2021 Integrated Resource Plan

IDAHO POWER
An IDACORP Company

Hydro Resources

IRPAC Meeting – April 8, 2021

John Hildreth

Senior Engineer

Introduction

- This presentation is intended to be informational, so you understand the development of the hydro generation inputs that go into the Aurora modeling.

- The presentation will discuss the expected drivers of change to the hydro system over the 20-year planning horizon.

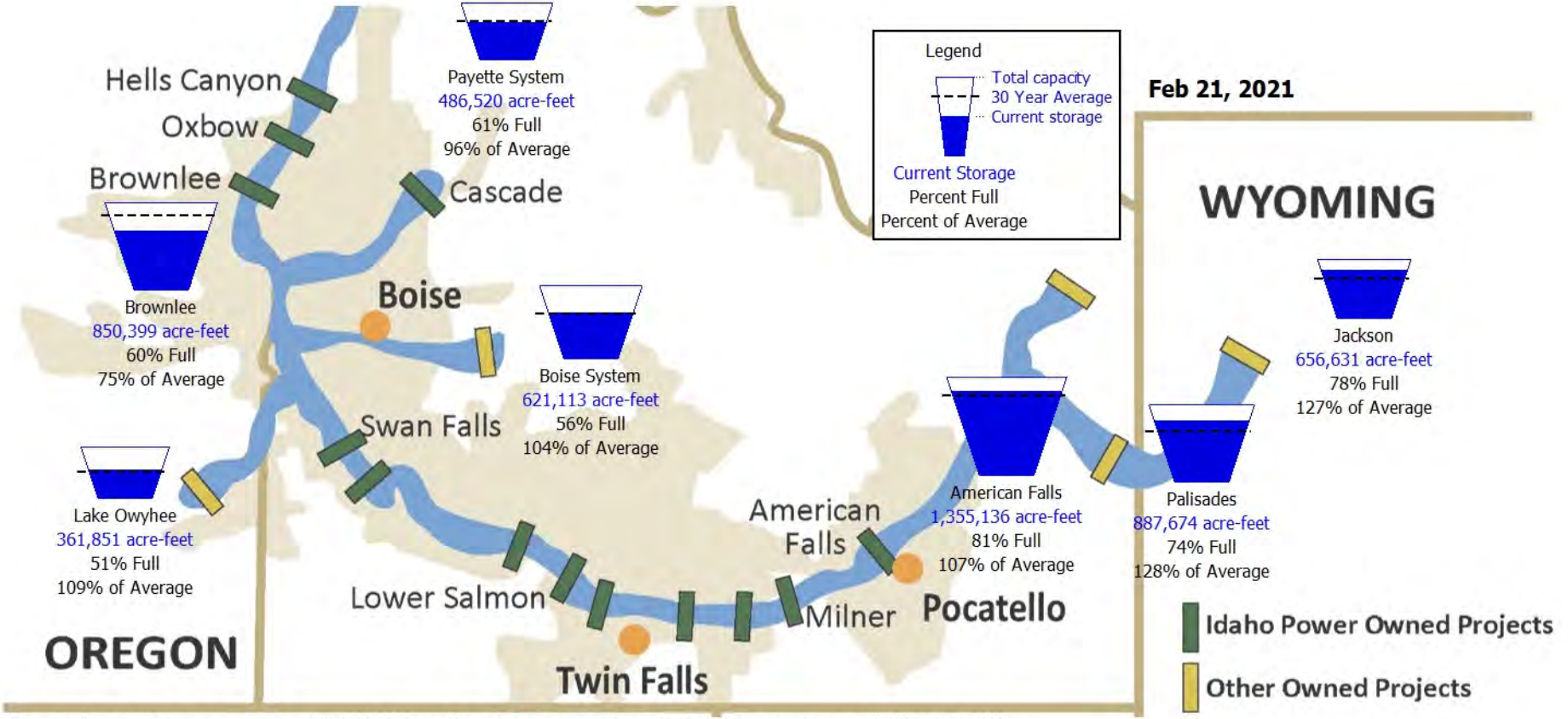
Importance

- Hydro generation modeling that goes into Aurora lays the building blocks for all other resources in the IRP.
- Idaho Power has almost 1,800 megawatts (MW) of hydroelectric generation capacity.
- Hydro is our largest energy resource.
- Hydro is an inexpensive fuel source and is a key factor in Idaho Power's ability to keep rates low for our customers.
- Hydro is a highly flexible resource that supports reliability of the system.

Overview

- Snake River System
- RMJOCII Climate Change Study
  - Part 1: future climate and natural flow
  - Part 2: regulated future flow
- Streamflow Development
  - Past IRP modeling methods
  - 2021 IRP modeling changes
    - Planning model
    - Hydrology Period of Record
  - Model validation
  - 2021 IRP model future assumptions and input development
  - Results
- Hydro production results

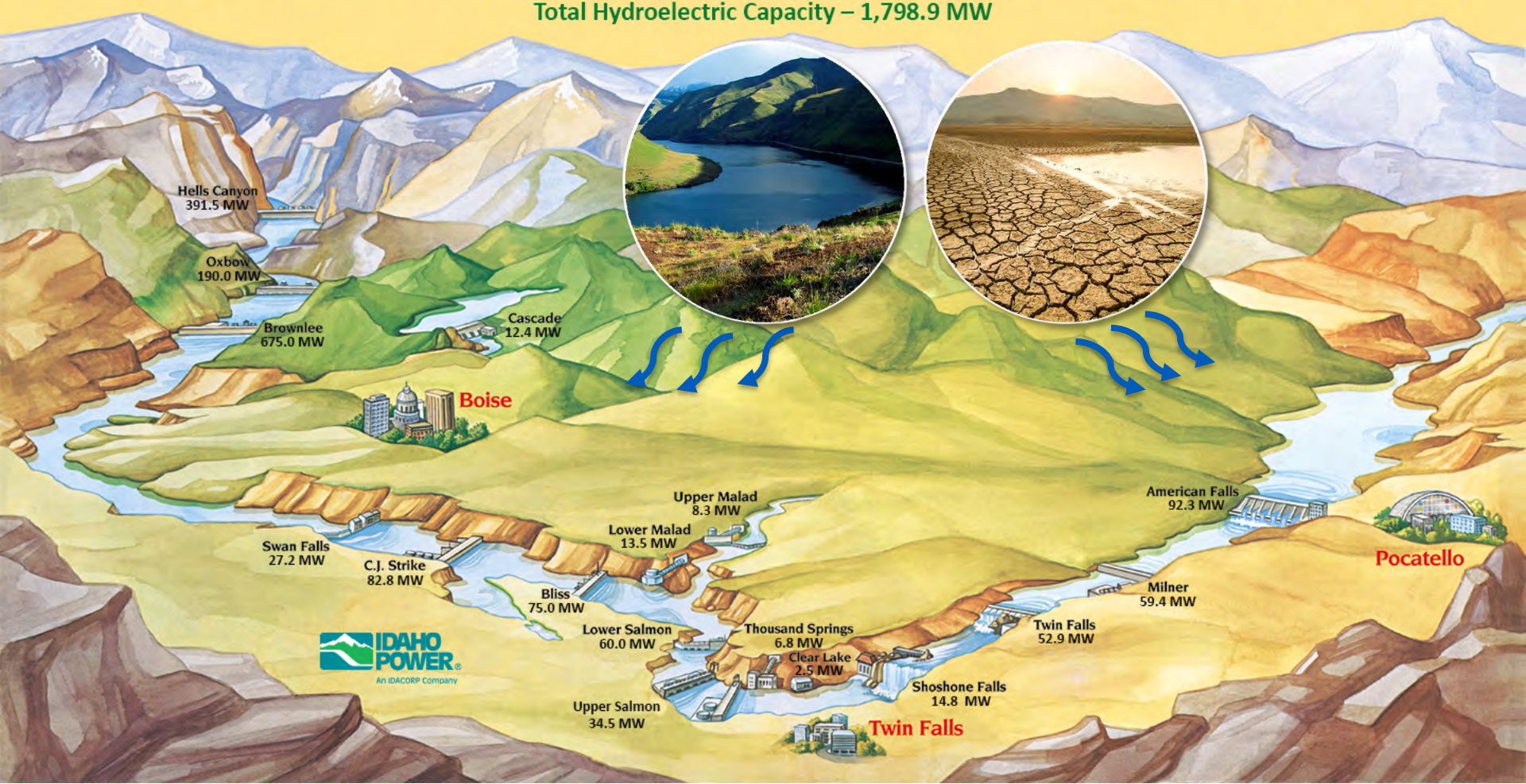
Snake River Basin Teacup Diagram



*Brownlee Percent of Average is based on WY1992-2020 to reflect fall Chinook operations. All other reservoirs use a period of WY1991-2020.

The Snake River and Idaho Power's Hydroelectric System

Total Hydroelectric Capacity – 1,798.9 MW



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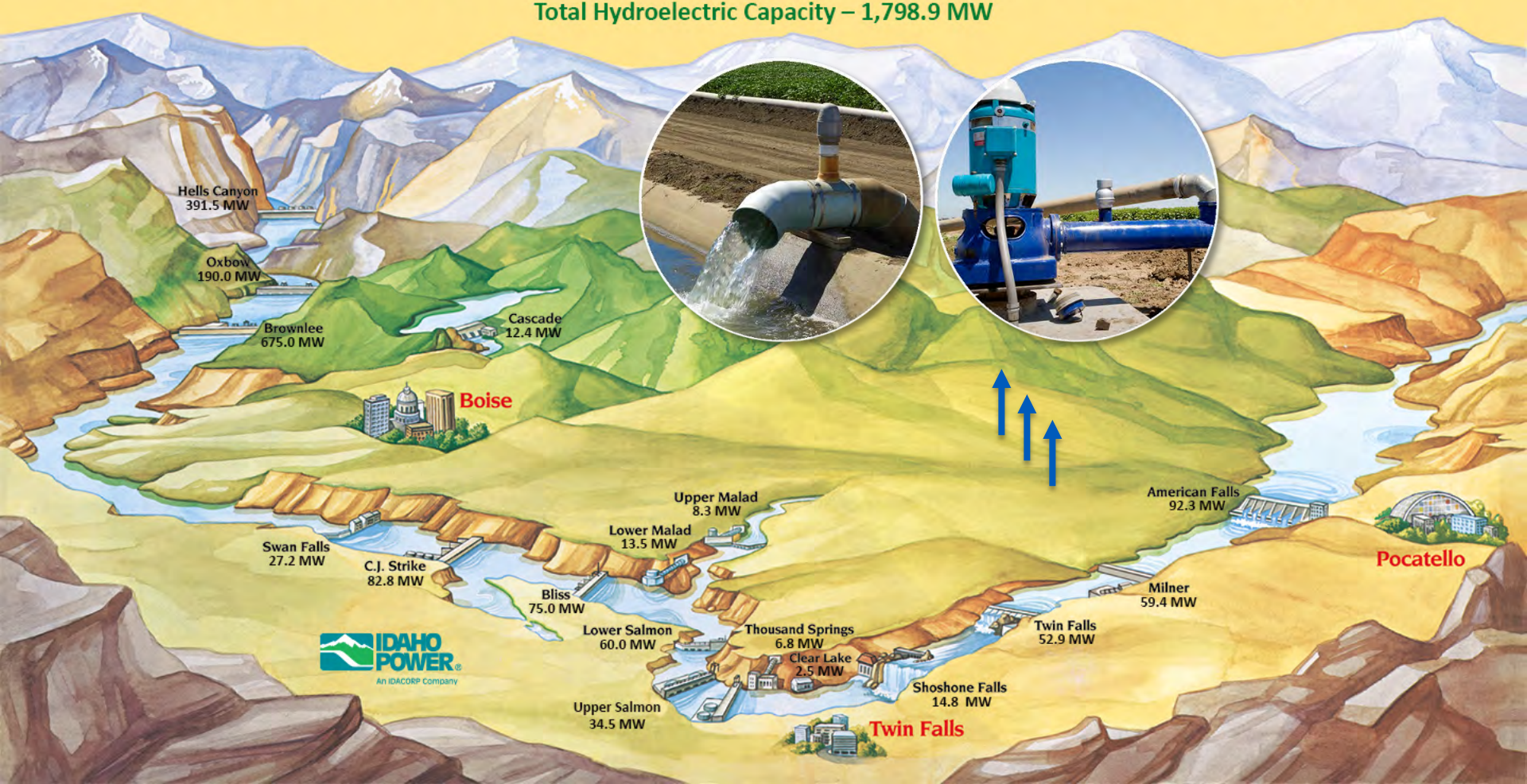

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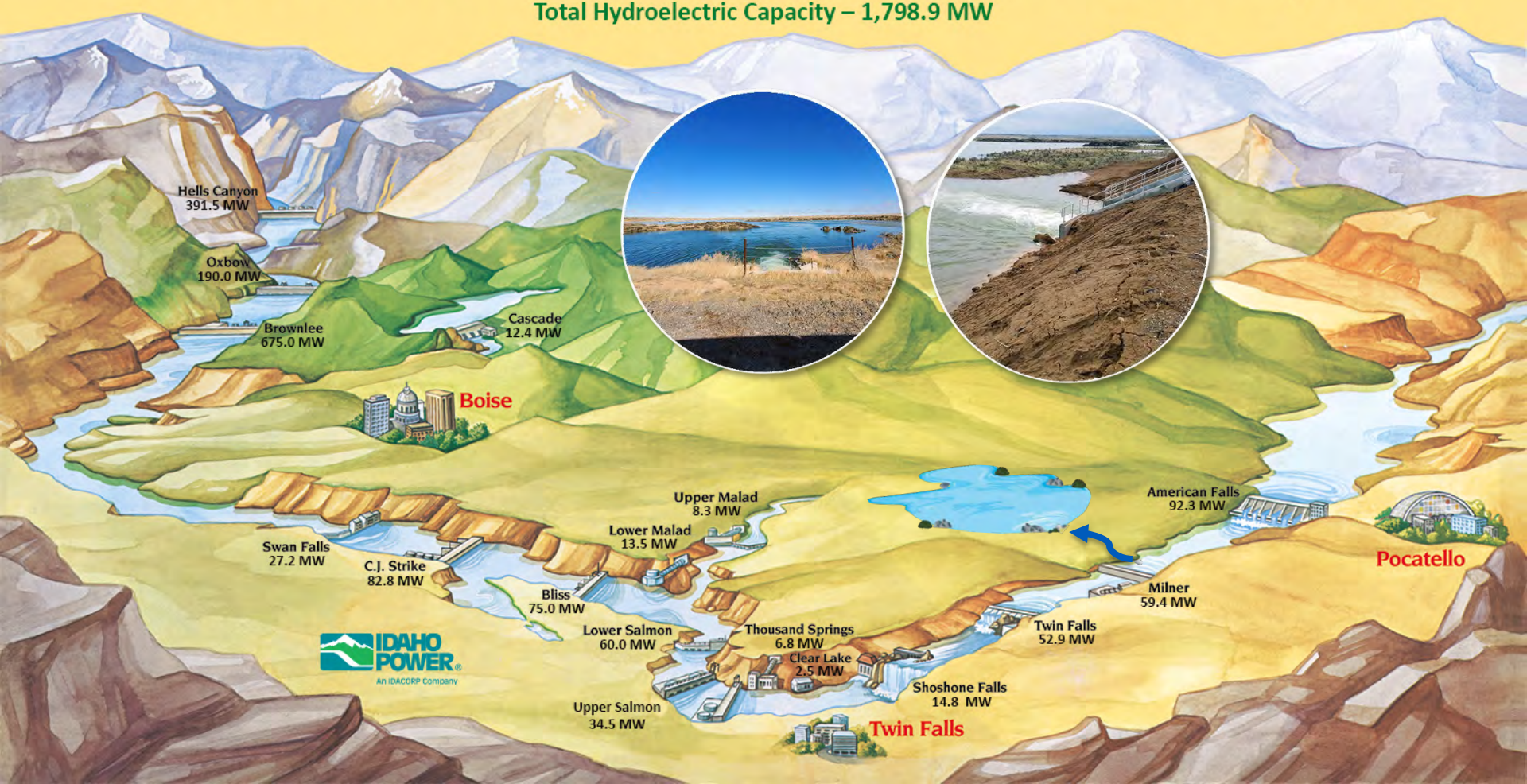

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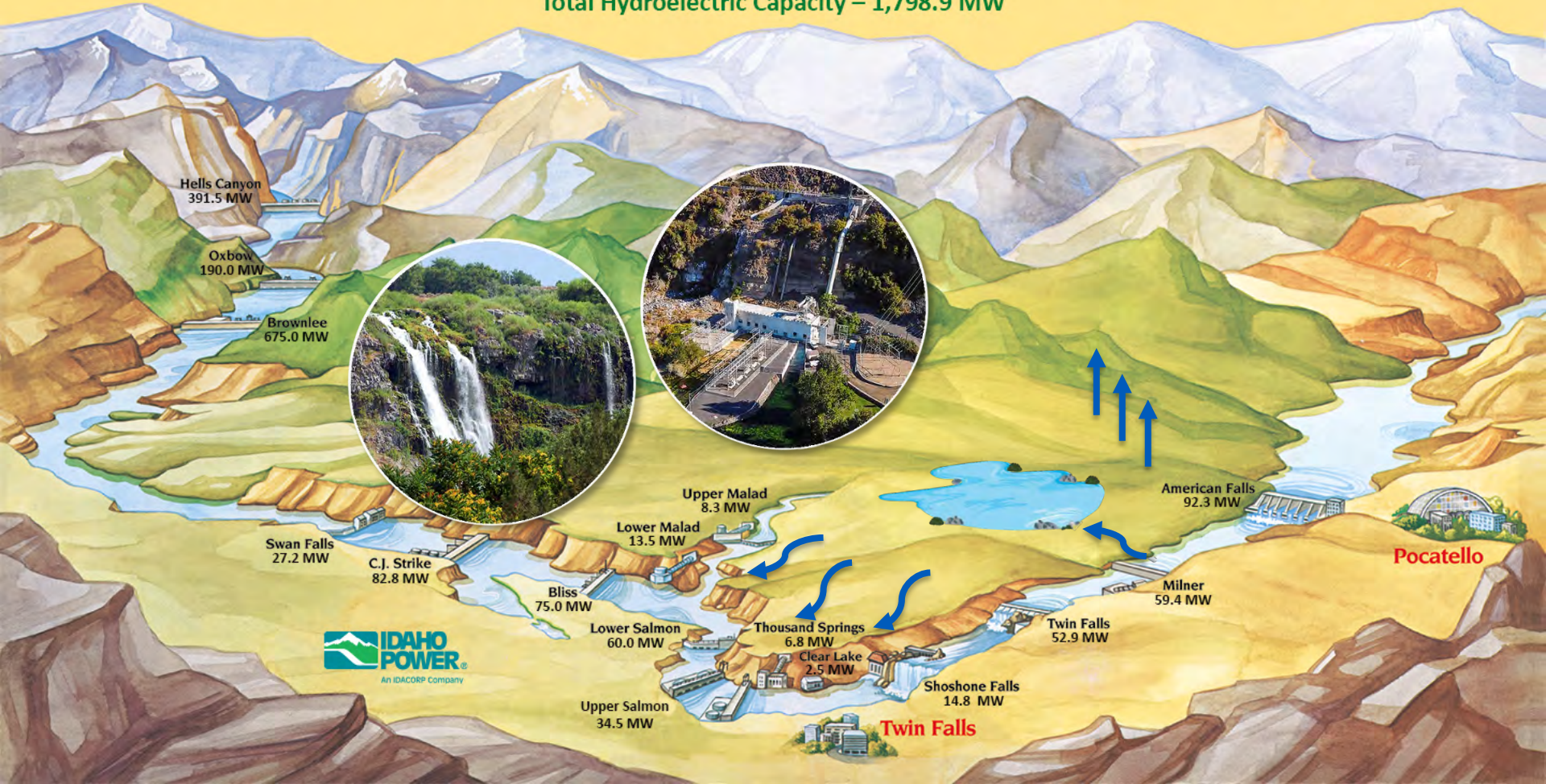

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Climate Change

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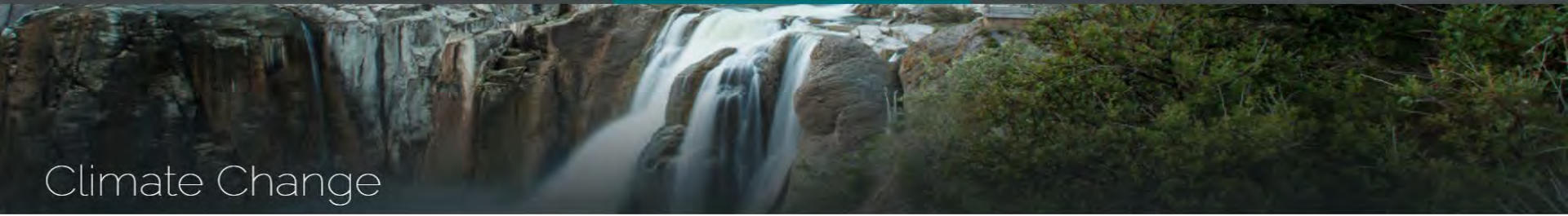


Climate change is a significant policy issue that will have major implications for Idaho Power and may transform the energy industry.

Policy and societal decisions made about climate change policy will significantly affect our customers and the future prices they pay for energy.

For more than 100 years, Idaho Power has relied on clean generation resources like our hydroelectric plants that have little if any greenhouse gas emissions.

Although our generation portfolio currently includes fossil fuel generation, our carbon emissions are some of the lowest in the utility industry.

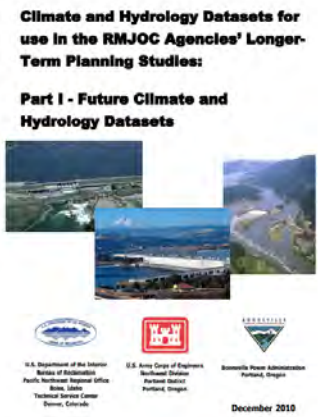
Our long-range plan details Idaho Power's glide path away from coal-fired generation, and our Clean Today, Cleaner Tomorrow initiative is a commitment to provide 100% clean energy by 2045 while keeping your electricity reliable and affordable.

