

# Preliminary Assessment of Hydropower and Environmental Opportunities in the Bighorn Basin

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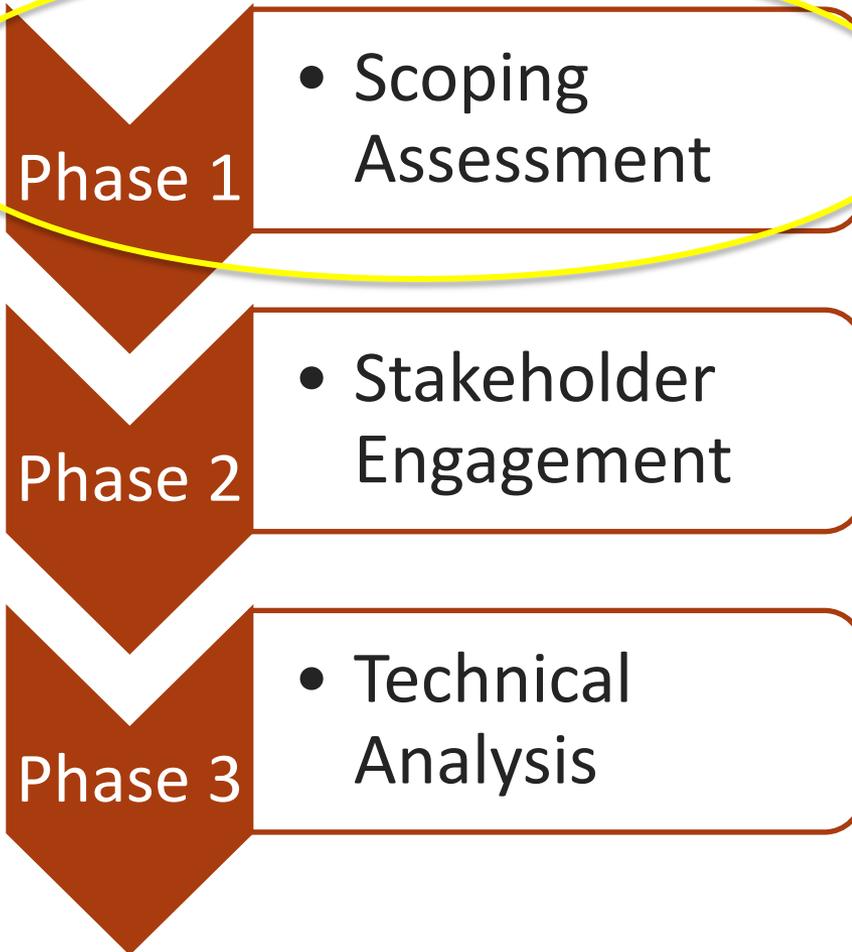
# DOE Basin Scale Opportunity Assessment Initiative

*GOAL: Develop and implement an integrative approach for the assessment of hydropower and environmental opportunities at a river-basin scale*

- ▶ Action item in the 2010 MOU for Hydropower among DOE, USBR, and USACE
- ▶ Emphasize sustainable, low-impact small hydropower *while* identifying opportunities for environmental improvements
- ▶ Collaborative effort between PNNL and ORNL



# Background



▶ Experience with BSOA pilot project in the Deschutes River basin identified three phases

▶ Current activity in the Bighorn is a scoping assessment (Phase 1)

# Phase 1 Objectives

- ▶ Rapidly identify type, location, and potential capacity of hydropower opportunities
  - ORNL's National Hydropower Asset Assessment Program (NHAAP)
  - USBR Hydropower Assessments
  
- ▶ Rapidly identify relevant environmental issues & their location
  - List common issues that may be affected by hydropower
  - Acquire available data from key stakeholders, GIS data repositories, NHAAP, and literature
  
- ▶ Define criteria that may preclude development
  
- ▶ Define criteria for identifying potential positive interactions
  
- ▶ Test approach in Connecticut, Roanoke, and Bighorn river basins

## ▶ Opportunity

- Possible action for hydropower development or environmental improvement
- Hydropower examples:
  - Powering a non-powered dam, efficiency improvements, new development, in-canal/in-conduit opportunities
- Environmental examples:
  - Flow restoration, fish passage, water quality, recreation, etc.

## ▶ Complementary hydropower-environmental opportunity:

- Situation in which an existing environmental issue can be improved, either directly or indirectly, as a result of or in conjunction with a hydropower development action

# Direct vs. Indirect Opportunities

	Direct Opportunity	Indirect Opportunity
Definition	Spatially explicit, direct environmental effect of a hydropower action	Non cause-and-effect environmental opportunity associated with a hydropower action
Spatial extent	Within the upstream & downstream “extent” of a project	Can occur near or far from project, but should be within same watershed
Applicability	NPD	All hydro opportunity types
Examples	<ul style="list-style-type: none"><li>• Installing/improving fish passage</li><li>• Operational effects on dissolved gases</li><li>• Meeting environmental flow requirements</li><li>• Providing recreational access</li></ul>	<ul style="list-style-type: none"><li>• Can include direct opportunities elsewhere in the basin</li><li>• Land or habitat acquisition</li><li>• Environmental restoration</li><li>• Other mitigation actions</li></ul>

# Phase 1 Assumptions

- ▶ Mechanism by which an opportunity is realized depends on a suite of factors that would be examined in later phases of development
  - May be direct effect, regulatory requirement, voluntary, etc.
  
