Decision Support Systems
Maximizing Operational Efficiency of Dams
Maintaining Regulatory Compliance

Mark D. Morehead, PhD
Outline

• Who is Idaho Power
• Hydropower System
• Mid-Snake & Bliss Dam
  – Bliss DSS
• Hells Canyon Complex
  – HCC DSS
Bliss Rapids Snail
Idaho Power
An Investor Owned, Regulated Electric Utility

- **Service Area**
  - Southern Idaho
  - Eastern Oregon
  - 24,000 sq. mi

- **Population**
  - 1 Million

- **Total Sales**
  - 15,500,000 MW / year

- **Employees**
  - 2,000

- **Fully Integrated Utility**
  - Generate Power
  - Interstate Transmission
  - Distribute to Customers

- **Regulated by**
  - FERC
    - USFS
    - IDEQ
    - ODEQ
    - NOAA ...
  - Idaho PUC
  - Oregon PUC
### Idaho Power Resources & Service Territory

#### Hydroelectric Facilities and Nameplate Capacities

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<thead>
<tr>
<th>Facility</th>
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<td><strong>Total</strong></td>
<td><strong>1,709.0 MW</strong></td>
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#### Thermal Facilities and Capacities

- **Coal**
  - Jim Bridger: 770.5 MW*
  - North Valmy: 283.5 MW*
  - Boardman: 64.2 MW*

- **Natural Gas**
  - Bennett Mountain: 172.8 MW
  - Evander Andrews: 270.9 MW**

- **Diesel**
  - Salmon Diesel: 5.0 MW

**Total Capacity: 1,566.9 MW**

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* Idaho Power Co. Share  ** Danskin
2010 Fuel Mix

- Hydroelectric: 48.8%
- Coal: 43.9%
- Natural Gas: 2.6%
- Wind: 3.1%
- Biomass: 0.5%
- Waste: 0.5%
- Other: 0.7%
Problem

• Maximize Operational Efficiency
  – Match Power Load
  – Account for variable wind generation

• Protect the Environment - Maintain Regulatory Compliance
  – Reservoir
    • Min/Max Levels
    • Ramp Rates
  – River
    • Minimum instream flows
    • Ramp Rates
  – Water Quality Criteria
    • Temperature
    • Nutrients
    • Dissolved Gas
### Previous Methodology is Unsuitable

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ramp Rate</th>
<th>1 Hour Max</th>
<th>1 Hour Min</th>
<th>1 Hour Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/12/2008</td>
<td>12:47</td>
<td>2284.42</td>
<td>2284.62</td>
<td>2284.42</td>
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</table>

### 1 Foot Rule Per Hour

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ramp Rate</th>
<th>24 Hour Max</th>
<th>24 Hour Min</th>
<th>24 HR Difference</th>
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</table>

### 3 Foot Rule Per 24 Hours

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<tr>
<th>Date</th>
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<th>24 Hour Min</th>
<th>24 HR Difference</th>
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<td>11-Dec-08</td>
<td>15:32:45</td>
<td>2284.06</td>
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<td></td>
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</tbody>
</table>

### 24 Hour Max/Min Criteria

\[
\text{val} = \min(\text{last 24h}) + 3\text{ft}
\]

Highest Ramp Gage We Can Go To: 2287.06

Currently: 2284.42

\[
\text{val} = \max(\text{last 24h}) - 3\text{ft}
\]

Lowest Ramp Gage We Can Go To: 2283.28

### Previous Days 3 Foot Per 24 Hours

#### Date = Now - 1 Day

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ramp Rate</th>
<th>24 Hour Max</th>
<th>24 Hour Min</th>
<th>24 HR Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-Dec-08</td>
<td>21:32:39</td>
<td>2286.45</td>
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<td>10-Dec-08</td>
<td>15:12:44</td>
<td>2283.90</td>
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</table>

#### Date = Now - 2 Days

<table>
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<th>Date</th>
<th>Time</th>
<th>Ramp Rate</th>
<th>24 Hour Max</th>
<th>24 Hour Min</th>
<th>24 HR Difference</th>
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<tbody>
<tr>
<td>10-Dec-08</td>
<td>06:34:39</td>
<td>2285.33</td>
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<td></td>
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<td>10-Dec-08</td>
<td>12:34:41</td>
<td>2284.01</td>
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<td></td>
</tr>
</tbody>
</table>

### Stage (ft) & Discharge (cfs) Relationship

- 0-207
- Annual Peak
- Power (0-207)

\[
y = 281.28x^{0.438}
\]
Wave Propagation Time

Bliss Model - Travel Time - Hysteresis

Q (cfs) vs. Travel Time (min)