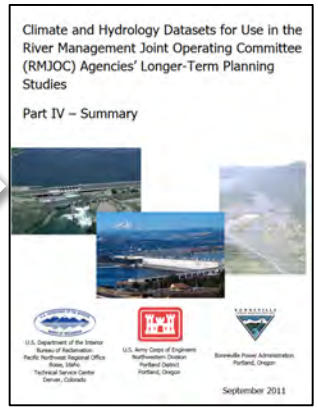
Idaho Power is committed to our goal of **100% clean energy by 2045.**

Learn more

Long-term Climate Change Planning Studies

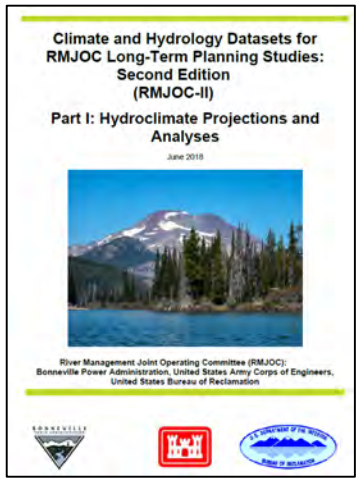
CMIP3



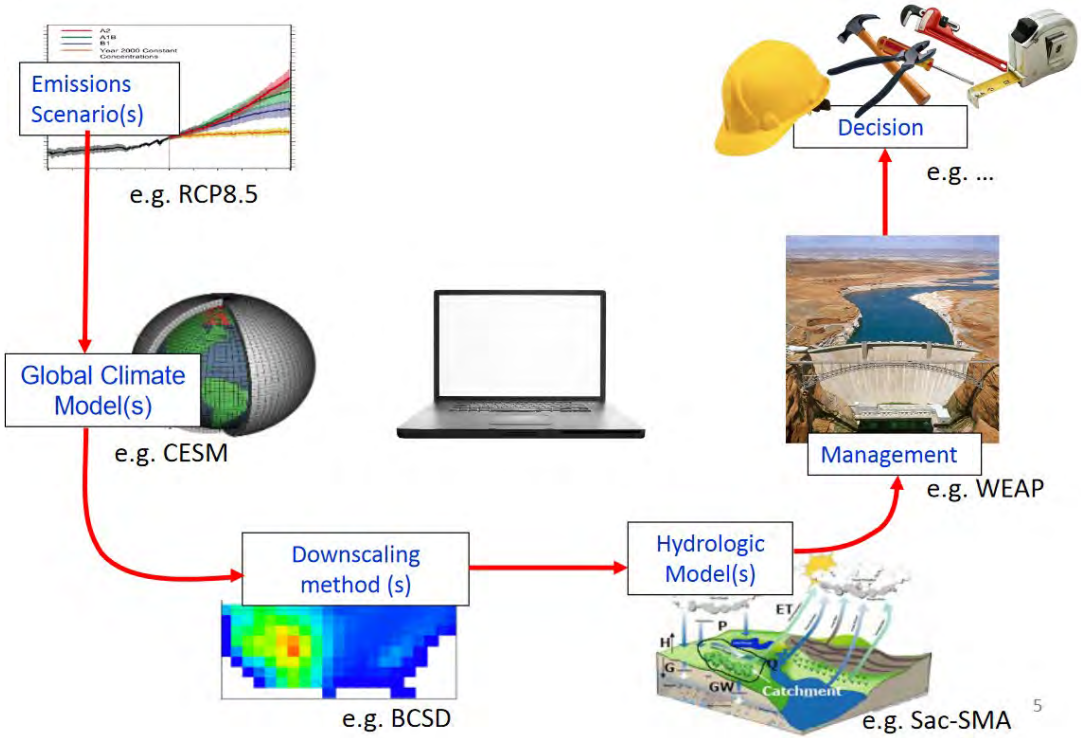


WCRP CMIP5

World Climate Research Programme

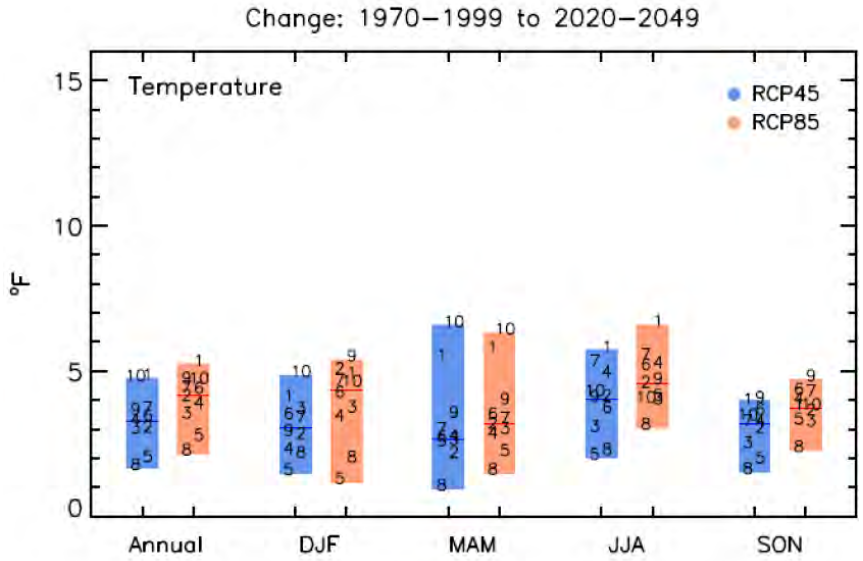


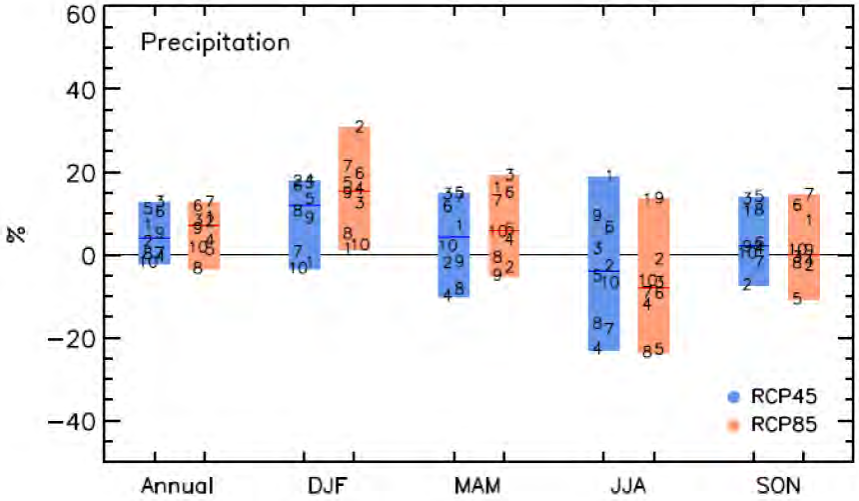
Climate Change Hydro Modeling Workflow



https://www.wucaonline.org/assets/pdf/7-0917-training-uncertainty.pdf

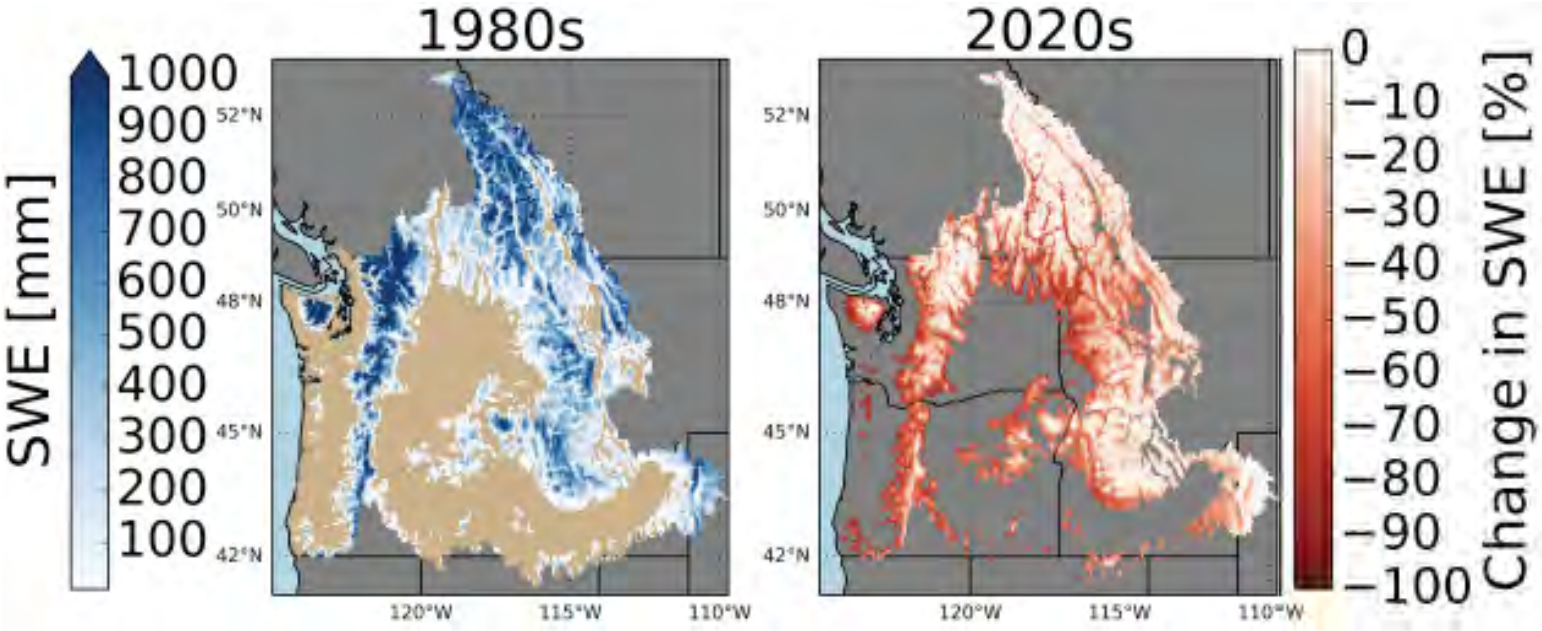
Snake Basin GCM Results





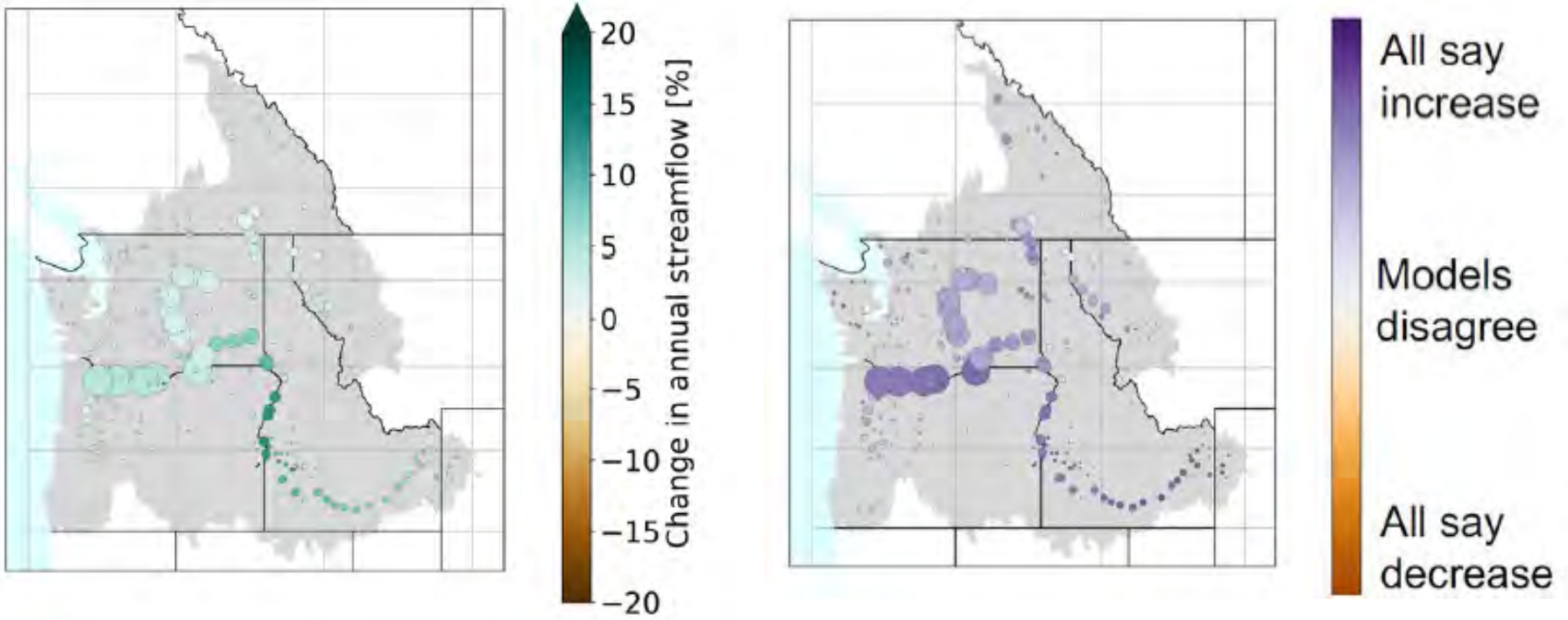
Adopted from Figure 39, Modeled temperature and precipitation changes of 10 GCM's for Snake River Basin above Lower Granite

Snow Water Equivalent



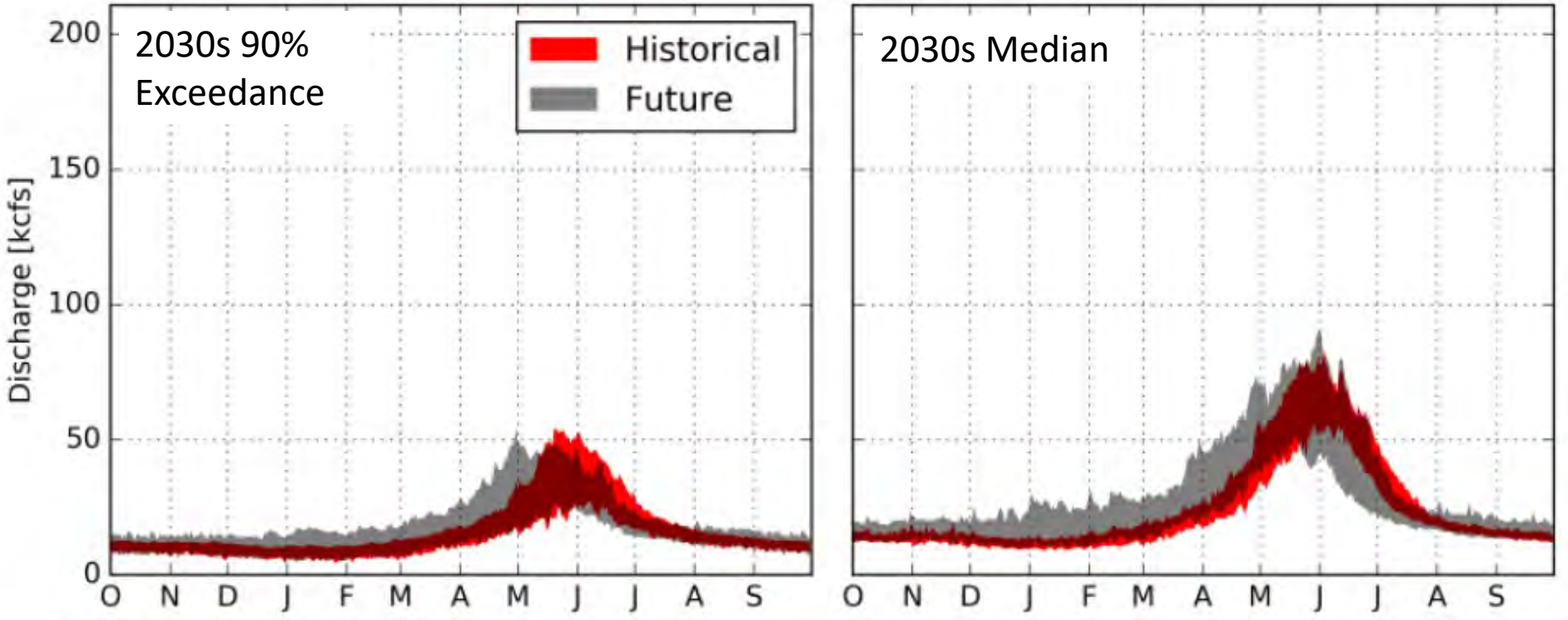
Adopted from Figure 41, Modeled Columbia Basin Snow Water Equivalent (SWE) in the 1980s and average SWE change of 10 GCM's using RCP 8.5 for the 2020s (2010–2039)

Annual Natural Flow Results



Adopted from Figure 60 and 61, 10 RCP8.5 GCM annual volume change in natural streamflow Historic (1976–2005) to Future (2020–2049)

Brownlee Natural Flow Results



Adopted from Figure 64, daily range of natural 50% exceedance flows at Brownlee for RCP8.5 Historic (1976–2005) and Future 2030s (2020–2049)

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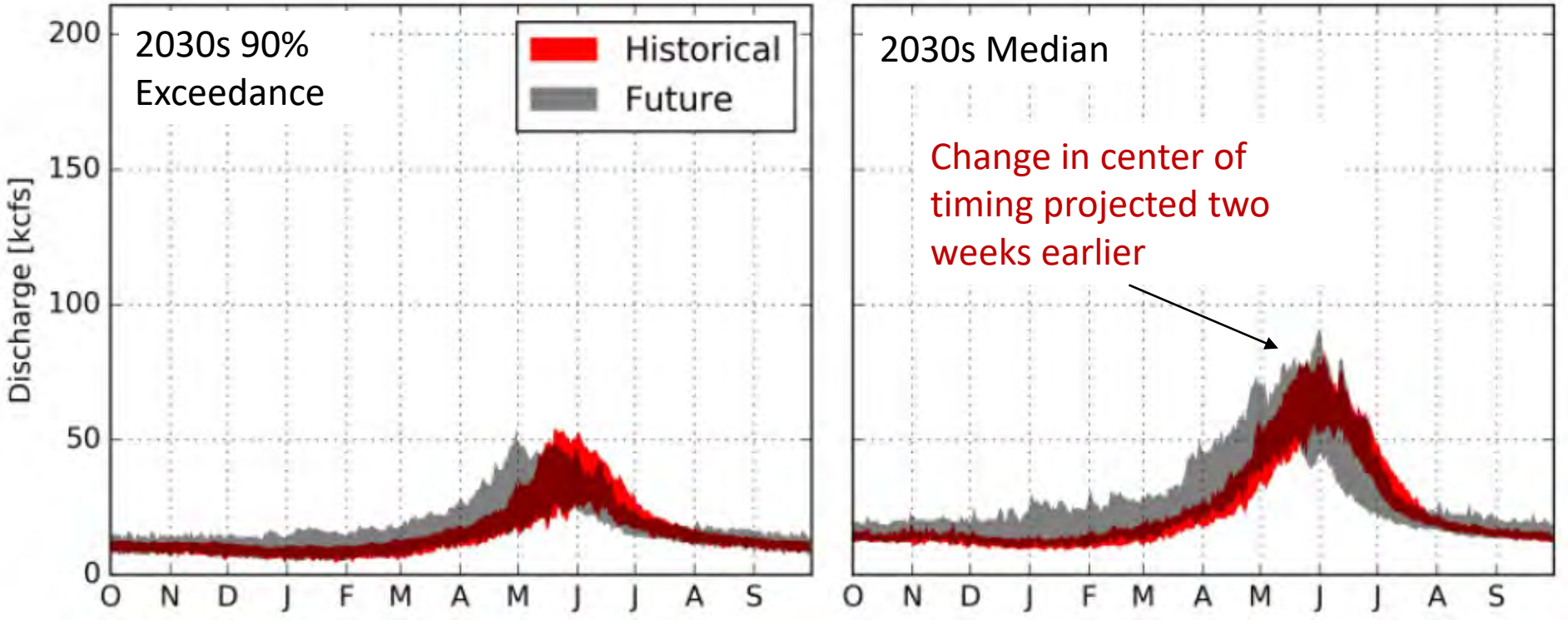

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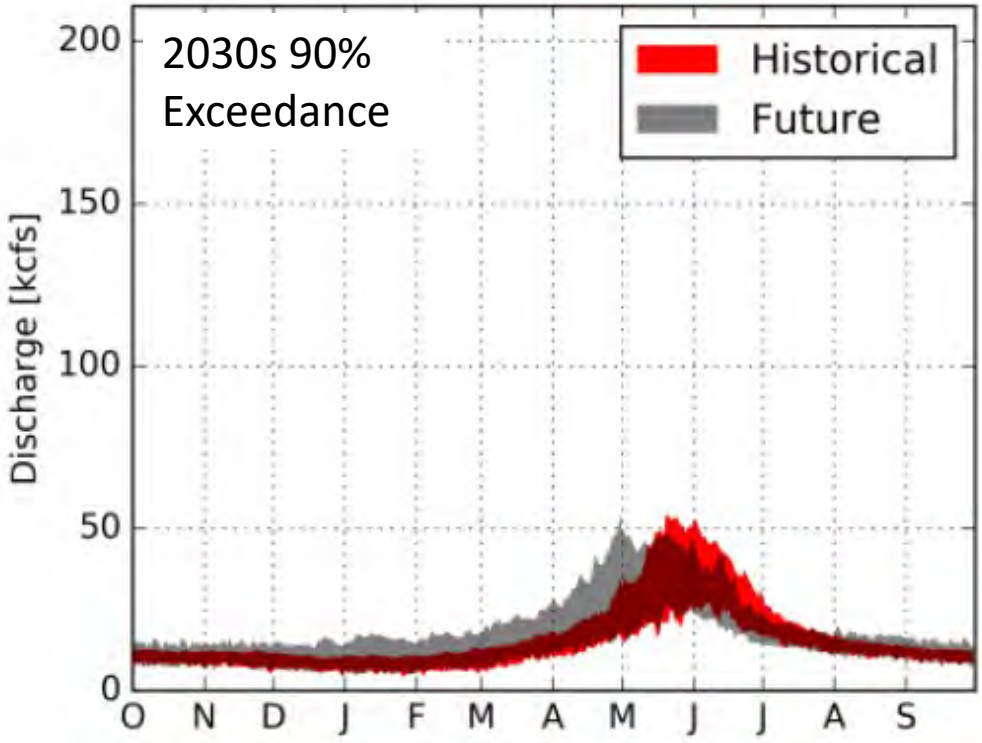