- ▶ Emphasis on low impact hydropower and environmental opportunities
  - Negative effects would be examined in later phases
  
- ▶ Opportunities are treated equally
  - Value is assigned by stakeholders

# Hydropower Opportunities

- ▶ Four types of opportunities
  - Non-powered dams (NPD)
  - New site development (NSD)
  - Efficiency improvements at existing powered dams (PD)
  - In-canal/In-conduit

- ▶ Data sources
  - ORNL National Hydropower Asset Assessment Program (NHAAP)
  - USBR existing dam & conduit assessments
  - Other basin-specific conduit assessments

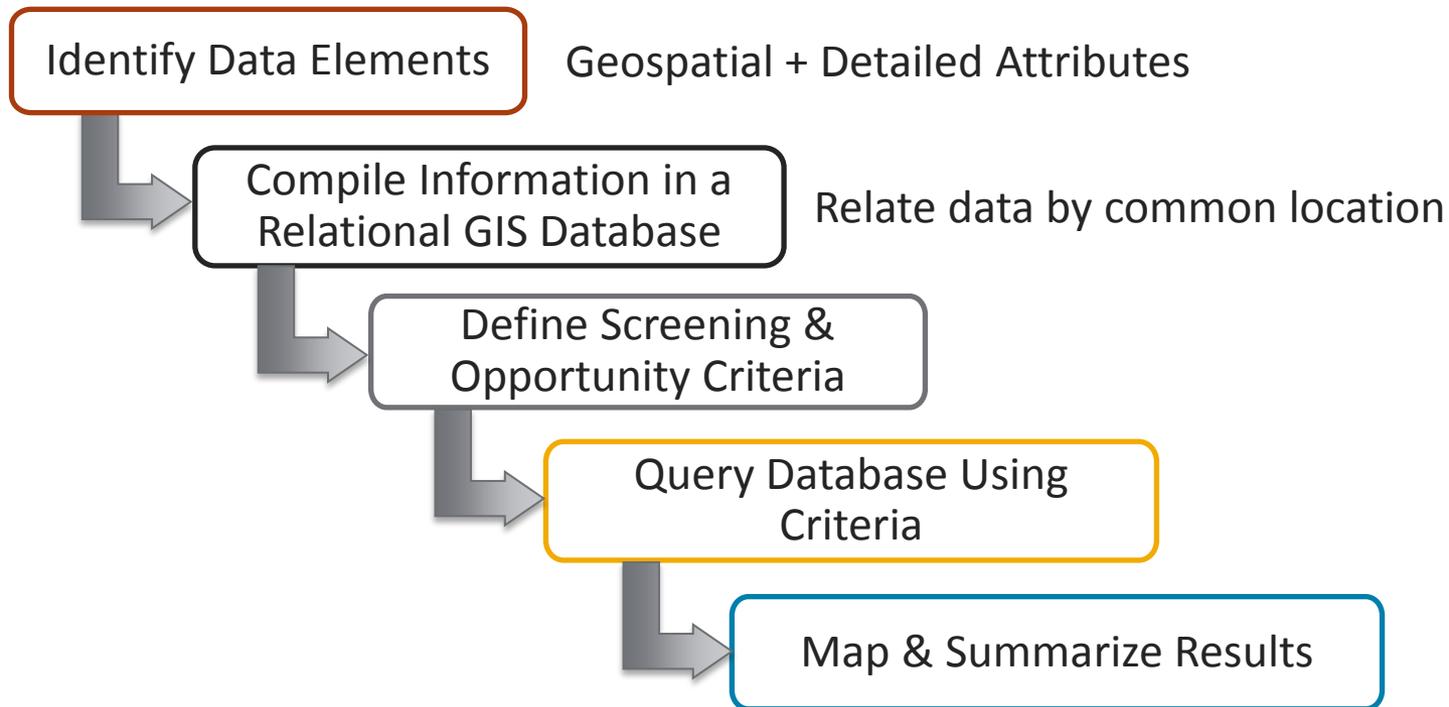
## ▶ Five categories of issues

- Water Quality
- Fish Interactions
- Aquatic Habitat
- Hydrology & Hydraulics
- Other

## ▶ Data sources

- Watershed planning documents
- Stakeholder reports
- Environmental Impact Statements
- Water-quality certifications
- Regulatory filings for hydropower projects
- Nationally and regionally available environmental data

- ▶ Geospatially-driven data model that facilitates identification of complementary hydropower-environmental opportunities



## ► Screening Criteria

- NPD & in-canal potential capacity < 0.1 MW
- NSD potential capacity < 1.0 MW
- Intersects Wild & Scenic River or GAP Status 1 or 2 protected lands
- Intersects Critical Habitat or T&E species habitat

Hydropower Opportunity Type	Number Examined	Number Retained (after screening)	Potential New Capacity (MW)
Powered Dams*	4	4	3.0
Non-powered Dams	143	4	9.6
New Stream Reaches	204	159	368.7
In-canal Sites	120	48	35.8

\* Screening criteria was not applied to existing powered dams because they are already licensed and presumably meet our criteria.

