assessed using known examples. Additional research needed to quantify values from non-traditional drivers including social and environmental improvements are being identified.

Intended Outcomes

- Identify alternative opportunities for hydropower projects that are ready for implementation.
- Identify and quantify value streams associated with such projects.
- Develop tools, datasets, and guidance for implementing such projects.
- Identify future research needed to unlock additional values from such projects.

Project Information

Principal Investigator(s)

- TJ Heibel, PNNL
- Travis Douville, PNNL

Project Partners/Subs

- None

Project Status

New

Project Duration

- December 5, 2019
- Continuing

Total Costed (FY20–FY21)

PNNL: \$600,000, INL: \$380,000

Project Objectives: Relevance

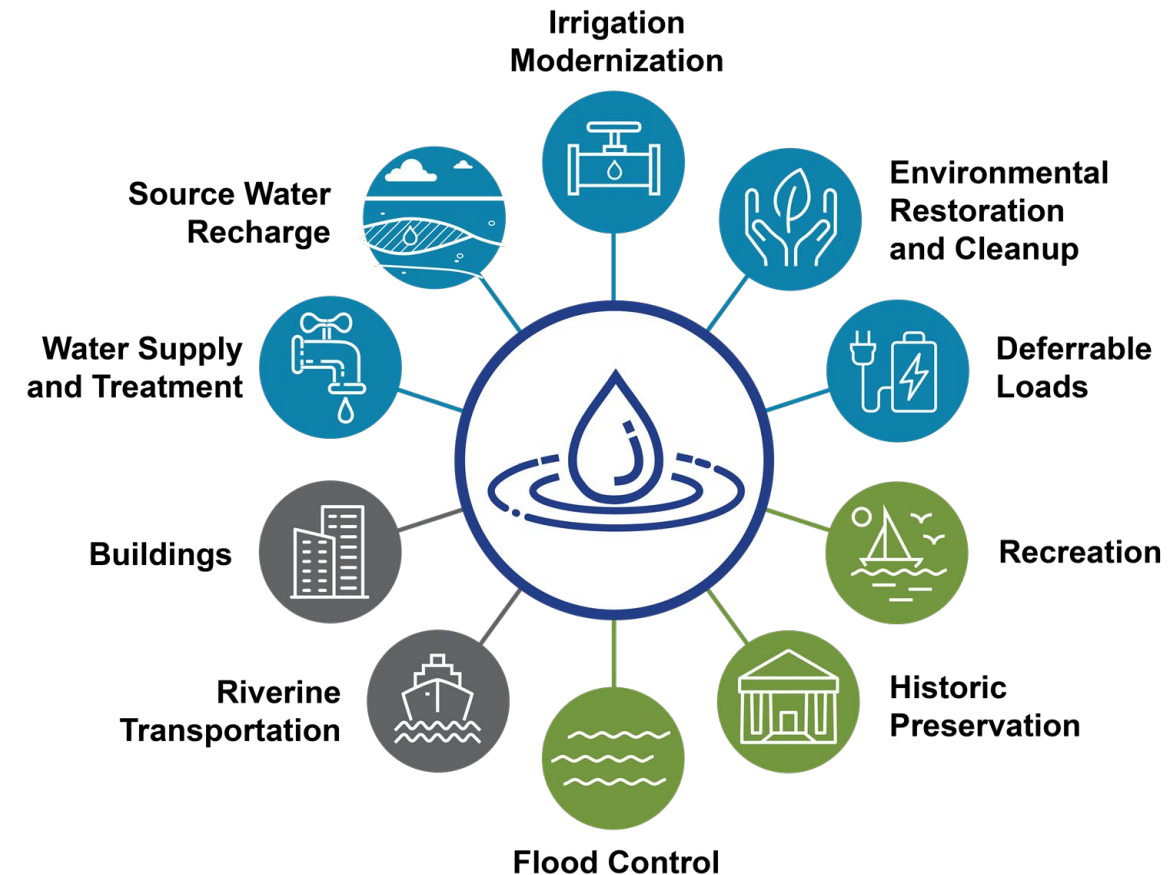
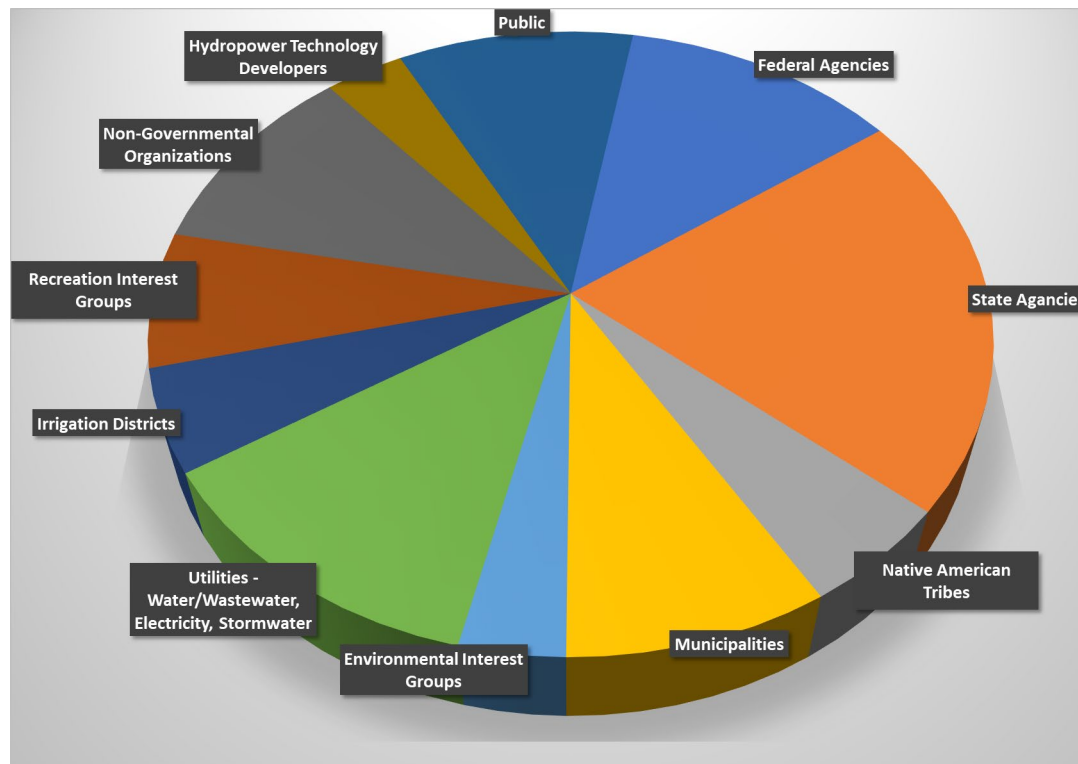
Relevance to Program Goals:

- Identify and quantify new value propositions within low-impact hydropower growth innovations activity
- Increase interest of resource owners, project developers, and investors in these new hydropower projects
- Develop a framework for addressing costs and benefits of these new hydropower projects
- Develop tools, datasets, and guidance for projects' use
- Foster partnerships among stakeholders.

Project Objectives: Approach

Approach:

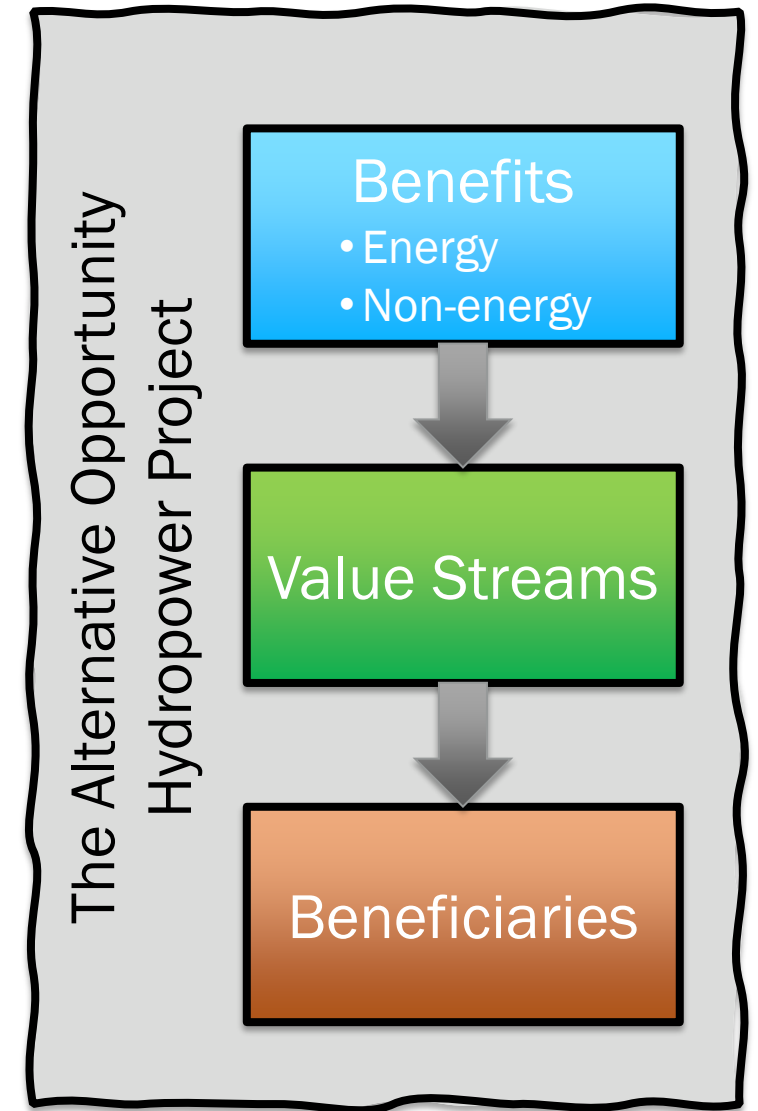
- Identify alternative opportunities for hydropower
 - Start with water infrastructure where implementing hydropower is plausible
 - Extensive stakeholder outreach



Project Objectives: Approach

Approach:

- Identify new value propositions
 - Identify subopportunities
 - specific outcome within a core opportunity that provides a direct benefit and possible pathway to monetize the value
 - Identify benefits and beneficiaries
 - Identify value streams
- Quantify values and value stacks
 - Market values and non-market values
 - Complimentary
- Develop tools and datasets
 - Hydropower technologies
 - Guidance for assessing alternative opportunity projects
- Conduct future research to fill gaps



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Describe alternative opportunities for hydropower projects
- Assess how and why some projects succeed
- Increase awareness of new value propositions for hydropower
- Provide guidance for wider implementation
- Project website:
<https://www.pnnl.gov/projects/alternative-opportunities-hydropower>
- Alternative Opportunities information flyer:
<https://www.pnnl.gov/sites/default/files/media/file/Alternative%20Opportunities%20for%20Hydropower.pdf>
- FY 2020 and FY 2021 reports to WPTO

Outcomes:

- Increased resource owner, developer, and investor interest
- Increased deployment of new hydropower projects
- Increased local, low-carbon, renewable energy availability

Project Timeline

FY 2020

- December 2019: Project start
- January 2020: Scoping memo
- May 2020: Stakeholder outreach summary
- September 2020: Alternative Opportunities for Hydropower – Draft FY2020 Report