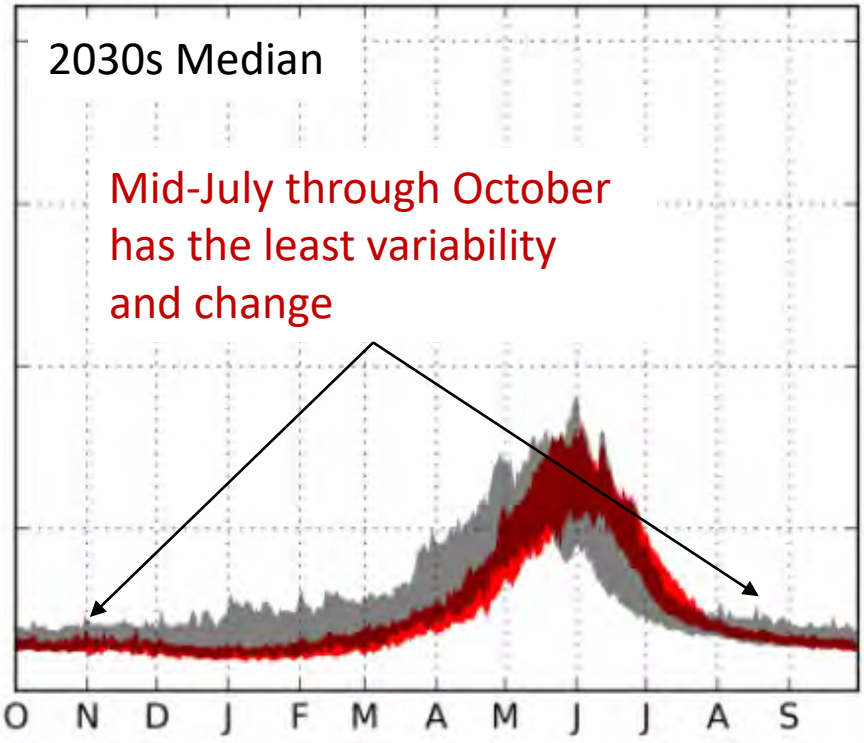

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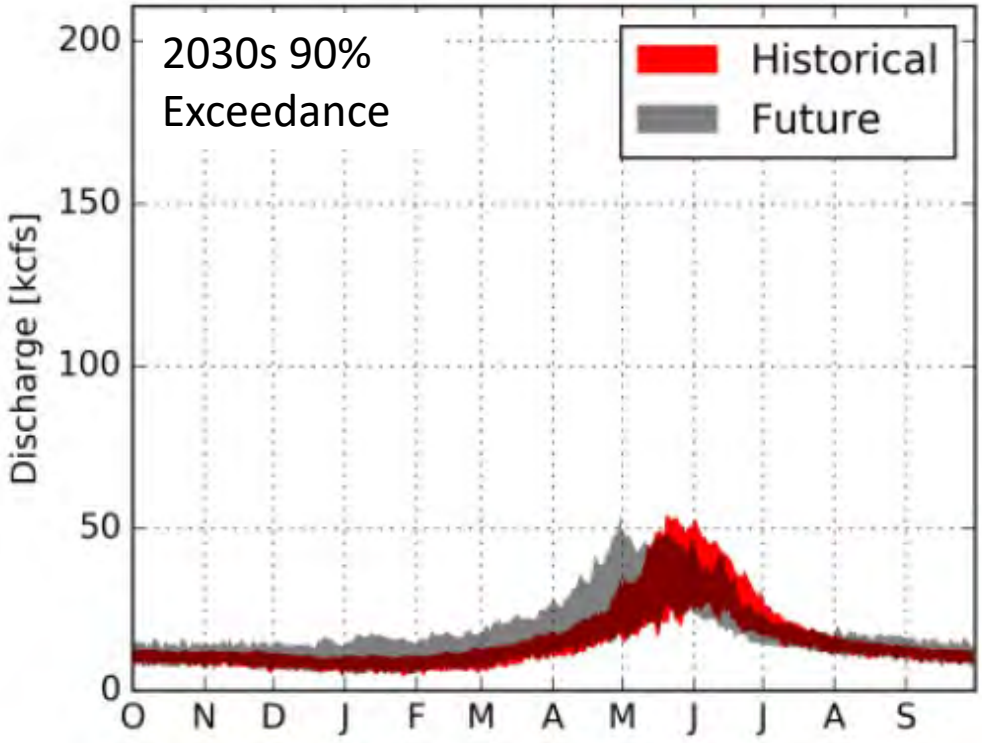

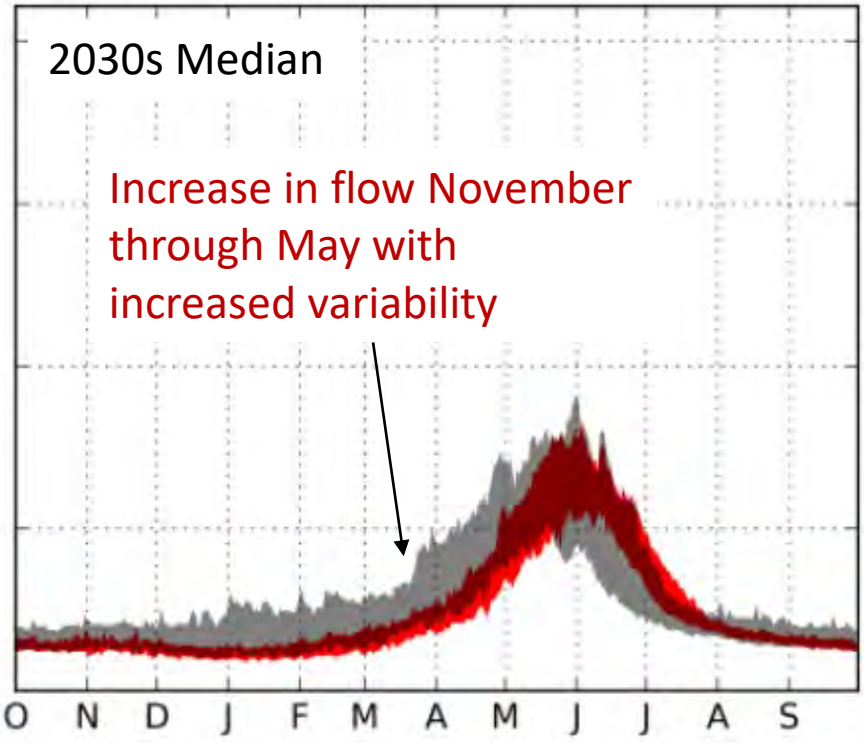

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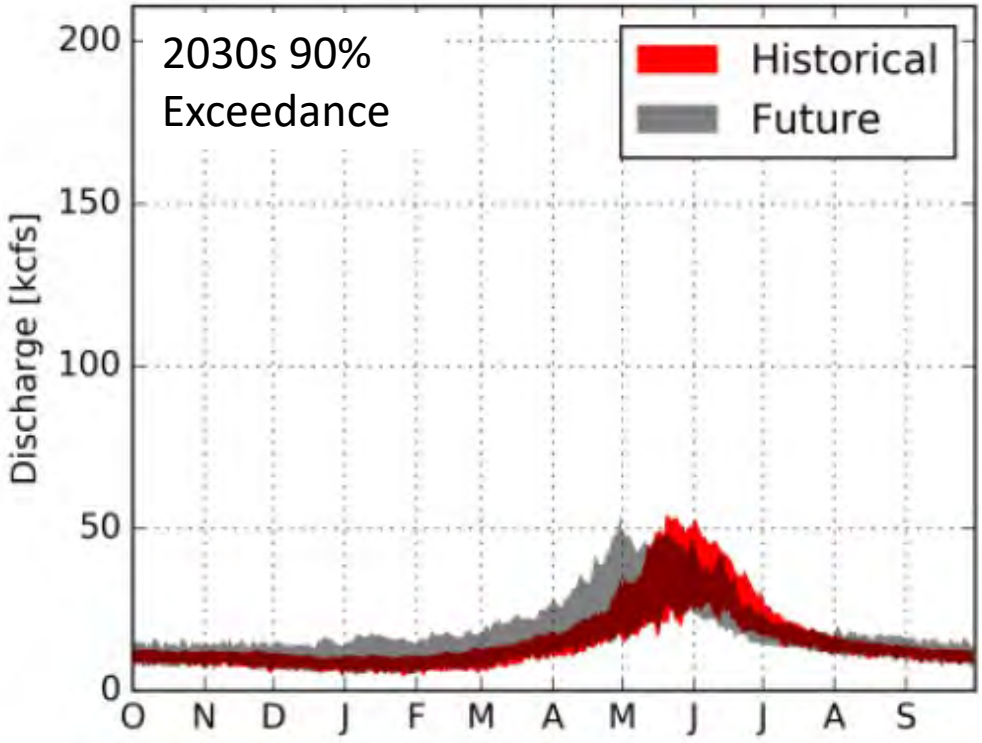

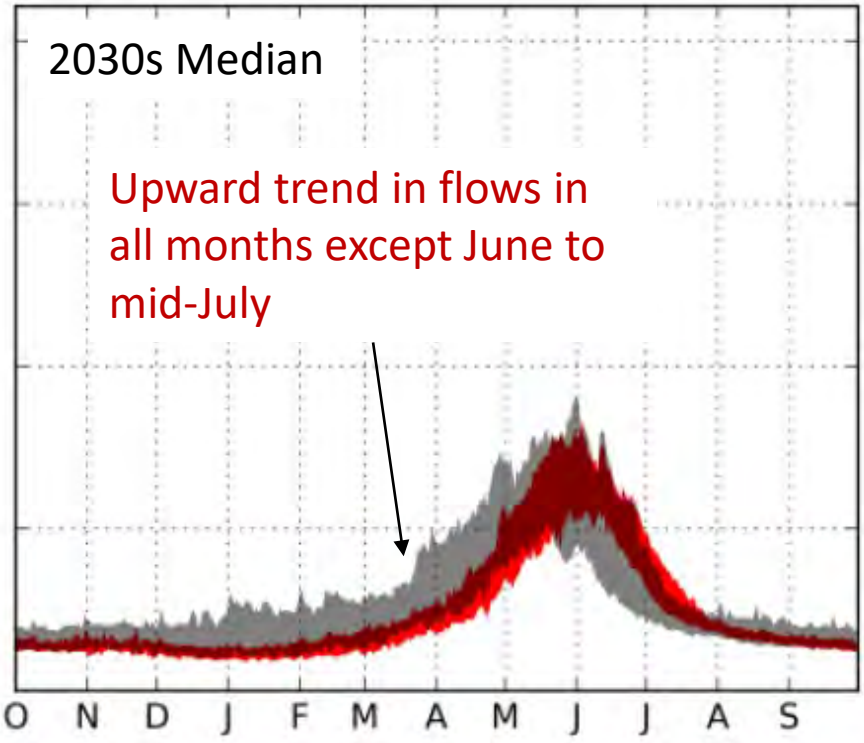

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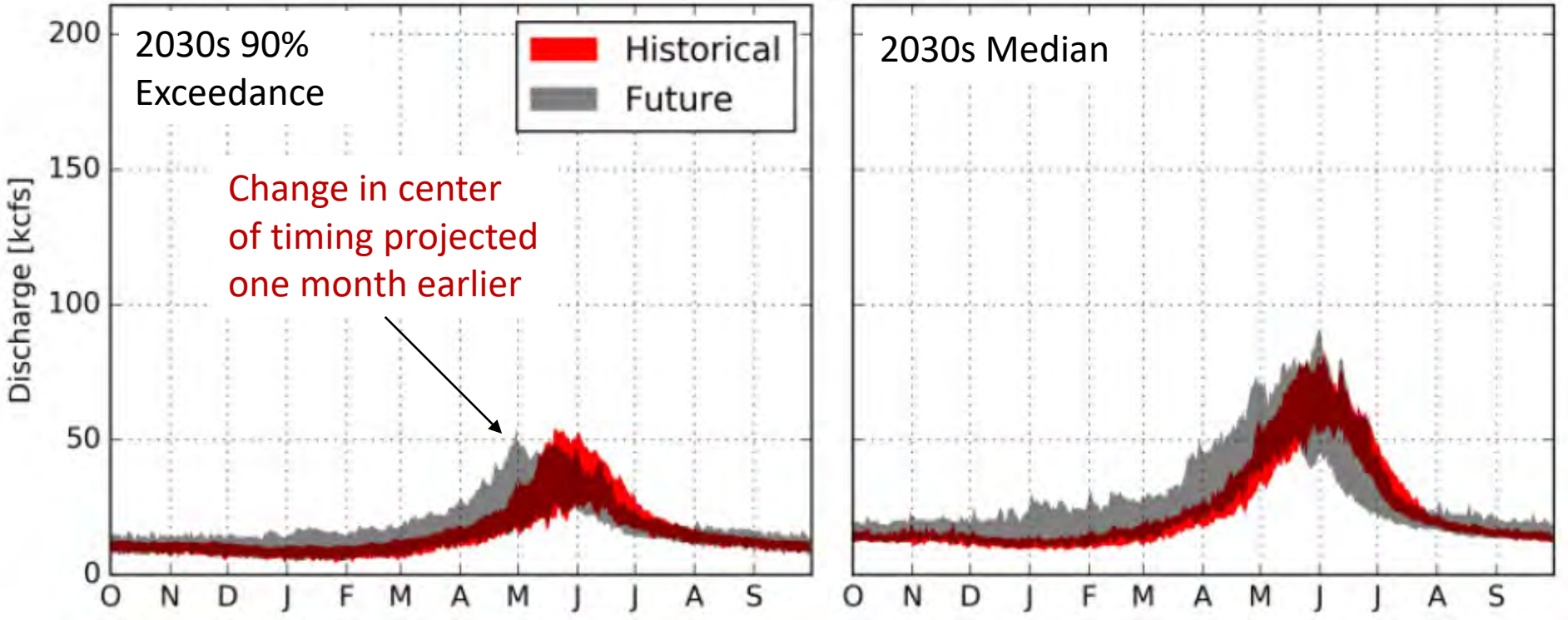

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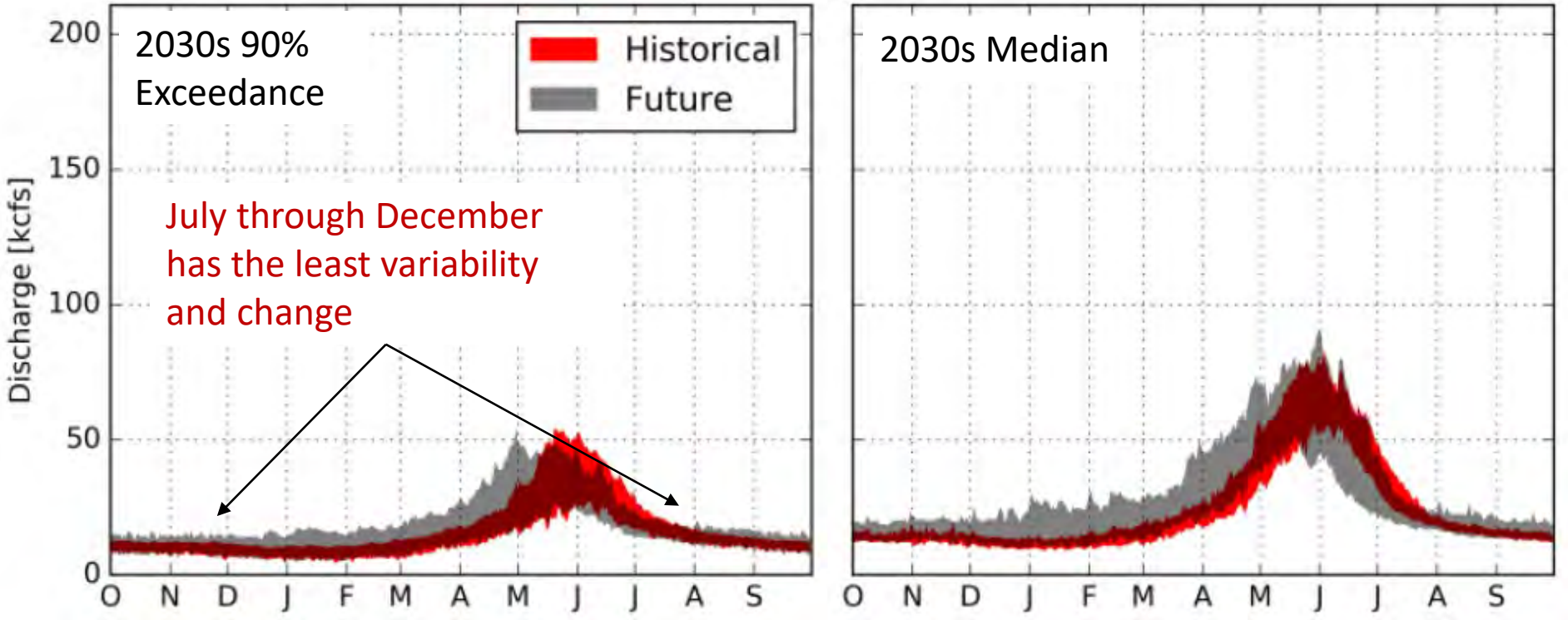

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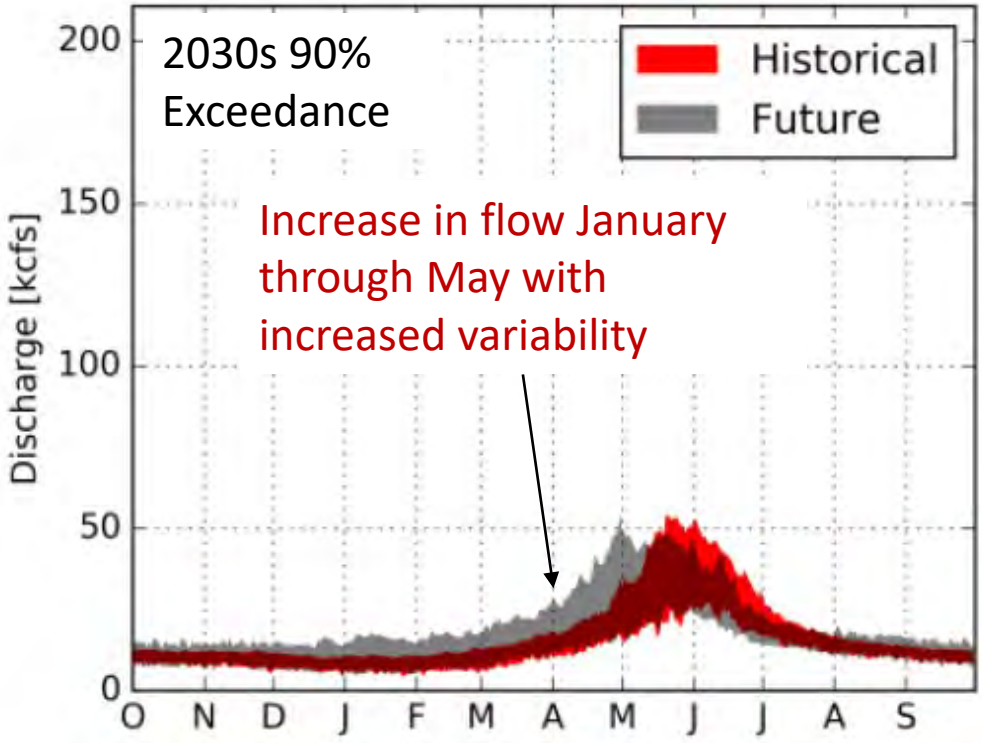

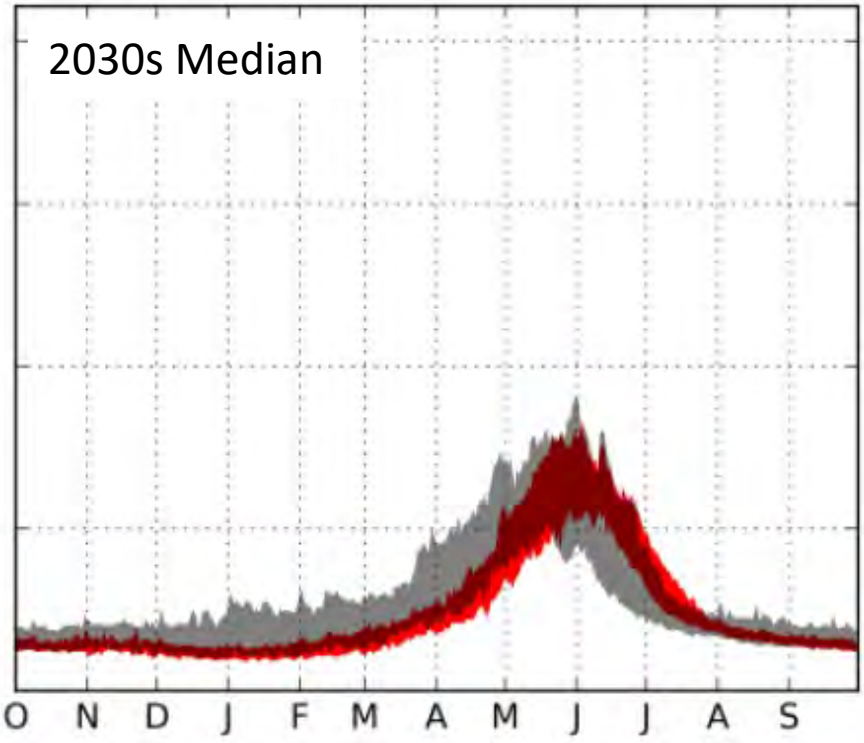

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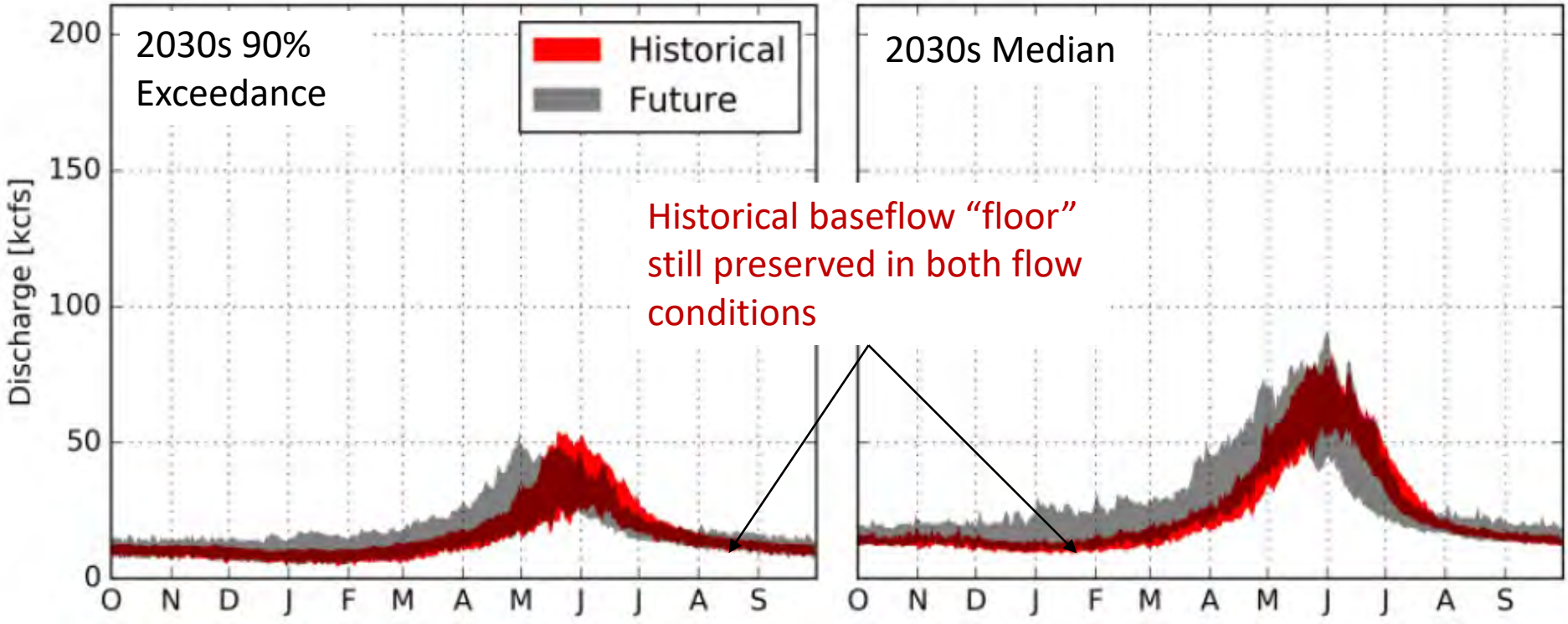

