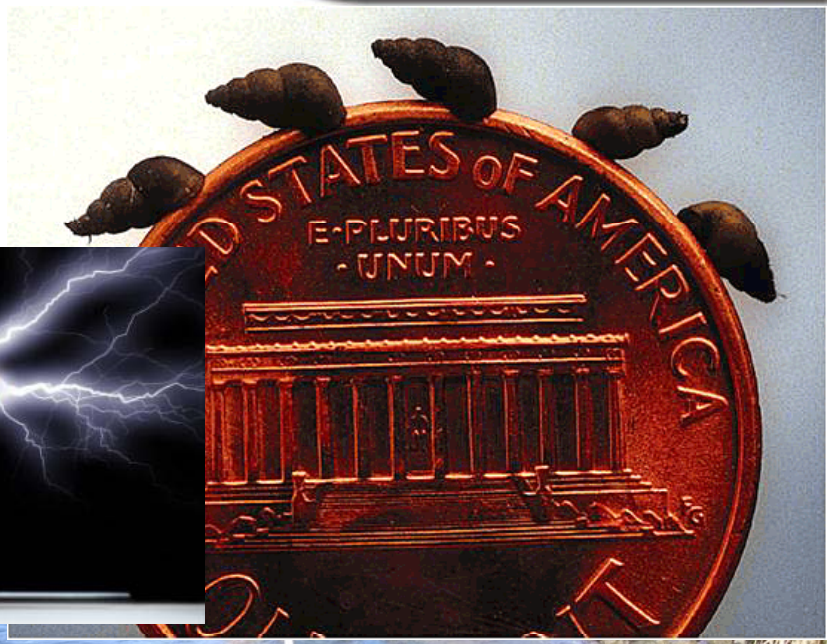
Decision Support Systems

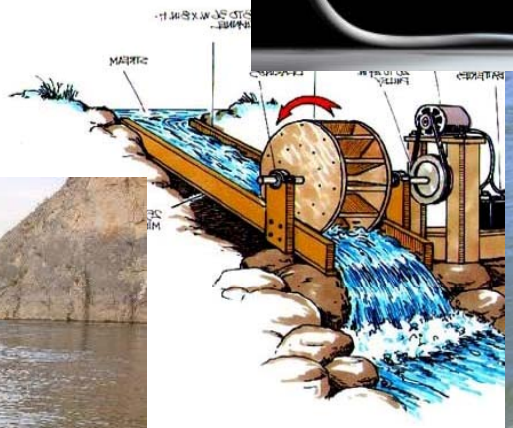
Maximizing Operational Efficiency of Dams
Maintaining Regulatory Compliance

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

1	Hells Canyon	391.5 MW
2	Oxbow	190.0 MW
3	Brownlee	585.4 MW
4	Cascade	12.4 MW
5	Swan Falls	27.2 MW
6	C. J. Strike	82.8 MW
7	Bliss	75.0 MW
8	Lower Malad	13.5 MW
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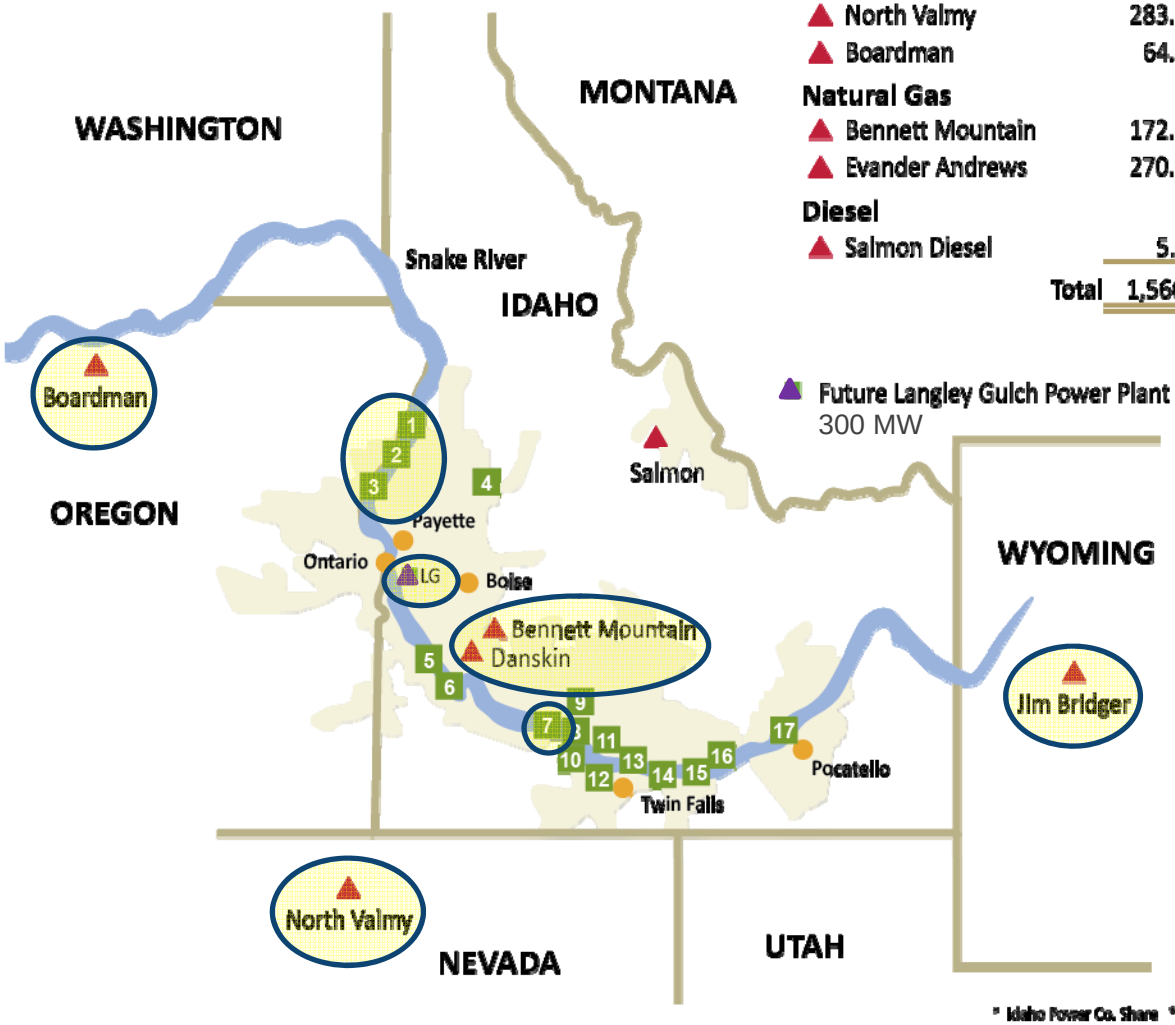
14	Shoshone Falls	12.5 MW
15	Twin Falls	52.9 MW
16	Milner	59.4 MW
17	American Falls	92.3 MW
	Total	1,709.0 MW