FY 2021

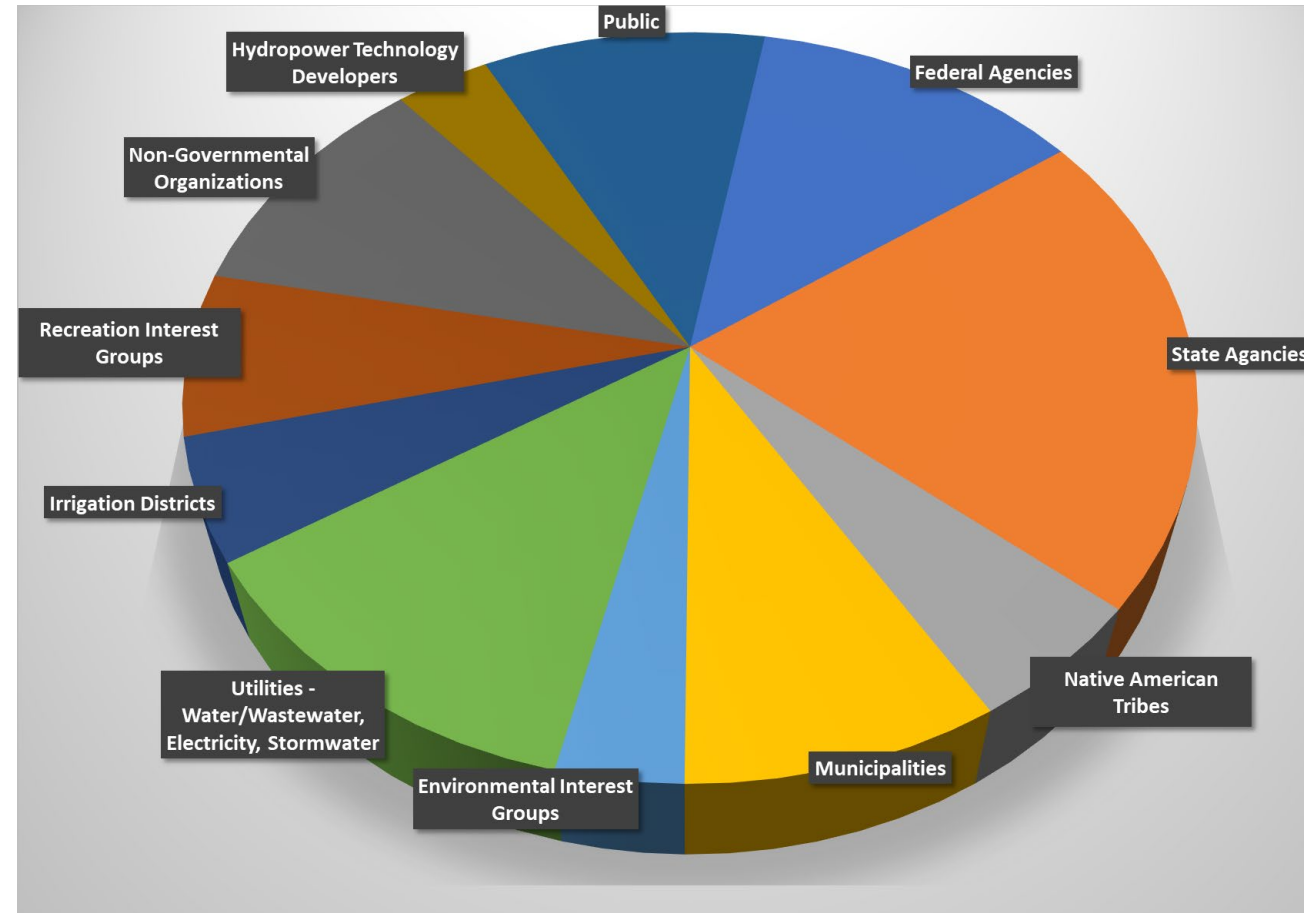
- February 2021: Task 1
 - Alternative opportunities categorization and value stacks presentation
- April 2021: Tasks 1 and 2 memo
 - Value stacking and selection of three use cases for preliminary valuation
- September 2021: Task 3 memo
 - Outreach to identify implementations of selected use cases
 - Identification of barriers

Project Budget

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
PNNL: \$0K INL: \$0K	PNNL: \$240K INL: \$128K	PNNL: \$360K INL: \$252K	PNNL: \$600K INL: \$380K