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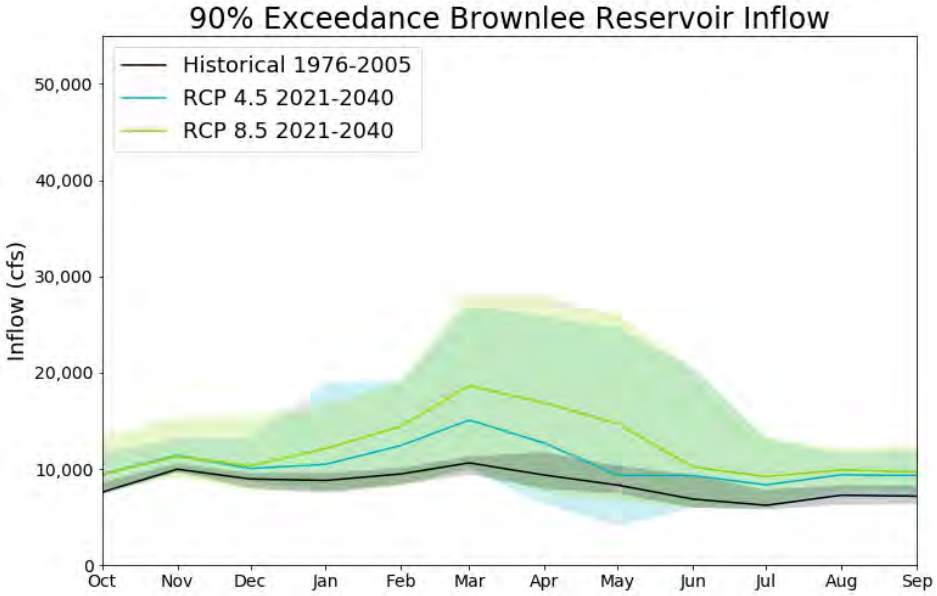
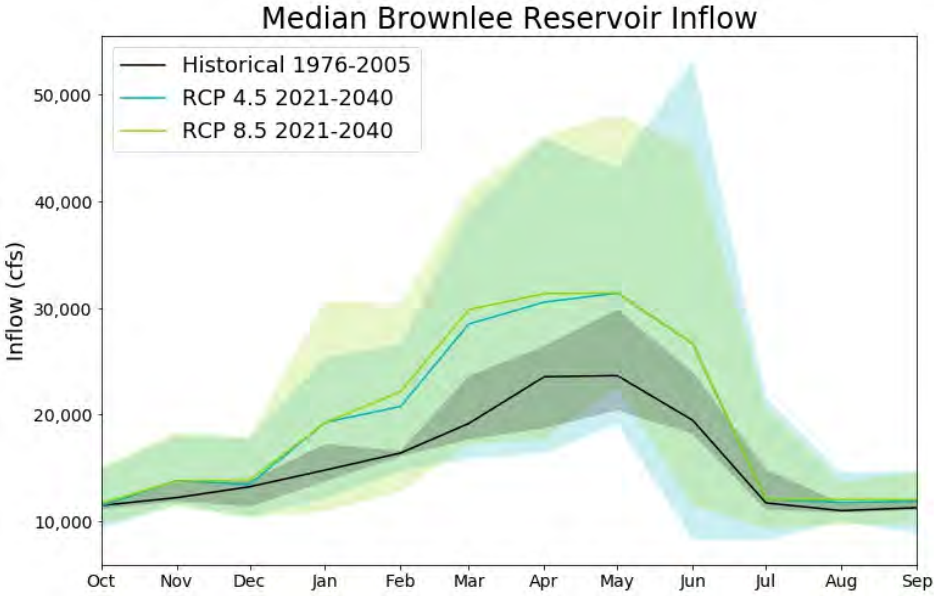
Brownlee Regulated Flow Results





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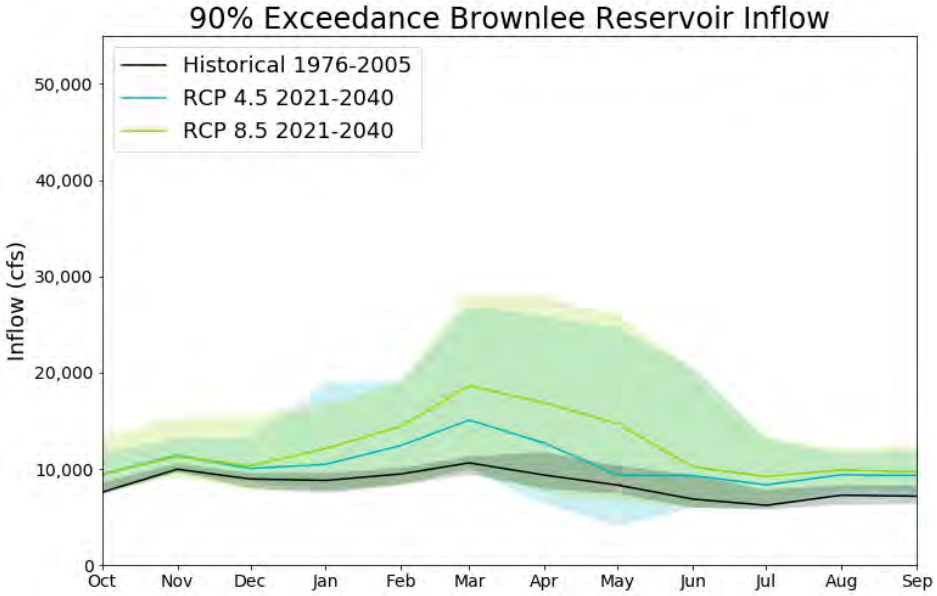
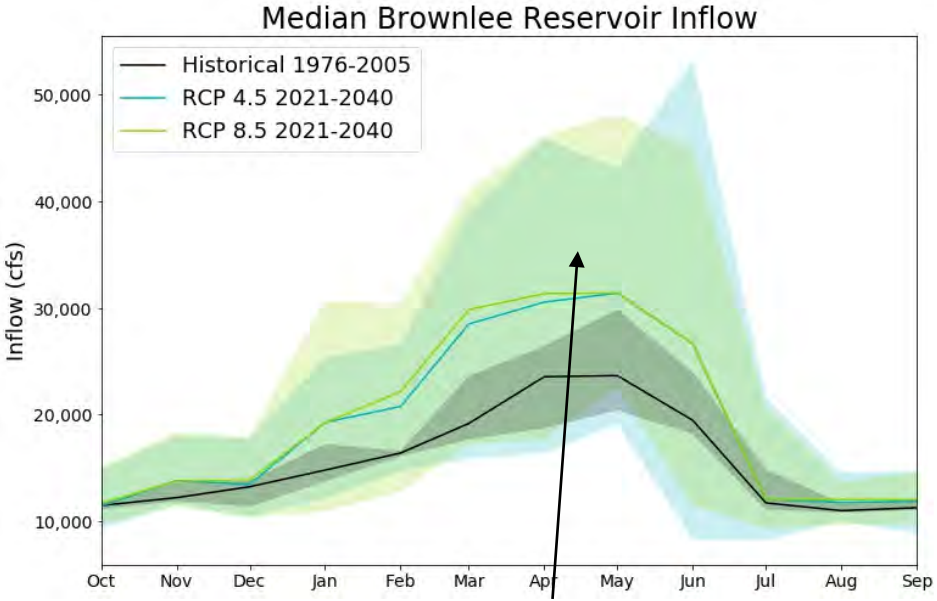
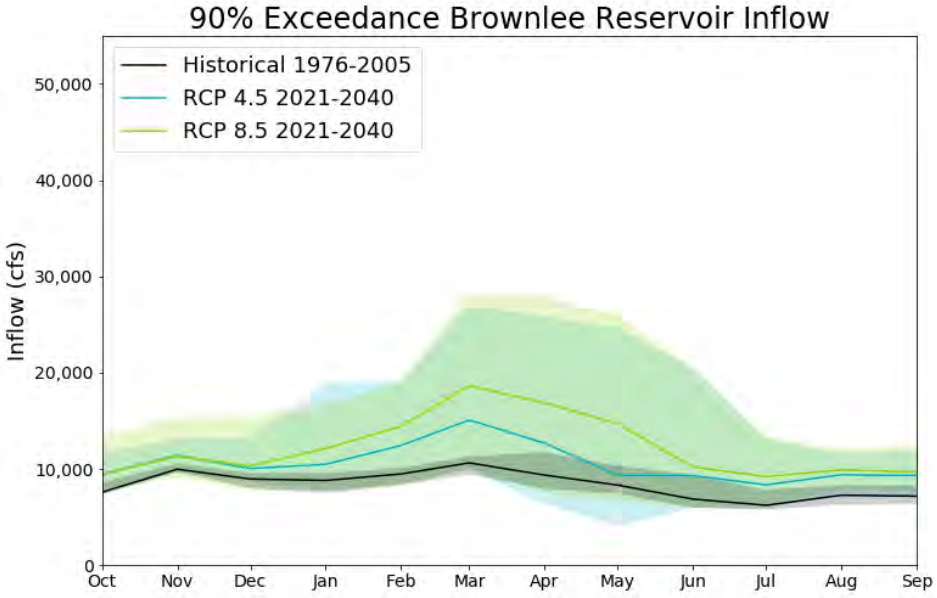
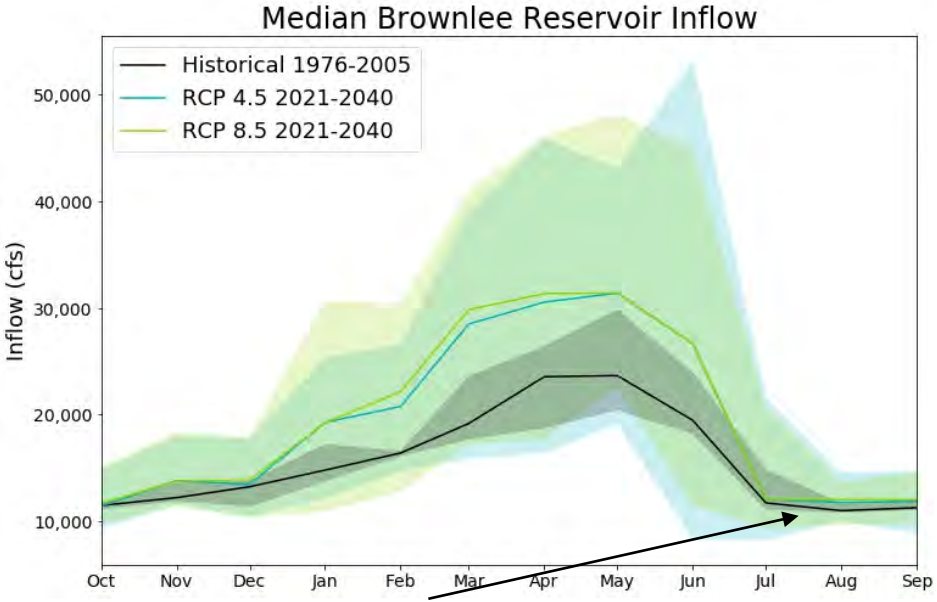