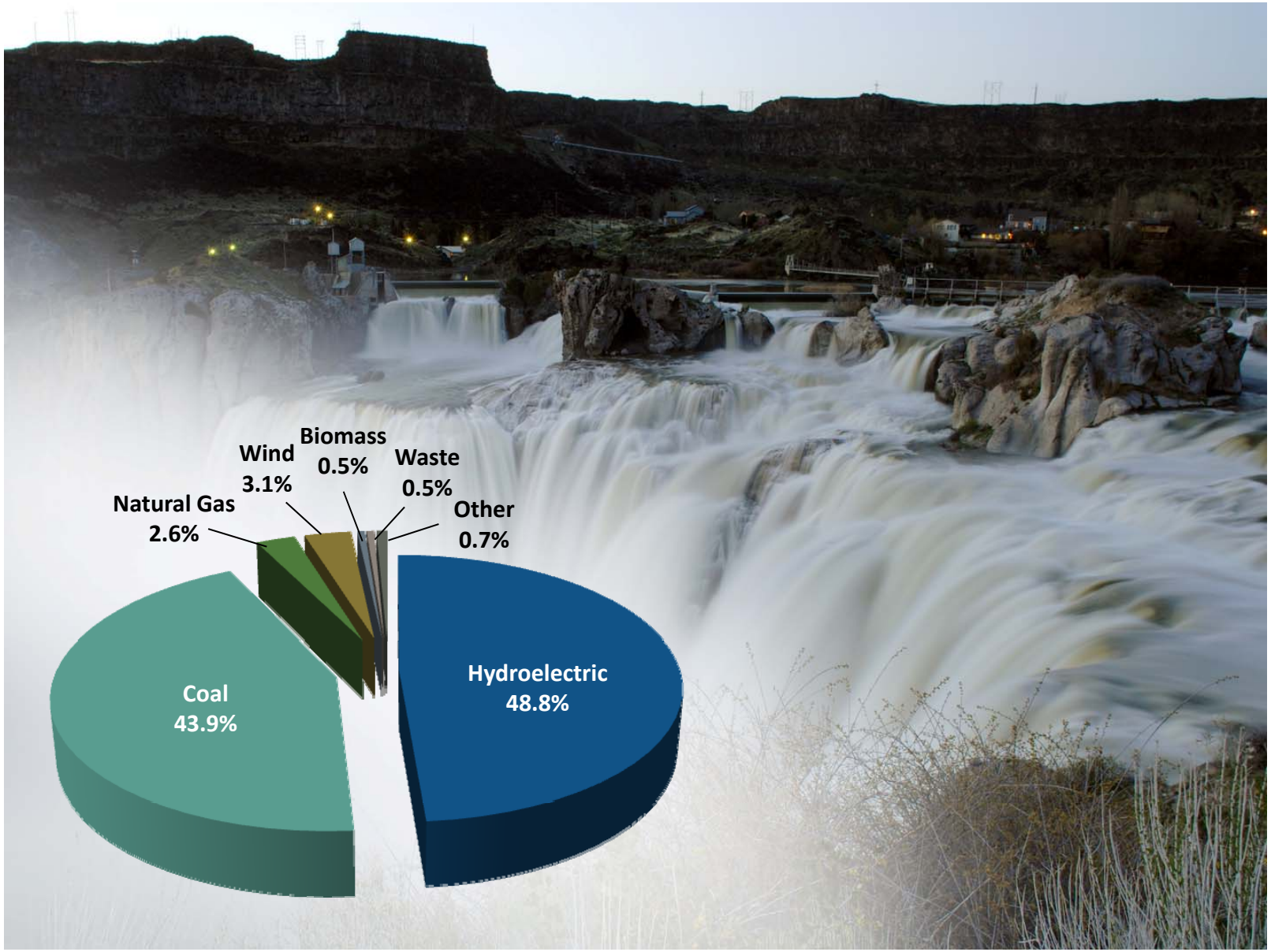


Thermal Facilities And Capacities

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	1,566.9 MW

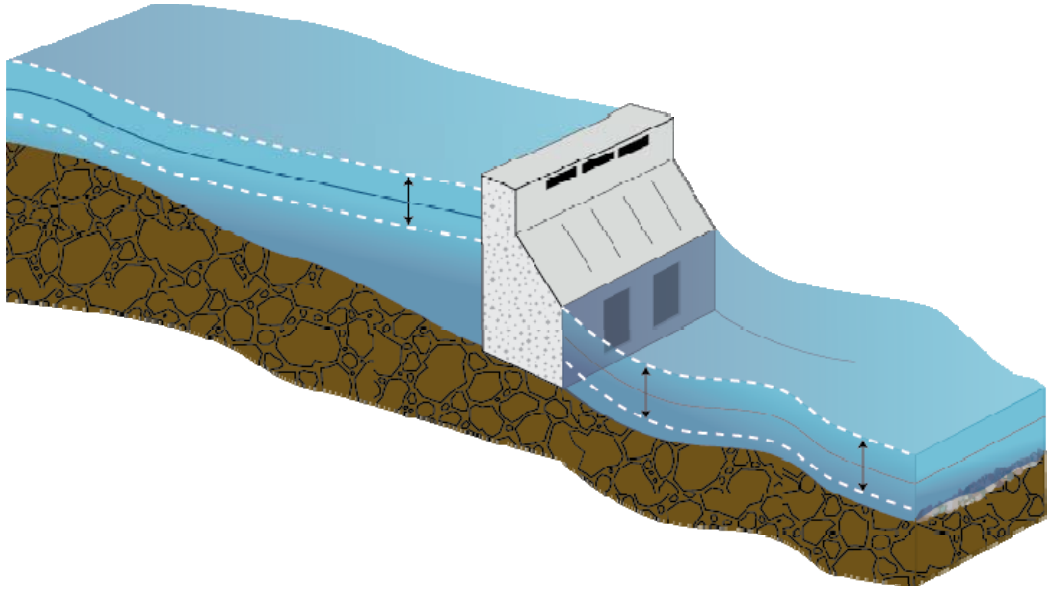
* Idaho Power Co. Share ** Danskin

2010 Fuel Mix



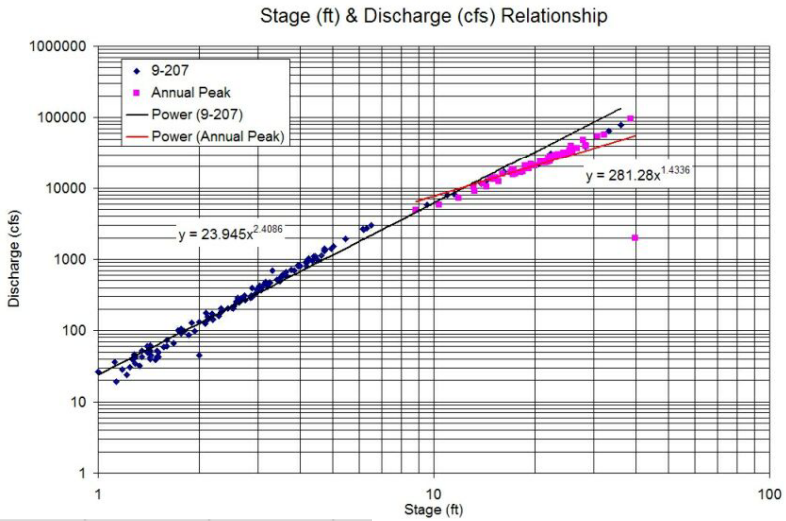
Problem ?

