hydroAMP: an equipment condition assessment framework
The Need

• Equipment reliability significantly affects system generation availability and financial performance.
  ▪ A significant amount of critical equipment in hydro facilities in North America is near or beyond its design life.
  ▪ Substantial investment to repair, refurbish, or replace unreliable equipment is anticipated.

• The process for identifying and prioritizing investments needs strengthening – capital is a limited resource.
  ▪ Equipment condition assessment tools used in the past have been complex and costly to administer.
  ▪ Establishing an objective, consistent and efficient assessment process is critical for informed decision making.
hydroAMP Partners

- In 2001, the Bureau of Reclamation (BOR), Hydro-Québec (HQ), the Army Corps of Engineers’ Hydroelectric Design Center (HDC), and Bonneville Power Administration (BPA) began collaborating on a hydroelectric equipment condition assessment technique that was later named “hydroAMP”, or hydro Asset Management Partnership.

- The hydroAMP Partners worked on the program for 5 years and in 2006, with the publication of a report describing the condition assessment technique, its development and its potential applications, officially rolled out hydroAMP during HydroVision.
hydroAMP Concept
Condition Assessment Principles

• Objective results
• Developed from routine tests and inspections
• Simplified process
• Easy interpretation
• Technically sufficient (valid though not necessarily perfect)
• Consistent and repeatable results
• Start small, expand with time
• Open to improvement
Framework

• A guidebook currently outlines condition ratings for 11 equipment types.
• The guidebook was developed to facilitate asset management decisions using equipment condition assessments.
• The guidance is open and flexible to fit into the existing structure of each utility’s maintenance, planning, budgeting and decision-making processes.
Equipment Guides

- Surge Arrestors
- Transformers
- Turbines
- Generators – in revision - 2011
- Governors
- Exciters – revised 2011
- Cranes
- Batteries
- Compressed Air System
- Emergency Closure Gate and Valve
Condition Assessment: Two-Tier Approach

Tier 1

- The rating is based on condition indicators derived from tests, measurements, and inspections that are normally performed during routine O&M activities.

- The assessment results in a “Condition Index” with a rating scale of zero to 10; higher CI means better condition.

- Mid- to low-range values may trigger a Tier 2 evaluation.

- Assessment results are easily entered into CMMS or other databases for tracking and reporting.
Tier 2

- Includes in-depth, non-routine tests or inspections that may be invasive and/or require specialized equipment and expertise not normally found at the hydro plant.
- Results are used to adjust the Condition Index score (either up or down).
- Adds confidence to the assessment results and conclusions.
Data Quality Indicator

- Is a stand-alone indicator used to reflect the quality of information available for performing the condition assessment.

- Recognizes that data may be missing, out of date, or of questionable integrity.

- Is important because poor data could affect the accuracy of individual condition indicator scores as well as the validity of the overall Condition Index.
Turbine Example
Tier 1 Condition Index and Data Quality Indicator

Tier 1 condition indicators:

- Age
- Physical Condition
- Operational Limitations
- Maintenance

Condition indicators are scored and weighted, then summed to calculate the Condition Index.

The Data Quality Indicator is scored separately.
## Tier 1 Condition Indicator Scoring

Table 1 – Turbine Age Scoring

<table>
<thead>
<tr>
<th>Age</th>
<th>Age</th>
<th>Condition Indicator Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>New / Full Rehabilitation</td>
<td>Partial Rehabilitation</td>
<td></td>
</tr>
<tr>
<td>0 – 25 years</td>
<td>0 – 15 years</td>
<td>3</td>
</tr>
<tr>
<td>26 – 35 years</td>
<td>16 – 25 years</td>
<td>2</td>
</tr>
<tr>
<td>36 – 45 years</td>
<td>26 – 35 years</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 45 years</td>
<td>&gt; 35 years</td>
<td>0</td>
</tr>
</tbody>
</table>
## Summary of Tier 1 Turbine Assessment