# Potential Complementary Opportunities

## ▶ Direct\*

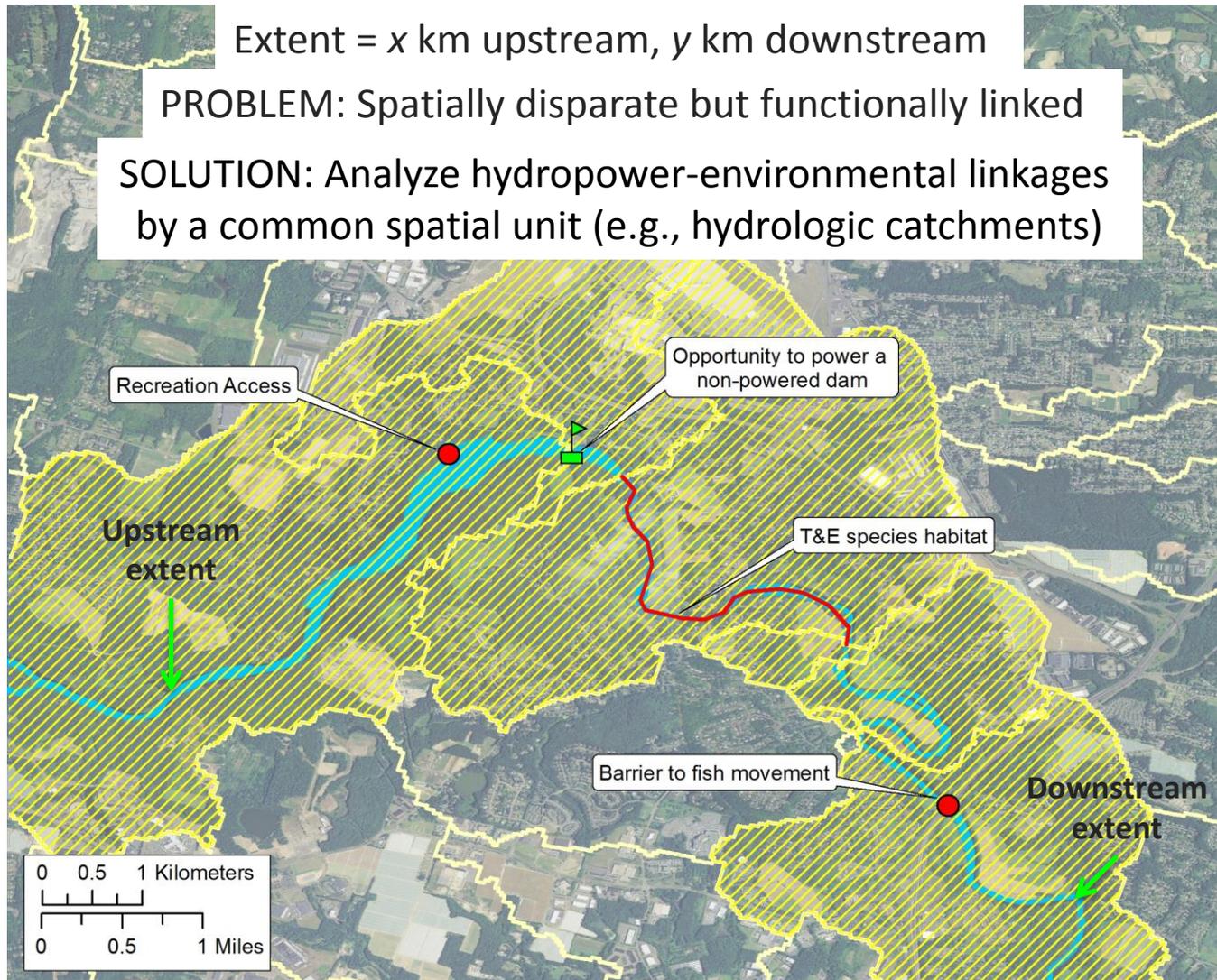
- Manage flow to mitigate impaired water quality
- Manage flow to mitigate hydrologic disturbance
- Manage flow to improve/maintain existing whitewater/paddling recreation
- Manage flow to maintain high-quality trout fisheries

## ▶ Indirect

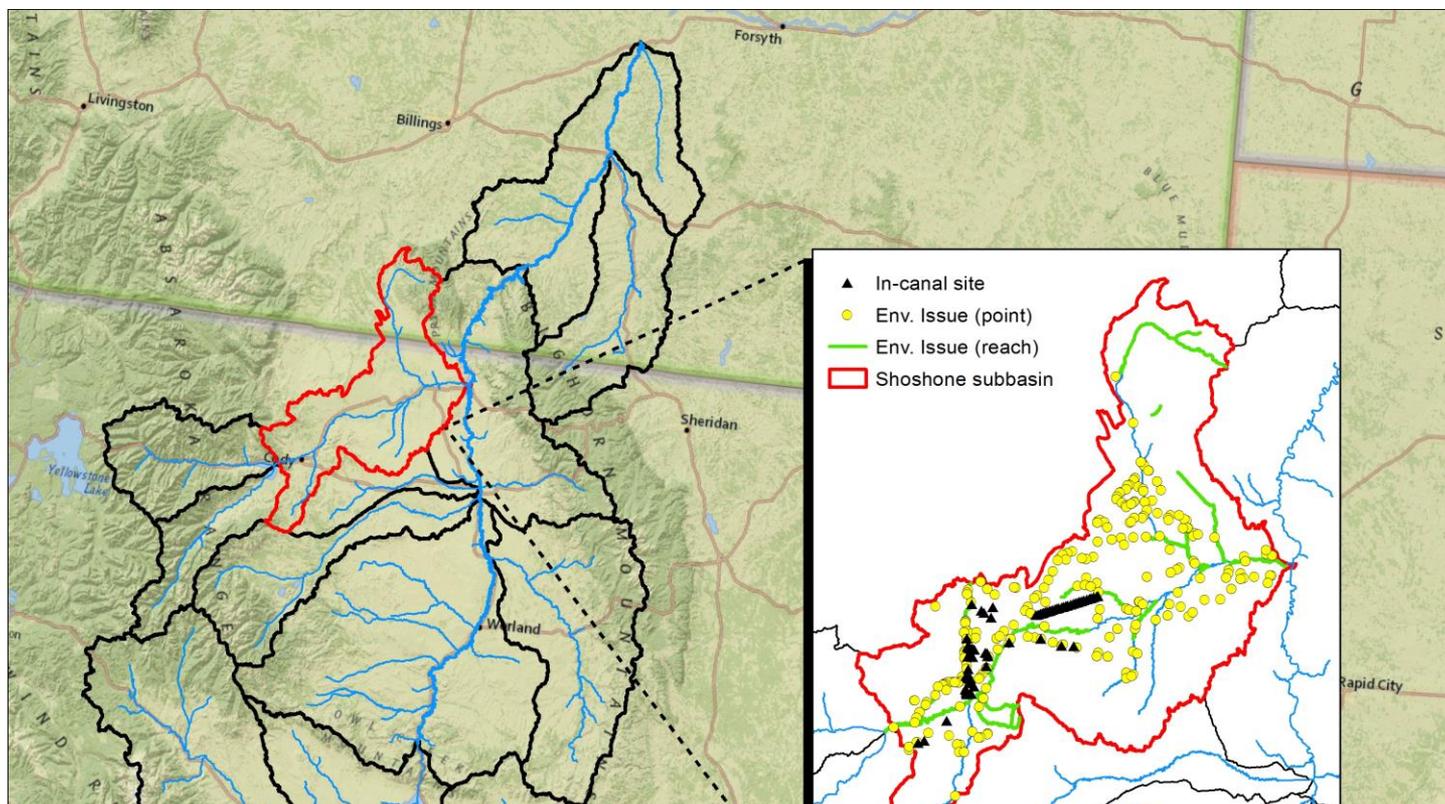
- Impaired water quality
- Hydrologic disturbance
- Whitewater recreation
- High-quality trout fisheries
- Instream flow filing
- Potential canal entrainments

