



Hydro Resource Modeling

Integrated Resource Plan

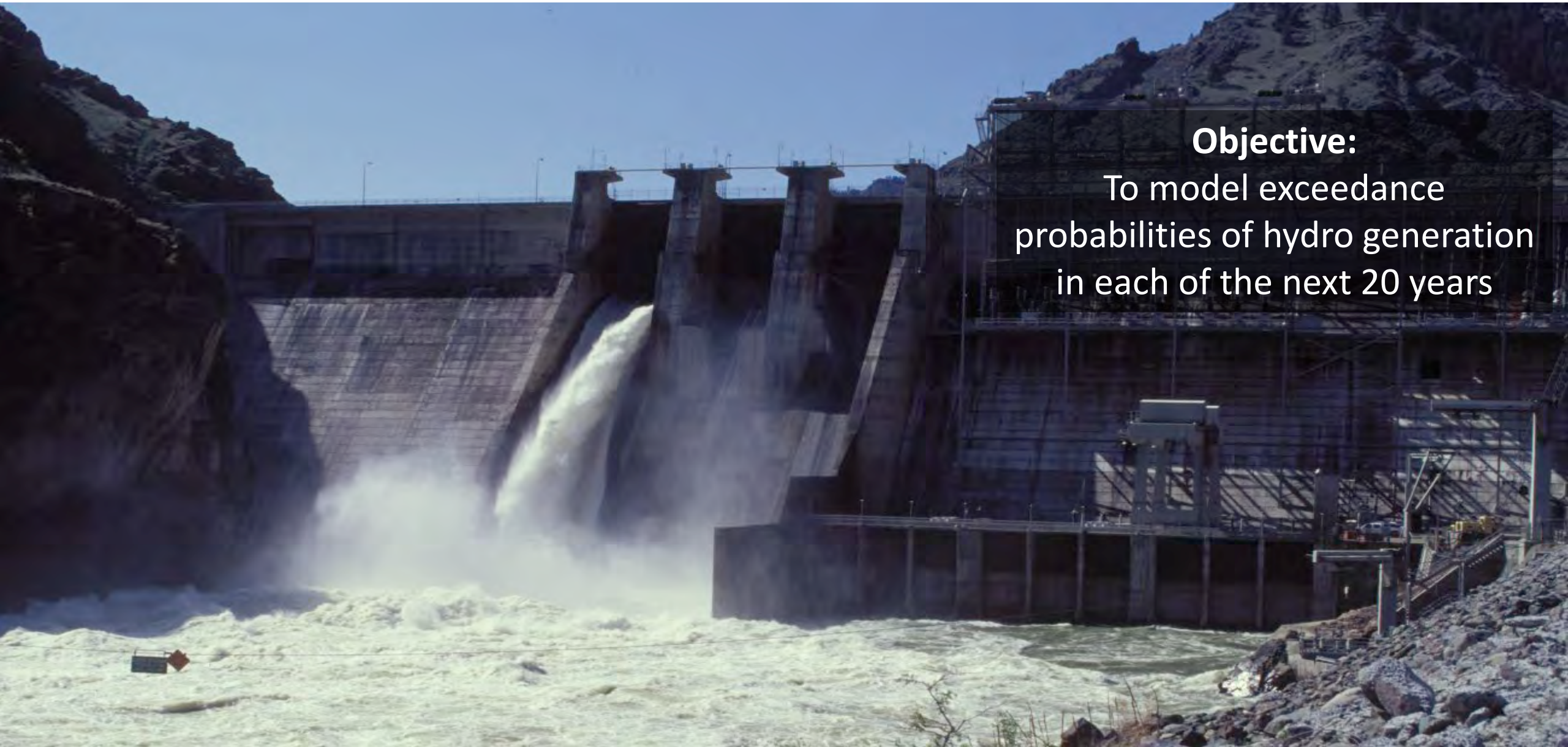
John Hildreth

Principal Engineer

IRP Hydro Generation Planning

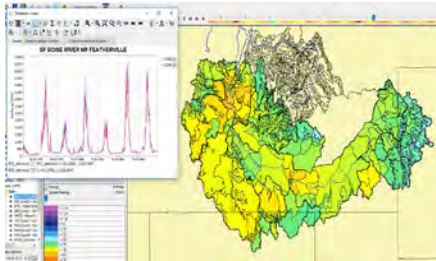
Objective:

To model exceedance probabilities of hydro generation in each of the next 20 years



Modeling Process

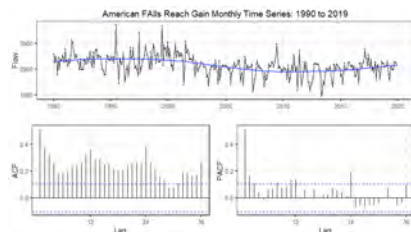
EFS Cloud Seeding SA



ESPAM 2.2

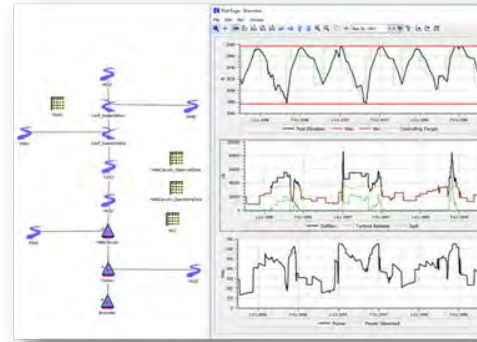


Statistical Trend Modeling



riverware

Center for Advanced Decision Support for Water and Environmental Systems
COLLEGE OF ENGINEERING & APPLIED SCIENCES



Monthly Exceedance
Plant Hydro
Generation (aMW)

AURORA
BY ENERGY EXEMPLAR

The figure shows a screenshot of the AURORA software, which displays a detailed table of monthly exceedance plant hydro generation data. The table includes columns for month, year, and generation values in aMW.

- Software from the University of Colorado Boulder, Center for Advanced Decision Support for Water and Environmental Systems
- What is it?
 - Object-oriented, multi-objective river and reservoir modeling decision support system
 - Widely used, well-funded, and actively developed software
 - Large collection of support tools
 - Allows for automation
 - Allows for adaptive water management modeling and implementation of water policy

RiverWare Users and Benefits



Bureau of Reclamation: 27 offices

Tennessee Valley Authority

U.S. Army Corps of Engineers: 13 offices

10 Federal agencies, Tribes and research labs

31 state, city and district water agencies

8 electric utilities in the U.S. and Canada

23 consulting companies and NGOs

12 universities and research groups

19 foreign entities

Baseline RiverWare Models

- Three different models used to represent different sections of river
 - Malad River Basin
 - Snake River above Brownlee
 - Hells Canyon Complex
- All models use a baseline recent historical hydrology
 - Building block for the future ensemble distribution
- Models are “present conditioned”
 - Water management is updated to reflect current operating logic
 - Irrigation demands patterned to reflect recent years
 - Irrigation return fractions updated to current estimates
 - Spring discharge represent current

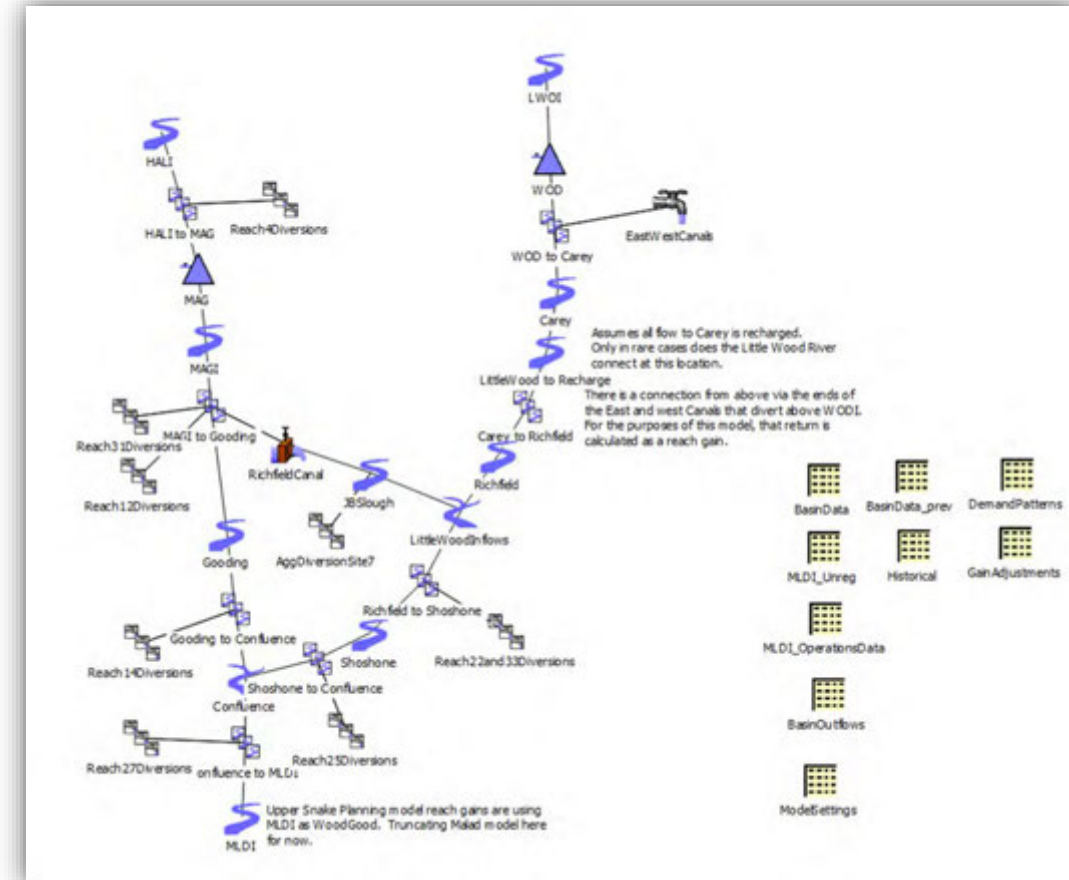
Malad RiverWare Planning Model

Purpose: Simulate change in reach losses (recharge) and basin outflow in response to cloud seeding

- Baseline reach gains from Malad unregulated model
- Reservoir operations simulated in rule logic
 - Flood releases
 - Irrigation releases
- Diversions simulated with demand patterns

Scenarios:

- Baseline (no reach gain adjustment)
- Current cloud seeding
- Full build-out cloud seeding