### Tier 1 Turbine Condition Summary

*(For instructions on indicator scoring, please refer to condition assessment guide)*

<table>
<thead>
<tr>
<th>No.</th>
<th>Condition Indicator</th>
<th>Score</th>
<th>X</th>
<th>Weighting Factor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>2</td>
<td>1.000</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Score must be 0, 1, 2, or 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Physical Condition</td>
<td>3</td>
<td>1.000</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Score must be 0, 1, 2, 3, or 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Operations</td>
<td>1.5</td>
<td>1.000</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Score must be 0, 0.5, 1, or 1.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Maintenance</td>
<td>1.5</td>
<td>1.000</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Score must be 0, 0.5, 1, or 1.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tier 1 Turbine Condition Index**  
*(Sum of individual Total Scores)*  
*(Condition Index should be between 0 and 10)*

| Tier 1 Turbine Condition Index | 8 |

**Turbine Data Quality Indicator**  
*(Value must be 0, 4, 7, or 10)*

| Turbine Data Quality Indicator | 4 |
Tier 2 Tests

Tier 2 Toolbox:

- Efficiency
- Capacity
- Off-Design
- Paint Film Quality
- Surface Roughness
- Cracking
- Other Specialized Tests

- Cavitation
- Condition of Remaining Parts
- Environmental
- Operating Conditions
- Maintenance

Tier 2 results are used to refine the Tier 1 score.

The Data Quality Indicator also may be adjusted.


## Tier 2 Tests and Condition Index Adjustments

Condition assessment guides also provide criteria for using Tier 2 test results.

### Table 12 – Cavitation Damage of Runner and Discharge Ring Test Scoring

<table>
<thead>
<tr>
<th>Cavitation Damage</th>
<th>Adjustment to Condition Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal:</td>
<td></td>
</tr>
<tr>
<td>Stainless – frosting only</td>
<td>Add 0.5</td>
</tr>
<tr>
<td>Carbon – frosting only</td>
<td></td>
</tr>
<tr>
<td>Moderate:</td>
<td></td>
</tr>
<tr>
<td>Stainless:</td>
<td>No Change</td>
</tr>
<tr>
<td>Depth:</td>
<td>&lt; 1/8”</td>
</tr>
<tr>
<td>Area:</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Carbon:</td>
<td></td>
</tr>
<tr>
<td>Depth:</td>
<td>&lt; 3/8”</td>
</tr>
<tr>
<td>Area:</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Severe:</td>
<td></td>
</tr>
<tr>
<td>Stainless:</td>
<td>Subtract 0.5</td>
</tr>
<tr>
<td>Depth:</td>
<td>&gt; 1/8”</td>
</tr>
<tr>
<td>Area:</td>
<td>&gt; 5%</td>
</tr>
<tr>
<td>Carbon:</td>
<td></td>
</tr>
<tr>
<td>Depth:</td>
<td>&gt; 3/8”</td>
</tr>
<tr>
<td>Area:</td>
<td>&gt; 5%</td>
</tr>
</tbody>
</table>
Using hydroAMP

hydroAMP was intended to be used in conjunction with performing annual maintenance.

- Turbines: As you fill out your performing your cavitation mapping, the hydroAMP turbine assessment should be filled in.

- If you have Tier 2 data, use it: Cavitation, Reliable On-line Efficiency Monitoring, etc.
hydroAMP Simplicity

The idea was to “KEEP IT SIMPLE.”

- Minimal time to perform, if you’re doing it while you are performing maintenance.
- You’re already thinking about the equipment and how it’s performing.

How not to use it:

- Not a paperwork exercise.
- Last minute reporting of condition because of performance measures.

Make it meaningful.
hydroAMP Data Management

Equipment guides and assessment data and are stored in a secure web-accessible database.