\*Most hydropower types, with the exception of NPDs, were not considered applicable to the set of direct complementary opportunities explored in the preliminary assessment because there is greater uncertainty regarding potential positive effects.

# Identifying Direct Opportunities

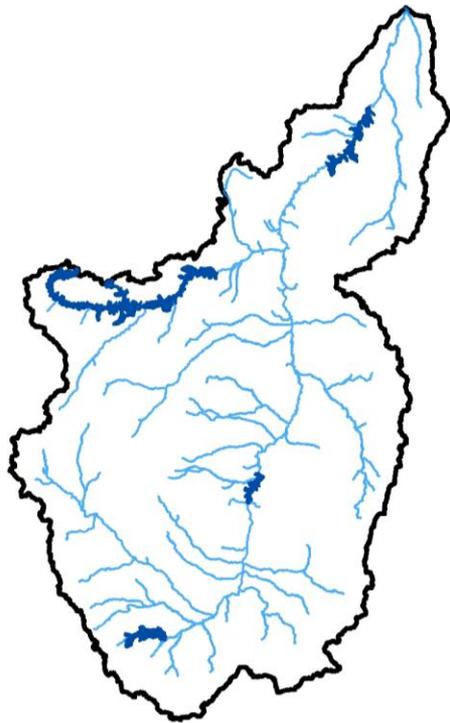


# Identifying Indirect Opportunities

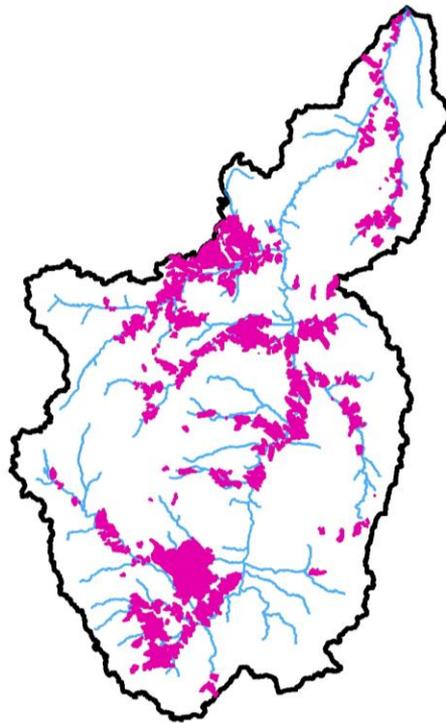


Sub-Basin	In-canal Hydro Opps	Total Capacity (MW)	# Affected Catchments by Environmental Issue			
			Water Quality	Hydrologic Disturbance	Potential Entrainment	Recreation
Shoshone	33	13.5	68	574	187	59
Greybull	5	12.5	638	1119	185	28
Nowood	0	0	11	188	44	20