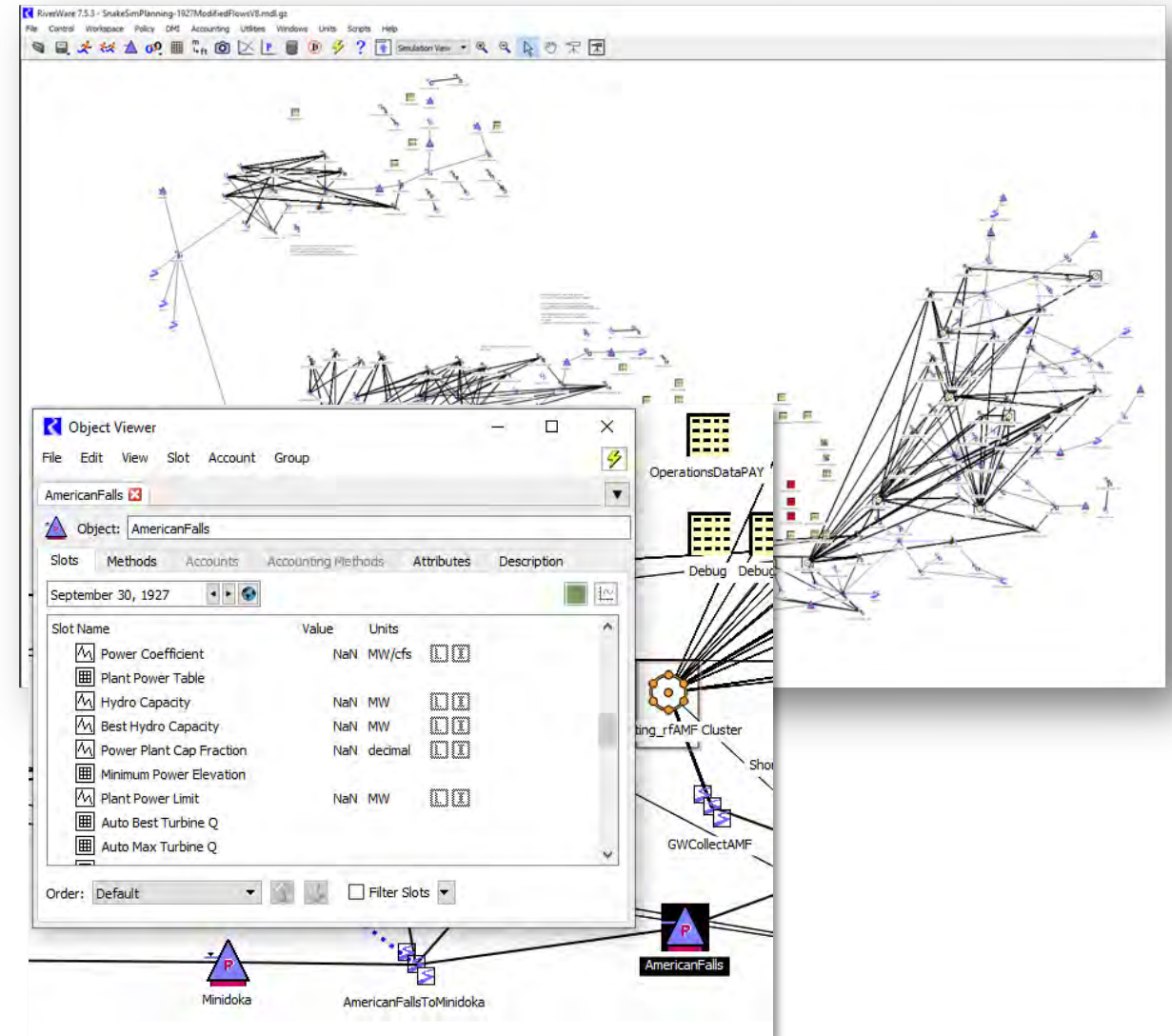
Snake RiverWare Planning Model

Acquired model from U.S. Bureau of Reclamation (USBR) in early 2020

- Same model used by USBR for the BPA 2020 Modified flows study

Model was created to answer USBR-specific questions

- Model has undergone major changes from the original USBR model
- Enhancements added to be used for Idaho Power modeling
 - Inclusion of managed recharge
 - Update to reflect current reservoir operations
 - Inclusion of cloud seeding and other management practices affecting reach gains
 - Inclusion of Idaho Power primary American Falls storage
 - Allow 0 cfs at Milner
 - Inclusion of missing Idaho Power hydro projects
 - Update of plant capacities at all Idaho Power projects
 - Inclusion of hydrogeneration at all Idaho Power projects



Hells Canyon Complex Planning model

- CADSWES built HCC planning model in RiverWare for Idaho Power
- Reflects current level reservoir management practices
 - License requirements
 - Recreational
 - Environmental
 - Flood control
- Dynamic operations based on inflow and year
- Plant-based hydro generation modeling

Snake River below Hells Canyon Dam

Cost of Standing Operations through use of Fall Chinook Flows typically June 1st through mid-October

Maximum flow fluctuation 15,000 cfs daily (midnight to midnight) measured at Snake River at Johnson Bar

Fall Chinook Flows

Mid-October through Early December - Maintain a constant outflow with no fluctuations (highest flat flow establishes the new minimum for the current season and will be continued until released by IPC Biologists)

Early December through Early April - Maintain the minimum outflow established during Fall Chinook flat flow operations with daily load shaping allowed with a 15,000 cfs daily maximum flow fluctuation as measured at Johnson Bar

Standing Operations

Mid-March through Early June - Minimum outflow of 8,000 cfs or higher, if already established with load following operations consistent with Juvenile Fall Chinook Salmon Entrapment Management and Fall Trout Standing Monitoring Plan for the Hells Canyon Reach of the Snake River, as dictated by IPC Biologists

Fall Chinook Flows through Standing Operations

Mid-October through Early June - Minimum flow at Snake River below McDuff Rapids of 11,500 cfs (Snake River below Hells Canyon just below Johnson Bar at White Bluff) See Corps of Engineers Section below

After Fall Chinook Ends through Standing Operations

Maximum flow fluctuation 15,000 cfs daily (midnight to midnight) measured at Snake River at Johnson Bar (early December - mid-March)

FERC Article 43

Year Round Operations

Minimum flow 13,000 cfs @ Line Point 95% of the time - Calculated as Snake River at Anahoe less Grande Ronde at Troy (July thru September - Flows less than 13,000 cfs must be negotiated with the Corps of Engineers - see section below)

Maximum ramp rate 1000 cfs/minute measured at Snake River at Johnson Bar

Minimum instantaneous flow 5,000 cfs measured at Snake River at Johnson Bar

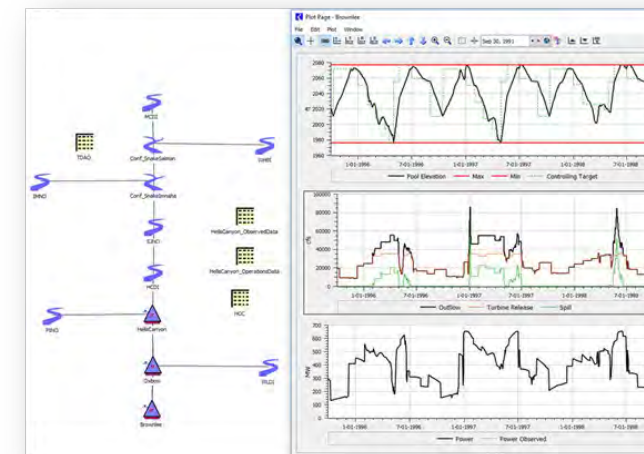
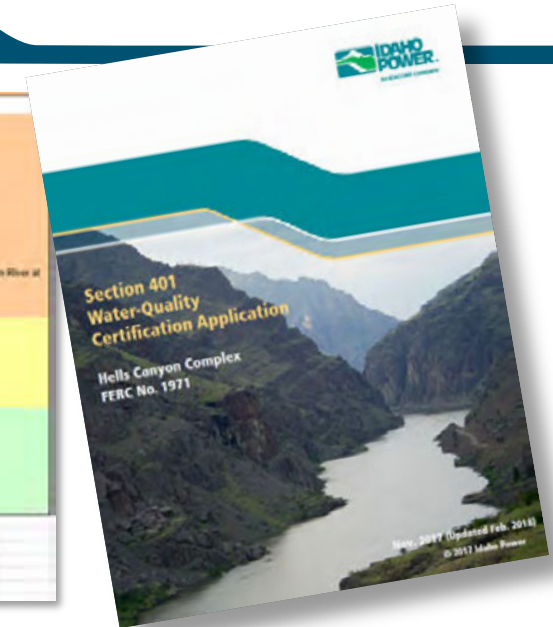
Corps of Engineers (inspired F 13.000 cfs at Linepoint variance is reported to IPC)

Minimum instantaneous flow 5,500 cfs (measured) at Snake River at Hells Canyon when the previous 3-day moving average Brownlee Reservoir inflow is at or above 5,500 cfs

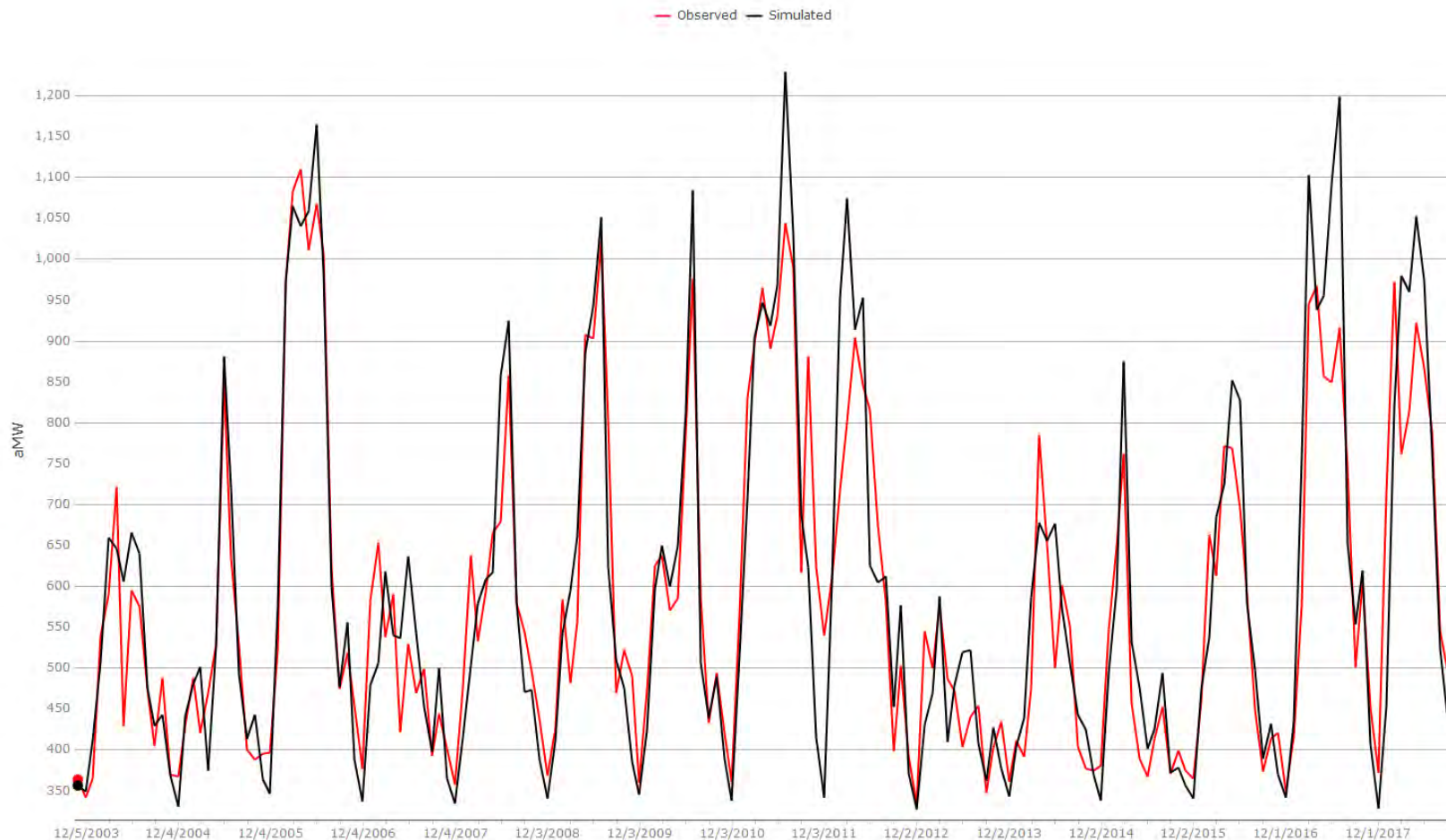
Minimum instantaneous flow 11,500 cfs (measured) at Snake River below McDuff Rapids unless it would require drafting Brownlee Reservoir