- The database stores and reports Tier 1 condition assessments.
- Adjustments for Tier 2 assessments have recently been added.
- It is expandable to include new plants and equipment.

www.bpa.gov/secure/hydroAMP
Aging and deteriorating equipment poses significant risk to hydro-electric equipment reliability and may result in low generating unit availability. Significant investment in replacing, repairing or refurbishing existing equipment and support equipment within hydro-electric projects is required to assure the continued viability of hydro-electric assets. The four organizations involved in hydroAMP, the Bureau of Reclamation (BOR), Hydro-Quebec (HQ), the US Army Corps of Engineers (COE) and the Bonneville Power Administration (BPA), joined together to develop a common framework or process to streamline, simplify and improve the evaluation and documentation of the condition of hydro-electric equipment and facilities in order to support condition-based prioritization of hydropower asset business decision-making.

A two-tiered approach for assessing equipment condition and risk of failure for hydro-power equipment was developed. Tier 1 of the condition assessment process incorporates test results and/or inspections that are normally obtained during routine operation and maintenance activities. These condition indicators are combined to compute an equipment Condition Index. Tier 2 of the assessment relies on more in-depth, non-routine test results and inspections requiring specialized knowledge to further refine the equipment Condition Index.

This website represents an additional effort that was developed in order to allow plants and agencies to input their equipment condition data into a single database in a common format. It also allows for individual plant/plant analyses and reporting.

Please select an option from the list below:

- **Condition Assessments**
  - Input equipment condition data for tier 1 assessment.

- **Equipment**
  - Add, update and delete equipment for specific plants.

- **Reports**
  - View and export condition assessment reports.

- **My Account**
  - View and make changes to your account.

- **Help**
  - Need help? Have comments?

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**What's Next**

- 6/4/2008 - On Thursday June 4th between 3:00 and 4:00 pm the hydroAMP system will be unavailable due to a system update. Please make sure that you are logged off the system during this time period. Thank you.
- 2/26/2008 - We are pleased to announce that the Phase II release of the hydroAMP system is complete. Please feel free to look around and experience some of the new features that are available. You can now manage equipment for both generation facilities and electrical facilities, many new reports and capabilities are available along with new tools to manage equipment and components within your facility, the ability to download and upload complete condition assessment information, and many new enhanced features on the administration side that allows for better management from our side as well.

Thanks

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**Assessment Guides**

- Circuit Breakers - September 2006 (pdf)
- Turbines - September 2006 (pdf)
- Transformers - September 2006 (pdf)
- Generators - September 2006 (pdf)
- Governors - September 2006 (pdf)
- Exciters - September 2006 (pdf)
- Surge Arrestors - September 2006 (pdf)
- Cranes - September 2006 (pdf)
- Batteries - September 2006 (pdf)
- Compressed Air System - September 2007 (pdf)
- Emergency Closure Gate & Valve - September 2007 (pdf)
### Tier 1 Condition Assessment

#### HydroAMP Database: Tier 1 Turbine Assessment

#### Tier 1 Turbine Condition Assessment

**Plant:** Grand Coulee  
**Unit:** G24  
**Type:** Francis  
**Manufacturer:** Allis-Chalmers  
**Rated Head:** 285 ft (ft)  
**Discharge Diameter:** 32.2 ft (ft)  
**Partial Rehab Year (non runner):** 1996  
**Rated Power:** 980000 (HP)  
**Speed:** 85.7 (RPM)

<table>
<thead>
<tr>
<th>No.</th>
<th>Condition Indicator</th>
<th>Score</th>
<th>Weighting Factor</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In-Service Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Partial Rehab Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Physical Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cavitation and Surface Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Operation Limitations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Corrective Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Tier 1 Turbine Condition Index

- **Data Quality Indicator:** 1 or more, 6 - 24 months past normal frequency
- **Condition Index:** 4.6
- **Rating:** Marginal

#### Tier 2 Turbine Condition Assessment

- **Total Tier 2 Adjustment:** 1.0

In this comment box, please list which of the Tier 2 tests or inspections you conducted and note the incremental adjustment for each that was used in calculating the total adjustment reported above.