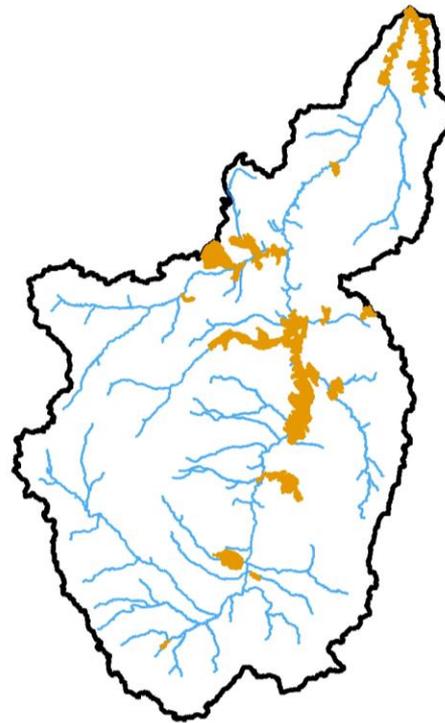
# Summary of Key Environmental Issues



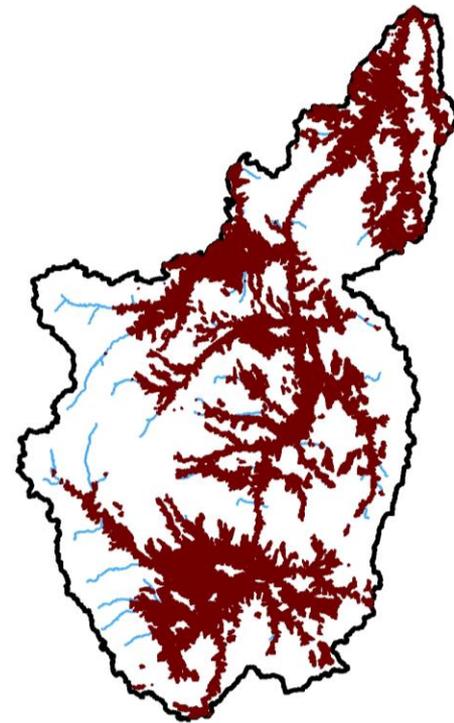
Blue Ribbon Fisheries



Potential Canal Entrainments



EPA 303d-Listed Streams



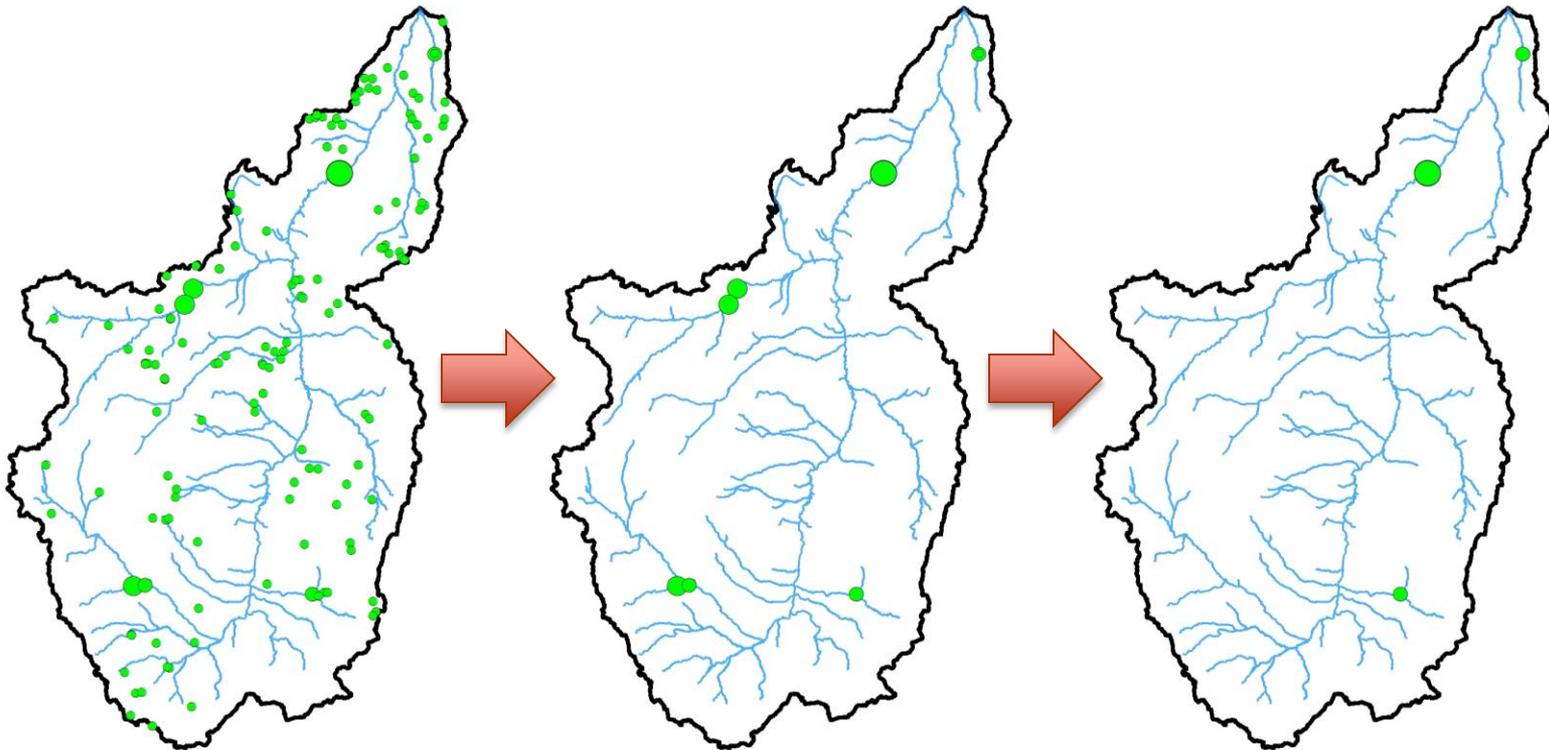
High Hydrologic Disturbance

# Non-Powered Dam Opportunities

All Non-Powered Dams  
(N = 143)

Non-Powered Dams +  
Screening Criteria  
(N = 8)

Non-Powered Dams +  
Screening Criteria +  
>=1 Complementary Opportunity  
(N = 3)