- 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

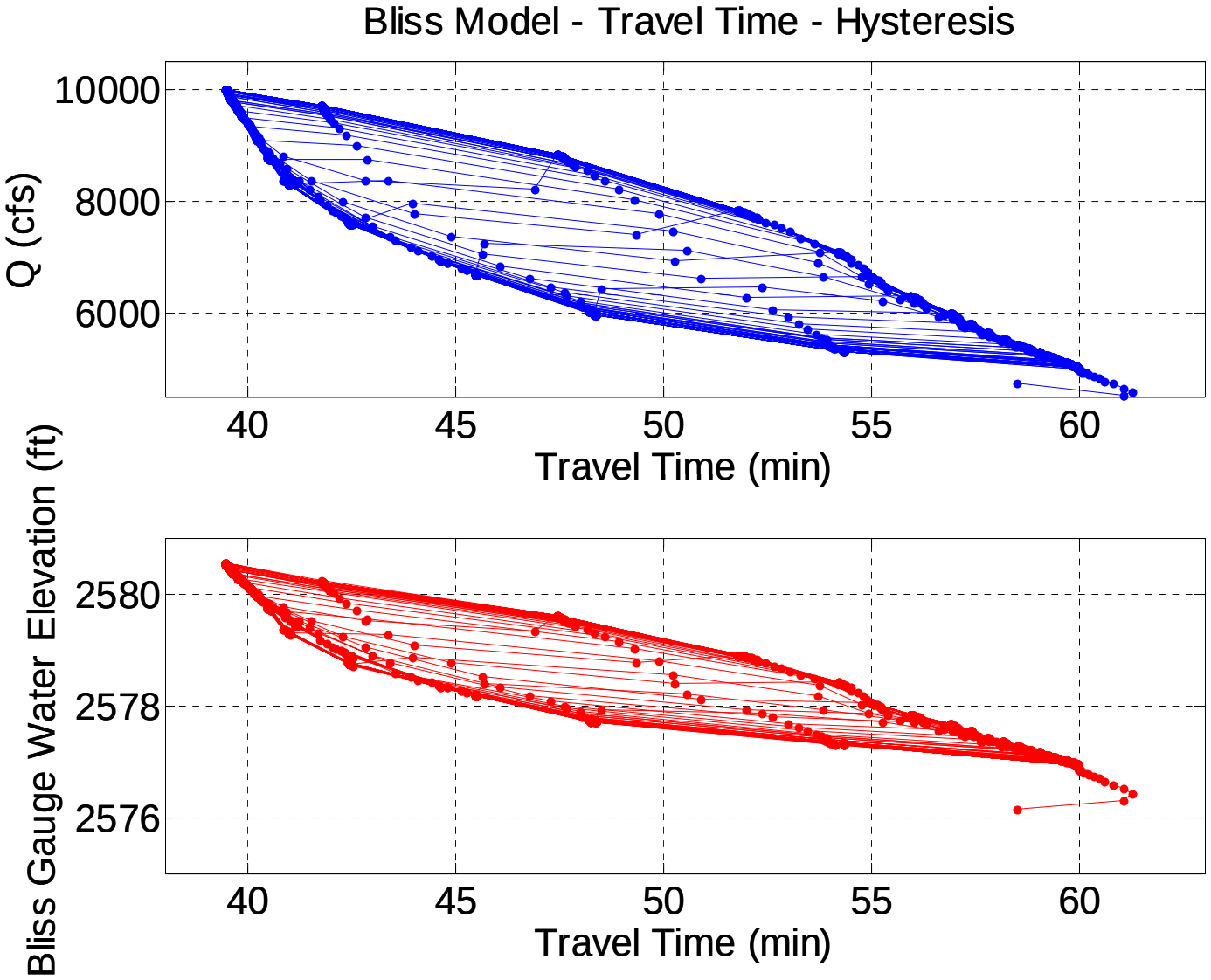


Previous Methodology is Unsuitable

day = now - 24hrs			
now ->	12/12/2008 12:47		SWPO RAMP RATE
pi criteria data	SWPO_RAMP_FT		
			CURRENT READING
pi_current_value(B,3) ->->		12-Dec-08 12:46:45	2284.42
	1 FOOT RULE PER HOUR		
	12-Dec-08 11:47:17	2284.62	1 HOUR MAX
	12-Dec-08 12:46:45	2284.42	1 HOUR MIN.
		0.20	1 HR DIFFERENCE
	3 FOOT RULE PER 24 HOURS		
	12-Dec-08 01:44:45	2286.28	24 HOUR MAX
	11-Dec-08 15:32:45	2284.06	24HOUR MIN
		2.22	24 HR DIFFERENCE
24 hour max/min criteria			
val = min(last 24hrs) + 3ft	HIGHEST RAMP GAGE WE CAN GO TO	2287.06	
		CURRENTLY =	2284.42
val = max(last 24hrs) - 3ft	LOWEST RAMP GAGE WE CAN GO TO	2283.28	
	PREVIOUS DAYS 3 FOOT PER 24 HOURS		
date = now - 1day		12/11/2008 12:47	
	10-Dec-08 21:32:39	2286.45	24 HOUR MAX
	10-Dec-08 15:12:44	2283.96	24HOUR MIN
		2.49	24 HR DIFFERENCE
date = now - 2days		12/10/2008 12:47	
	10-Dec-08 06:34:39	2285.33	24 HOUR MAX
	10-Dec-08 12:34:41	2284.01	24HOUR MIN
		1.32	24 HR DIFFERENCE



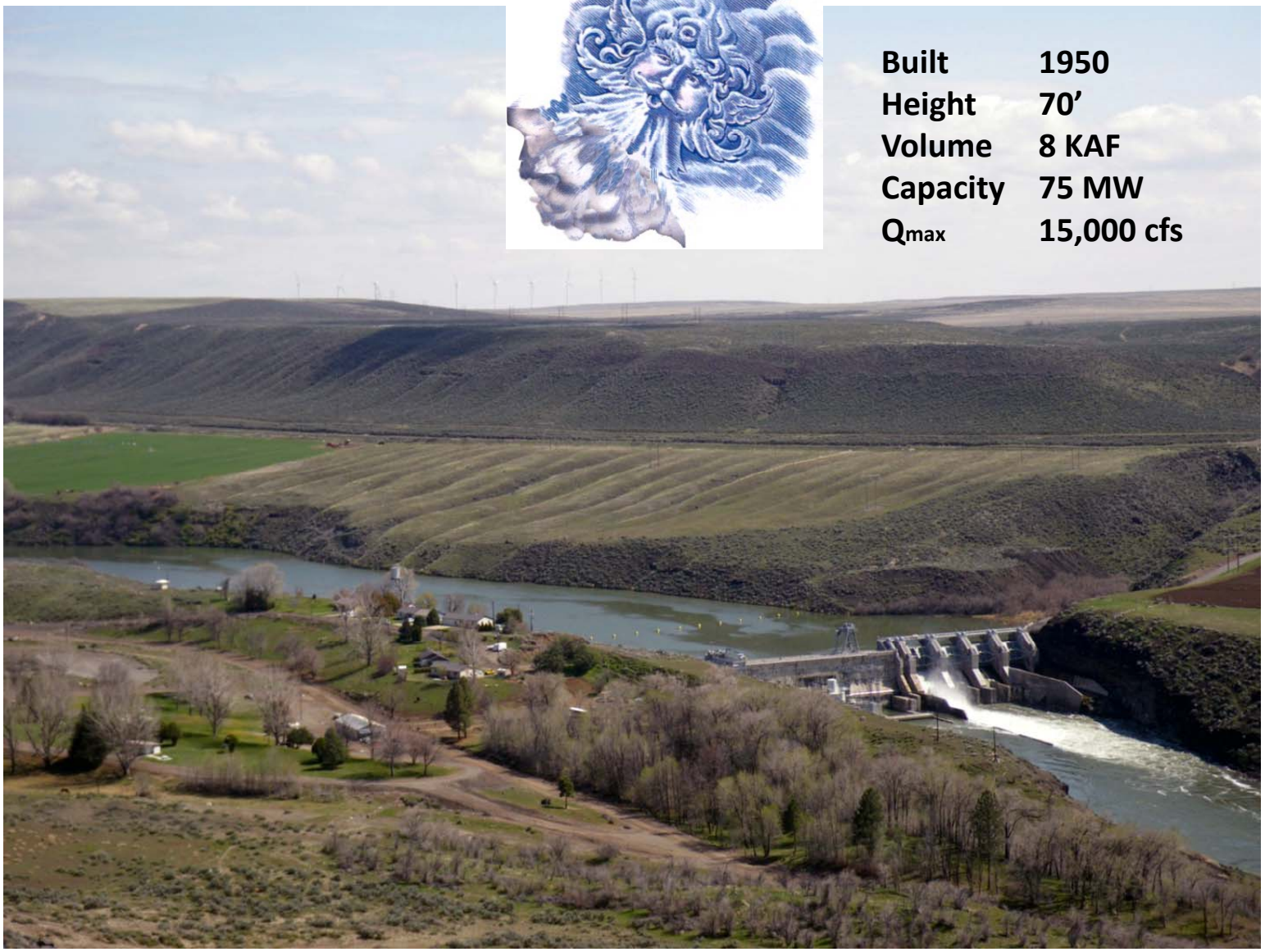
Wave Propagation Time



Channel Morphology

Controls Flood Wave Propagation Shallow Water Wave Speed ~ √gh

Bliss Dam



Built	**1950**
Height	**70’**
Volume	**8 KAF**
Capacity	**75 MW**
Q_{max}	**15,000 cfs**

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

Evolution

- Poorly informed decisions
- Well informed decisions
- Decision Support Systems
- Automated Systems
  - Dependent on pre-defined rules