Bliss Gauge Water Elevation (ft) vs. Travel Time (min)
Channel Morphology
Controls Flood Wave Propagation

Shallow Water Wave Speed \( \sim vgh \)
### Bliss Dam

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built</td>
<td>1950</td>
</tr>
<tr>
<td>Height</td>
<td>70’</td>
</tr>
<tr>
<td>Volume</td>
<td>8 KAF</td>
</tr>
<tr>
<td>Capacity</td>
<td>75 MW</td>
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<tr>
<td>$Q_{\text{max}}$</td>
<td>15,000 cfs</td>
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![Bliss Dam Image](image_url)
What Is a DSS

• An information system that supports decision-making

• Aids the decision making process
  – During rapidly changing conditions
  – When decisions are not easily specified in advance

• Integrates complex information into a user friendly form

• A tool
  – A decision system DOES NOT make the decisions
  – The users make the decisions
## Evolution of Decision Making

<table>
<thead>
<tr>
<th>Evolution</th>
<th>Cost of Consequences</th>
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<tr>
<td>Poorly informed decisions</td>
<td>Low</td>
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<tr>
<td>Well informed decisions</td>
<td>High</td>
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<tr>
<td>Decision Support Systems</td>
<td></td>
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<tr>
<td>Automated Systems</td>
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<tr>
<td>– Dependent on pre-defined rules</td>
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Process To Create the DSS

- Learn what the operators
  - Want
  - Will use
  - Test & Iterate
- Build a hydraulic model
  - DHI – Mike11
- Build a database
  - Dam Operations
  - Compliance Gages
    - Reservoir
    - River
- Create the DSS
  - User interface
  - Model optimization
  - Discharge limits
  - User scenario execution
Learn From the Operators

- **Most Important Part of Building a DSS**

- Must make a Tool that the operators will use
  - Implement a complex model
  - Easy to use
  - Quick
  - Accurate
  - Easy to Read

- “Every good conversation begins with good listening”
Create a Numerical Model
Bliss Operational Requirements

• Reservoir
  – Minimum Elevation
  – Maximum Elevation

• River
  – Minimum Instream Flow
  – Hourly Ramp Rates
  – Daily Ramp Rates

• Compliance Type
  – Run-of-River
  – Load-Following
Build a Data Base

• Pull data from a secure SCADA system
  – Dam Operations
  – Compliance Gauges

• Screen the real-time data
  – Data spikes
  – Missing Data

• Calculate needed values
  – Sum dam discharge data
    • Turbines
    • Spill Gates

• Need a GOOD data base programmer
DSS

“Geek to Human Interface”

User Interface
Operator Input

Information Management System

Database
Data Import
Data Checking
Calculations

Error Checking

Hydraulic Model
Optimizer
Scenarios
Next Step
Hells Canyon Complex

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Diesel
- Salmon Diesel: 5.0 MW

Total 1,566.9 MW

* Idaho Power Co. Share ** Danskin
Brownlee Dam
Upstream in the HCC

- Built: 1959
- Height: 420’
- Volume: 1,420 KAF
- Capacity: 585 MW
- $Q_{max}$: 35,000 cfs
Oxbow Dam
Middle in the HCC

- **Built**: 1961
- **Height**: 175’
- **Volume**: 58 KAF
- **Capacity**: 190 MW
- **Q_{max}**: 28,000 cfs
Hells Canyon Dam
Downstream in the HCC

Built: 1967
Height: 330’
Volume: 186 KAF
Capacity: 390 MW
Q_{max}: 30,000 cfs
Hells Canyon Complex - DSS

Brownlee
- Inflow
- Pool Elevation
  - Power Generation
  - Flood Control
  - Recreation
  - Fisheries
- Ramp Rates
  - Bank Stability

Oxbow
- Pool Elevation
  - Power Generation

Hells Canyon
- Pool Elevation
  - Power Generation
- River Q
  - $Q_{\text{min}}$
  - Ramp Rates
  - Fisheries
  - Recreation
- $\Delta$ Compliance Point
Brownlee Reservoir - Annual Operations

Reservoir Elevation (ft)

Max = 2077'
Min = 2007'
Flood = 1976'
Plan
1997
1998
1999
2010
2011
2012
HCC Operations

HCC Flows & ReRegulation

- Brownlee Inflow
- Brownlee Outflow
- Hells Cyn Outflow

Date: 16-Jan-11 to 23-Jan-11

Q (K cfs)
Hells Canyon Complex
– DSS Tasks

- Listen to Users
- Determine user input
- Build a Rule System
- Design a user interface
- Build a Database
- Build Hydraulic model(s)
- Build the DSS
- Iterate
Questions?