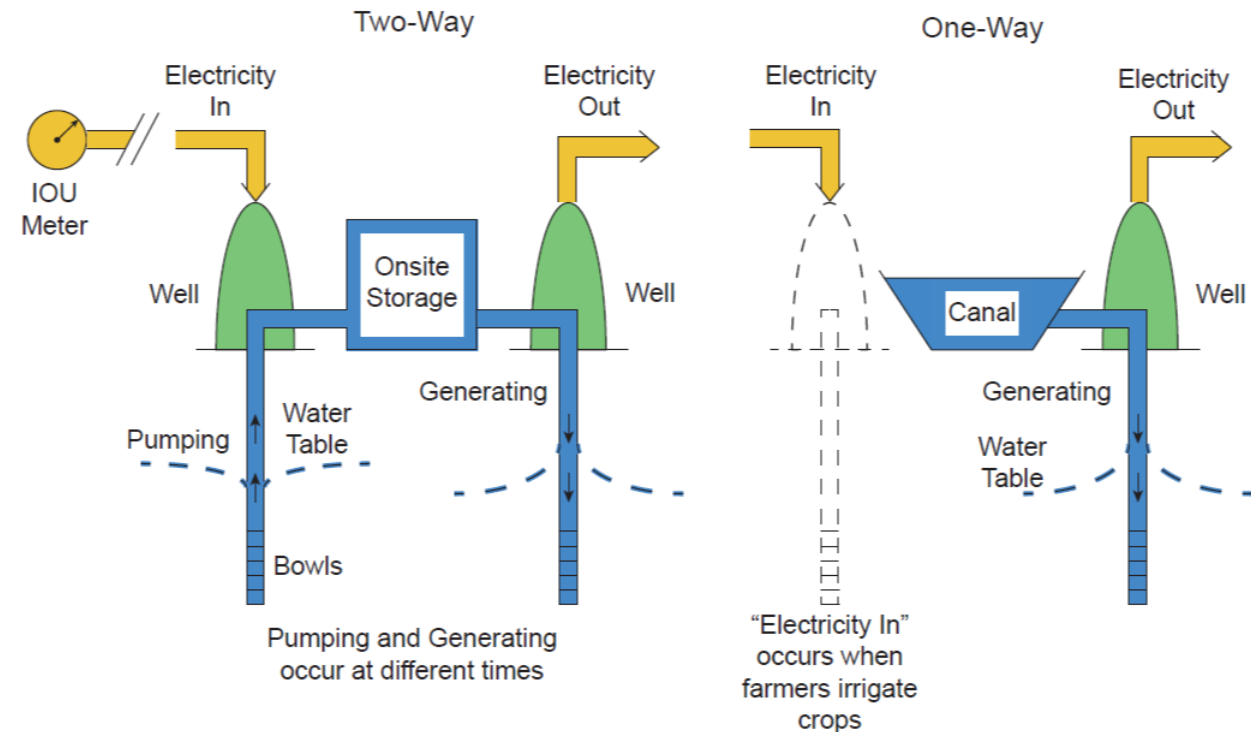
End-User Engagement and Dissemination

- FY20 stakeholder engagement strategy
 - Wide-ranging outreach
 - Ten starting opportunities
 - Learn about existing and likely application of hydropower within water infrastructure
 - Learn about benefits and revenue streams
 - Narrow down selection to most likely alternative opportunities
- Stakeholder outreach summary



End-User Engagement and Dissemination

- FY21 stakeholder engagement strategy
 - Targeted outreach
 - Learn about specific (complete or partial) implementations
 - Learn about technical, financial, and regulatory challenges
 - Learn about revenue potential
 - Derive insights into how alternative opportunity projects can be more widely implemented
- FY21 memos