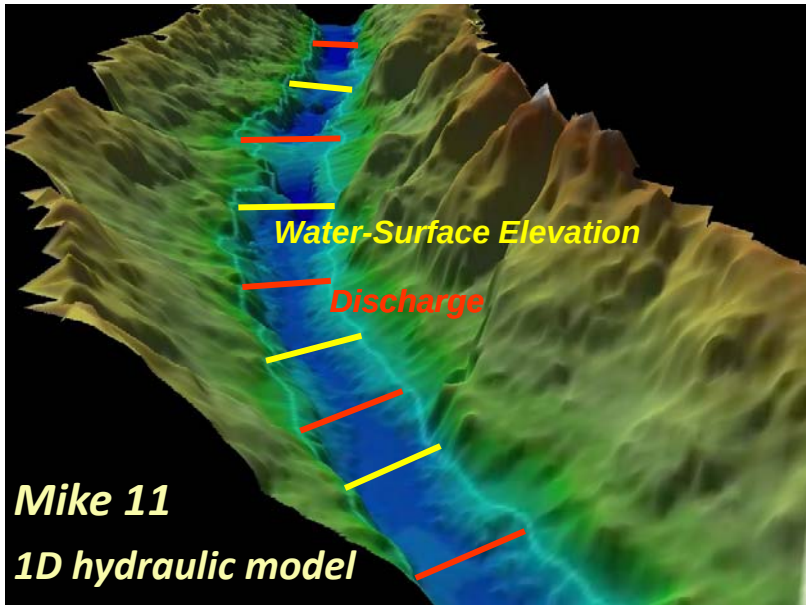
Cost of Consequences

⇐Low

⇐High

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

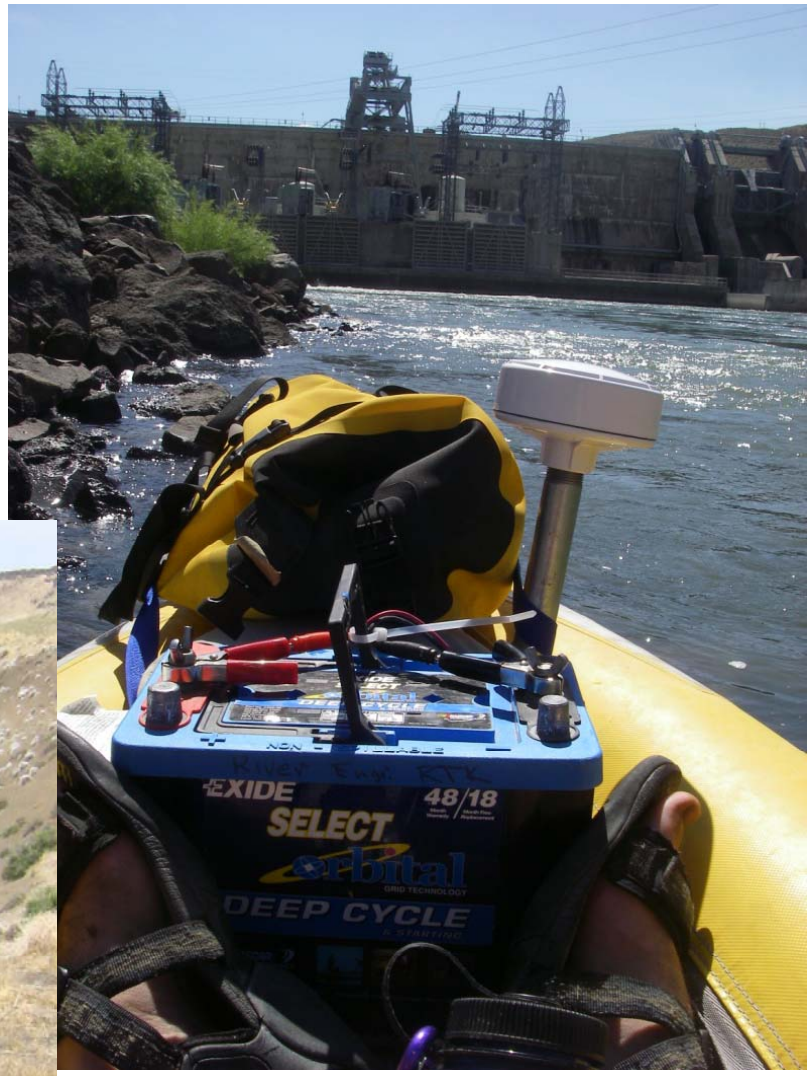
Learn From the Operators

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

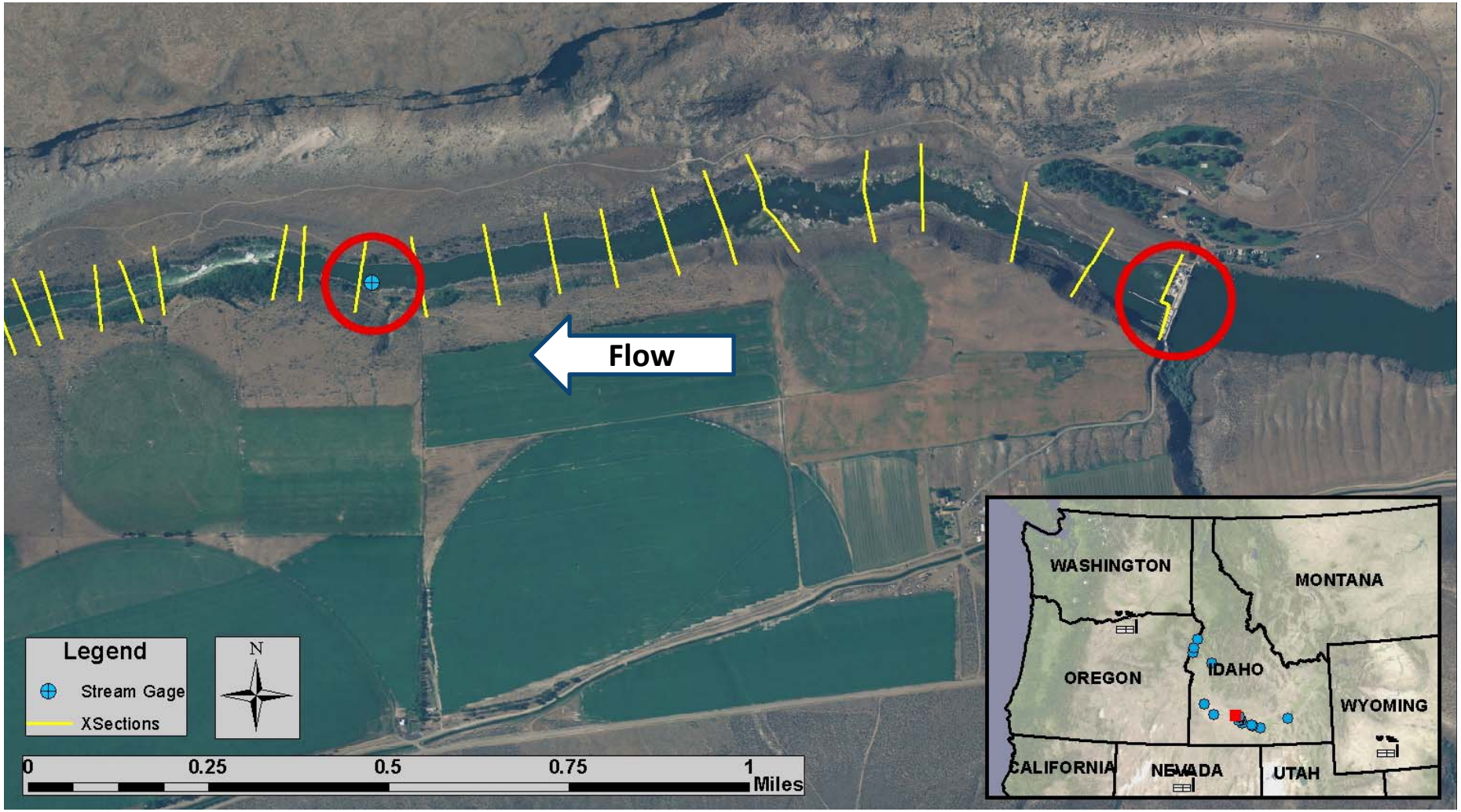
- Must make a Tool that the operators will use
  - Implement a complex model
  - Easy to use
  - Quick
  - Accurate
  - Easy to Read

- "Every good conversation begins with good listening"