Large increase in variability, greatest in spring

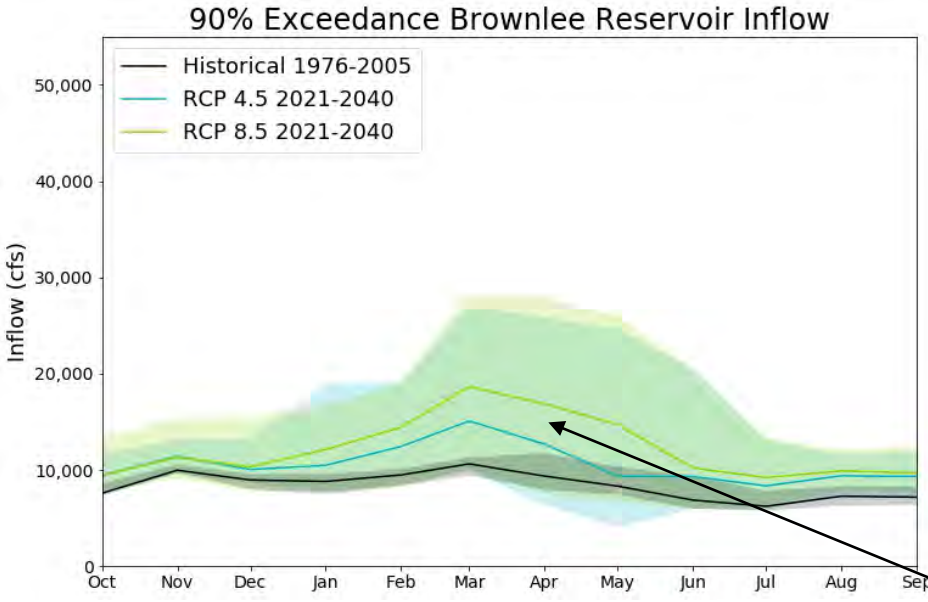
Brownlee Regulated Flow Results

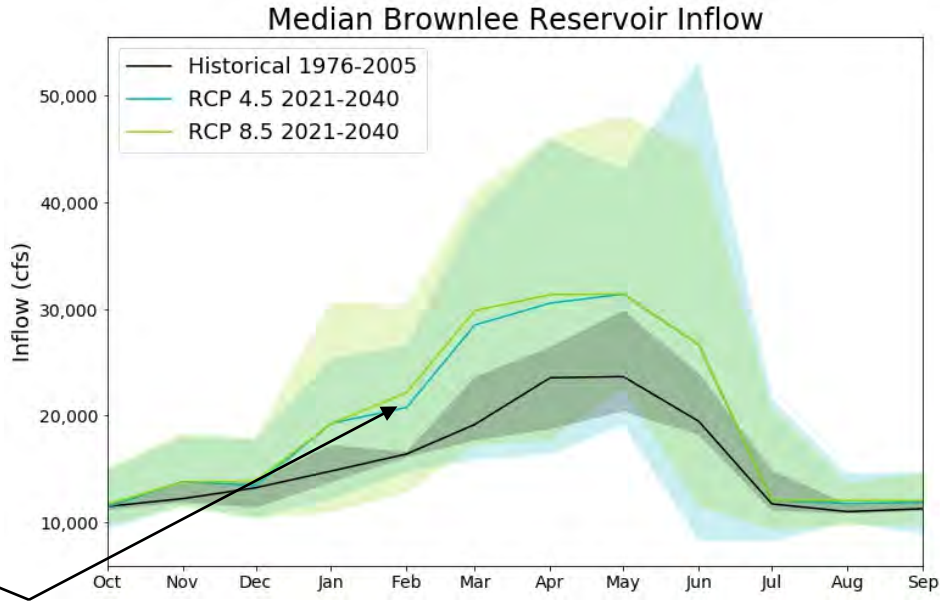




Least variability and change
July through December,
most critical energy time

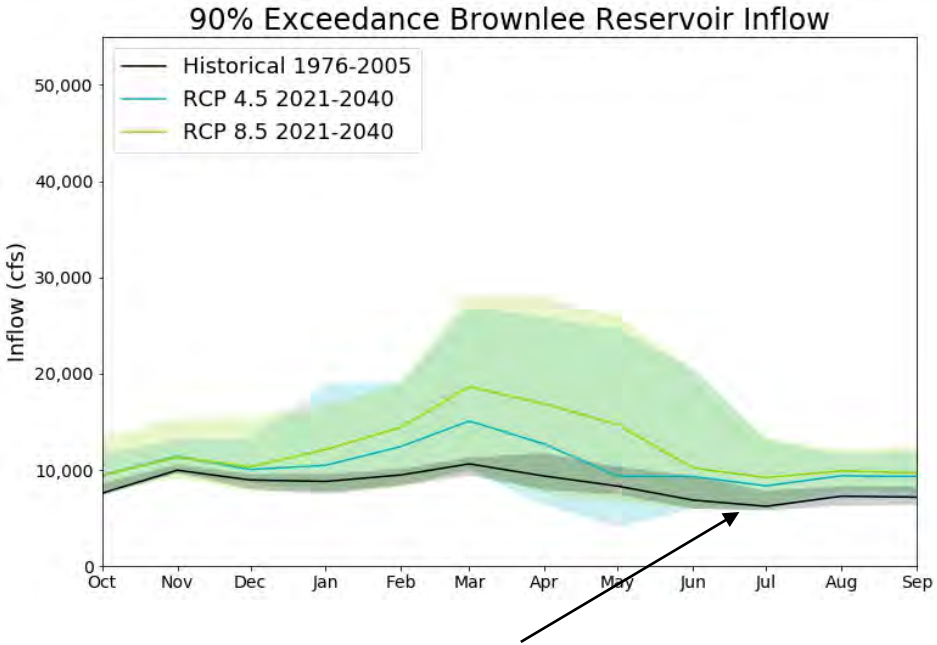
Brownlee Regulated Flow Results

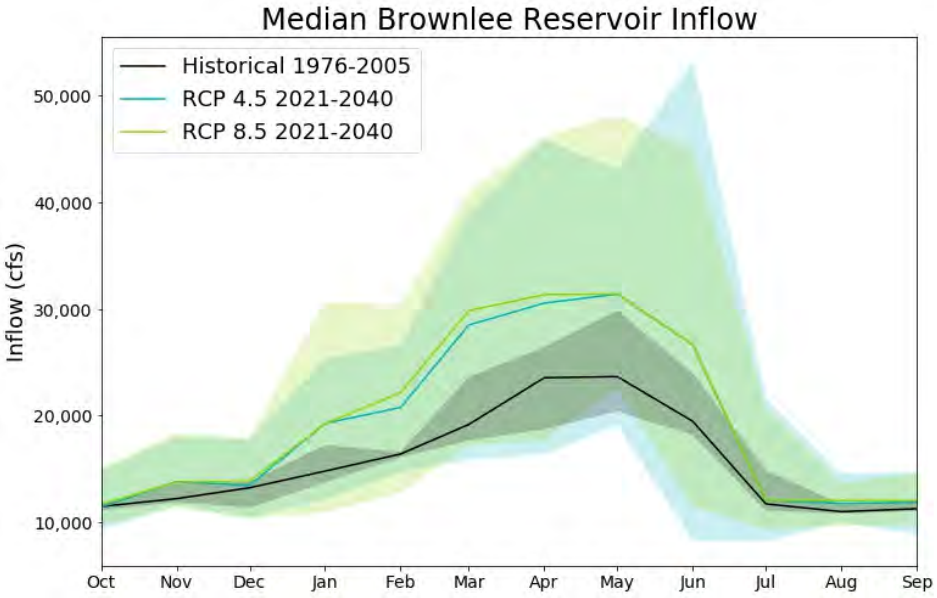




Higher or unchanged flows year-round for both water conditions

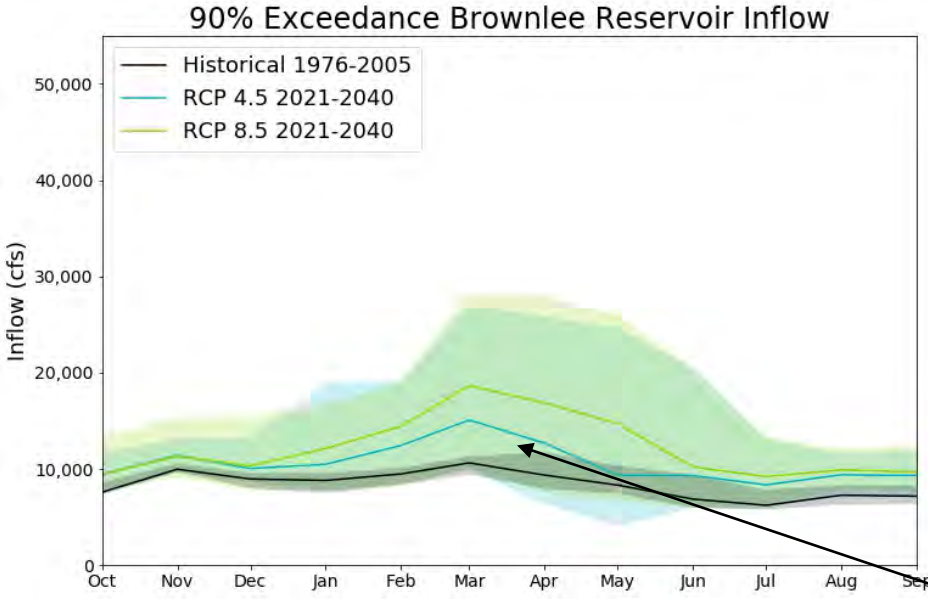
Brownlee Regulated Flow Results

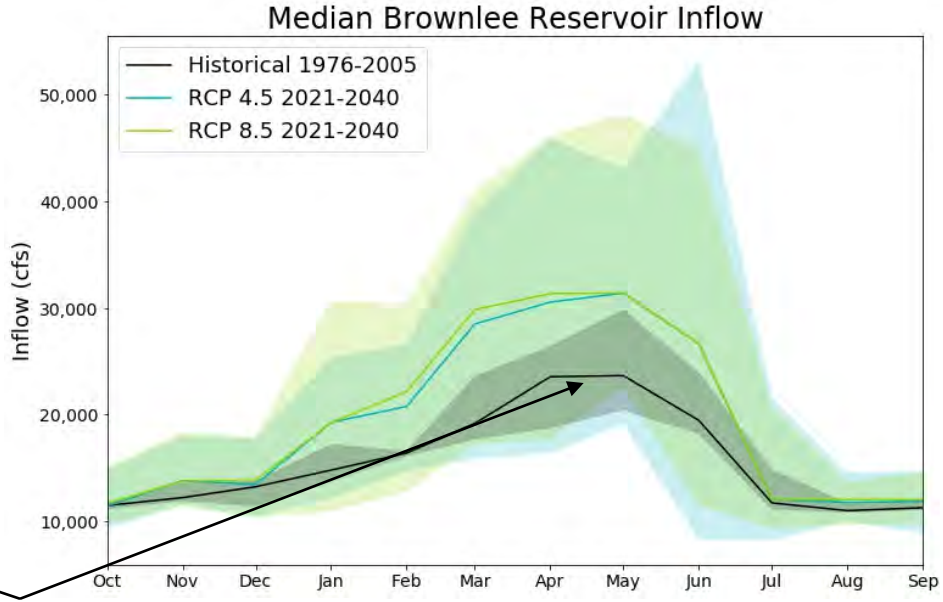




Low baseflow conditions
"floor" higher in future

Brownlee Regulated Flow Results



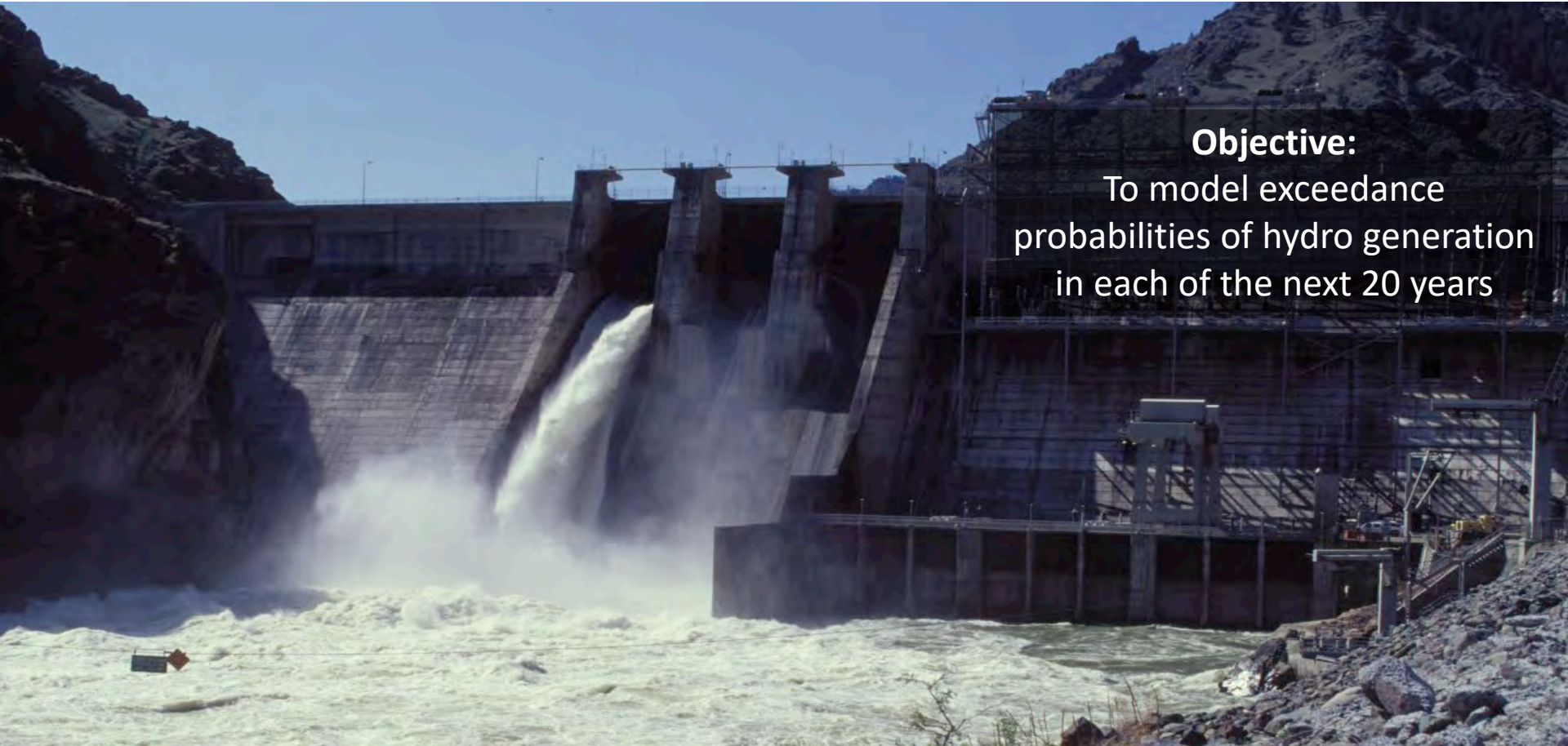


Upstream reservoir regulation significantly alters and dampens the projected natural flow change

Summary

- For IRP modeling, Idaho Power continues to evaluate the projected distribution of water supply in climate change modeling
  - Over the 20-year planning horizon of the IRP, other factors such as managed aquifer recharge and weather modification also influence future water supply distributions.

IRP Hydro Generation Planning

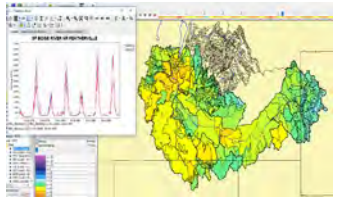


Objective:
To model exceedance probabilities of hydro generation in each of the next 20 years

Modeling Changes From Past IRPs

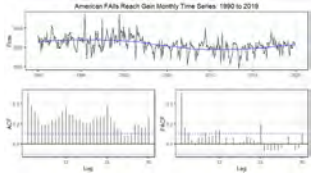
Old Modeling Process

EFS Cloud Seeding SA

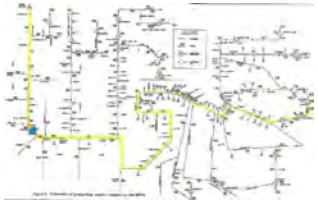


ESPAM 2.1

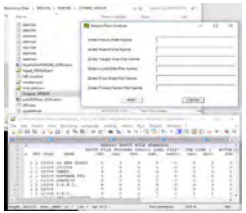
Statistical Trend Modeling



SRPM



PDR580



AURORA

BY ENERGY EXEMPLAR

Modeling Limitations

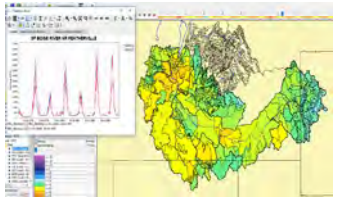
- Both models are “black boxes.” Results are very difficult to interpret.
- Both models were written in old coding languages.
  - No modern support or maintenance
- Extensive manual manipulation is required to process inputs and outputs to the model.
- There’s no automation of modeling.

Modeling Limitations

- Model Specific Limitations
  - SRPM
    - Updated through 2009
      - Reach gains
      - Reservoir operations
      - Demands
    - Monthly model
    - Flood control not dynamic to changing hydrology
  - PDR580
    - Reflects outdated plant capacities
    - Irregular timesteps (monthly and sub-monthly)
    - Reservoir management of Hells Canyon Complex done outside model in a spreadsheet

New Modeling Process

EFS Cloud Seeding SA



ESPAM 2.1

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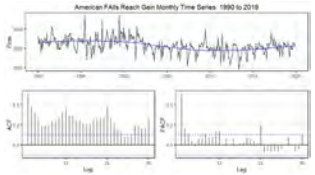
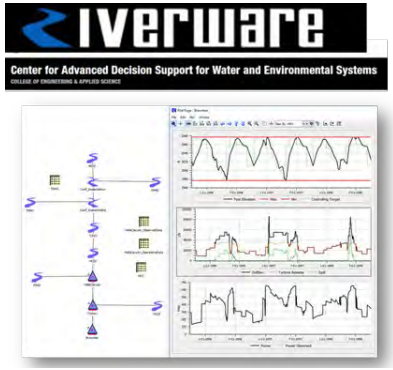
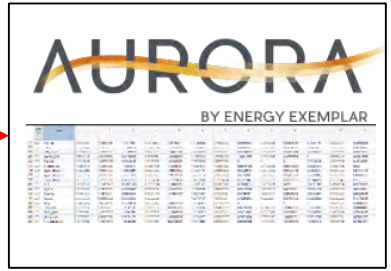




Monthly
Exceedance Plant
Hydro Generation
(aMW)



CADSWES RiverWare

- 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

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

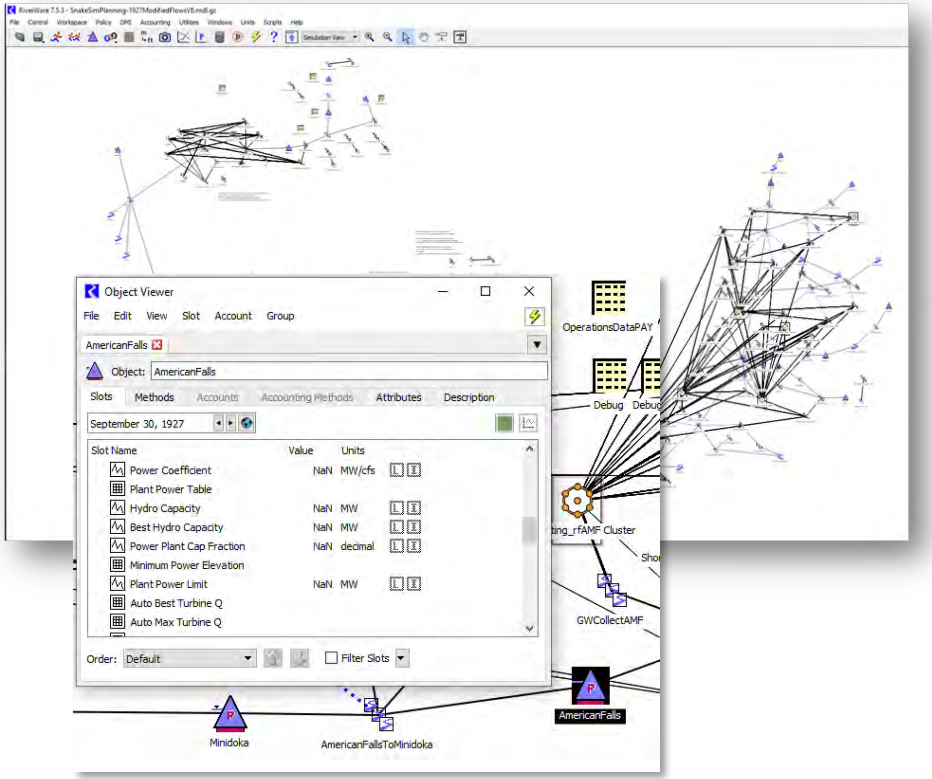
Snake RiverWare Planning Model

- 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
  - Enhancements added to be used for Idaho Power modeling
    - Inclusion of managed recharge
    - Update to reflect more 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 flow augmentation estimates when accounting is not run

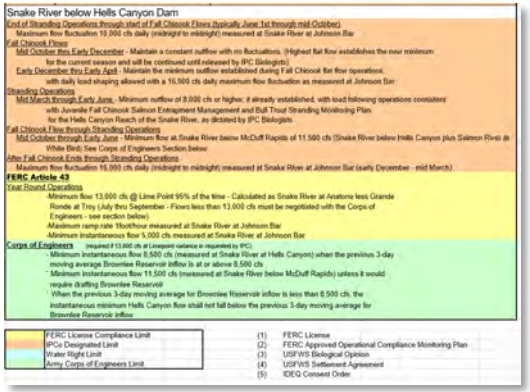
Snake RiverWare Planning Model

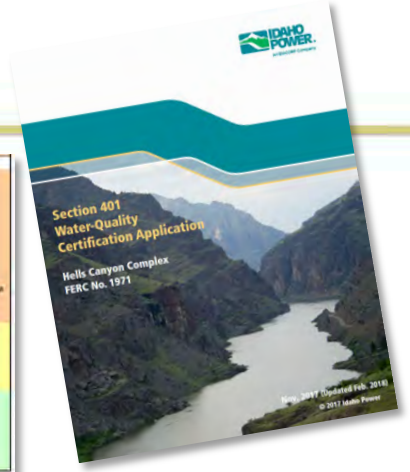
- Daily timestep
- Present conditioned to reflect 2018 conditions
  - Aquifer Response
    - ESPAM 2.1
  - Reservoir management
  - Demand patterns
- Updated reach gains to extend through WY2018
- Total ensemble of reach gains extends from WY1951–WY2018
- Ends at Brownlee inflow



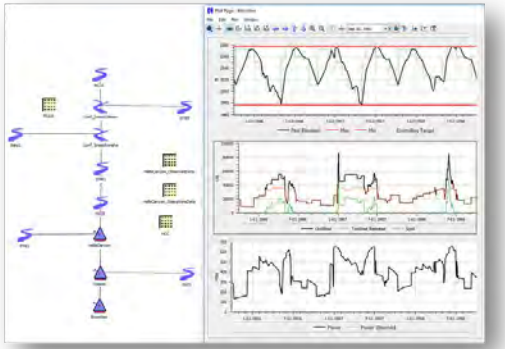
Hells Canyon Complex Planning model

- Contracted with CADSWES to build HCC planning model in RiverWare
- Reflects current level reservoir management practices
  - License requirements
  - Recreational
  - Environmental
  - Flood control
- Dynamic operations based on inflow and year
- Plant-based hydro generation modeling





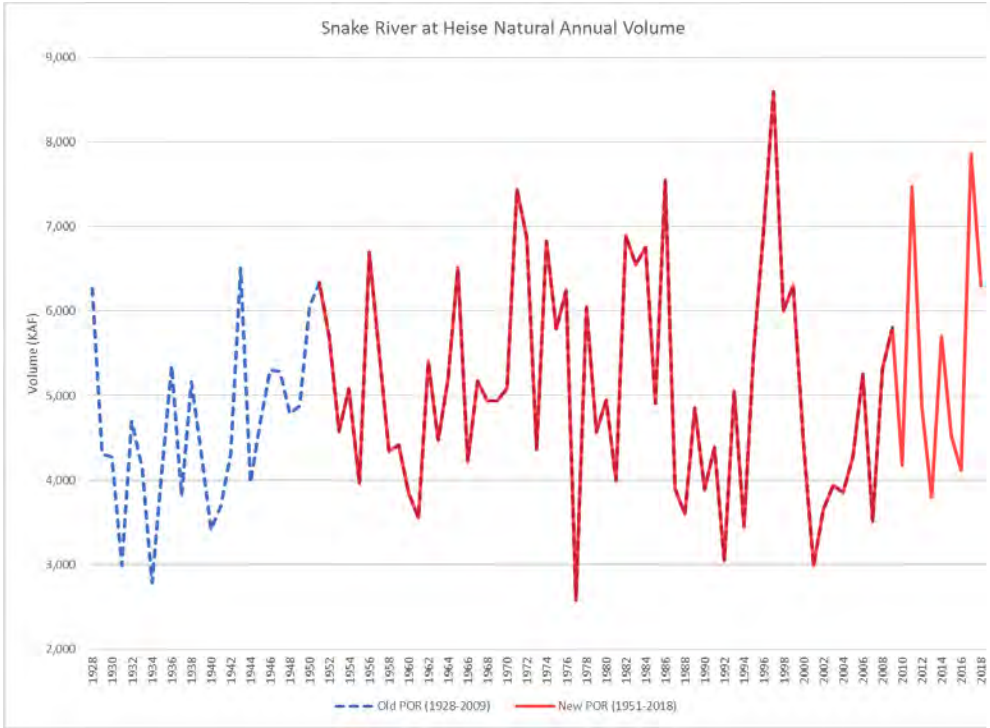
RiverWare
Center for Advanced Decision Support for Water and Environmental Systems

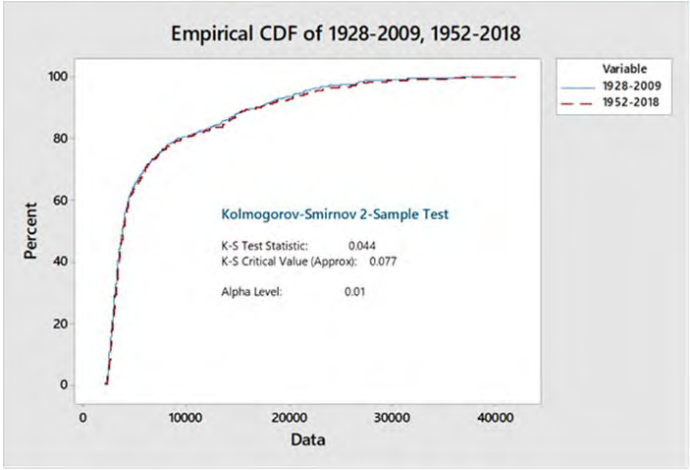


Hydrology Period Of Record (POR)

- Past IRP Modeling
  - Reach gains used records from 1928-2009.
- Reasons for pursuing new POR
  - Data back to 1928 was not complete; extensive development of data was needed.
  - Certain models did not cover entire period.
    - Like-year mapping was performed.
  - Some reservoirs where not constructed which impact hydrologic characteristics.
    - Reservoir evaporation, seepage, etc.
    - These changes were mostly ignored in recreating data for modeling back to 1928.
  - Data quality decreases the further back in time the study goes.

Hydrology POR Study



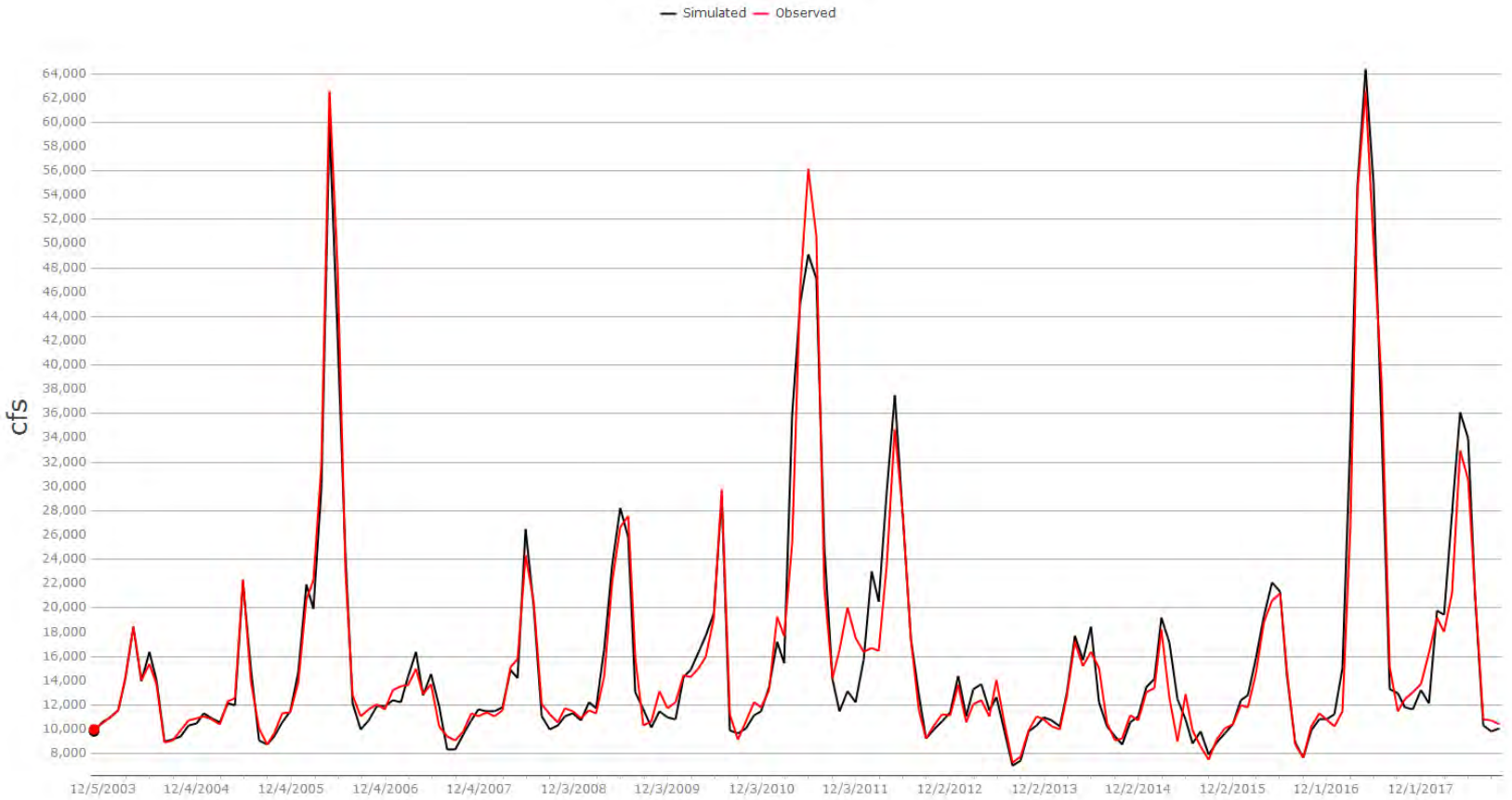


- Evaluated 3 natural flow locations using the Kolmogorov-Smirnov 2-Sample Test
  - Upper Snake, Boise, Payette
- Conclusion: Using an alpha value of 0.01 the results showed that for both annual and monthly that the test statistic was less than the critical value and there is not sufficient evidence that the underlying distributions are different
- IRP Modeling Benefits
  - Easier to understand modeling
  - More transparent
  - Uses better quality and more reliable data
  - Minimal reconstruction of data needed
  - Modeling confidence
  - More recent years includes more recent climate signal