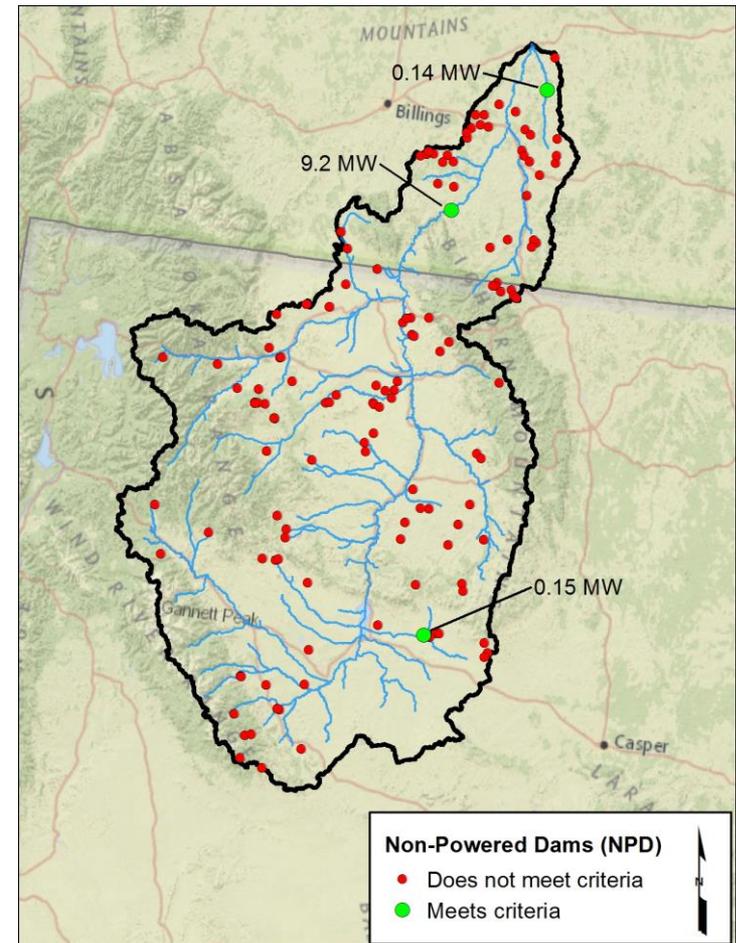


Potential Capacity (MW)    • 0.00 - 0.10    • 0.11 - 0.40    • 0.41 - 1.06    • 1.07 - 9.20

# NPD Direct Complementary Opportunities

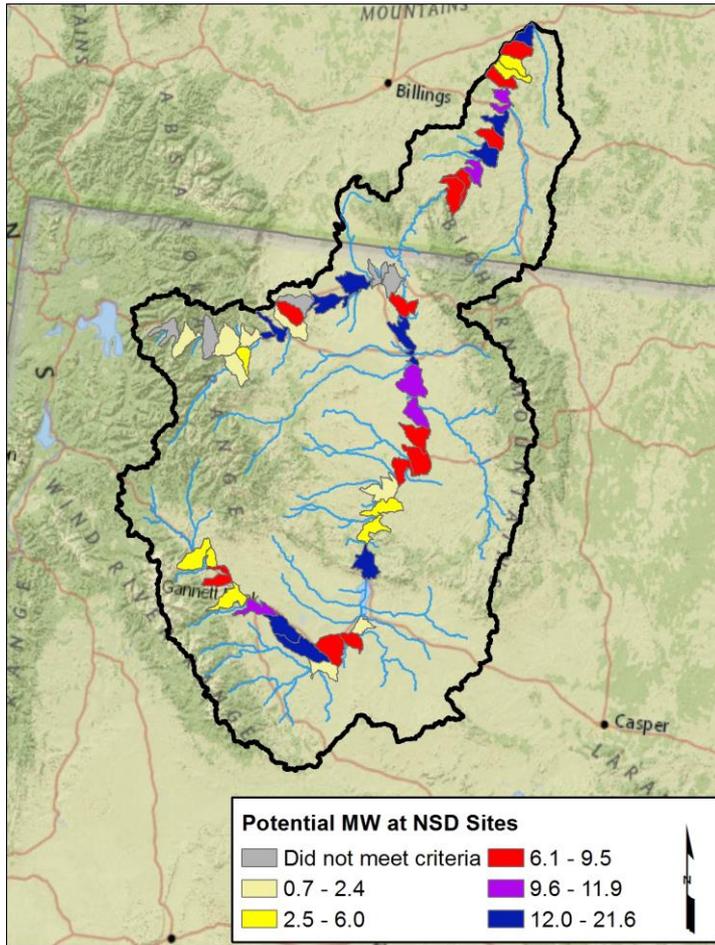
Complementary Opportunity Description	Number	MW
Provide better flow management in downstream reaches with water quality impairment.	2	9.3
Provide better flow management in downstream reaches with high hydrologic disturbance.	3	9.5
Provide better flow management in whitewater/paddling reaches below dam.	0	0
Provide better flow management in downstream reaches with high-quality trout fisheries.	1	9.2
<b>Total number of sites/MW that have at least one potential environmental opportunity**</b>	<b>3</b>	<b>9.5</b>

\* The total number of sites and megawatts is not equal to the sum of the rows above because some sites may have more than one complementary opportunity.