Create a Numerical Model

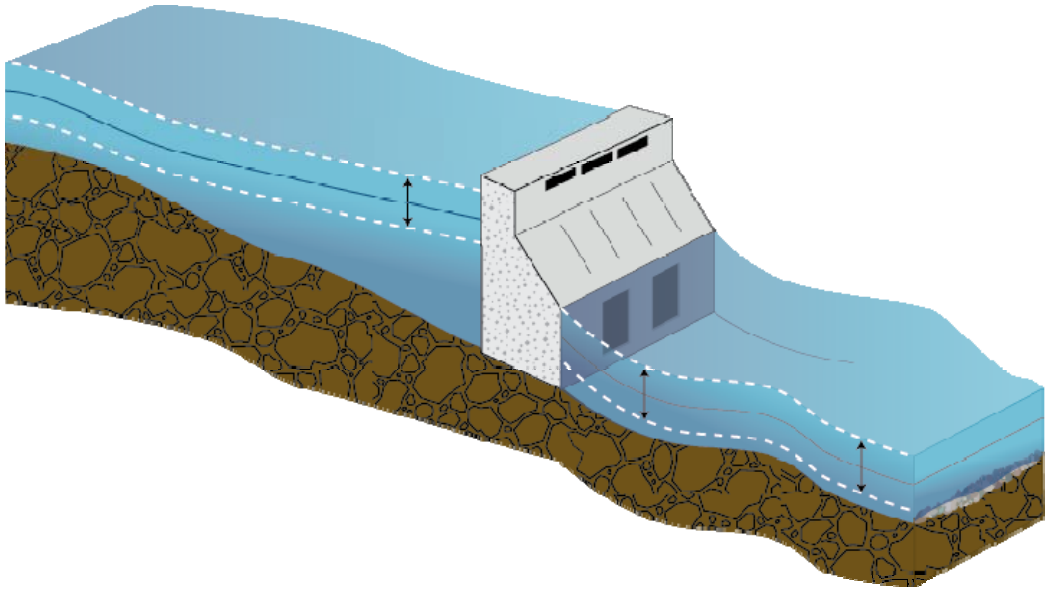


Bliss Dam & Compliance Gauge



Bliss Operational Requirements

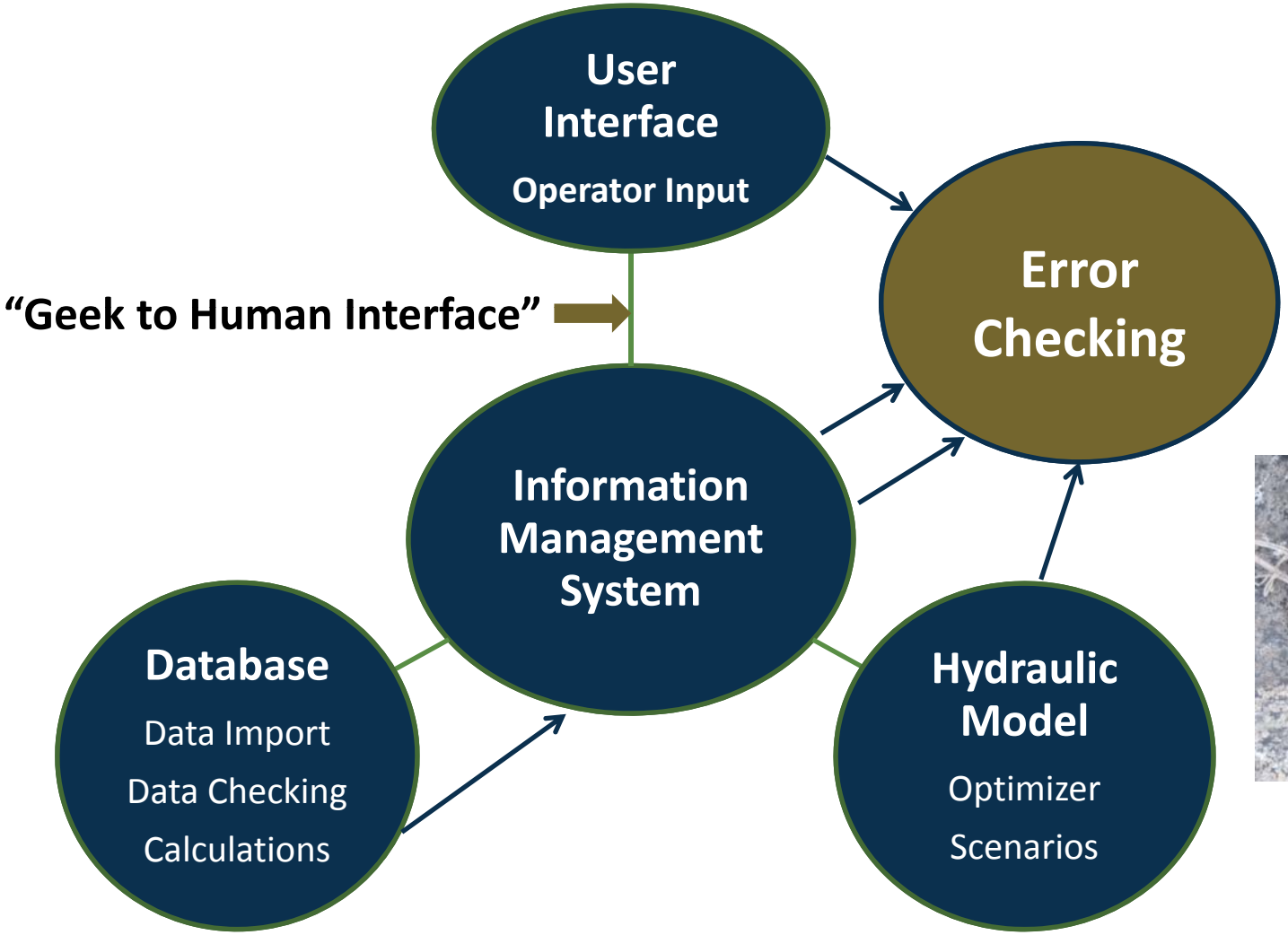
- Reservoir
  - Minimum Elevation
  - Maximum Elevation
- River
  - Minimum Instream Flow
  - Hourly Ramp Rates
  - Daily Ramp Rates
- Compliance Type
  - Run-of-River
  - Load-Following



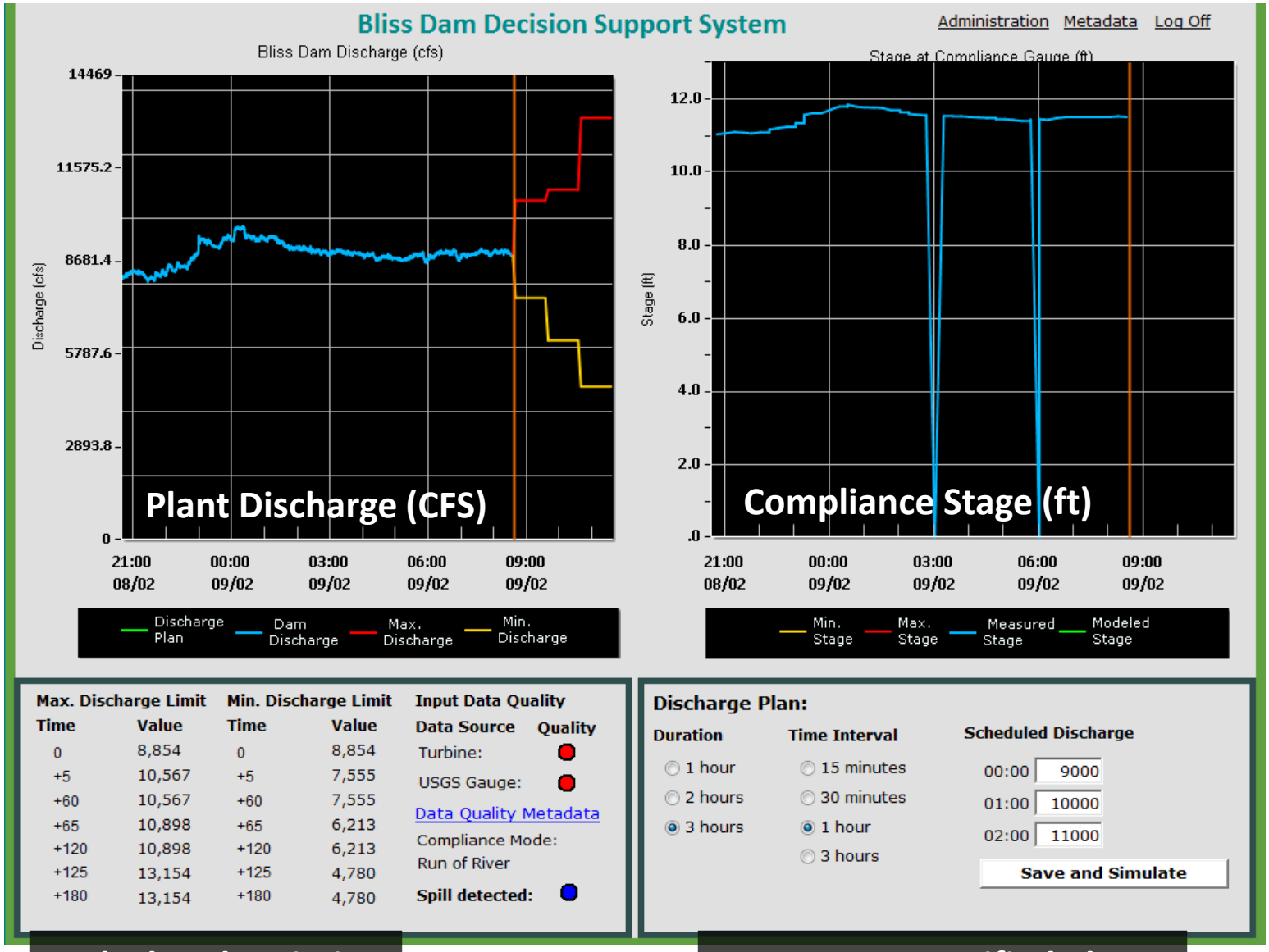
Build a Data Base

- 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


User Interface
Operator Input
"Geek to Human Interface"
Error Checking
Information Management System
Database
Data Import
Data Checking
Calculations
Hydraulic Model
Optimizer
Scenarios