**Certification Information**

- **Last Assessment Date:** 10/8/2011  
- **Evaluated By:** Strombach, Michael on 10/4/2011
- **Approved By:** N/A
### Condition Index Summary (Power Train)

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Condition Index</th>
<th>Condition Rating</th>
<th>Condition Index</th>
<th>Condition Rating</th>
<th>Condition Index</th>
<th>Condition Rating</th>
<th>Condition Index</th>
<th>Condition Rating</th>
<th>Condition Index</th>
<th>Condition Rating</th>
<th>Condition Index</th>
<th>Condition Rating</th>
<th>Condition Index</th>
<th>Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Coulee 1</td>
<td>5.9</td>
<td>Marginal</td>
<td>7.6</td>
<td>Fair</td>
<td>3.7</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 2</td>
<td>5.9</td>
<td>Marginal</td>
<td>8.0</td>
<td>Good</td>
<td>8.0</td>
<td>Fair</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 3</td>
<td>5.9</td>
<td>Marginal</td>
<td>8.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 4</td>
<td>5.9</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 5</td>
<td>5.9</td>
<td>Marginal</td>
<td>5.3</td>
<td>Marginal</td>
<td>5.8</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 6</td>
<td>5.9</td>
<td>Marginal</td>
<td>7.1</td>
<td>Fair</td>
<td>8.1</td>
<td>Fair</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 7</td>
<td>5.9</td>
<td>Marginal</td>
<td>5.3</td>
<td>Marginal</td>
<td>5.8</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>3.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 8</td>
<td>5.9</td>
<td>Marginal</td>
<td>7.6</td>
<td>Fair</td>
<td>5.8</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>4.0</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 9</td>
<td>5.9</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>6.8</td>
<td>Fair</td>
<td>4.0</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 10</td>
<td>6.9</td>
<td>Fair</td>
<td>8.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>10.0</td>
<td>Good</td>
<td>7.8</td>
<td>Fair</td>
<td>3.0</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 11</td>
<td>8.1</td>
<td>Good*</td>
<td>9.0</td>
<td>Good*</td>
<td>4.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>7.8</td>
<td>Fair</td>
<td>4.2</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 12</td>
<td>8.1</td>
<td>Good*</td>
<td>9.0</td>
<td>Good*</td>
<td>4.5</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
<td>7.8</td>
<td>Fair</td>
<td>4.2</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
<tr>
<td>Grand Coulee 13</td>
<td>8.5</td>
<td>Fair*</td>
<td>7.7</td>
<td>Fair*</td>
<td>7.3</td>
<td>Fair</td>
<td>10.0</td>
<td>Good</td>
<td>7.8</td>
<td>Fair*</td>
<td>4.2</td>
<td>Marginal</td>
<td>10.0</td>
<td>Good</td>
</tr>
</tbody>
</table>
**hydroAMP Database: User Accounts**

- Access to the database and website is restricted and requires a user account.

- Accounts may be requested by e-mail to [hydroAMP@bpa.gov](mailto:hydroAMP@bpa.gov), by providing the user’s first and last name, company, job title, telephone number, and e-mail address. The request should also identify the hydro plants the user wishes to access.

- The hydroAMP administrator will assign a log-in and password, and send this information via e-mail to the user.
Applying hydroAMP Results in Asset Planning
Current Condition by Plant: All Equipment
Current Condition: Unit Reliability Equipment

Bearing Guide
Bearing Thrust
Generator Cooling & Misc.
Generator Core
Generator Rotor
Generator Winding
Governor Electrical
Governor Mechanical
Transformer Fire Protection
Transformer Main Unit
Transformer Protective Relay Systems
Breaker Unit
Exciter
Fire Protection Unit
Protective Relay Systems
Power Bus
Transformer
Turbine
Unit Control Boards

0% 20% 40% 60% 80% 100%
Bearing
Generator
Governor
Transformer

Good Fair Marginal Poor

Green Blue Yellow Red

The hydro program correlates a condition rating with the likelihood of equipment failing to perform as expected. An equipment component with a low condition rating has a higher likelihood of failure than one with a higher rating. The correlation is shown below.