RiverWare Modeling Validation

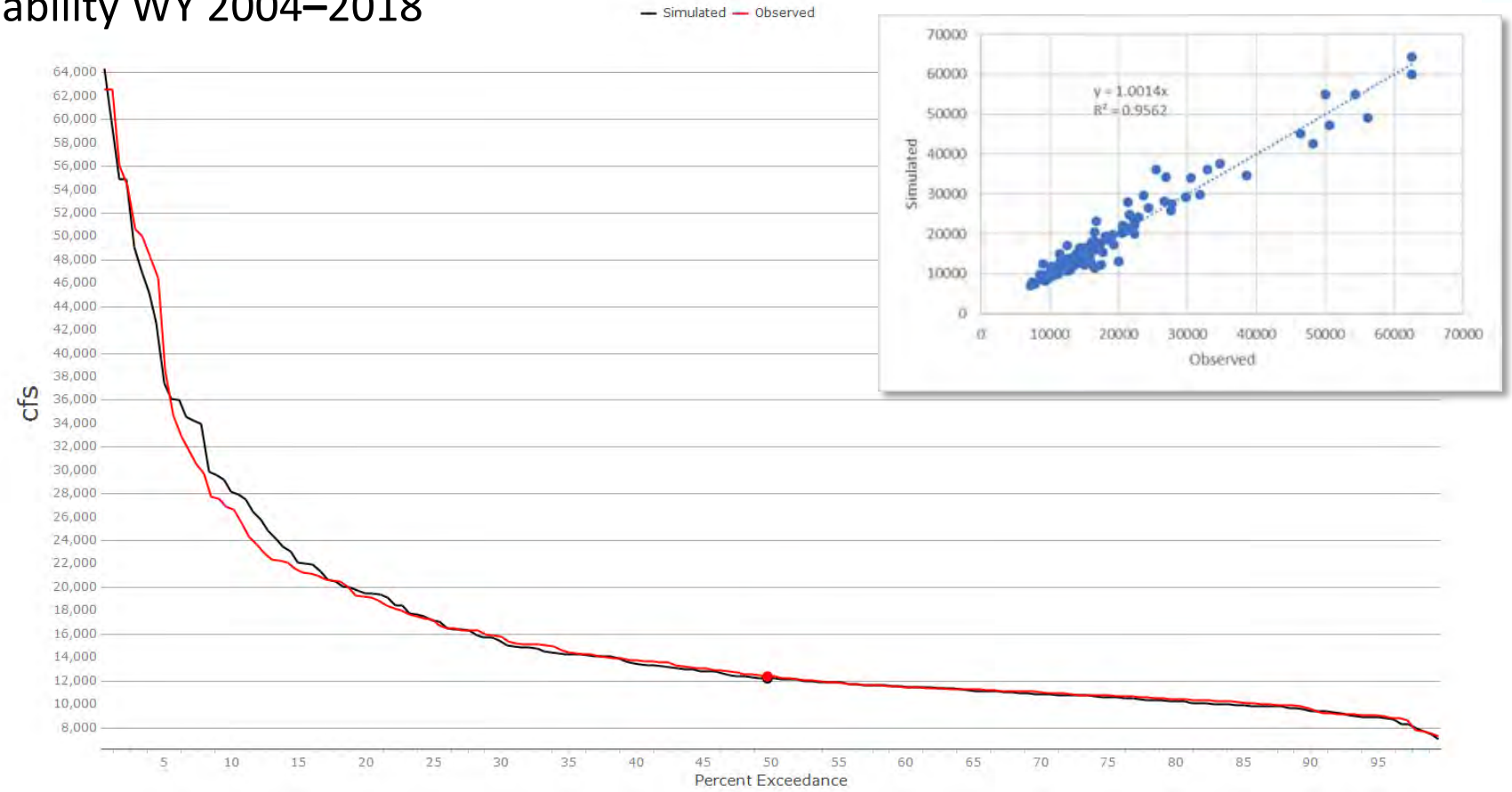
- Looked at model performance from WY 2004–2018
- Model is present-conditioned to current reservoir operations (WY 2018).
- These results are prior to future conditioning the model to expected changes over the IRP planning period.
- Goal: To provide evidence models are performing as expected and provide confidence in the hydro results going into Aurora.

Brownlee Reservoir Inflow



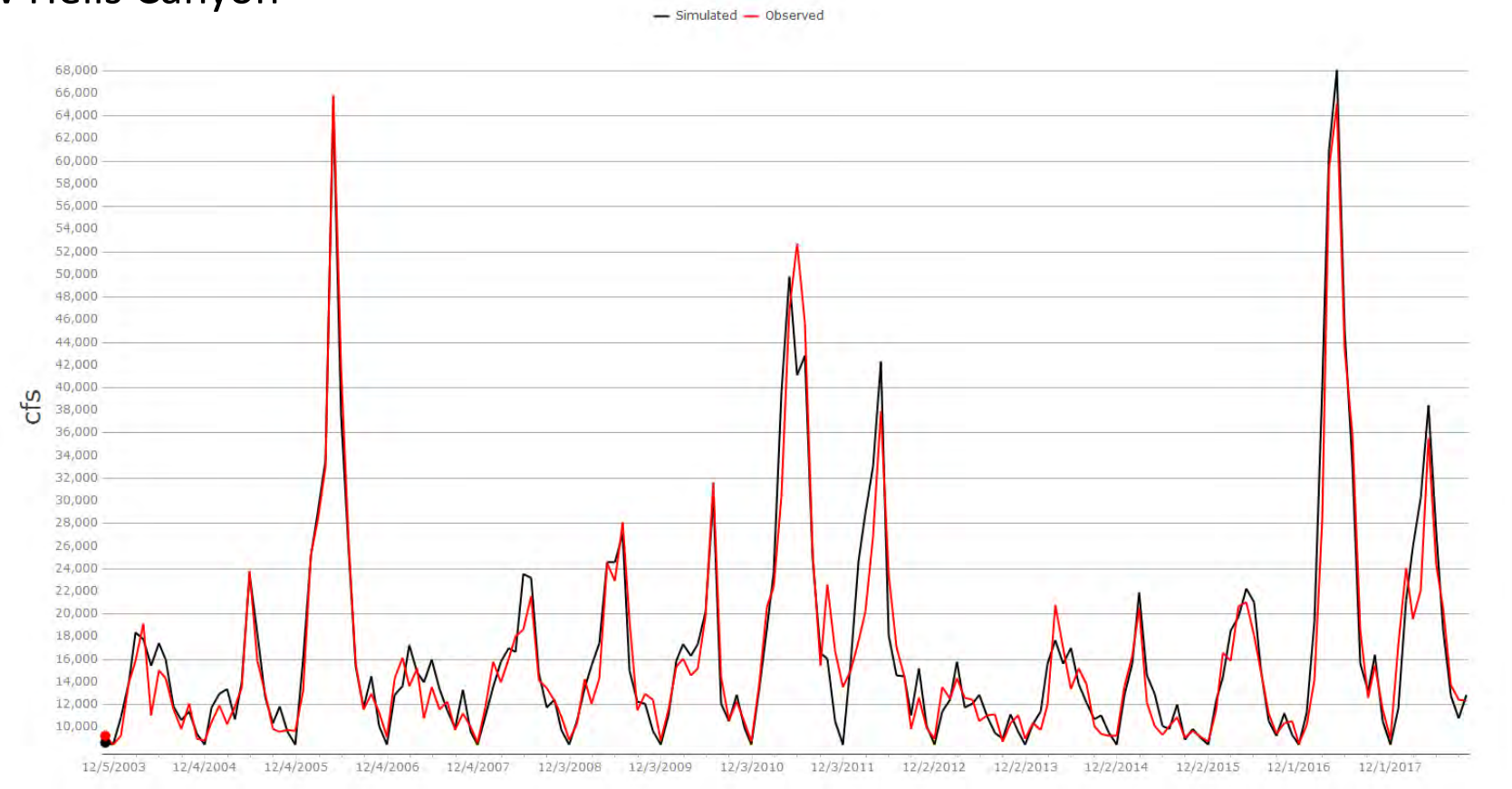
Brownlee Inflow Exceedance

Probability WY 2004–2018

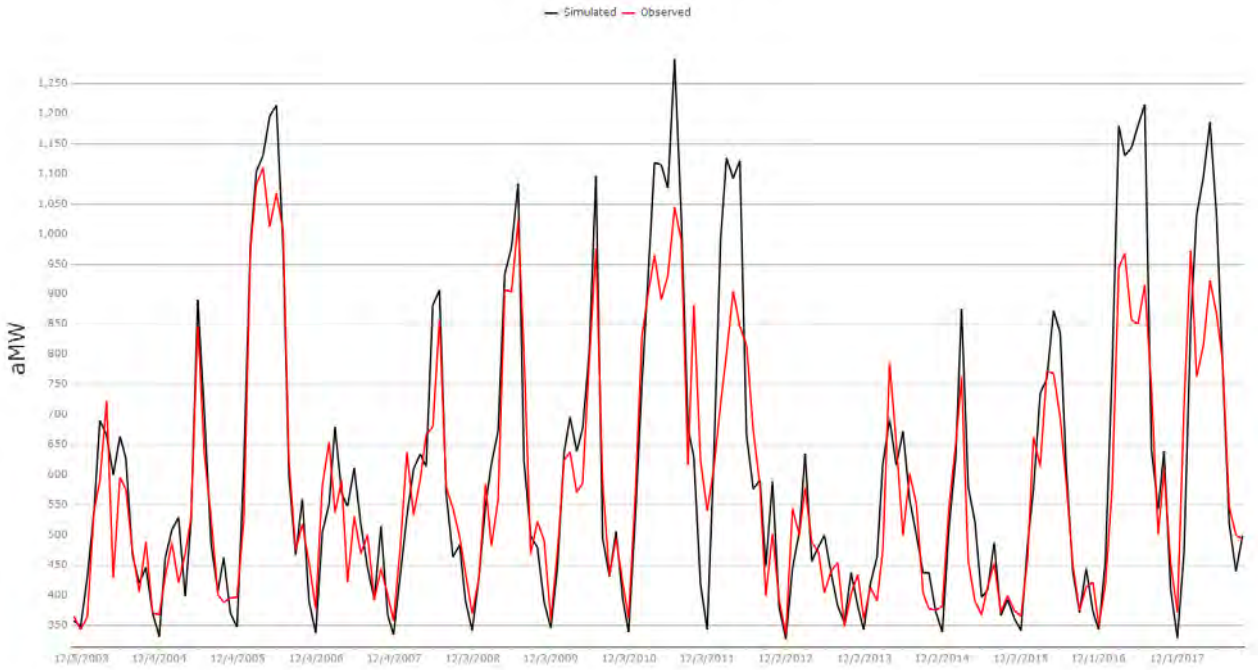


Snake River Outflow

Below Hells Canyon



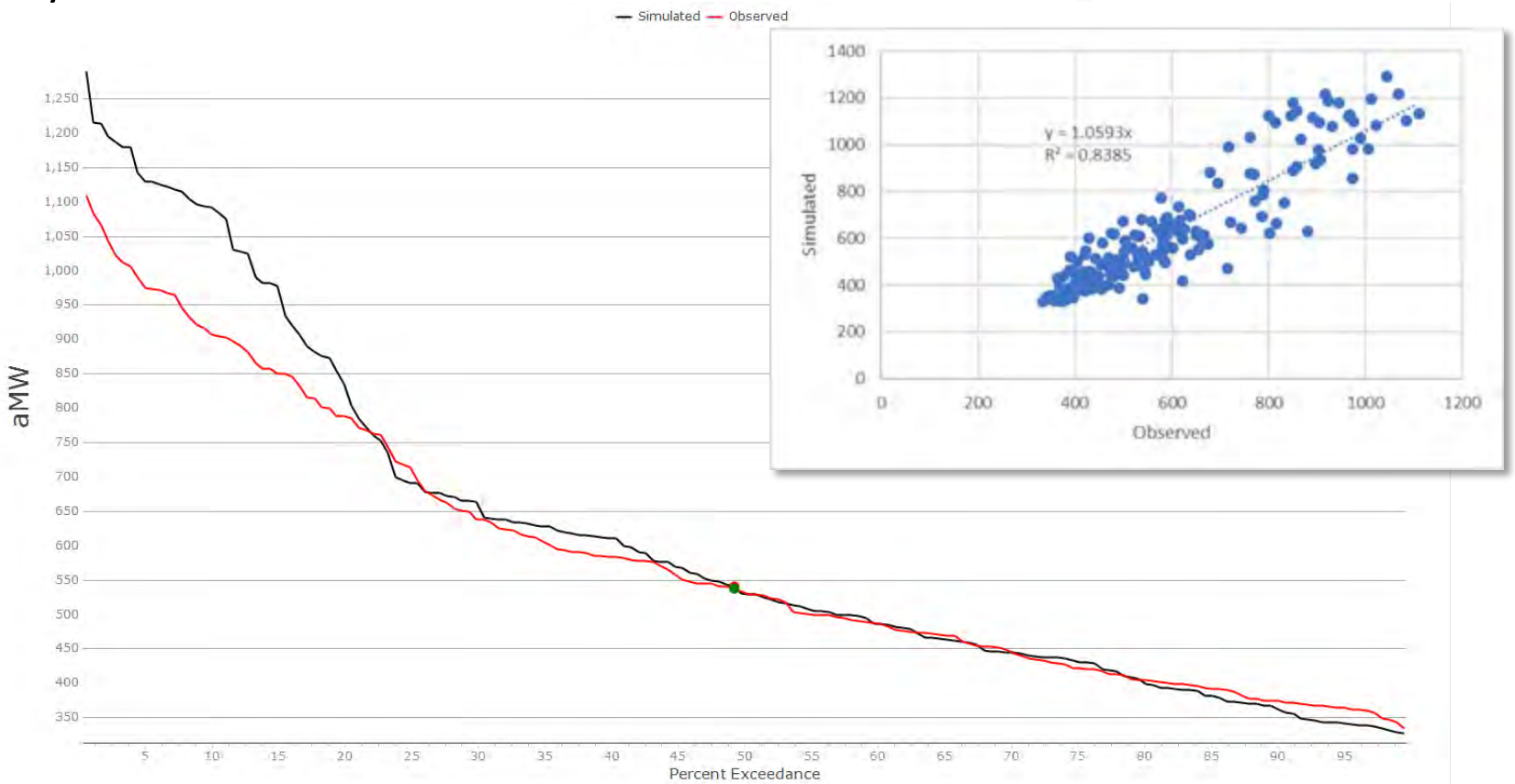
Hells Canyon Complex Generation



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

Hells Canyon Monthly Exceedance

Probability WY 2004–2018

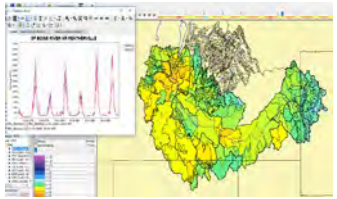


Future Assumptions Influencing Water Supply

- Expected water management activities
  - Managed Recharge
    - IWRB
    - Private
  - Groundwater pumping reductions
  - System conversions (groundwater supply converted to surface water supply)
- Weather modification
- Reach declines
  - Based on trend analysis (1990–2019)

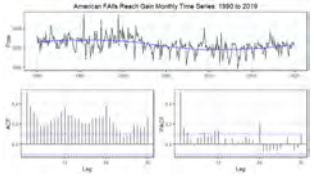
New Modeling Process

EFS Cloud Seeding SA



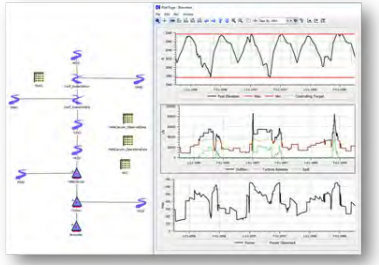
ESPAM 2.1

Statistical Trend Modeling



RiverWare

Center for Advanced Decision Support for Water and Environmental Systems



Monthly Exceedance Plant Hydro Generation (aMW)

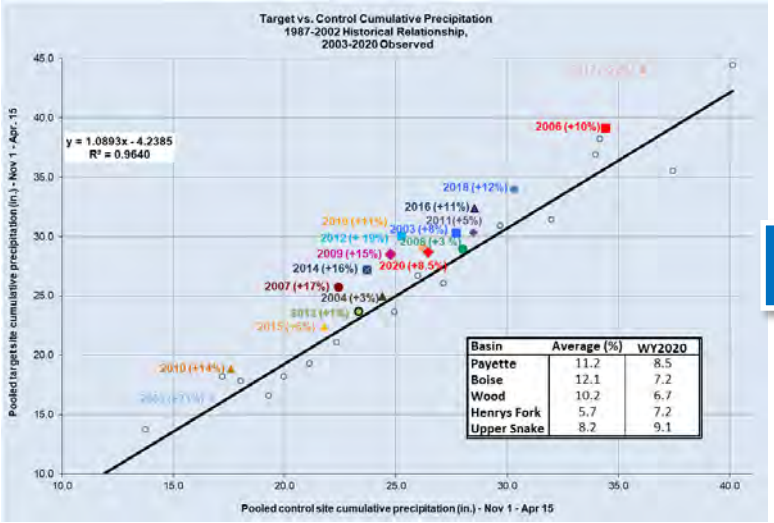
AURORA

BY ENERGY EXEMPLAR

The Snake River and Idaho Power's Hydroelectric System

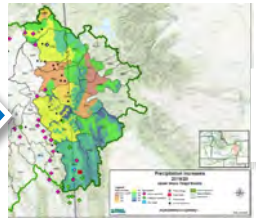
Total Hydroelectric Capacity – 1,798.9 MW

Cloud Seeding Benefit Modeling



Spatial distribution of percent increase to catchment

Basin Percent Increase

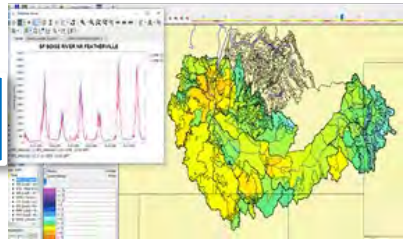


Catchment Percent Increase

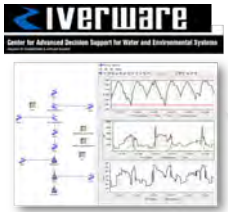
Mean Areal Precipitation development

MAP

EFS Cloud Seeding SA

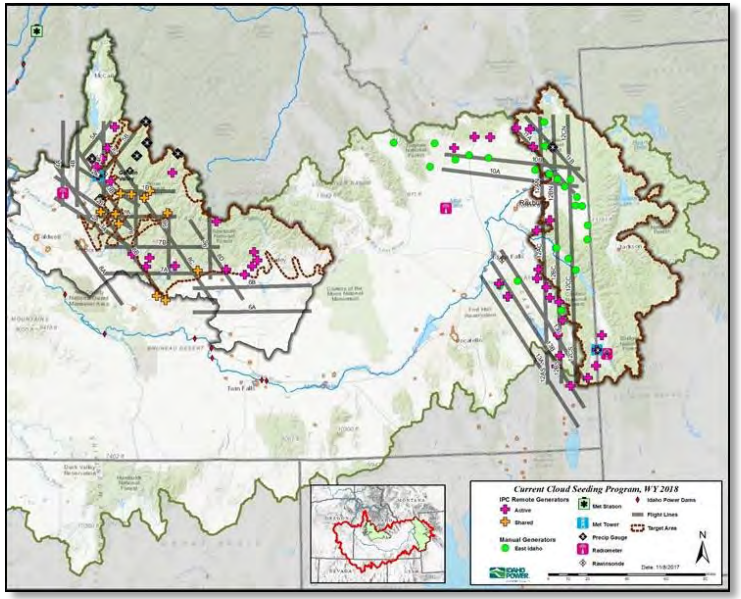


Reach Gains to RiverWare



- EFS is our internal streamflow forecasting system
  - Calibrated lumped parameter hydrologic model of the Snake Basin
  - Inputs to the model include Mean Areal Precipitation and Mean Areal Temperature
  - Have historic data from WY1951-Current
- 2 Scenarios Developed
  - 2021 Cloud Seeding Program
  - 2026 Future Cloud Seeding Build Out