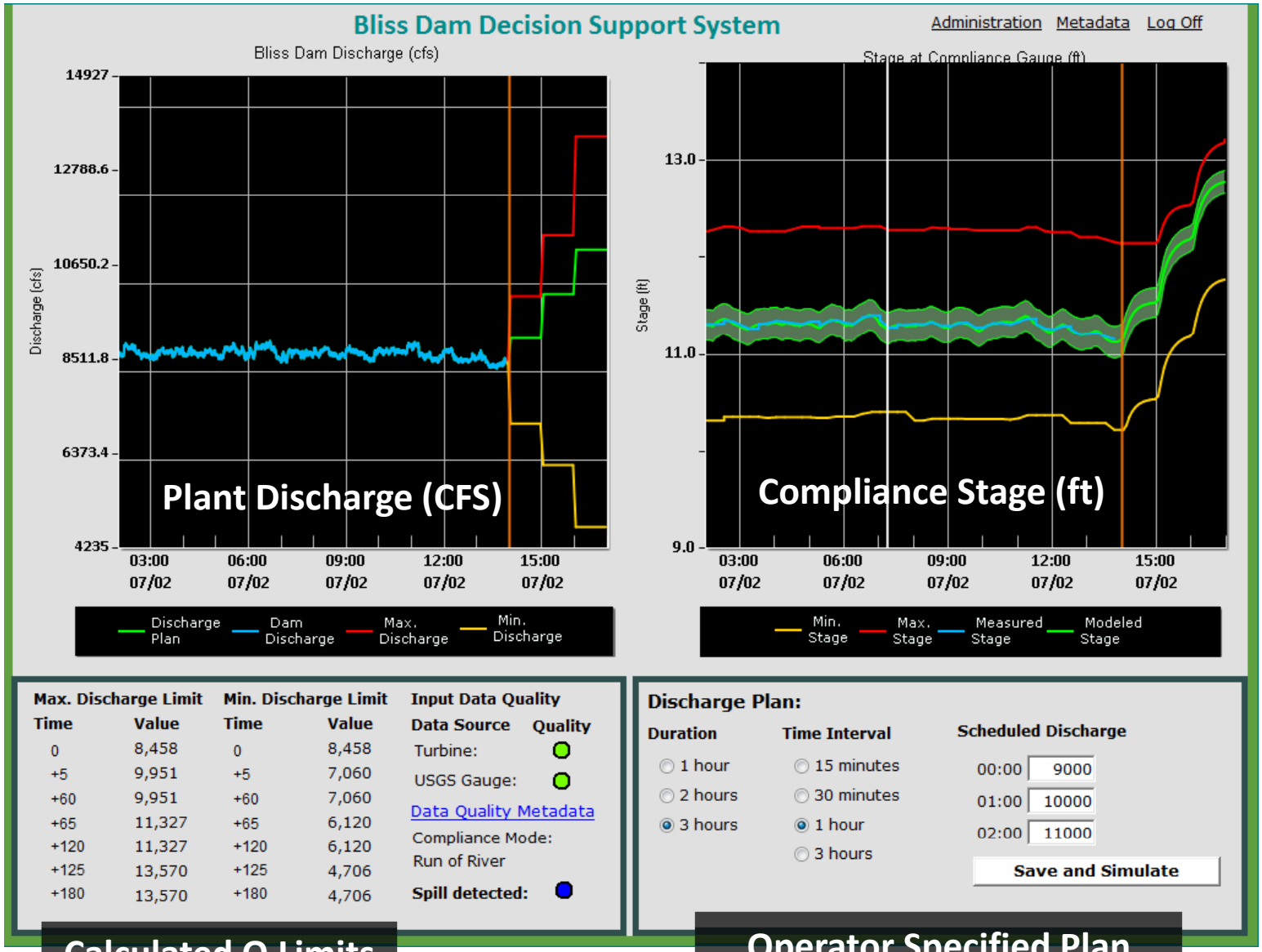
Bliss DSS



Calculated Q Limits

Operator Specified Plan

Bliss DSS


Bliss Dam Decision Support System
Administration
Metadata
Log Off
Bliss Dam Discharge (cfs)
14927
12788.6
10650.2
8511.8
6373.4
4235
Discharge (cfs)
03:00 07/02
06:00 07/02
09:00 07/02
12:00 07/02
15:00 07/02
Plant Discharge (CFS)
Discharge Plan
Dam Discharge
Max. Discharge
Min. Discharge
Stage at Compliance Gauge (ft)
13.0
11.0
9.0
Stage (ft)
Compliance Stage (ft)
Min. Stage
Max. Stage
Measured Stage
Modeled Stage
Max. Discharge Limit
Time Value
0 8,458
+5 9,951
+60 9,951
+65 11,327
+120 11,327
+125 13,570
+180 13,570
Min. Discharge Limit
Time Value
0 8,458
+5 7,060
+60 7,060
+65 6,120
+120 6,120
+125 4,706
+180 4,706
Input Data Quality
Data Source Quality
Turbine:
USGS Gauge:
Data Quality Metadata
Compliance Mode:
Run of River
Spill detected:
Discharge Plan:
Duration
1 hour
2 hours
3 hours
Time Interval
15 minutes
30 minutes
1 hour
3 hours
Scheduled Discharge
00:00 9000
01:00 10000
02:00 11000
Save and Simulate
Calculated Q Limits
Operator Specified Plan

Next Step

Hells Canyon Complex

Hydroelectric Facilities and Nameplate Capacities

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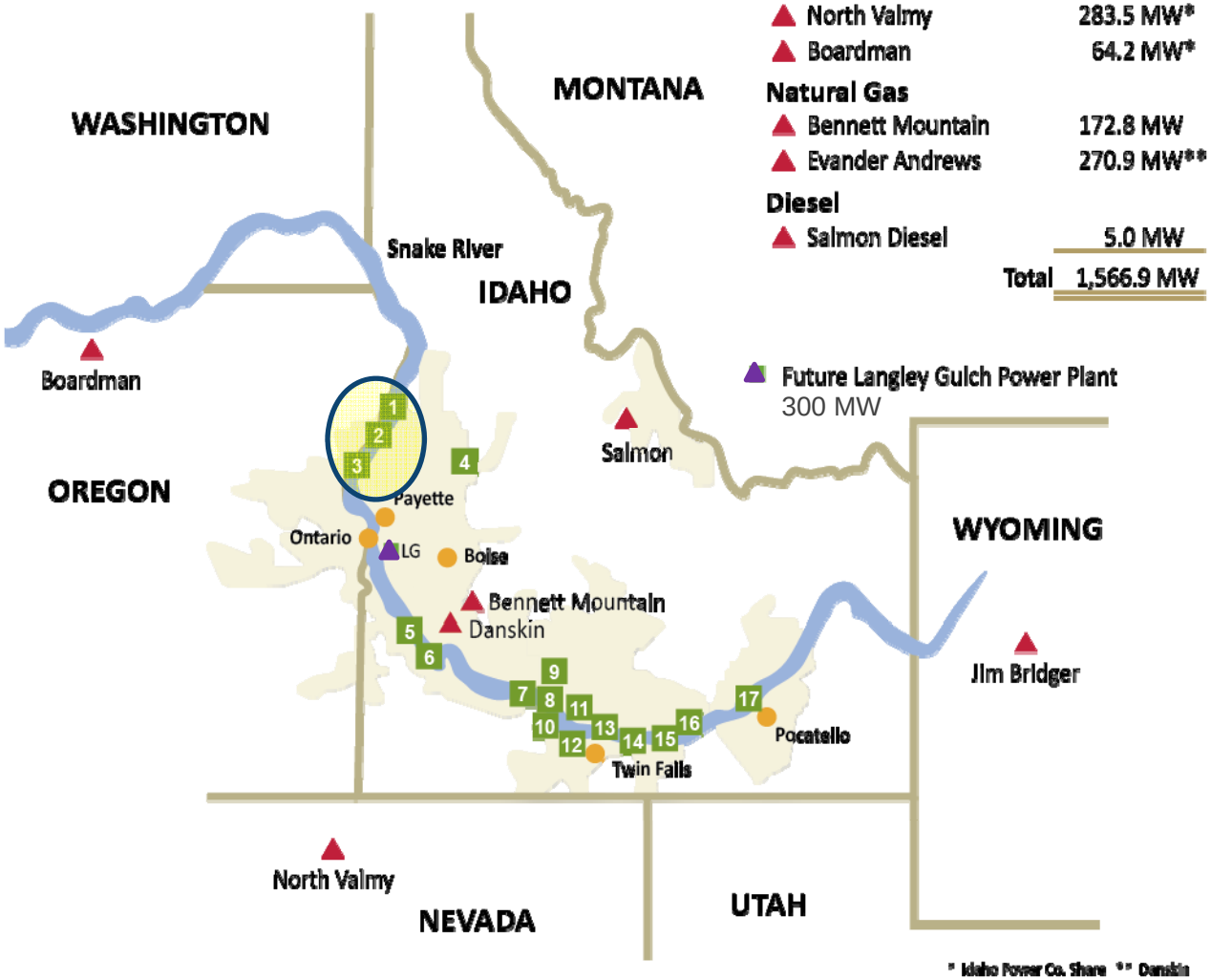