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Condition Index</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rare</td>
<td>0 to 0.9</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>1 to 1.9</td>
<td>Marginal</td>
</tr>
<tr>
<td></td>
<td>2 to 2.9</td>
<td>Fair</td>
</tr>
<tr>
<td></td>
<td>3 to 3.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 to 4.9</td>
<td></td>
</tr>
<tr>
<td>Almost Certain</td>
<td>5 to 5.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 to 6.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 to 7.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 to 8.9</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>9 to 10</td>
<td></td>
</tr>
</tbody>
</table>
### Current Financial Risk Map

<table>
<thead>
<tr>
<th>Condition Index</th>
<th>Poor</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

#### Likelihood

<table>
<thead>
<tr>
<th>Likely</th>
<th>16 Operations Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>1 Operations Support</td>
</tr>
<tr>
<td>Likely</td>
<td></td>
</tr>
<tr>
<td>Possible</td>
<td></td>
</tr>
<tr>
<td>Unlikely</td>
<td></td>
</tr>
<tr>
<td>Rare</td>
<td></td>
</tr>
</tbody>
</table>

#### Consequence

<table>
<thead>
<tr>
<th>Insignificant</th>
<th>Minor</th>
<th>Moderate</th>
<th>Major</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consequence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
</table>
Prioritizing Investments

Without intervention, condition degrades over time and the risk of equipment failing to perform as expected increases. Three factors influence the prioritization of investments:

- Replacement Cost, Lost Generation Risk, and Direct Cost Risk

![Graph]

The **Total Cost** is the present value sum of replacement and risk costs. The cost minimum of this curve is the point at which cost risk is forecasted to begin growing faster than the benefit of investment deferral. This represents the optimum timing for equipment replacement.
Least Cost Case

- The least cost case represents all equipment being replaced at the cost minima.

Large Capital Forecast
When funding constraints are applied, Total Cost for the system (system cost) increases because new investments are deferred past their cost minima.
System Cost Impacts of Funding Constraints

- System costs increase as funding is further constrained because more investments are deferred past the cost minimum.
Condition by Plant in 2022: Unit Reliability Equipment

Condition Index

Current
Committed Only
Plan
Current Average
Committed Only Avg
Plan Avg

Main Stem Columbia
Headwater/Lower Snake
Area Support
Local Support

Bonneville
Chief Joseph
Grand Coulee
John Day
McNary
The Dalles
Dworshak
Hungry Horse
Ice Harbor
Libby
Little Goose
Lower Granite
Lower Monumental
Albeni Falls
Big Cliff
Cougard
Detroit
Dexter
Foster
Green Peter
Hills Creek
Lookout Point
Lost Creek
Palisades
Anderson Ranch
Black Canyon
Boise Diversion
Chandler
Green Springs
Minidoka
Roza
Lost Generation Risk by Plant in 2022

Total = 247 aMW

- Bonneville
- Chief Joseph
- Grand Coulee
- John Day
- McNary
- The Dals
- Dworshak
- Hungry Horse
- Ice Harbor
- Libby
- Little Goose
- Lower Granite
- Lower Monumental
- Albeni Falls
- Big Chief
- Cougar
- Detroit
- Dexter
- Foster
- Green Peter
- Hills Creek
- Lookout Point
- Lost Creek
- Palisades
- Anderson Ranch
- Black Canyon
- Boise Diversion
- Chandler
- Green Springs
- Minidoka
- Roza

Lost Generation Risk (aMW)
Thank you

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