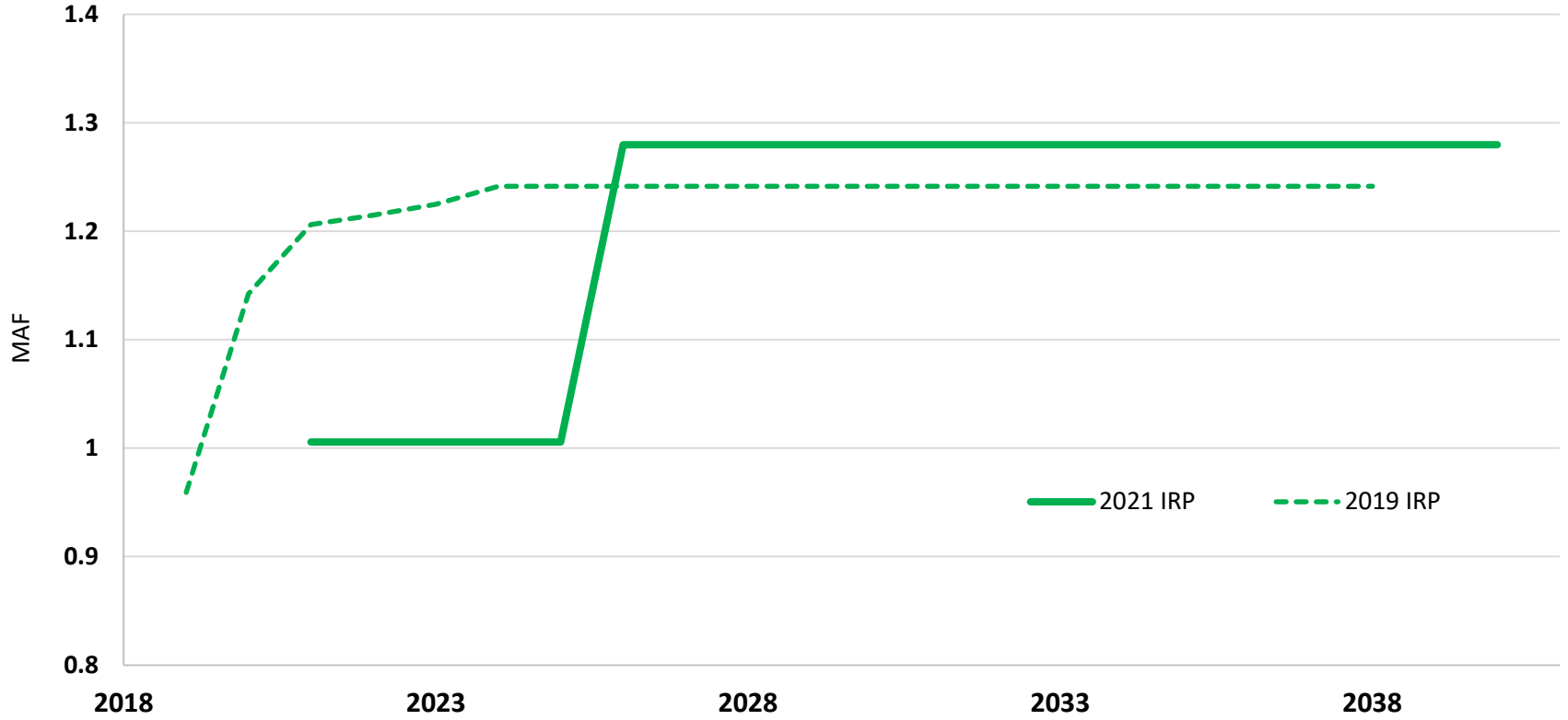
Weather Modification



- 2021 IRP assumptions:
  - Current level of weather modification in Payette
  - Expansion in the Upper Snake and Henrys Fork
  - Development and expansion in Boise and Wood River basins
  - Implement full build-out in WY2026

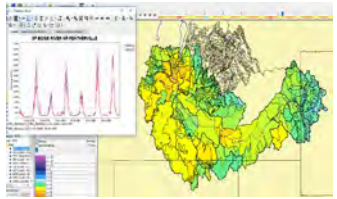
Estimated Natural Flow Benefit Volume (acre-feet)					
Yearof IRP	Boise	Payette	Upper Snake	Wood	Total
2021	264,363	221,489	414,859	104,870	1,005,582
2026	323,176	221,489	602,334	132,757	1,279,757

Weather Modification Reach Gains



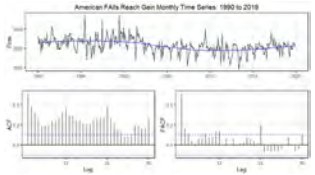
New Modeling Process

EFS Cloud Seeding SA



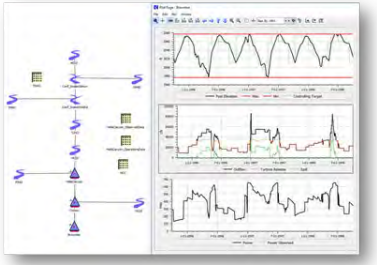
ESPAM 2.1

Statistical Trend Modeling



RiverWare

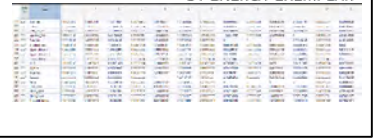
Center for Advanced Decision Support for Water and Environmental Systems



Monthly Exceedance Plant Hydro Generation (aMW)

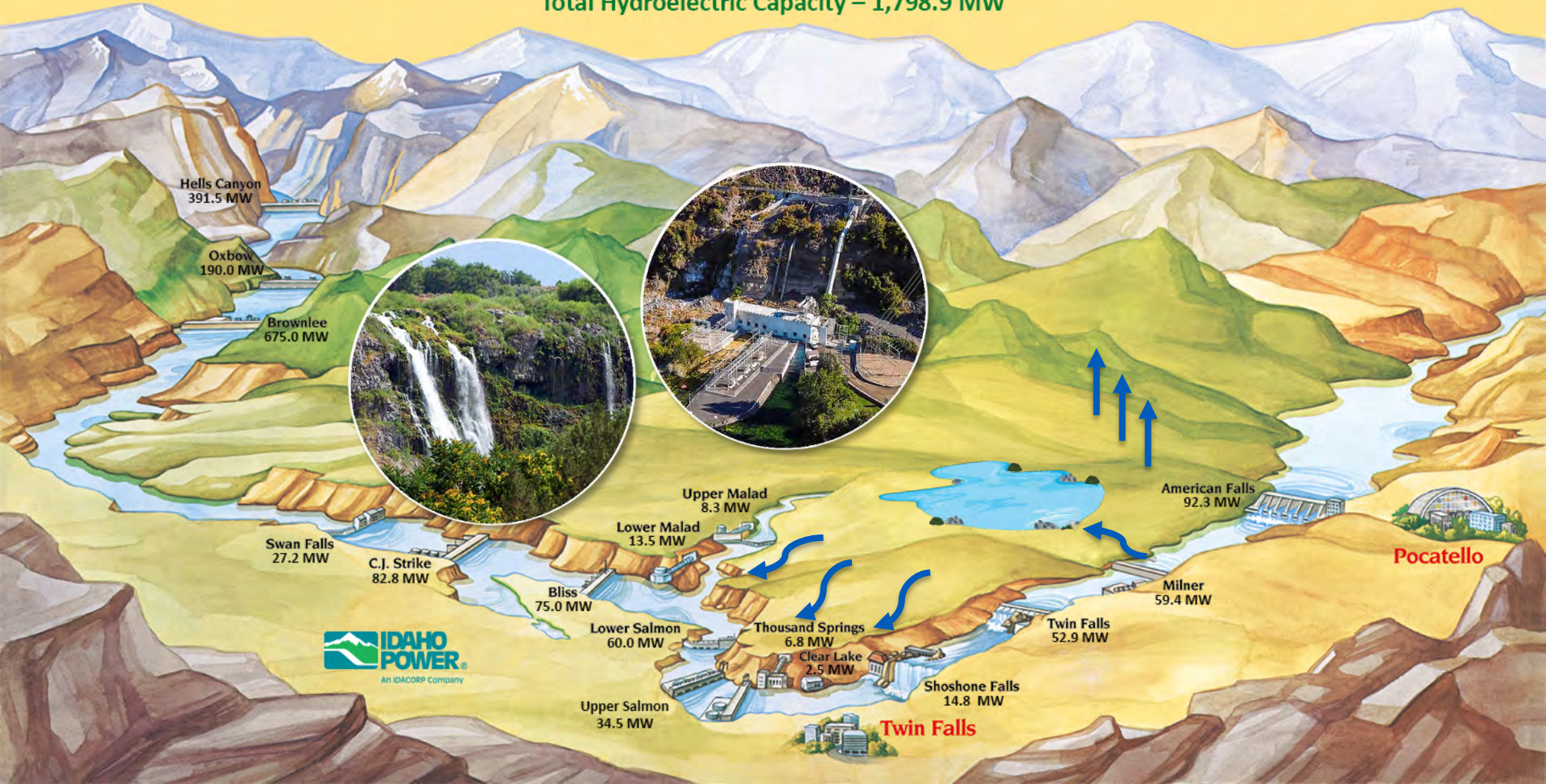
AURORA

BY ENERGY EXEMPLAR



The Snake River and Idaho Power's Hydroelectric System

Total Hydroelectric Capacity – 1,798.9 MW



Modeled Management Activities

NEWS RELEASE - FOR IMMEDIATE RELEASE

Idaho Water Resource Board contact: Brian Patton, Chief, Planning Bureau, 208-287-4800

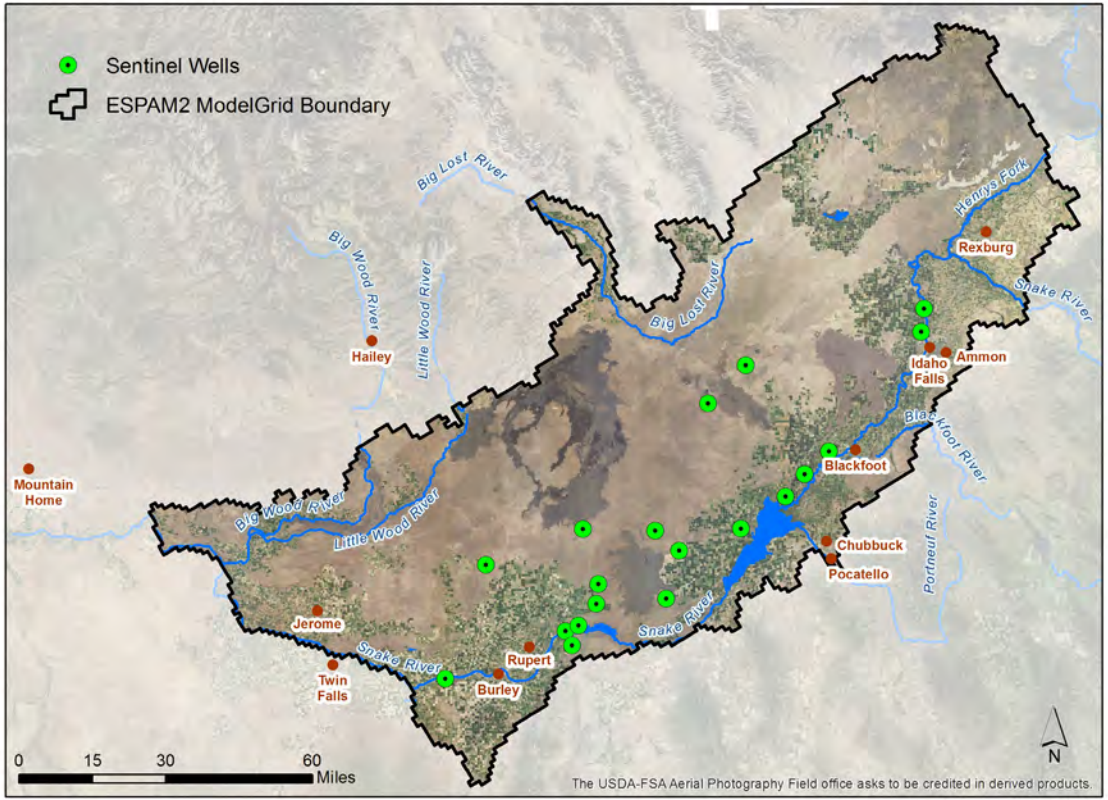
Idaho Water Resource Board recharges about 447,950 acre-feet of water into the Eastern Snake Plain Aquifer in winter 2019-20

BOISE - (May 20, 2020) – The Idaho Water Resource Board recharged approximately 447,950 acre-feet of water into the Eastern Snake Plain Aquifer in the winter of 2019-20, according to a staff report presented on Tuesday.

It was the fourth year in a row that the Board has been able to exceed its goal to recharge an average of 250,000 acre-feet into the ESPA on annual basis. Gary Spackman, Director of the Idaho Department of Water Resources, praised the Board for meeting and exceeding recharge targets.

2016 Settlement Agreement

Sentinel Well Locations: SWC - IGWA Settlement Agreement



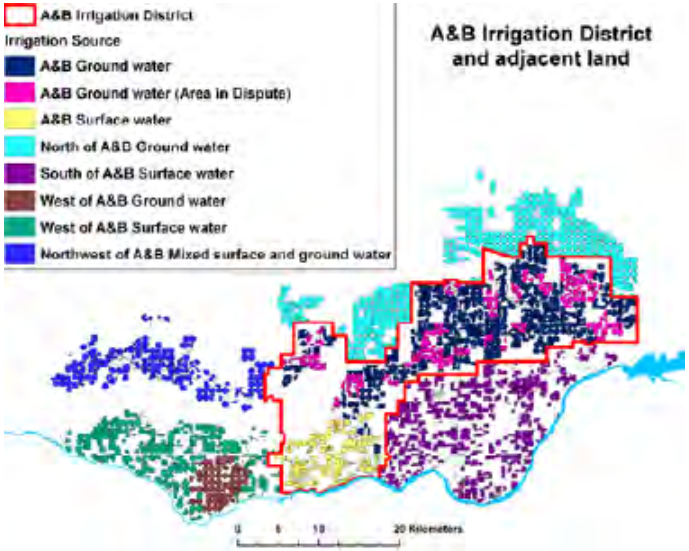
Brian W. Ragan, IDWR 4/20/2017
(2015 Aerial Imagery)

System Conversions

Adopted from the Interim Mitigation Agreement between SWID-SWC

b. **Conversions:** SWID will provide surface water to convert, in total or in part, approximately 30,000 ground water irrigated acres within SWID's boundary. Subject to water availability and delivery capability, SWID will attempt to accomplish not less than the following amounts of surface water conversion (identified by delivery system):

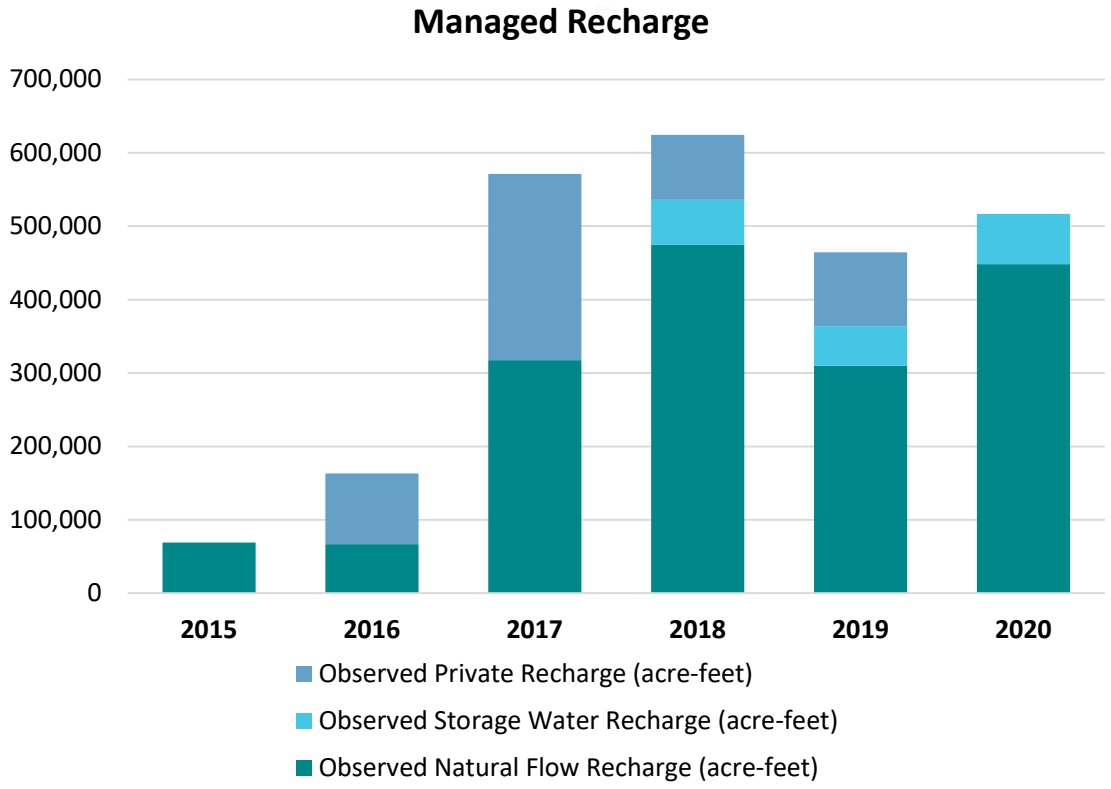
i.	Burley Irrigation District	=	23,100 acre-feet
ii.	Milner Irrigation District	=	12,630 acre-feet
iii.	Twin Falls Canal Company	=	6,500 acre-feet
iv.	West Cassia Pipeline	=	12,120 acre-feet
	Total		54,350 acre-feet



Courtesy of Idaho Department of Water Resources.

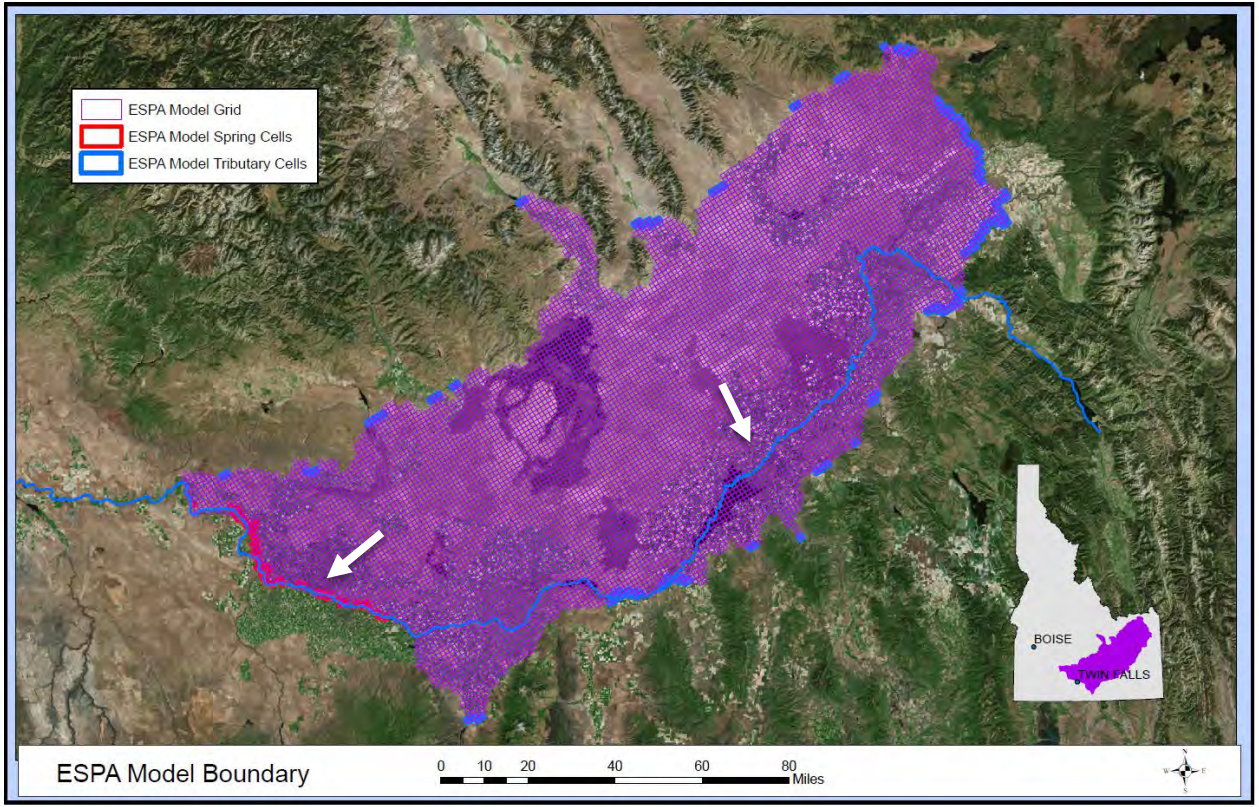
IDAHO GROUND WATER ASSOCIATION

Managed Recharge



*2020 Private Recharge not yet available

Enhanced Snake Plain Aquifer Model (ESPAM)



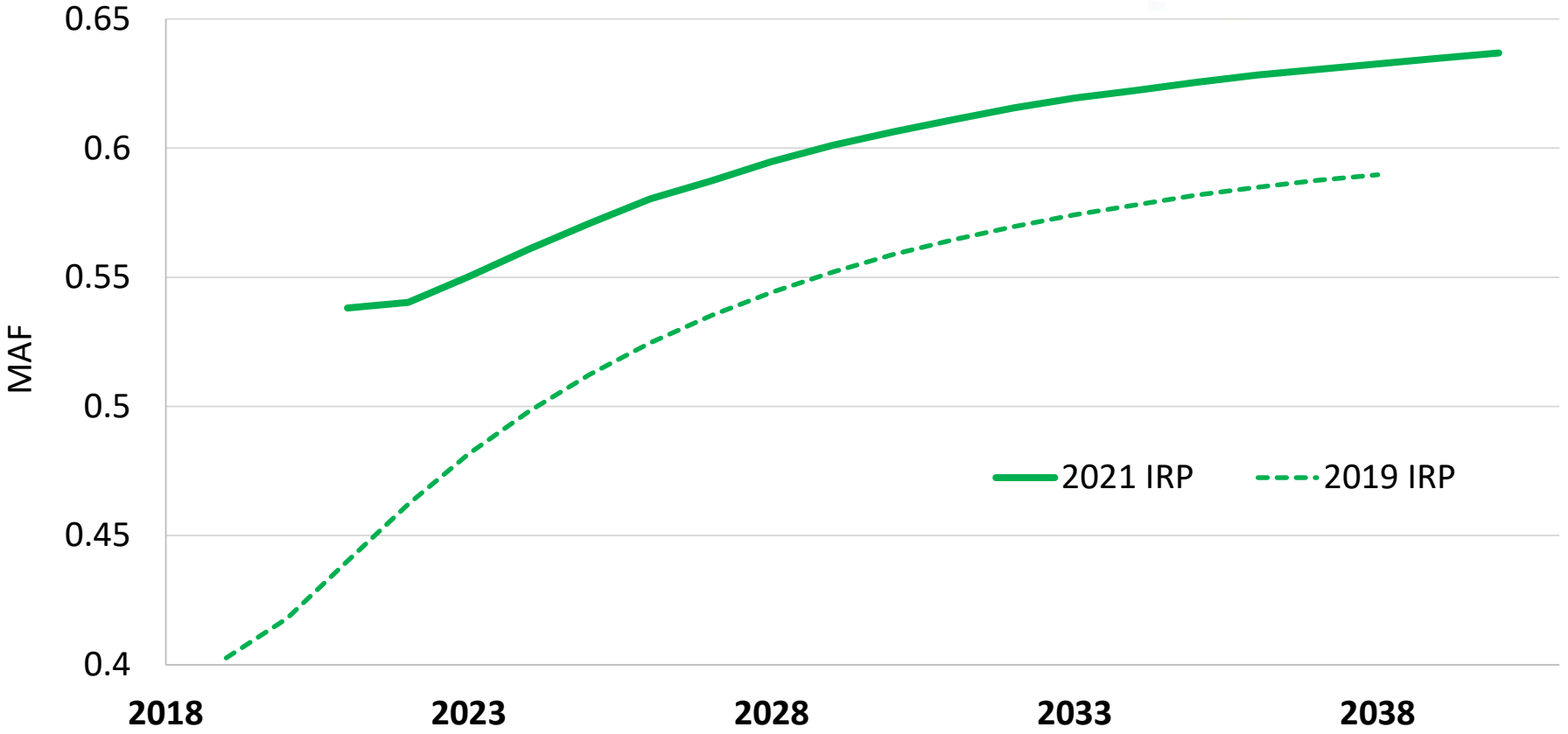
Modeling Sequence

- Add expected reach gains to year 2021 of the IRP
  - Cloud seeding
  - Trend declines
  - 2015–2020 observed management practices run through ESPAM
    - SWC agreement implementation
    - System conversions
    - Recharge
      - Idaho Water Resource Board
      - Private