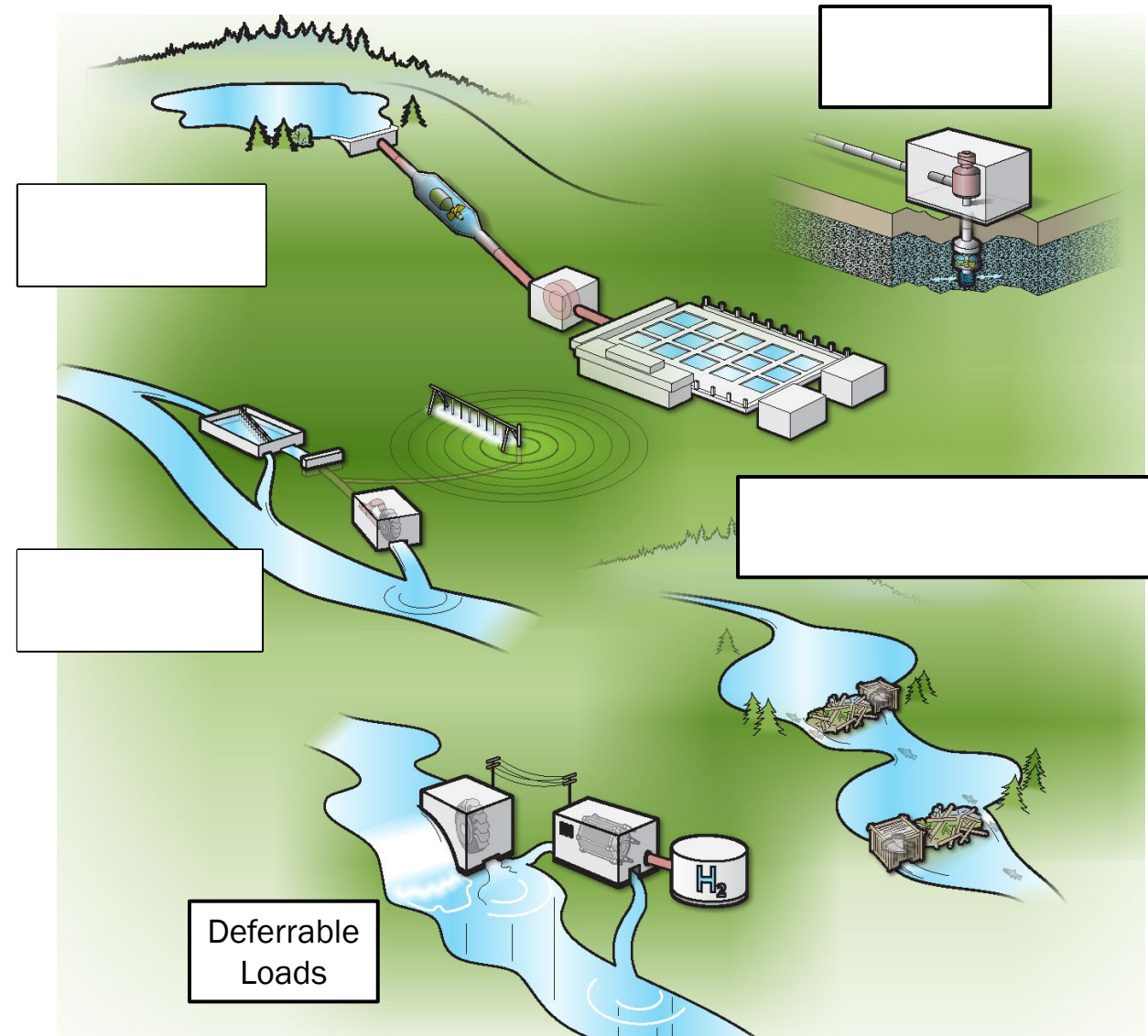
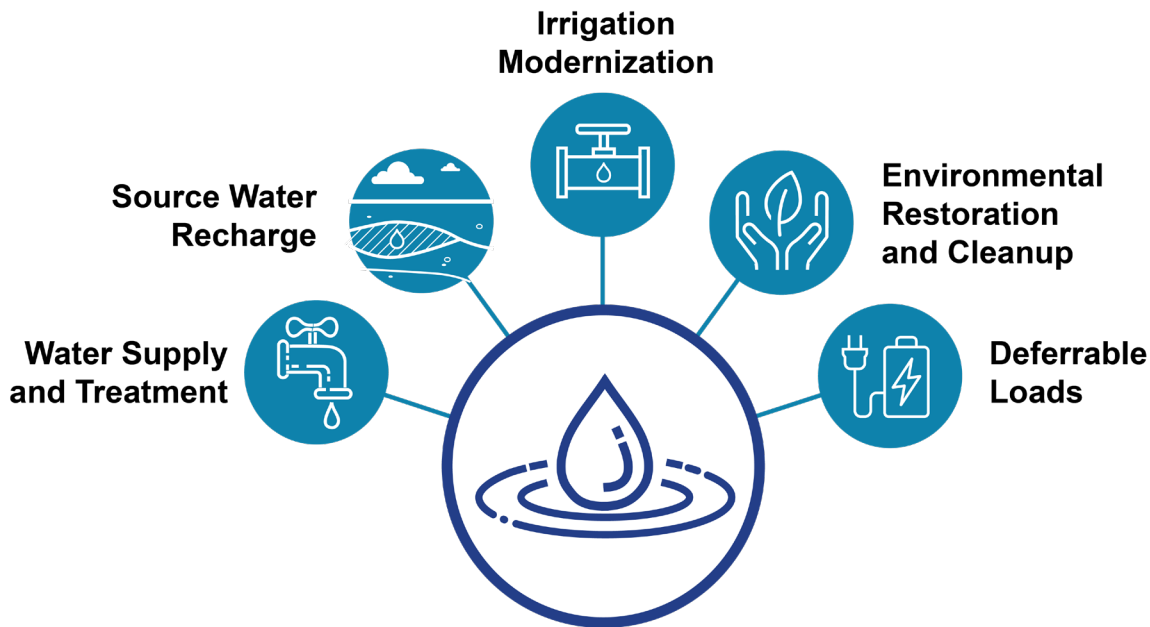