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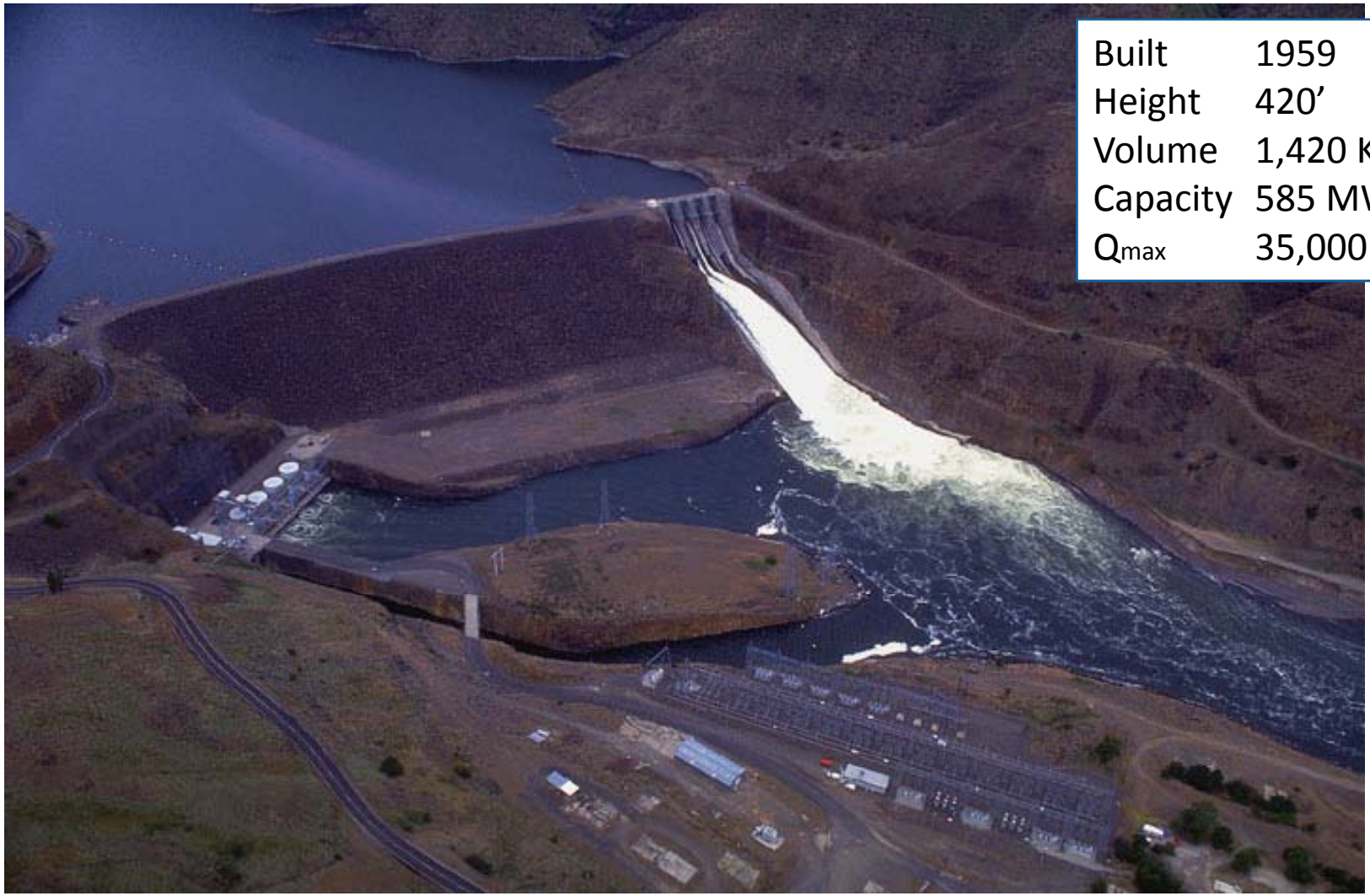
Brownlee Dam

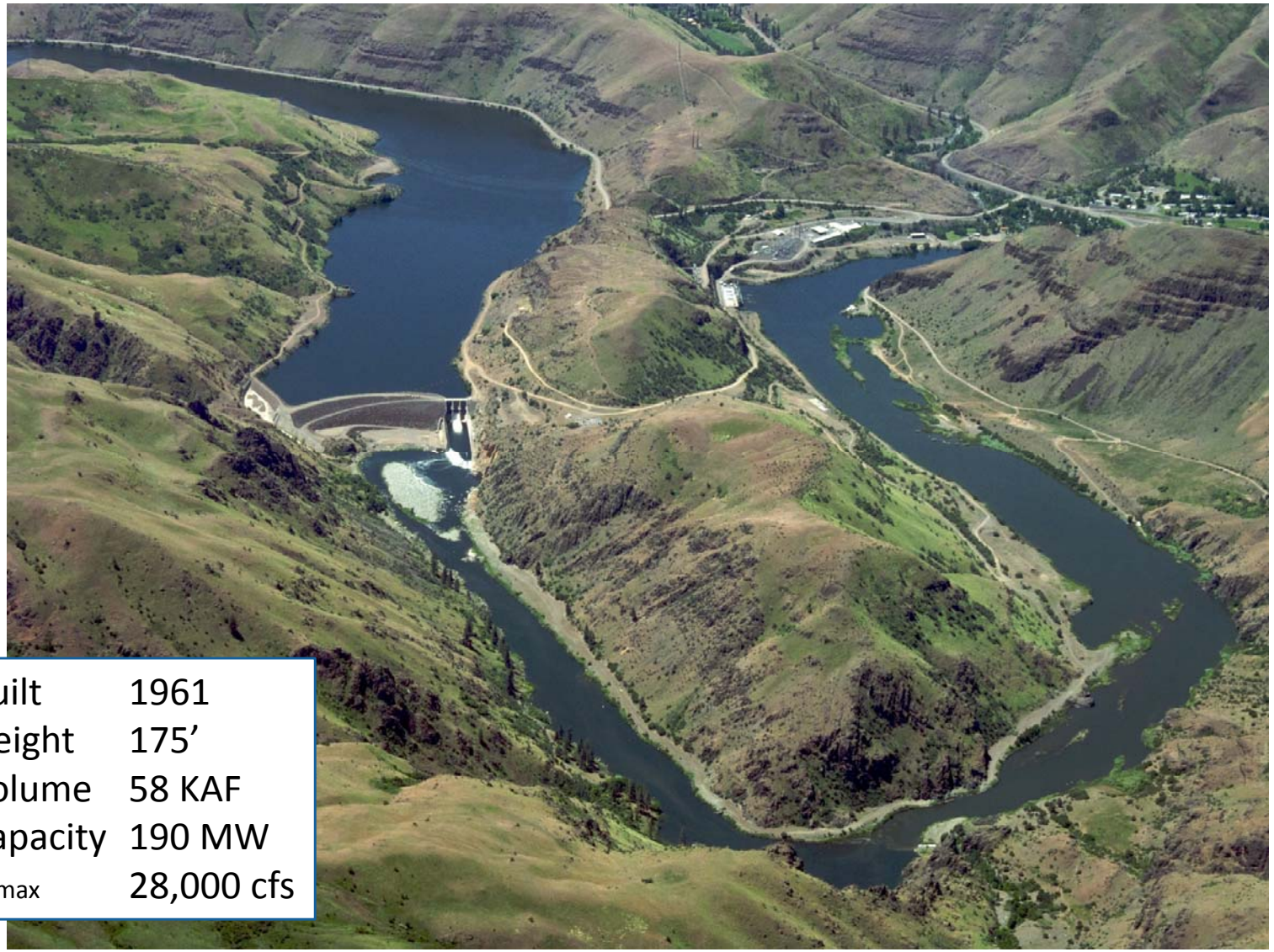
Upstream in the HCC



Built	1959
Height	420’
Volume	1,420 KAF
Capacity	585 MW
Q_{max}	35,000 cfs

Oxbow Dam

Middle in the HCC



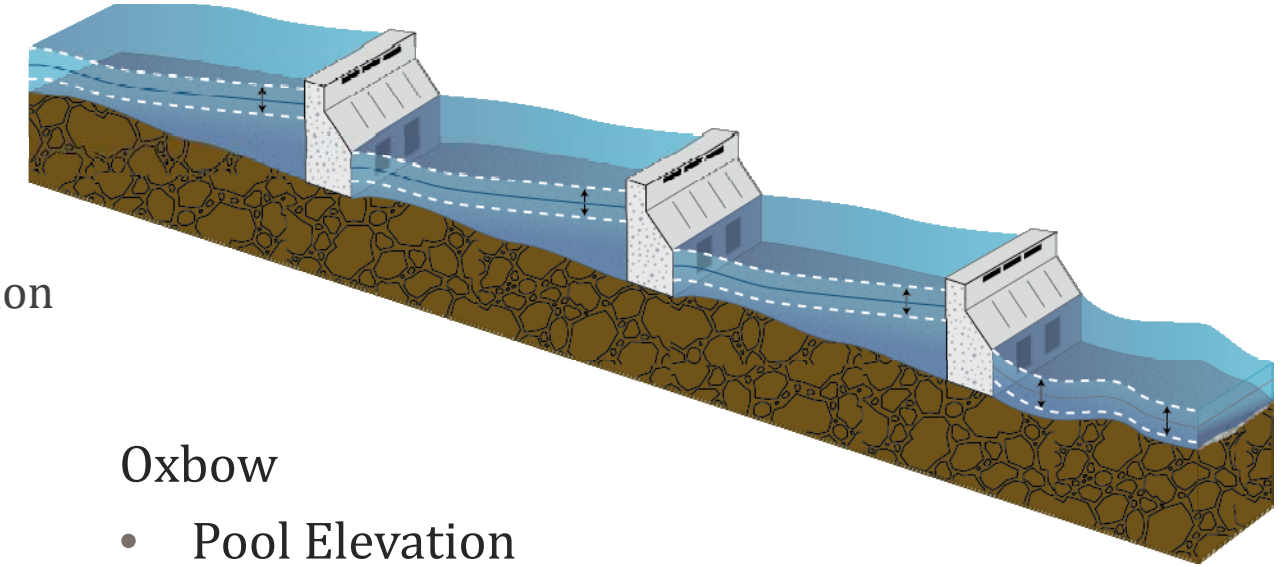
Built	1961
Height	175’
Volume	58 KAF
Capacity	190 MW
Q_{max}	28,000 cfs

