Preliminary Assessment of Hydropower and Environmental Opportunities in the Bighorn Basin

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

- **Phase 1**: Scoping Assessment
- **Phase 2**: Stakeholder Engagement
- **Phase 3**: Technical Analysis

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
Terminology

**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

<table>
<thead>
<tr>
<th>Direct Opportunity</th>
<th>Indirect Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Spatially explicit, direct environmental effect of a hydropower action</td>
</tr>
<tr>
<td><strong>Spatial extent</strong></td>
<td>Within the upstream &amp; downstream “extent” of a project</td>
</tr>
<tr>
<td><strong>Applicability</strong></td>
<td>NPD</td>
</tr>
</tbody>
</table>
| **Examples**       | • Installing/improving fish passage  
                    • Operational effects on dissolved gases  
                    • Meeting environmental flow requirements  
                    • Providing recreational access | • Can include direct opportunities elsewhere in the basin  
                    • Land or habitat acquisition  
                    • Environmental restoration  
                    • Other mitigation actions |
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
Environmental Issues

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
Approach

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

1. Identify Data Elements
2. Compile Information in a Relational GIS Database
3. Define Screening & Opportunity Criteria
4. Query Database Using Criteria
5. Map & Summarize Results

Geospatial + Detailed Attributes
Relate data by common location
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

<table>
<thead>
<tr>
<th>Hydropower Opportunity Type</th>
<th>Number Examined</th>
<th>Number Retained (after screening)</th>
<th>Potential New Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powered Dams*</td>
<td>4</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>Non-powered Dams</td>
<td>143</td>
<td>4</td>
<td>9.6</td>
</tr>
<tr>
<td>New Stream Reaches</td>
<td>204</td>
<td>159</td>
<td>368.7</td>
</tr>
<tr>
<td>In-canal Sites</td>
<td>120</td>
<td>48</td>
<td>35.8</td>
</tr>
</tbody>
</table>

* 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

PROBLEM: Spatially disparate but functionally linked

SOLUTION: Analyze hydropower-environmental linkages by a common spatial unit (e.g., hydrologic catchments)

Extent = x km upstream, y km downstream
Identifying Indirect Opportunities

<table>
<thead>
<tr>
<th>Sub-Basin</th>
<th>In-canal Hydro Opps</th>
<th>Total Capacity (MW)</th>
<th>Water Quality</th>
<th>Hydrologic Disturbance</th>
<th>Potential Entrainment</th>
<th>Recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoshone</td>
<td>33</td>
<td>13.5</td>
<td>68</td>
<td>574</td>
<td>187</td>
<td>59</td>
</tr>
<tr>
<td>Greybull</td>
<td>5</td>
<td>12.5</td>
<td>638</td>
<td>1119</td>
<td>185</td>
<td>28</td>
</tr>
<tr>
<td>Nowood</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>188</td>
<td>44</td>
<td>20</td>
</tr>
</tbody>
</table>
Summary of Key Environmental Issues
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

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

* 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.

![Map of Non-Powered Dams (NPD)](image)

- **Non-Powered Dams (NPD)**
  - Red: Does not meet criteria
  - Green: Meets criteria

- **Locations**:
  - 0.14 MW
  - 9.2 MW
  - 0.15 MW
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](http://basin.pnnl.gov)