Source: Willow Springs Water Bank

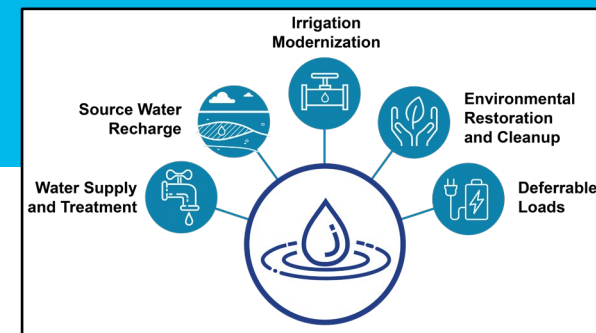
Performance: Accomplishments and Progress

Accomplishments:

- Identified alternative opportunities for hydropower
 - Top five alternative opportunities
 - FY 2020 report to WPTO



Performance: Accomplishments and Progress



Accomplishments:

- Identified new value propositions
 - Energy
 - Non-energy
 - FY 2021 reports to WPTO

Benefits

Power & reliability & resilience

Environmental protection

Water quality & availability

Flood protection

Agricultural productivity & reliability

Community revitalization

Job creation

Business development

Value Streams

- Increased revenues
- Increased system reliability
- Reduced net energy use
- Reduced rates
- Improved water quality
- Improved public health & safety
- Improved environment
- Reduced flood damage
- Increased agricultural productivity
- Sustainable water supplies
- Improved environmental outcomes
- Improved quality of life
- Improved energy storage & load balancing
- New revenue sources

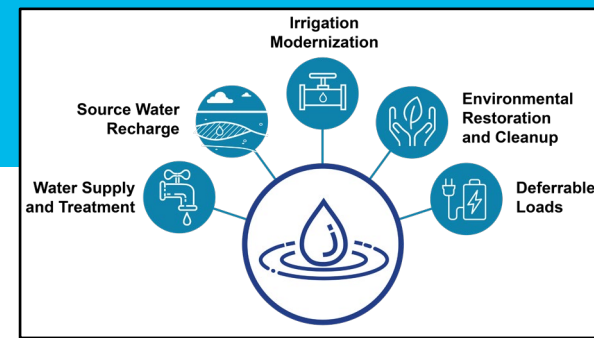
Beneficiaries

- Resource owners
- Energy and water consumers
- Farmers
- Commercial entities
- Community
- The environment

Performance: Accomplishments and Progress

Accomplishments:

- Identified challenges and barriers
 - FY 2021 reports to WPTO



Challenges and Barriers

Information availability

Access to incentives and funding

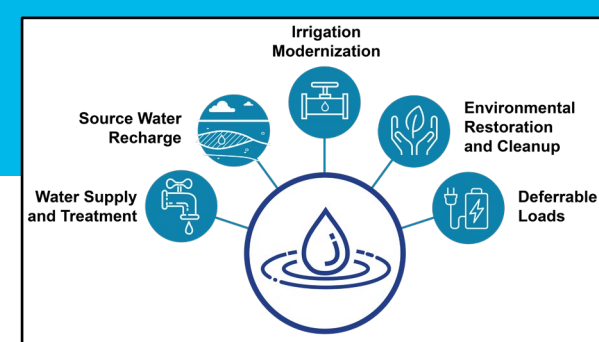
Policy and legal issues

Market constraints

Technical and engineering constraints

Future Work

- FY 2022 and Beyond
 - Develop a template for replicating known alternative opportunities projects
 - Develop tools and datasets
 - Develop guidance for assessing alternative opportunities projects
 - Obtain stakeholder feedback
 - Identify research gaps



KEY: O=Optional, E=Eliminates, R=Required, X=Included, Blank=Site Specific Judgement
IC=In-Conduit, D-Dam, ROR=Run of River, C-Canal, OC=Open Channel, H-Hybrid

Technology	Provider	Name	Type	Application	Operational Parameters										
					Power Rating		Head or Water Depth (HK)				Flow or Flow Rate (HK)				Grid
					Minimum (MW)	Maximum (MW)	Minimum (ft)	Maximum (ft)	Minimum (cfs)	Maximum (cfs)	Minimum (MGD)	Maximum (MGD)	Minimum (MGD)	Maximum (MGD)	
3R Valve		ASR Generation	Pipeline	IC				40	2000	0	13				
Anjet Turbine System		A13-B	Kaplan Turbine	IC	3	50	7	50	6	15					
Anjet Turbine System		A13-32	Kaplan Turbine	IC, D, ROR, C	50	850	7	50	98	250					
Anjet Turbine System		A13-63	Kaplan Turbine	IC, D, ROR, C	200	2500	7	50	39	925					
ANDRITZ		HYBROMATRIX	Axial Propeller	D, C, ROR		Small		6.5	65		3500				
ANDRITZ		HybaTec-Hybrid Battery	Controls	H											
ANDRITZ		Kaplan Turbine	Reaction turbine	D, C, ROR											
ANDRITZ		Francis Turbine	Reaction turbine	D, C, ROR											
ANDRITZ		Pelton Turbine	Impulse Turbine	IC, C											
ANDRITZ		Axial Flow Turbine	Reaction turbine	D, OC, ROR											
ANDRITZ		Pump As Turbines (PaT)	Centrifugal Pump	IC, C											
Aqua-Auger		Aqua-Auger	Hydrokinetic	OC, C, ROR	0.5	3.5	10							3	
Canadian Hydro		PAX Rotor	Hydrokinetic	OC											
Canadian Hydro		Axial Flow Turbine	Reaction turbine	D, OC, ROR				16	115						
Canyon Hydro		Inline Turbines (ILT)	Pipeline	IC	100	2000	50	570	1	67					
Canyon Hydro		Pump As Turbines (PaT)	Centrifugal Pump	IC	5	350	50	500	1	24					
Canyon Hydro		Mico Hydro	Pipeline	IC											
Canyon Hydro		Pico Hydro	Pipeline	IC				0.3							
Canyon Hydro		Kaplan Turbine	Reaction turbine	D, C, ROR											
Canyon Hydro		Francis Turbine	Reaction turbine	D, C, ROR											
Canyon Hydro		Pelton Turbine	Impulse Turbine	IC, C											
Canyon Hydro		Crossflow Turbine	Impulse Turbine	IC, C											
Clean Power		Turbinator	Reaction Turbine	D, OC, C	100	3000	15	180	18	350					
Cornell Pump Company		Pump As Turbines (PaT)	Centrifugal Pump	IC, C				50	600	0.24	18				



Q&A