When the previous 3-day moving average for Brownlee Reservoir inflow is less than 5,500 cfs, the instantaneous minimum Hells Canyon flow shall not fall below the previous 3-day moving average for Brownlee Reservoir inflow

FERC License Compliance Limit	(1) FERC License
IPC Designated Limit	(2) FERC Approved Operational Compliance Monitoring Plan
Water Right Limit	(3) USFWS Biological Opinion
Army Corps of Engineers Limit	(4) USFWS Settlement Agreement
	(5) BDEI Consent Order



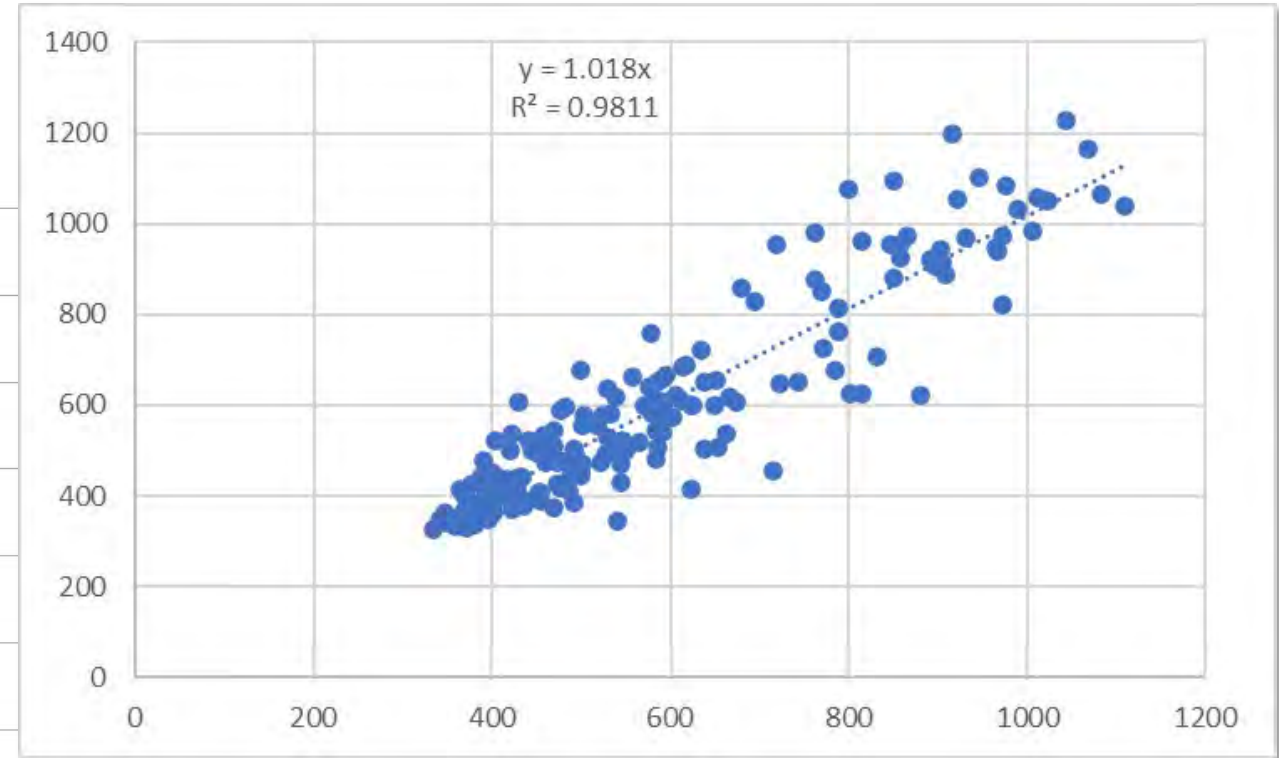
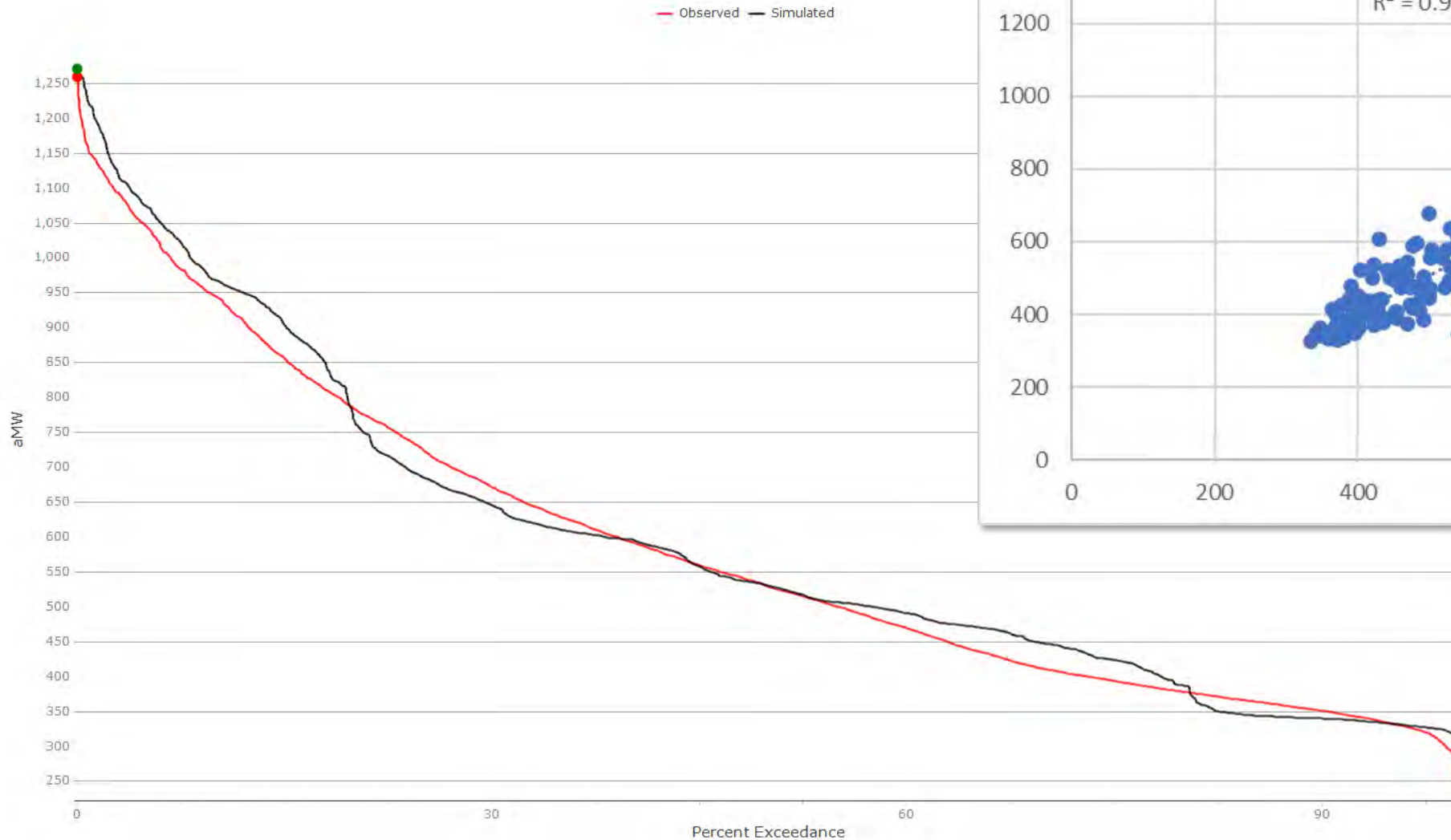
Hells Canyon Complex Generation



- Observed maintenance and operating reserves are not simulated in RiverWare. This is accounted for in Aurora.
- Modeling purpose is to produce total available aMW with the given water conditions.

Hells Canyon Monthly Exceedance

Probability: water years 2004–2018

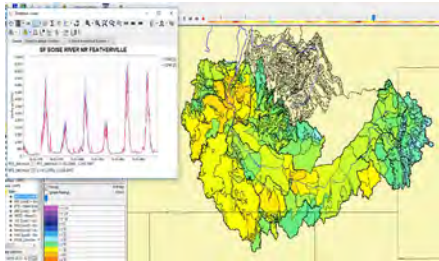


Future Assumptions Influencing Water Supply

- Weather modification
- Reach declines
 - Based on trend analysis
- Expected water management activities
 - Managed Recharge
 - Idaho Water Resource Board
 - Private
 - Groundwater pumping reductions
 - System conversions (groundwater supply converted to surface water supply)

Modeling Process

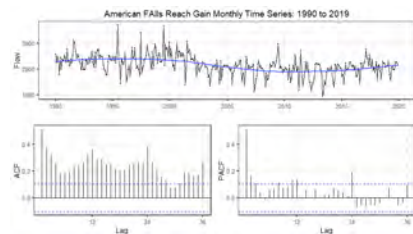
EFS Cloud Seeding SA



ESPAM 2.2

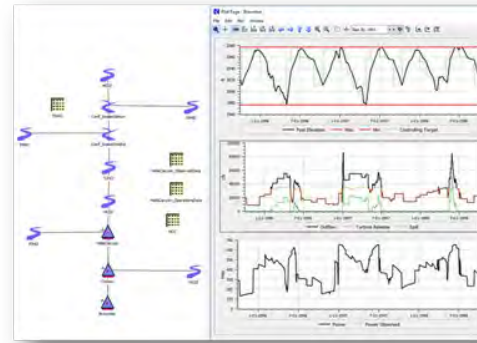


Statistical Trend Modeling



riverware

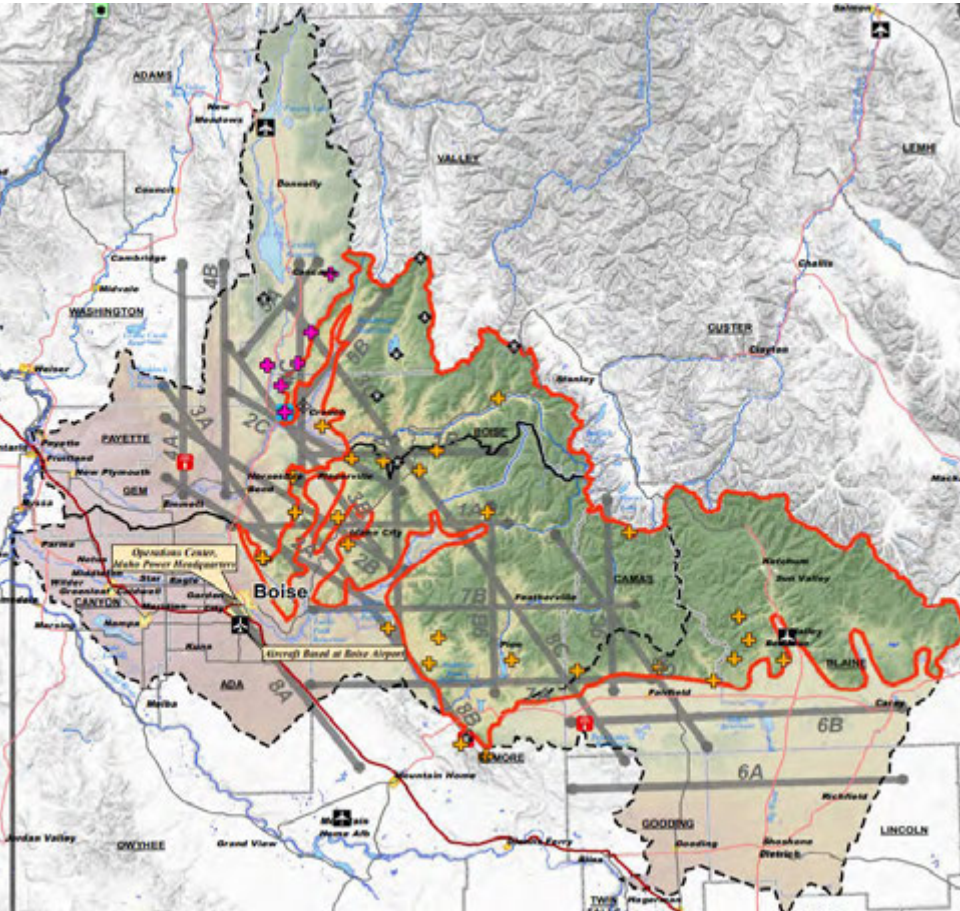
Center for Advanced Decision Support for Water and Environmental Systems
COLLEGE OF ENGINEERING & APPLIED SCIENCES