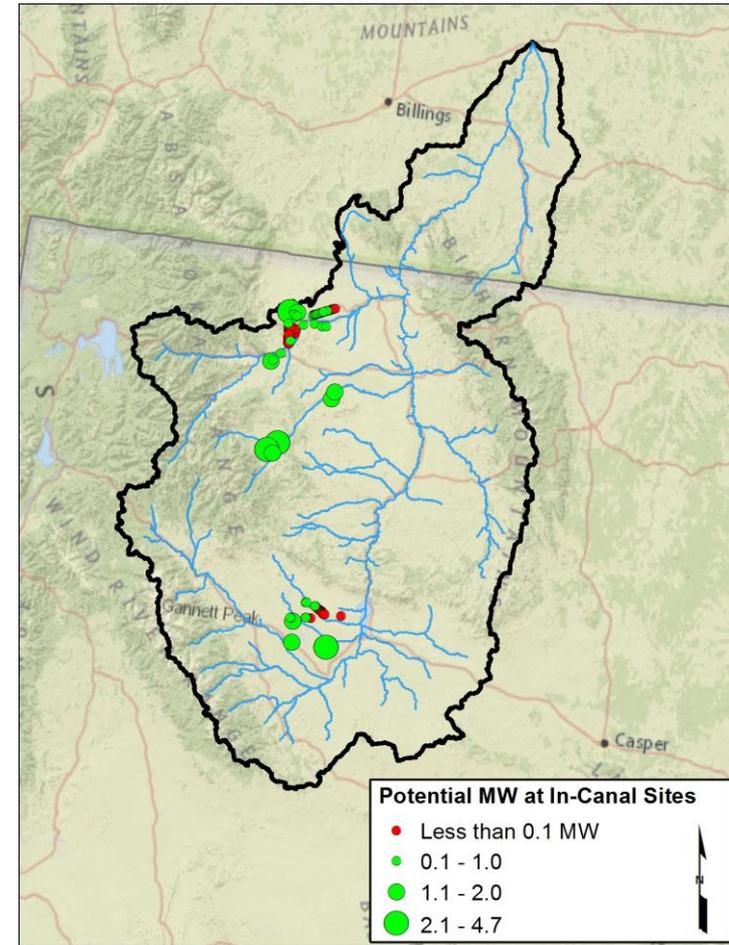


# NSD & In-canal Hydro Opportunities

## New Stream Reach Opportunities\*



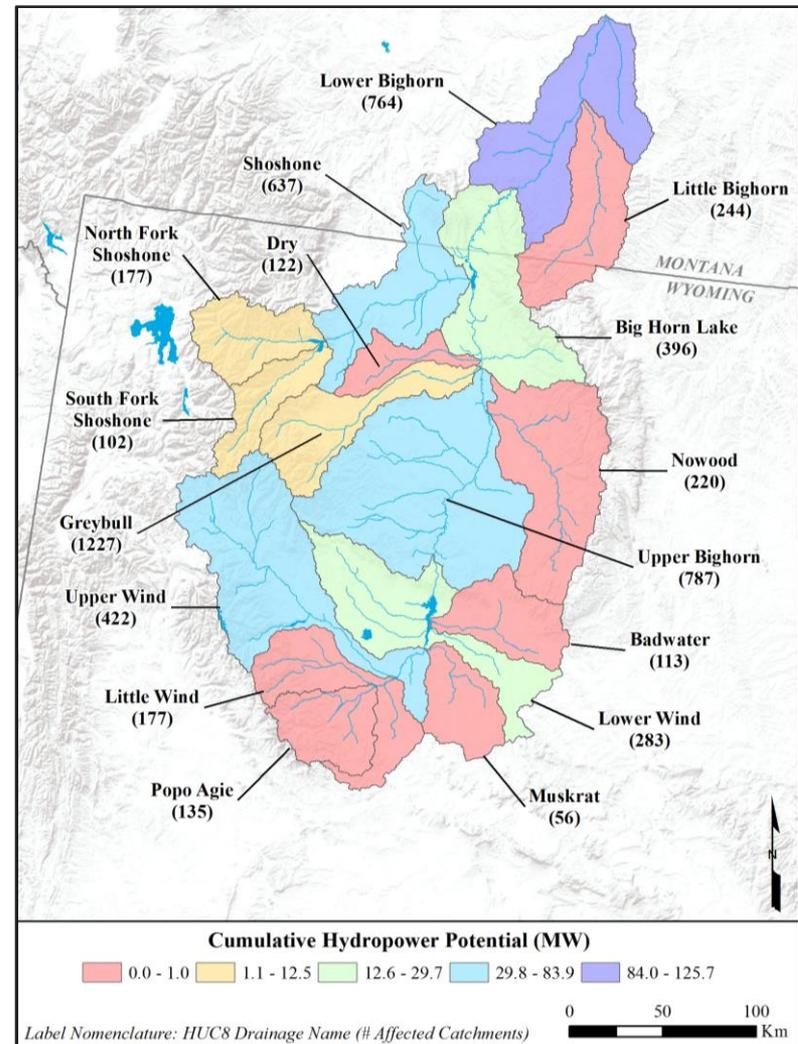
## In-Canal Opportunities



\* NSD sites (N=159) are aggregated to HUC-12 drainages (N=44)

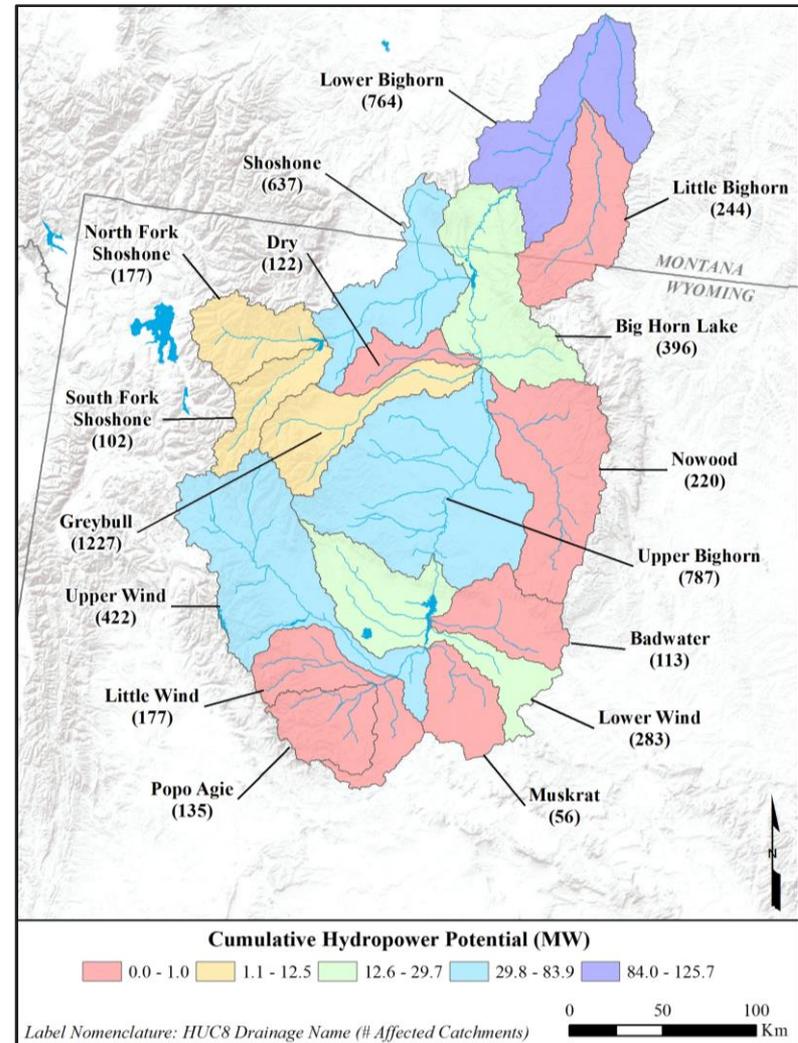
# Indirect Opportunities at the Basin Scale