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

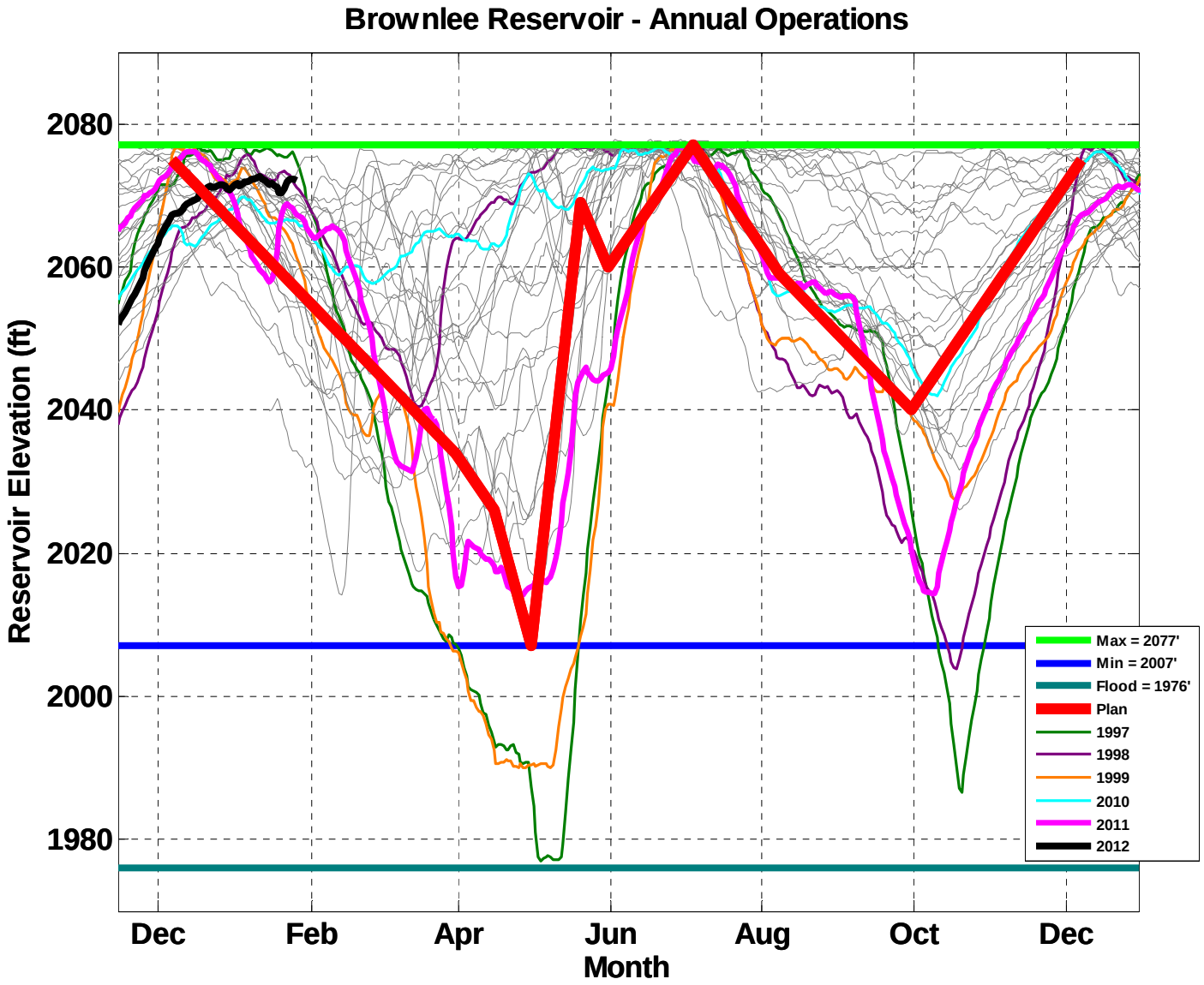


Brownlee
- Inflow
- Pool Elevation
  - Power Generation
  - Flood Control
  - Recreation
  - Fisheries
- Ramp Rates
  - Bank Stability

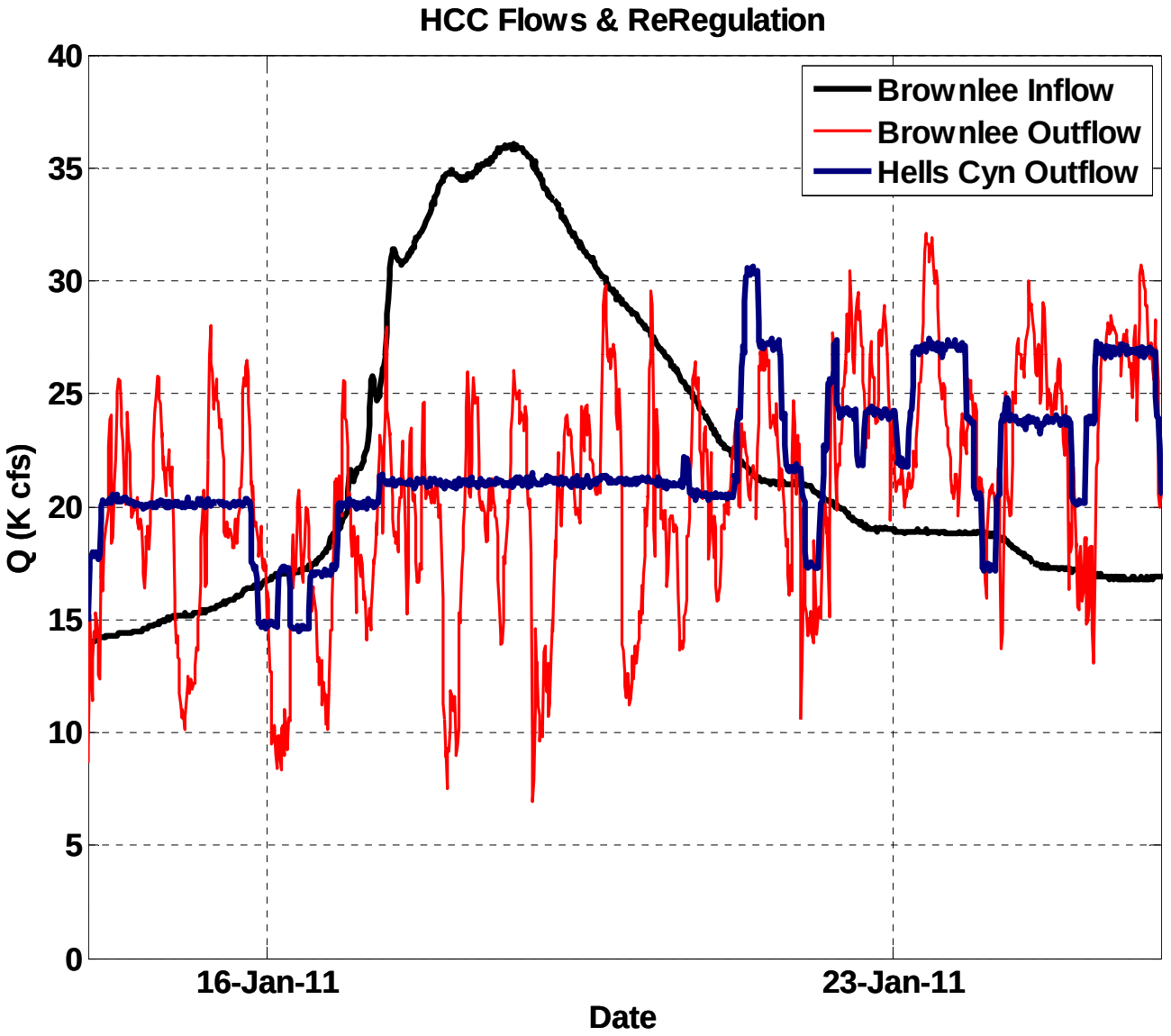
Oxbow
- Pool Elevation
  - Power Generation

Hells Canyon
- Pool Elevation
  - Power Generation
- River Q
  - Q_{min}
  - Ramp Rates
  - Fisheries
  - Recreation
- Δ Compliance Point

HCC Operations

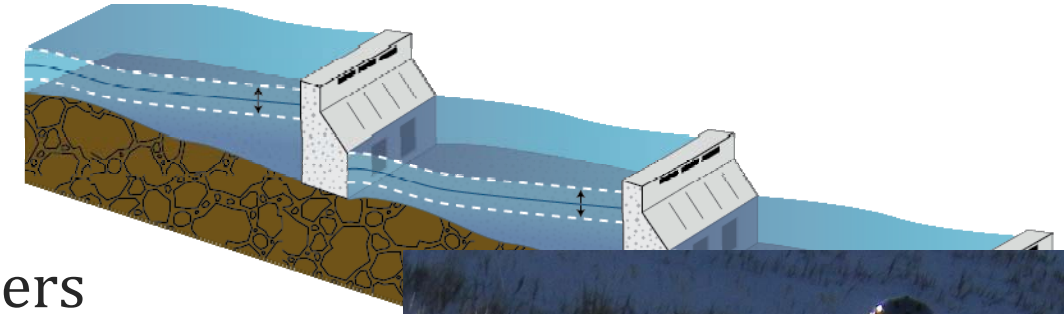


HCC Operations



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?