Monthly Exceedance
Plant Hydro
Generation (aMW)

AURORA
BY ENERGY EXEMPLAR

A screenshot of the AURORA software interface, showing a detailed table of hydro generation data. The table has multiple columns, including "Date", "Plant", "Generation (aMW)", and "Exceedance". The data is organized into a grid, with rows representing different time periods and plants. The text "AURORA" is prominently displayed at the top, with "BY ENERGY EXEMPLAR" below it.



Idaho Collaborative Cloud Seeding Program

Central Mountains

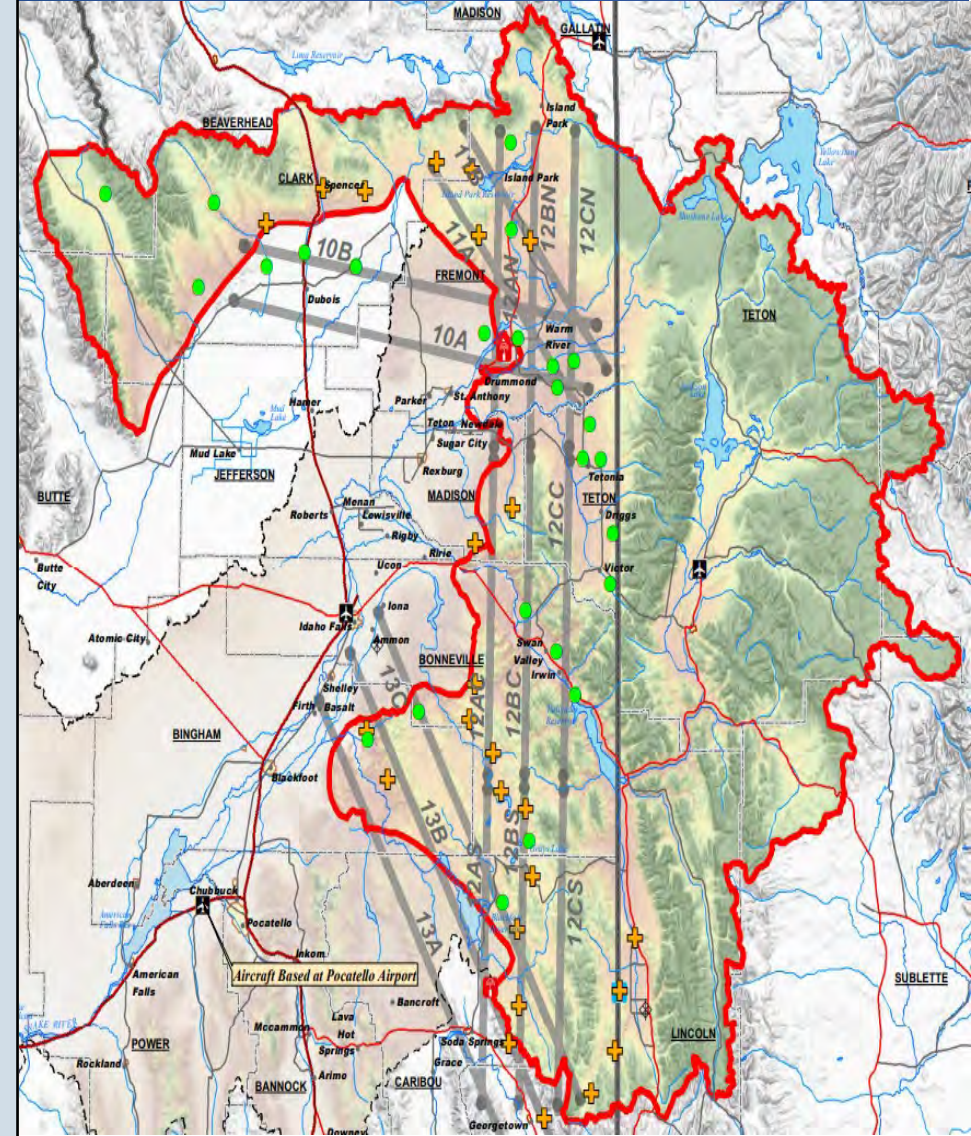
- 32 Idaho Power Remote Ground AgI Generators
 - 17 Payette
 - 15 Boise/Wood
- 2 Aircraft

Upper Snake

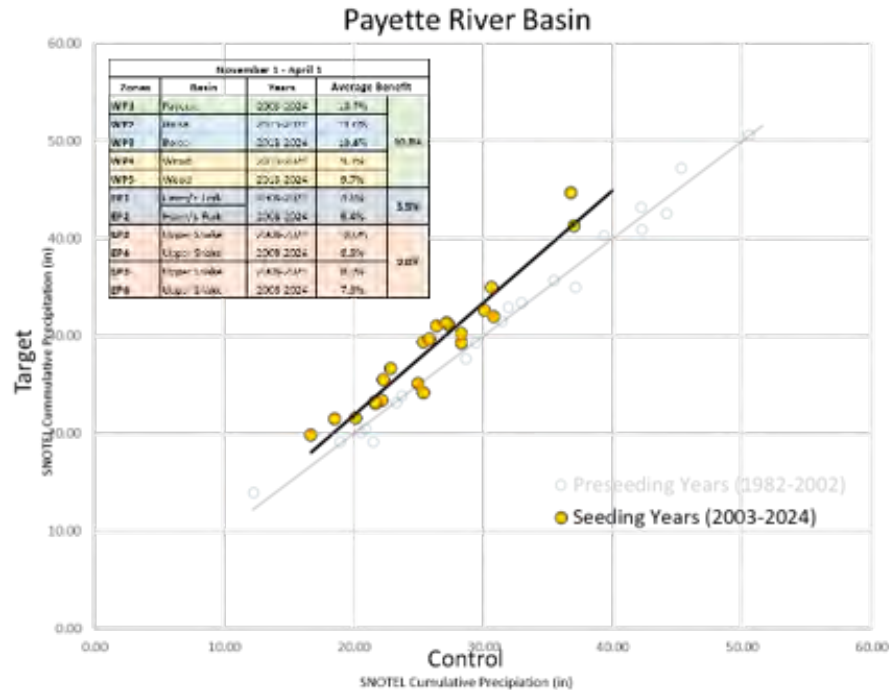
- 25 Idaho Power Remote Ground AgI Generators
- 1 Aircraft
- 25 Let It Snow Manual Ground AgI Generators

Across the Program

- High Performance Computing System
- High Resolution WRF Weather Model
- WRF-WxMod Module
- High Resolution weather instrumentation

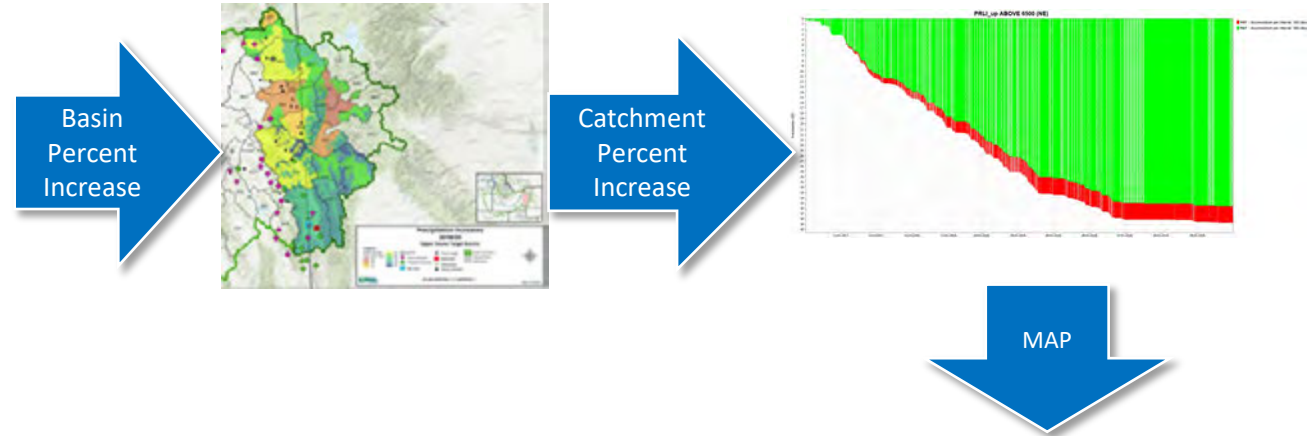


Cloud Seeding Benefit Modeling



Spatial distribution of percent increase to catchment

Mean Areal Precipitation development

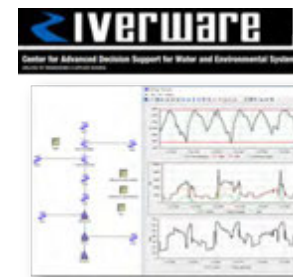


EFS is our internal stream-flow forecasting system

2 Scenarios Developed

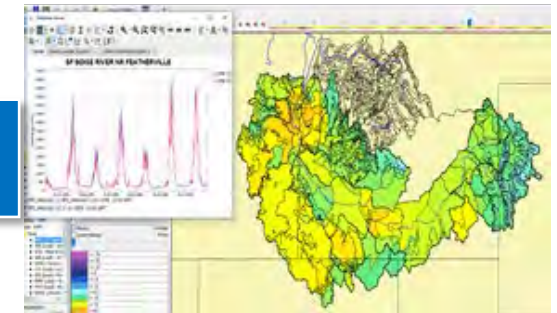
- Calibrated lumped parameter hydrologic model of the Snake Basin
- Inputs include Mean Areal Precipitation and Mean Areal Temperature