- ▶ 418 MW cumulative hydropower potential in basin
  - 89% NSD
  - 8% In-canal
  - 2% NPD
  - 1% efficiency improvement at existing facilities
- ▶ Key environmental issues
  - Hydrologic disturbance
  - Impaired water quality
  - Potential canal entrainments
  - Maintaining high-quality trout fisheries



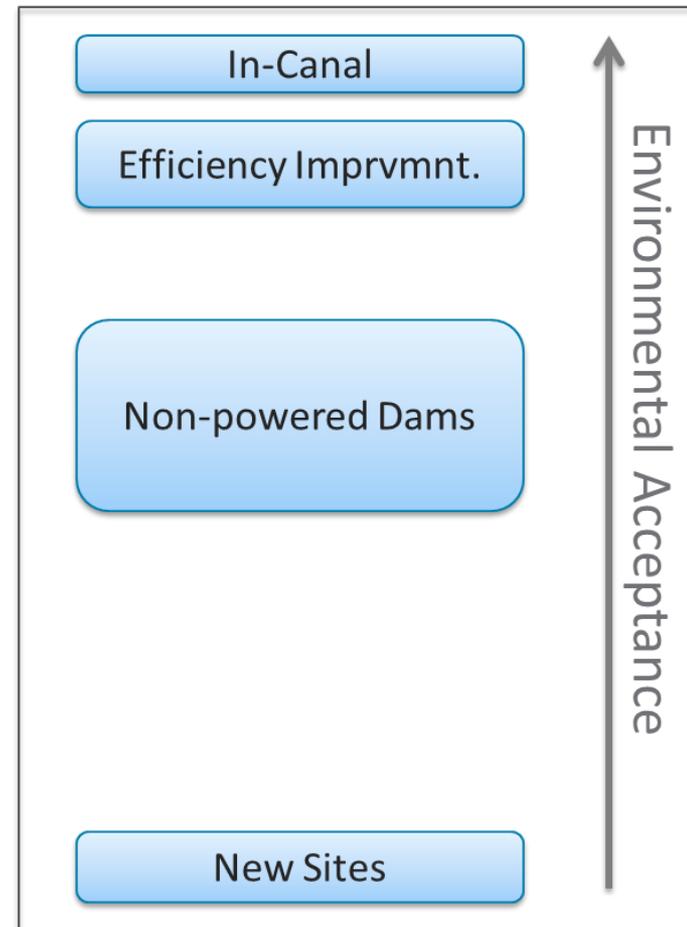
# Indirect Opportunities by HUC-8 Drainage

- ▶ Highest cumulative hydro potential in Lower Bighorn drainage
  - 92% attributed to NSD
  - May exacerbate existing levels of hydrologic disturbance
- ▶ More diverse set of potential opportunities in Shoshone drainage
  - 19% in-canal, 81% NSD sites
  - Hydrologic disturbance, high-quality trout fisheries, instream flow filings, potential canal entrainments



# Summary

- ▶ Bulk of hydropower opportunity is in new stream reach developments
  - Less tractable, but potential for new storage
  
- ▶ Significant potential for in-canal sites
  - Fewer complementary opportunities, but low impact
  - May not be economically viable
  
- ▶ Bulk of NPD opportunity represented by a single dam
  - Exclusive development rights belong to Crow Tribe



- ▶ Phase 1 assessment is:
  - Applicable to other basins and scalable to area of interest
  - An approach to quickly reduce scope of opportunities to focus discussion on a few
  - A framework to provide a common view of resources and challenges
  
- ▶ Phase 1 assessment is not:
  - Prescriptive suggestion for site-specific opportunities
  - Basin-wide plan for future development
  - Analysis of technical or economic feasibility

# Group Discussion

- ▶ Other key environmental constraints or opportunities?
- ▶ Applicability to USBR assessments of existing dams and conduits?
- ▶ New sites?
- ▶ What's Next?
- ▶ <http://basin.pnnl.gov>

The screenshot displays a web browser window with the URL [basin.pnnl.gov/BasinAssessments/BighornPhase1Study](http://basin.pnnl.gov/BasinAssessments/BighornPhase1Study). The page features the Pacific Northwest National Laboratory logo and a 50th anniversary badge. The main content area is titled "Integrated Basin Scale Opportunity Assessment" and "Bighorn River Basin Phase 1 Assessment". A sidebar on the left lists navigation options under "Basin Scale Opportunity Assessment", including "Home", "Basin Assessments", "Deschutes River Case Study", "Connecticut Phase 1 Study", "Roanoke Phase 1 Study", "Bighorn Phase 1 Study", "Opportunity Assessment Toolbox", and "Reports". The main text describes the purpose of the Phase 1 Scoping Assessment: to identify complementary hydropower-environmental opportunities. It notes that the BSOA National Steering Committee selected the Bighorn River basin for a Scoping Assessment due to its potential for energy from new sites, powering non-powered dams, and adding turbines to canals. The text also mentions that the Bighorn basin offers geographic, hydropower, and environmental challenges representative of western basins. A "Map" section is visible, showing a detailed map of the Bighorn River basin with an inset map of the United States. The map labels various locations including Billings, Foryth, Worland, Sheridan, and W Y. The page also includes a "Resources" section with "Contacts" for Simon Geerlofs and a Webmaster.