- Current cloud seeding program
- Future cloud seeding build-out

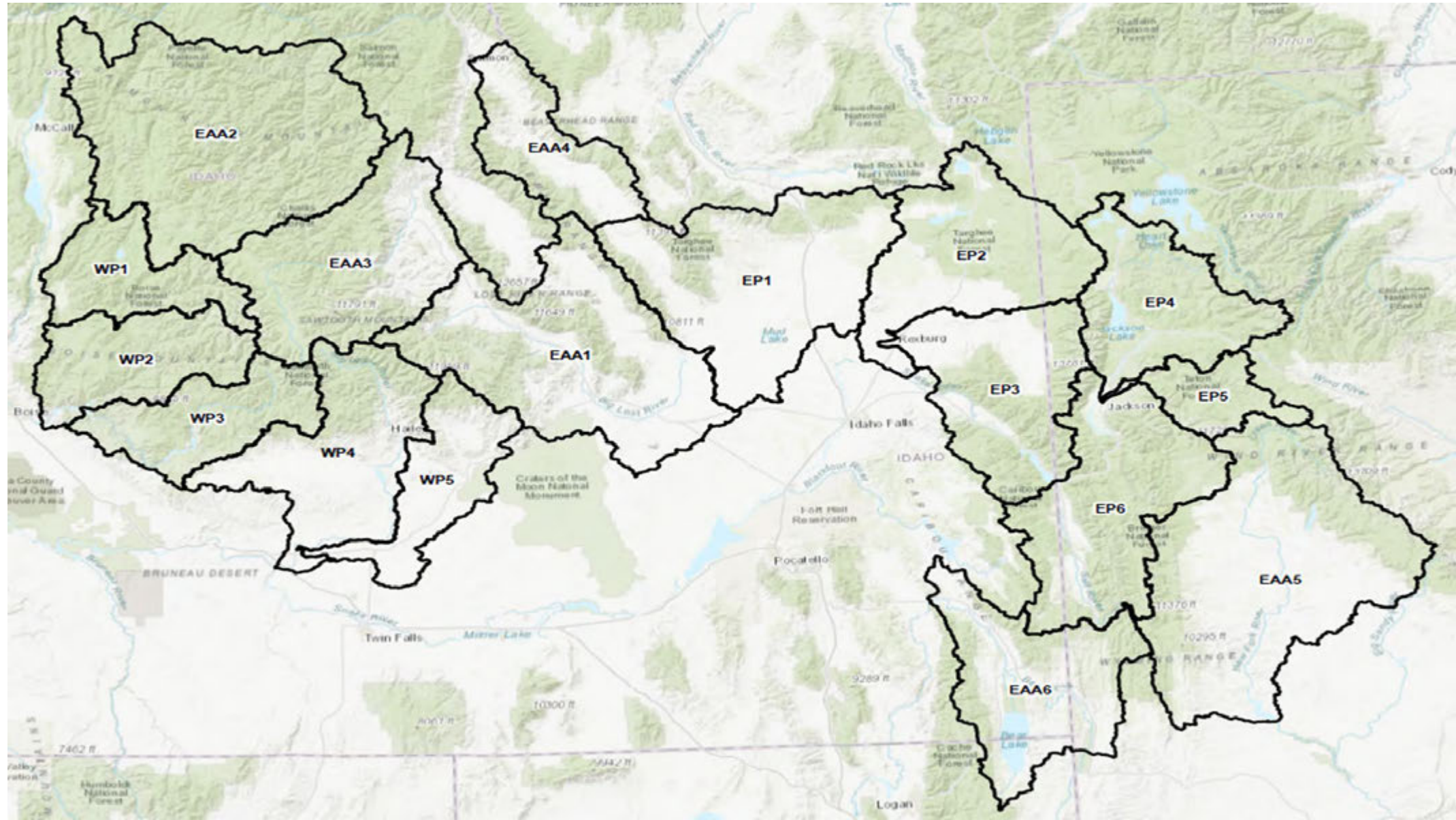


Reach Gains to RiverWare

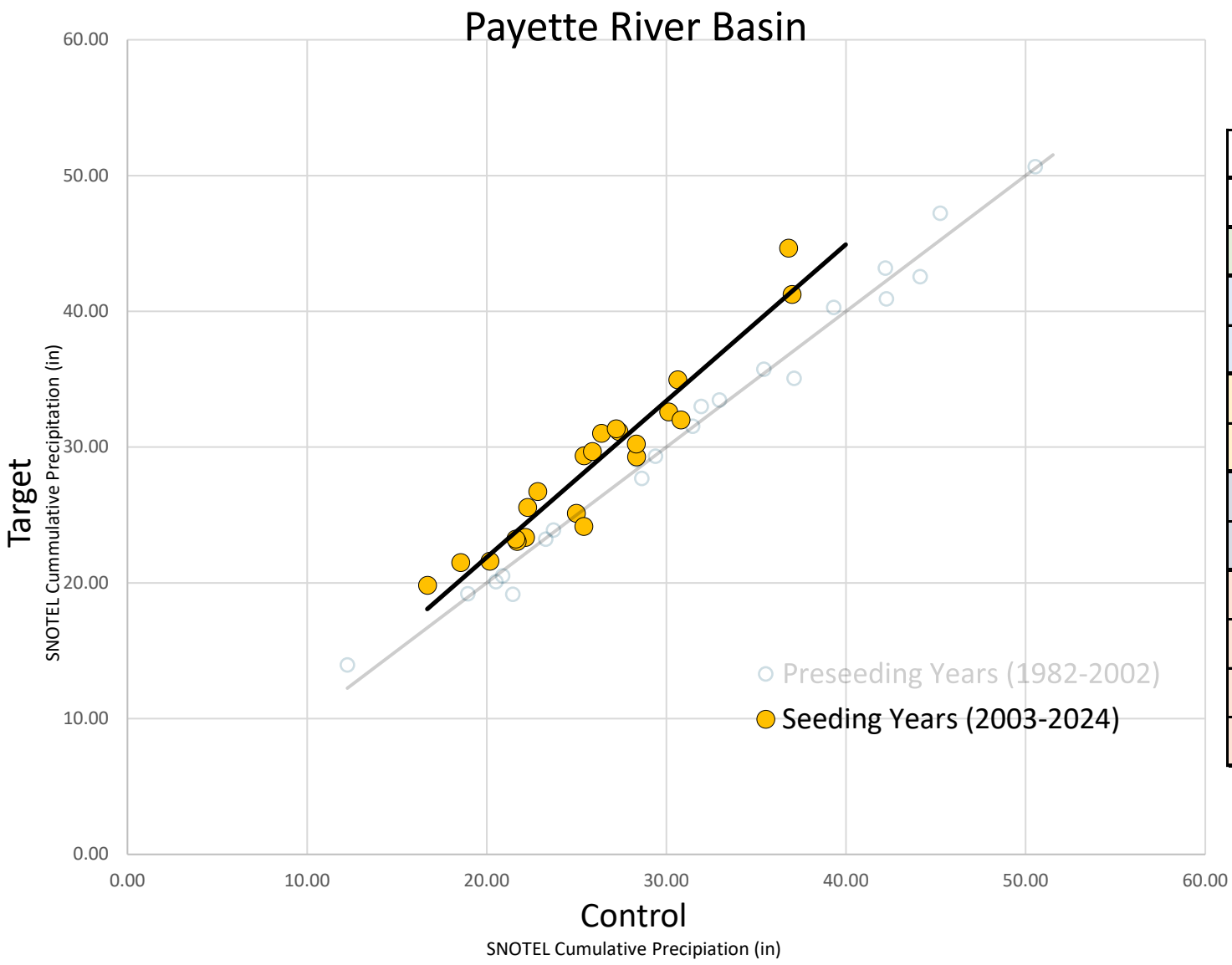
EFS Cloud Seeding SA



Target Control Areas



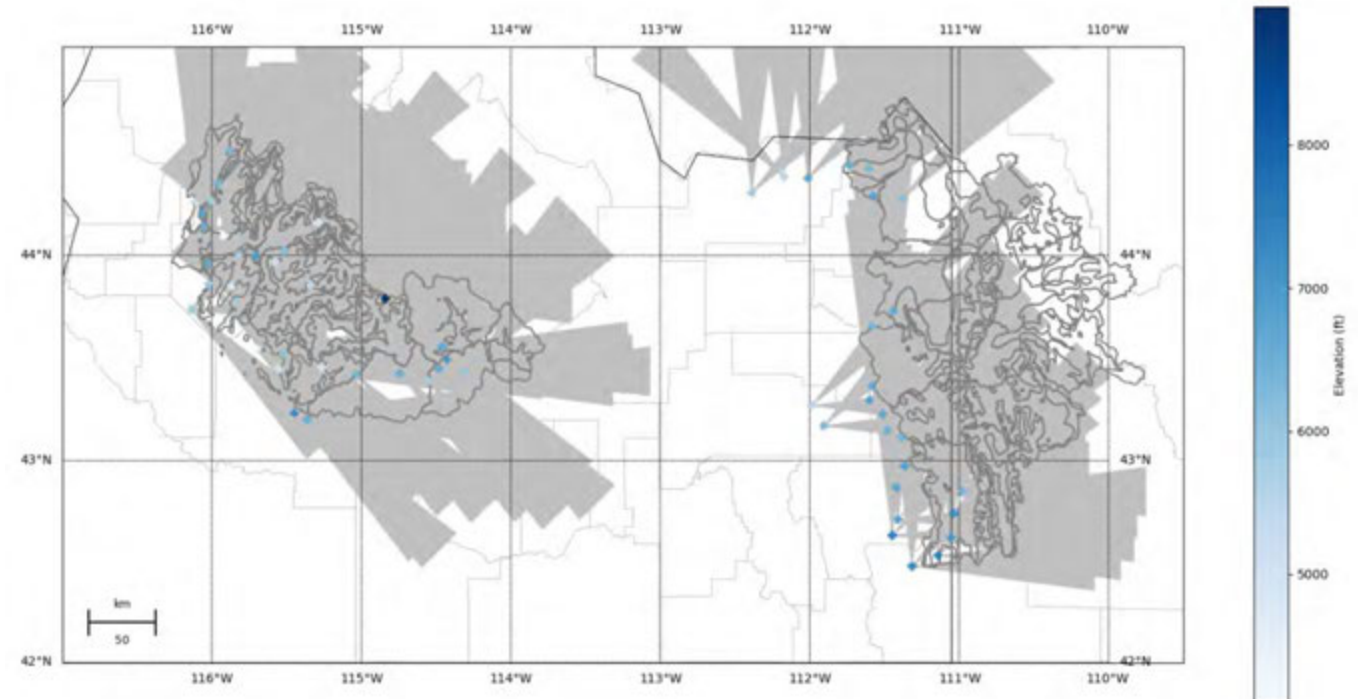
Target-Control Analysis



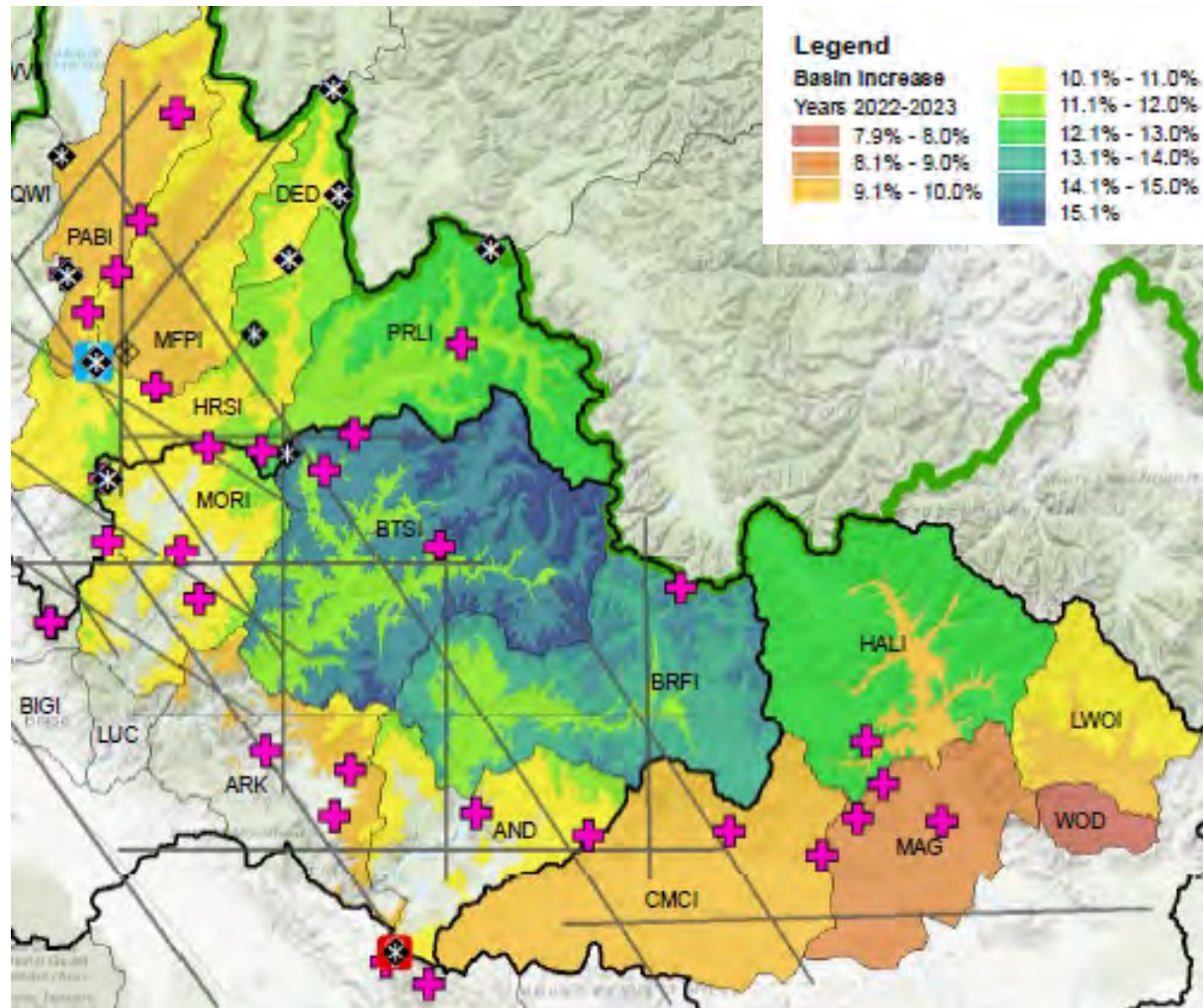
November 1 - April 1				
Zones	Basin	Years	Average Benefit	
WP1	Payette	2003-2024	10.7%	10.0%
WP2	Boise	2013-2024	11.0%	
WP3	Boise	2013-2024	10.4%	
WP4	Wood	2013-2024	9.3%	
WP5	Wood	2013-2024	9.7%	
EP1	Henry's Fork	2008-2024	4.8%	5.5%
EP2	Henry's Fork	2008-2024	6.4%	
EP3	Upper Snake	2008-2024	10.0%	9.0%
EP4	Upper Snake	2008-2024	8.8%	
EP5	Upper Snake	2008-2024	8.9%	
EP6	Upper Snake	2008-2024	7.8%	

Spatial Downscaling

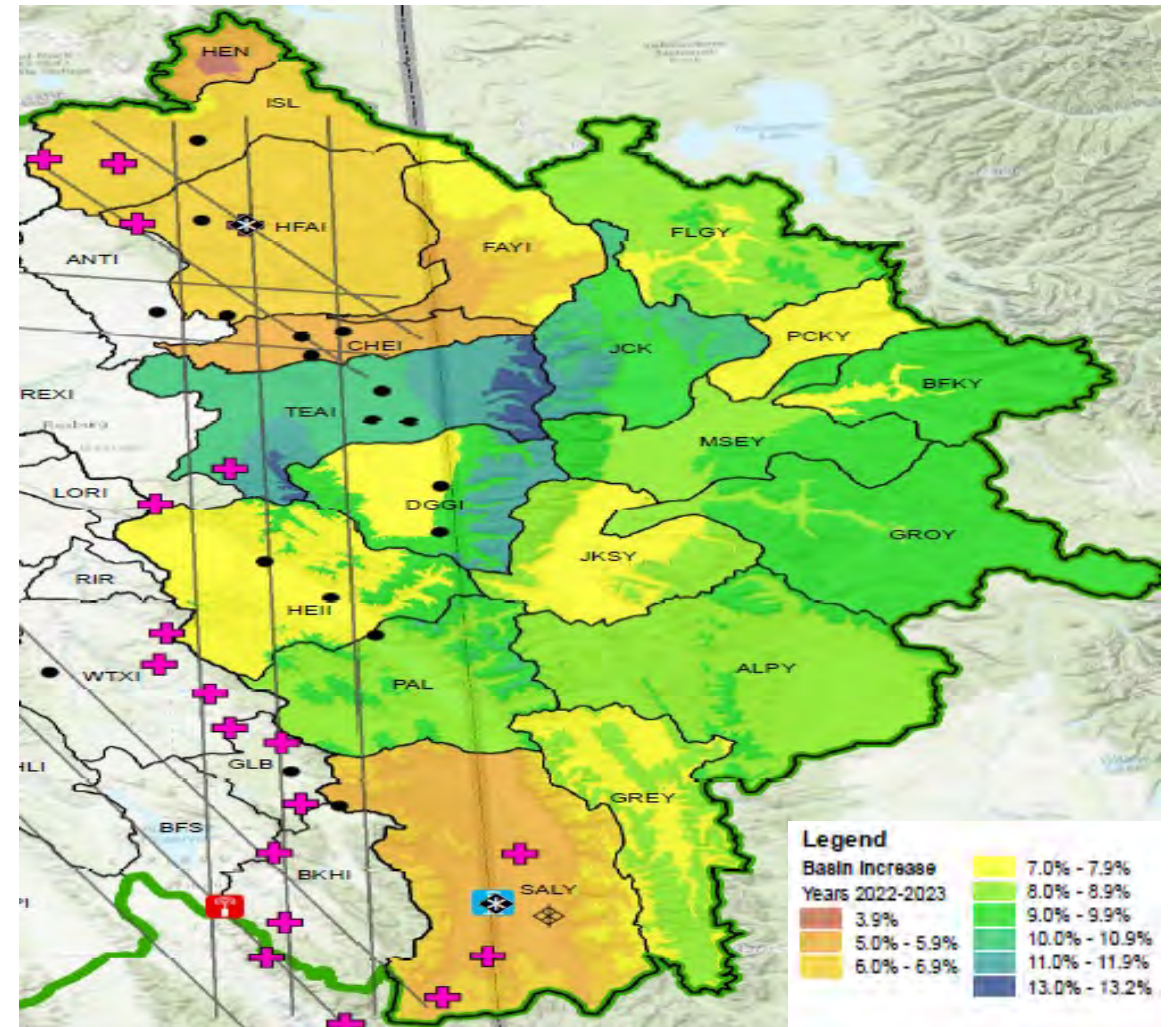
- Uses the Target Control operational units
- Disaggregates basin-wide results to spatial resolution that is used in hydrologic model
- Applies factors to the elevation bands within these units
 - Operational Usages
 - Historical operational hours
 - Wind Weight
 - Wind direction ratio
 - Elevation Weight
 - PRISM climate normal
 - Ratio of elevation band precipitation to entire basin precipitation



Average Precipitation Benefit Estimate



Central Mountain Target Basins



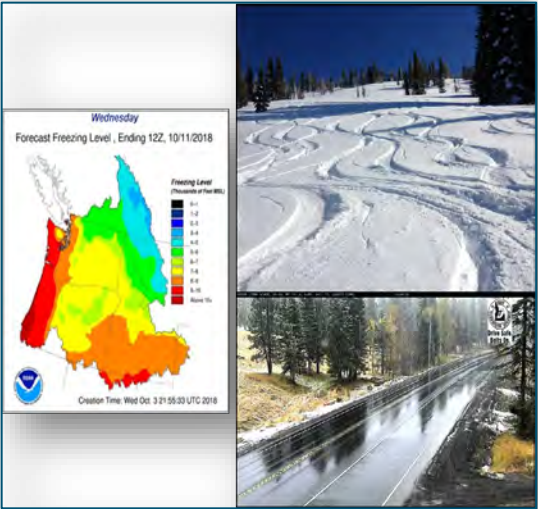
Upper Snake Target Basins

Enhanced Forecast System

Mean Areal
Precipitation



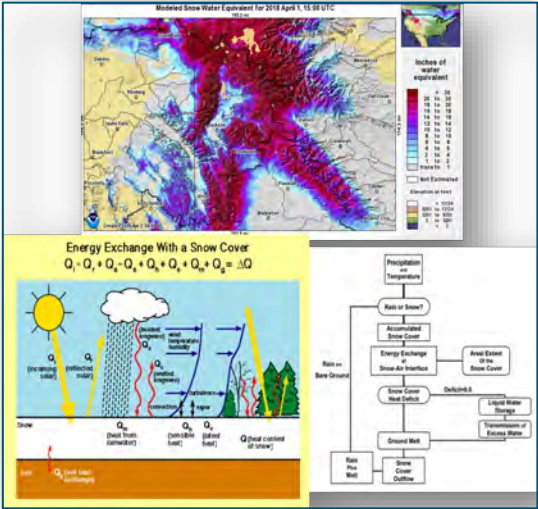
Precipitation Typing
(RSNWELEV)



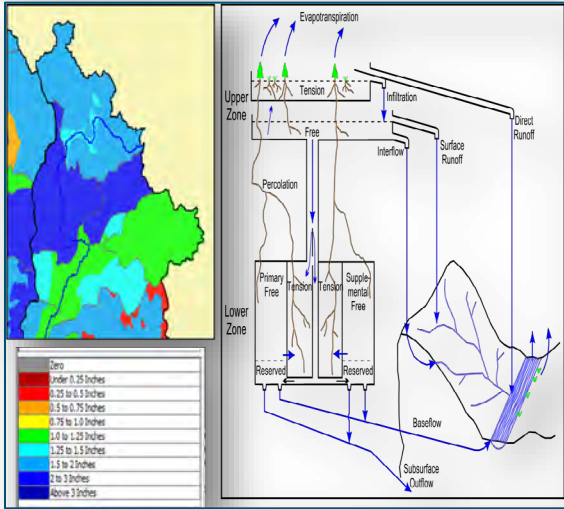
Mean Areal
Temperature



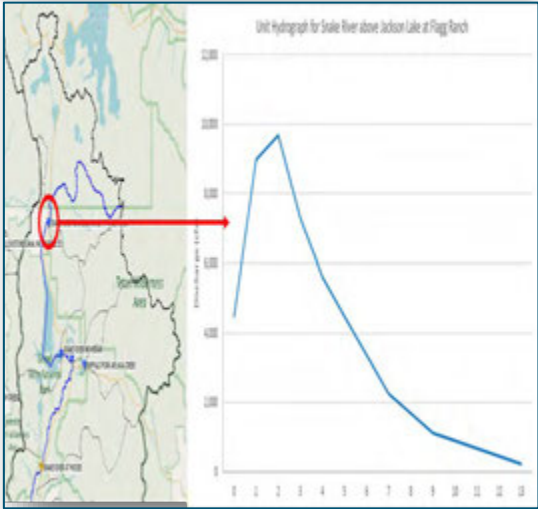
Snow Accumulation and Melt
(SNOW17)



Runoff, Infiltration, Percolation,
Baseflow (SACSMA)



Runoff Hydrograph (UNITHG)

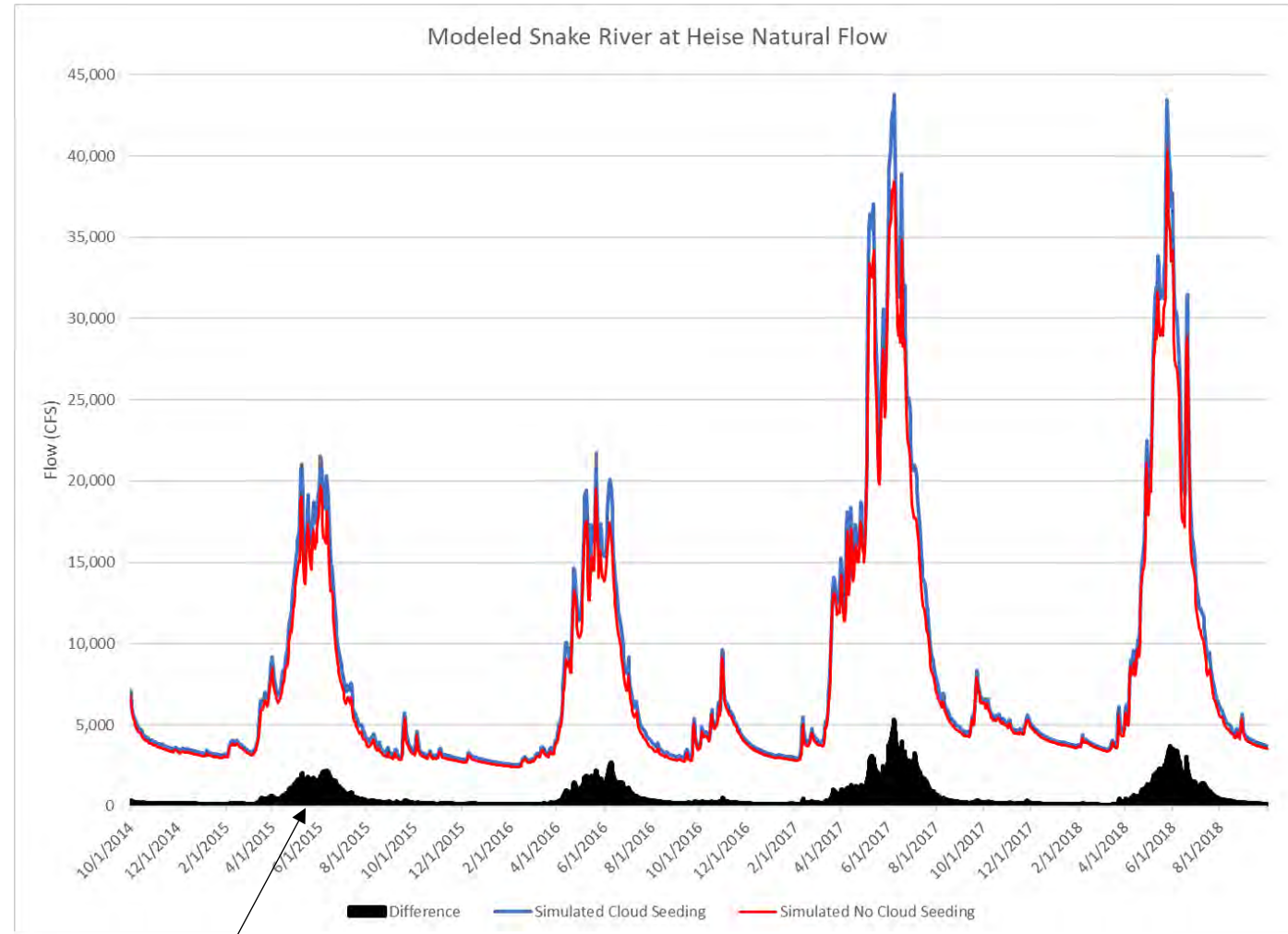


Natural Flow



Hydrologic Modeling

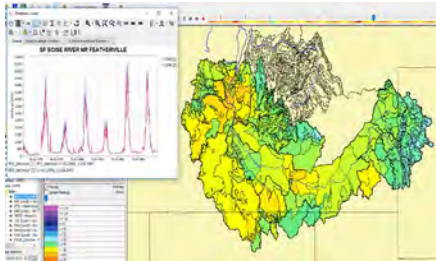
- Run scenarios through hydrologic model
 - Baseline
 - With cloud seeding
 - Without cloud seeding
- Scenarios adjusted for when cloud seeding was and was not occurring
- Runoff benefit =
(seeding) – (no seeding)



Estimated Daily Runoff Benefit

Modeling Process

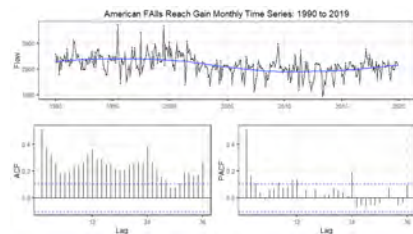
EFS Cloud Seeding SA



ESPAM 2.2

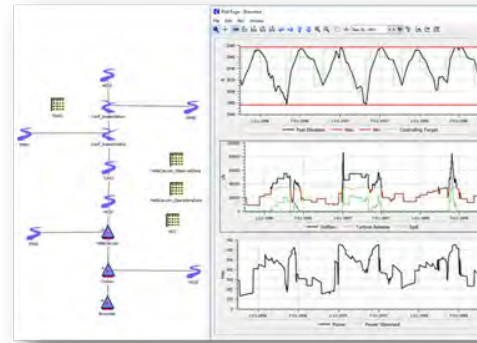


Statistical Trend Modeling



riverware

Center for Advanced Decision Support for Water and Environmental Systems
COLLEGE OF ENGINEERING & APPLIED SCIENCES



Monthly Exceedance
Plant Hydro
Generation (aMW)

AURORA

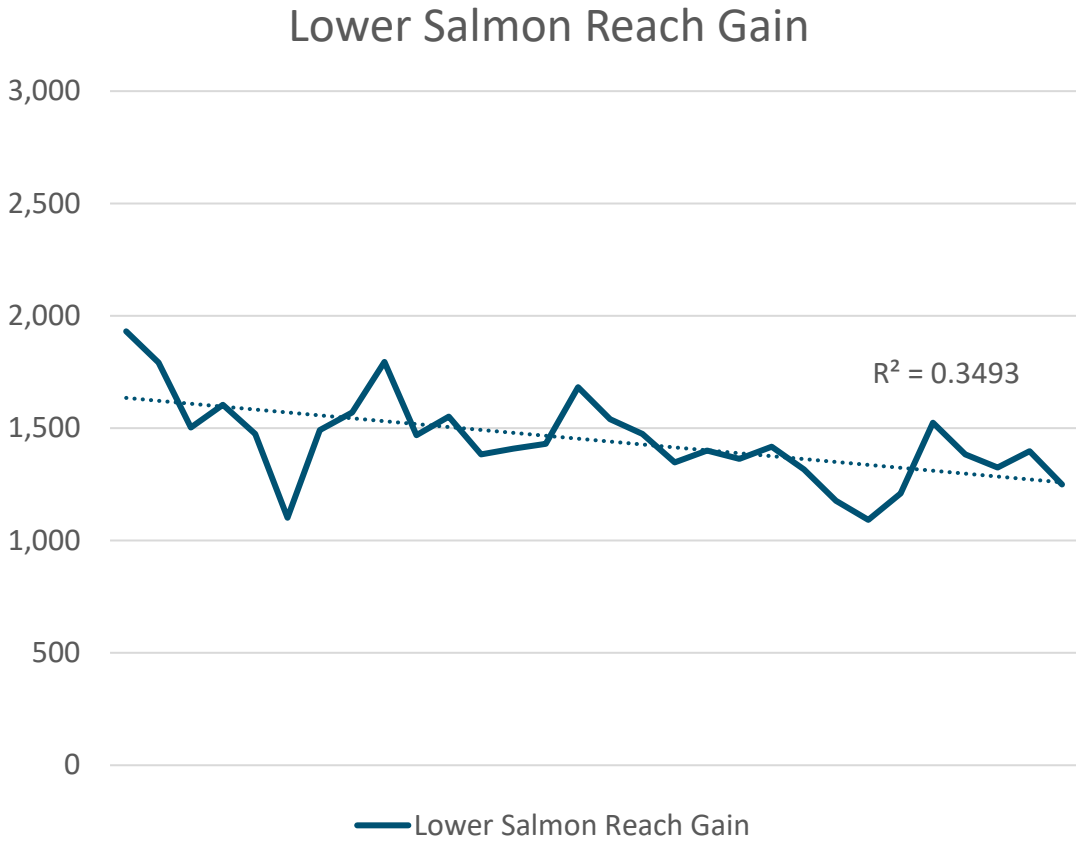
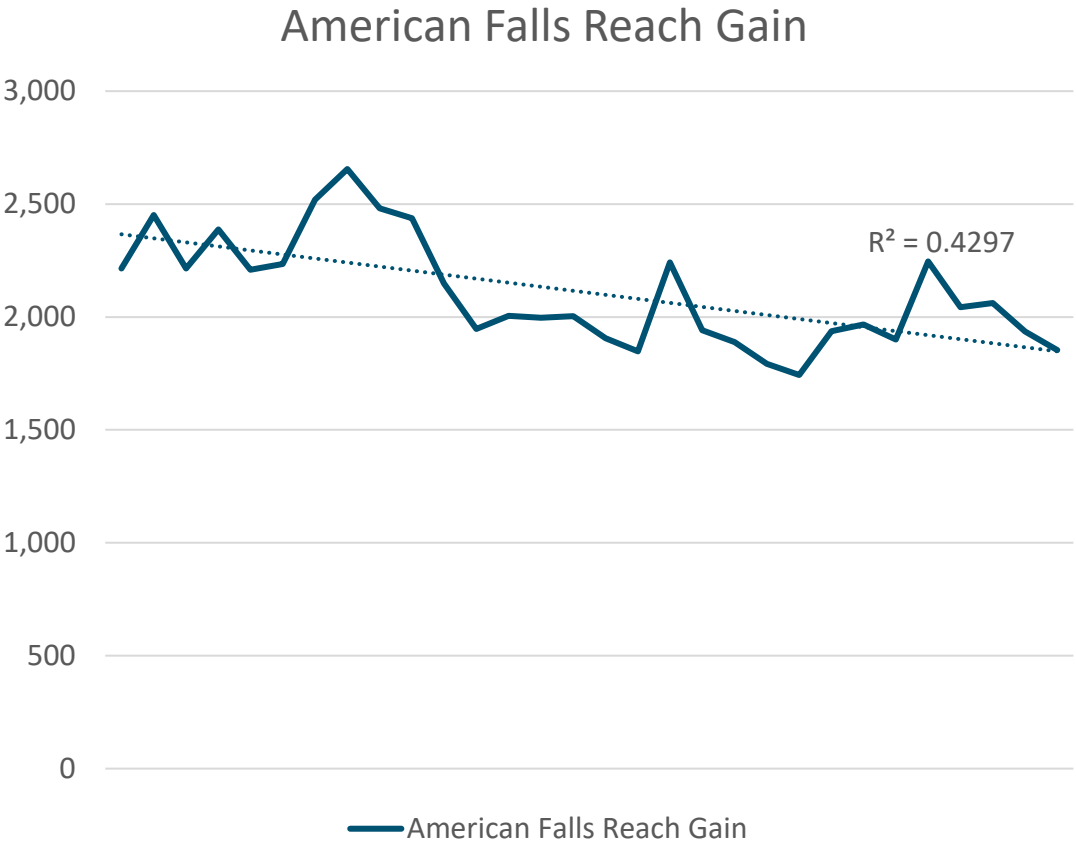
BY ENERGY EXEMPLAR

A screenshot of the Aurora software interface showing a detailed table of monthly exceedance plant hydro generation data. The table has multiple columns, including 'Month', 'Year', 'Generation (aMW)', and 'Exceedance'. The data is presented in a clear, organized manner, allowing for easy analysis and comparison of hydro generation over time.

Trend Analysis

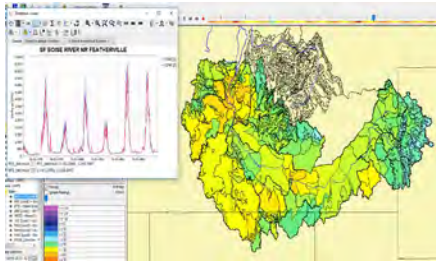


Reach Gain Location	Trend (cfs/month)	P-Value Less than 0.01	TFPW RESULTS
American Falls	-1.31	TRUE	(-) TREND
Lower Salmon Falls	-1.25	TRUE	(-) TREND



Modeling Process

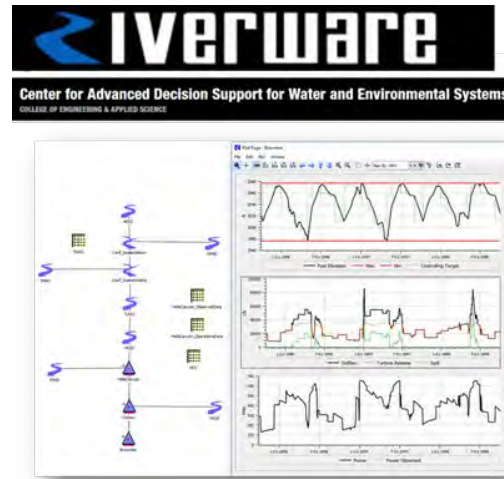
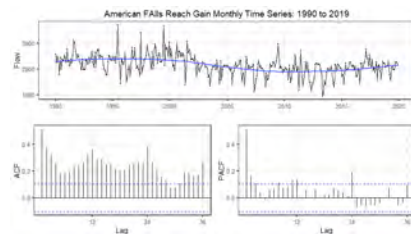
EFS Cloud Seeding SA



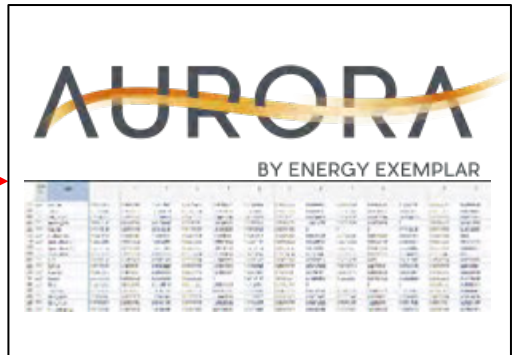
ESPAM 2.2



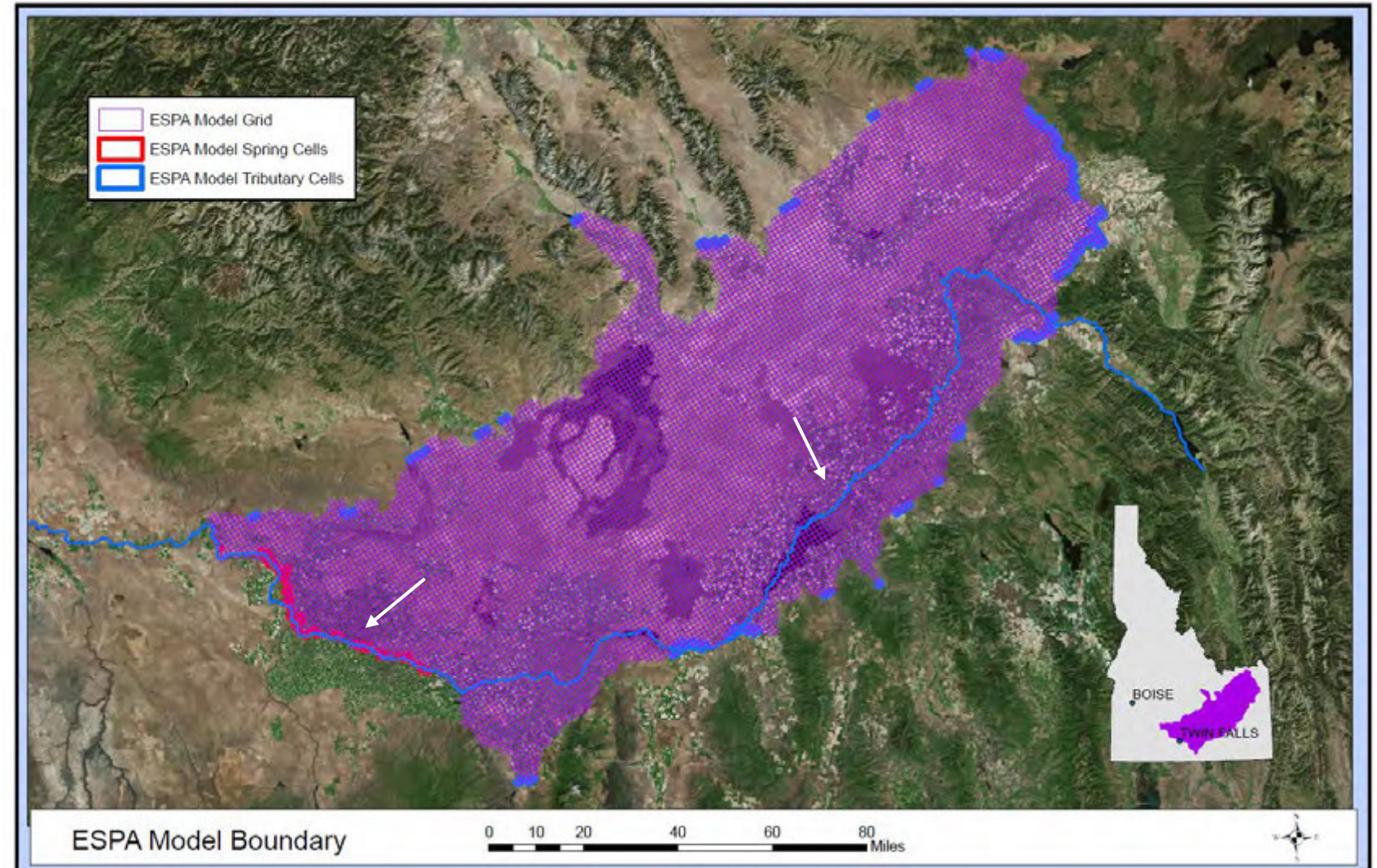
Statistical Trend Modeling



Monthly Exceedance
Plant Hydro
Generation (aMW)



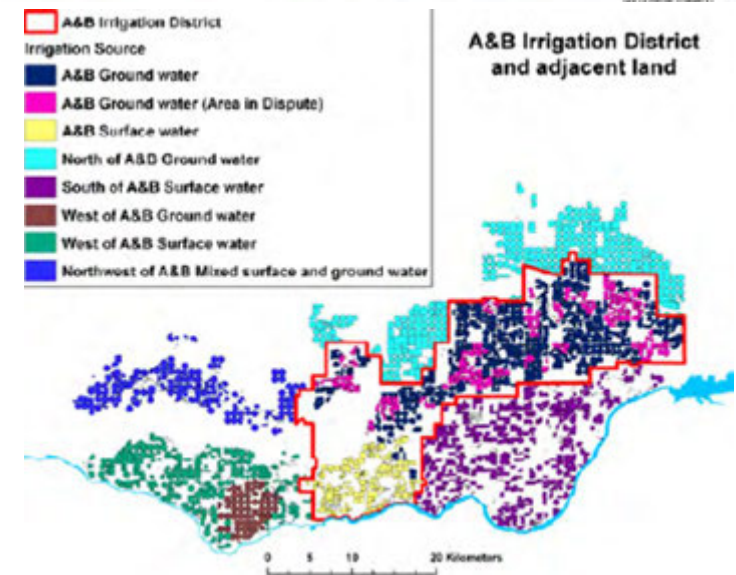
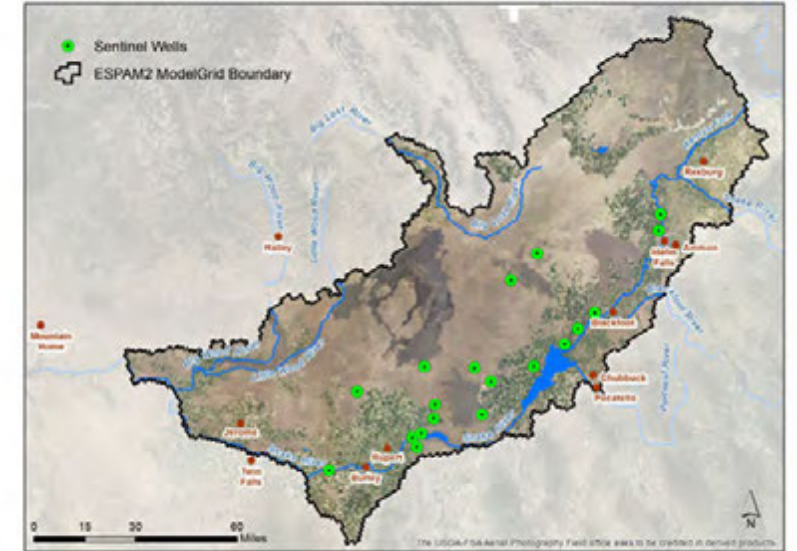
Enhanced Snake Plain Aquifer Model (ESPAM)



Conjunctive Management

- **SWC-IGWA* Settlement Agreement**
 - Reduced groundwater pumping
 - Support IWRB* managed recharge program
 - Storage water delivery to SWC
- **SWID-SWC* Agreement**
 - Conversion of groundwater to surface water irrigation
 - Delivery of storage water to cover conversions
- **Managed Recharge**
 - IWRB Natural and Storage
 - Private

Sentinel Well Locations: SWC - IGWA Settlement Agreement



Modeling Sequence

- Preliminary RiverWare run with expected reach gain changes
 - Cloud seeding
 - Trend declines
 - ESPAM simulated reach gains from observed water management practices
 - SWC agreement implementation
 - System conversions
 - Recharge
 - Idaho Water Resource Board
 - Private
- Use preliminary run determine the average monthly recharge volumes by upper valley and lower valley canals
- Rerun ESPAM with new recharge assumptions for the 20 years of the IRP

Additional Resources

- idwr.idaho.gov/legal-actions/settlements/SWC-IGWA/
- idwr.idaho.gov/water-data/projects/espam/
- iwrbrecharge-idwr.hub.arcgis.com/
- www.riverware.org/