Modeling Sequence

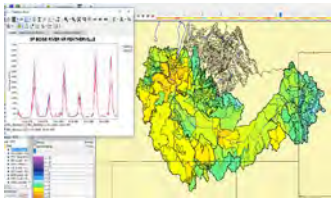
- Run model and refine recharge capacity assumptions to achieve as close as possible to desired assumptions
  - 405 KAF/yr total recharge
    - 250 KAF/yr IWRB natural recharge
    - 55 KAF/yr IWRB storage water recharge
    - 100 KAF/yr private recharge
- Determine the distribution of monthly recharge volumes by upper valley and lower valley canals assuming static distribution from 2021–2040
- Rerun ESPAM with new recharge assumptions from 2015–2040

Water Management Reach Gains



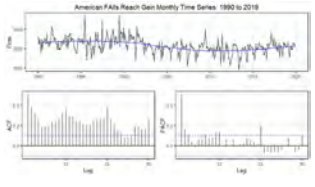
New Modeling Process

EFS Cloud Seeding SA



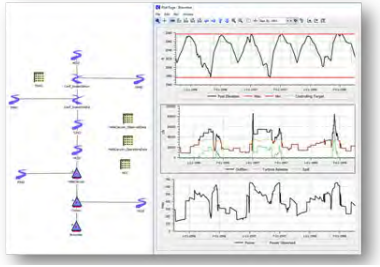
ESPAM 2.1

Statistical Trend Modeling



RiverWare

Center for Advanced Decision Support for Water and Environmental Systems



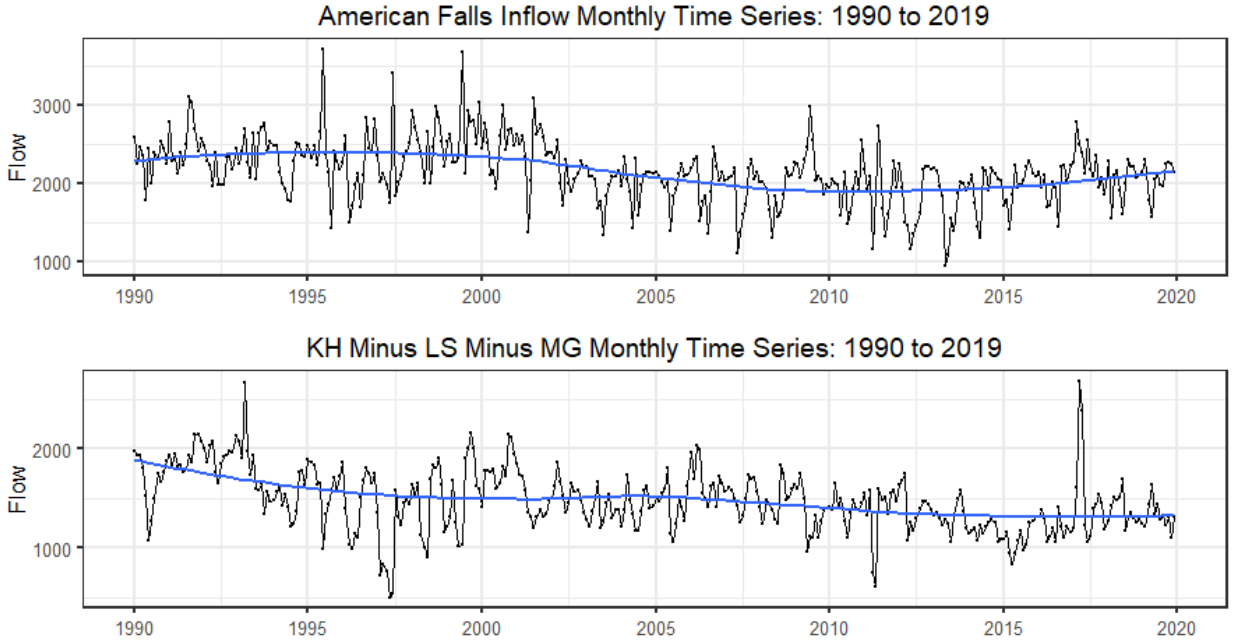
Monthly Exceedance Plant Hydro Generation (aMW)

AURORA

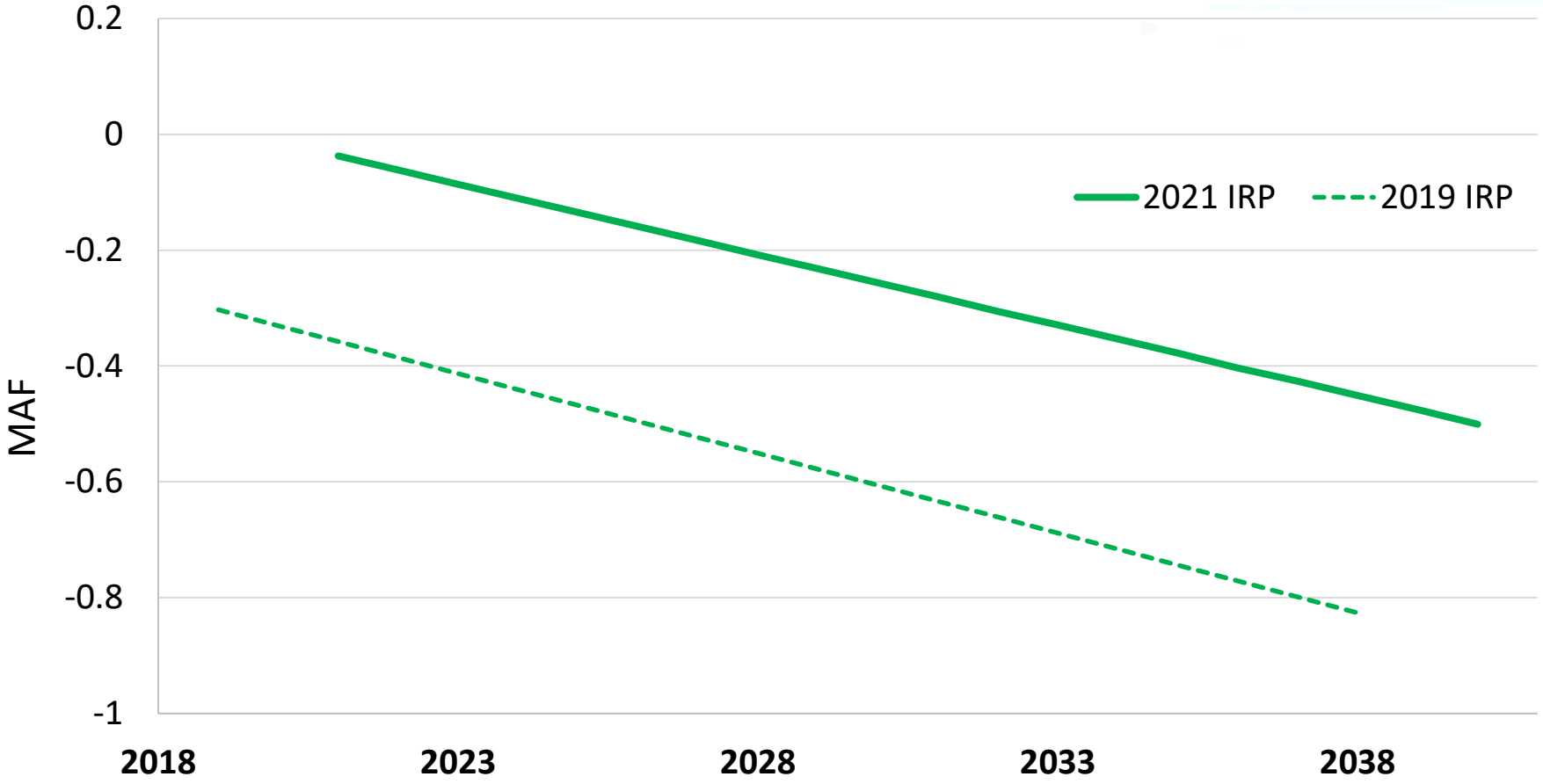
BY ENERGY EXEMPLAR

Trend Analysis

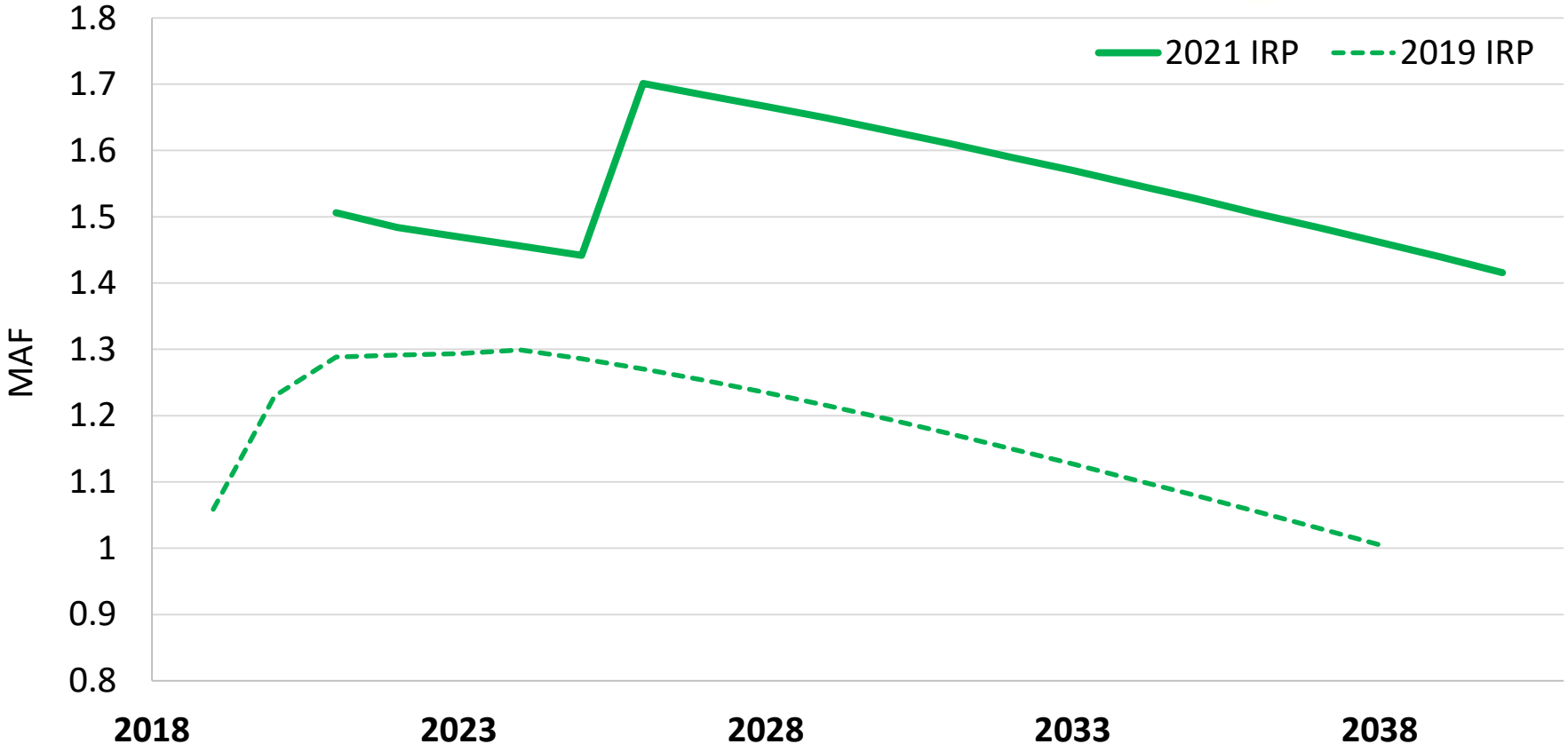
Reach Gain Location	Trend (cfs/year)	P-Value Less than 0.01	TFPW RESULTS
Blackfoot to Neely	-15.9	TRUE	(-) TREND
Lower Salmon Falls To Bliss	-17.6	TRUE	(-) TREND



Trend Analysis Reach Gains

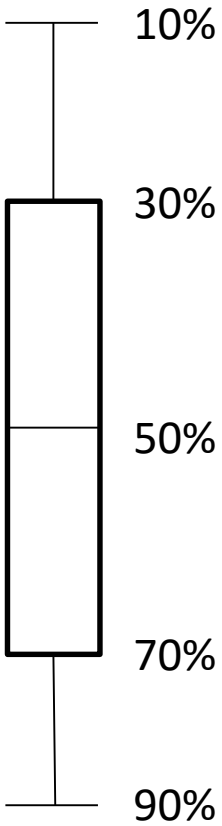


Total Reach Gain Adjustments

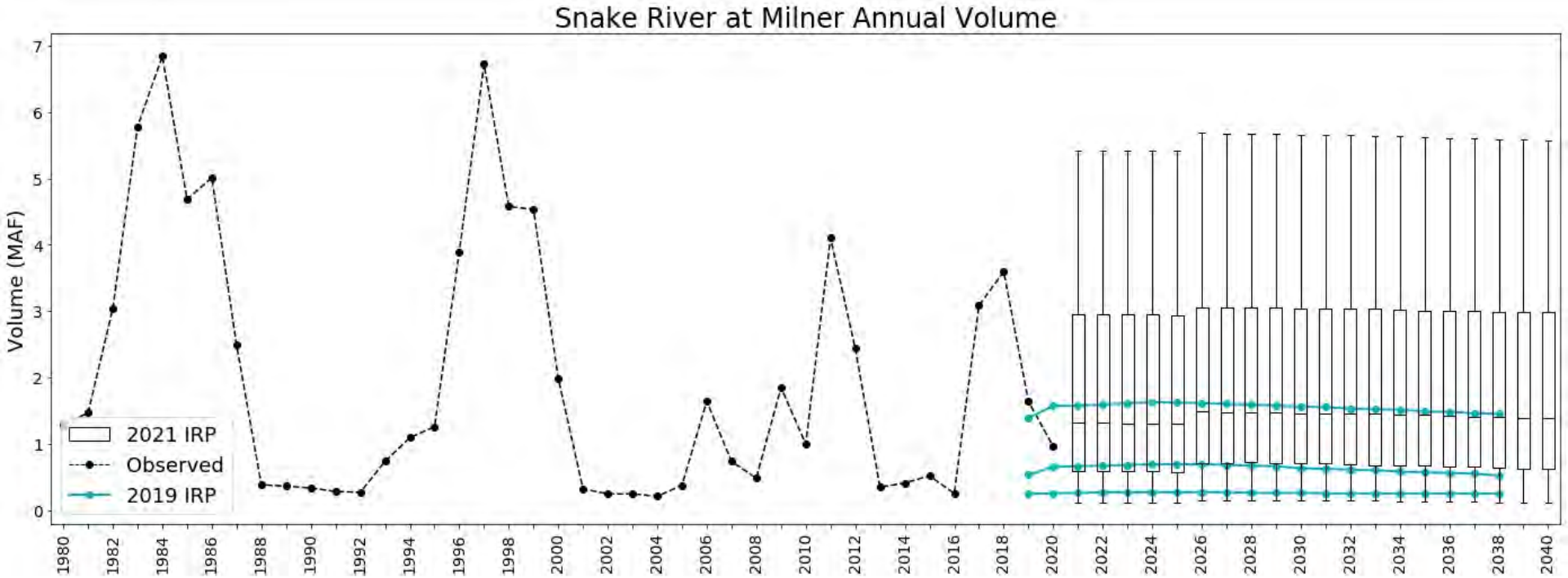


Planning Flow Results

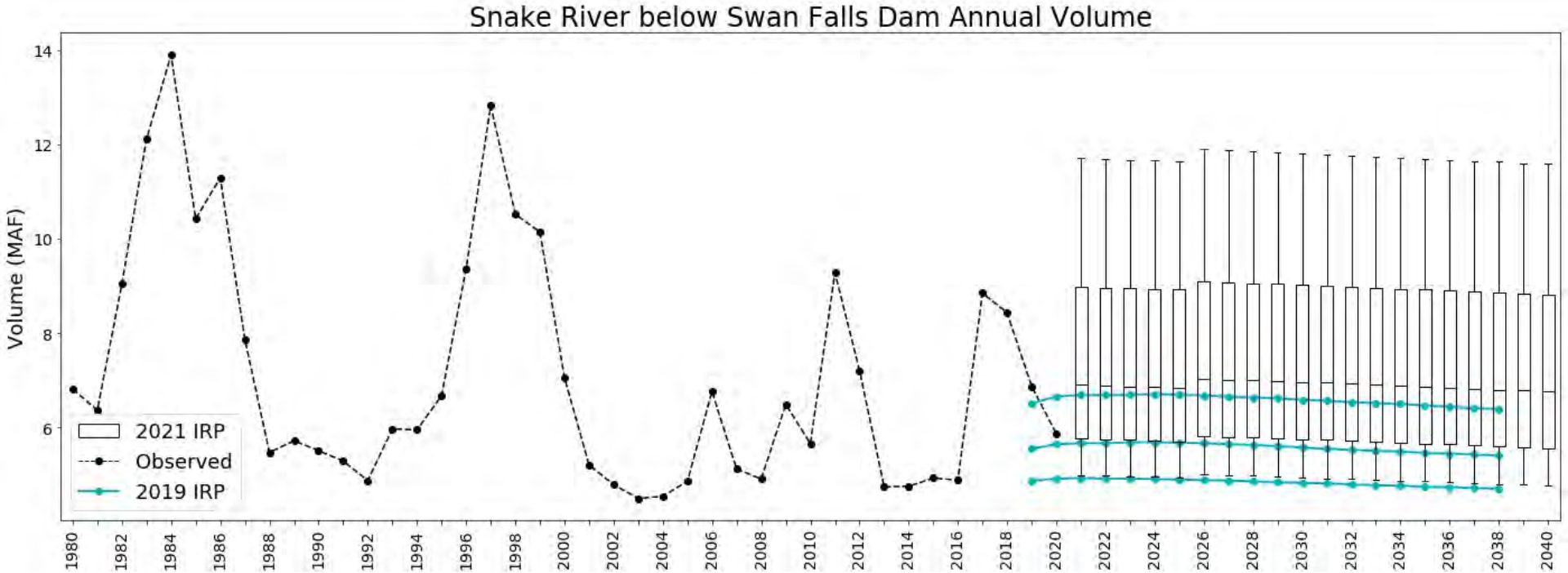
Exceedance Plot Interpretation



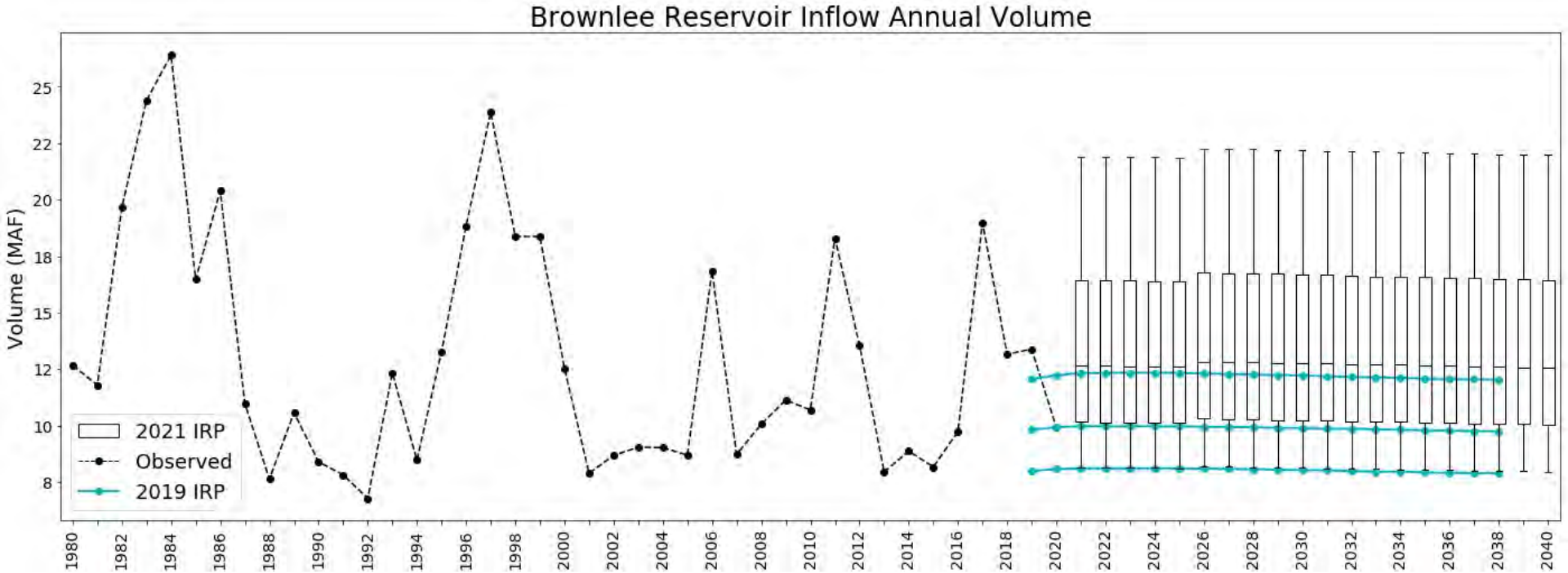
Milner Results



Swan Falls Results

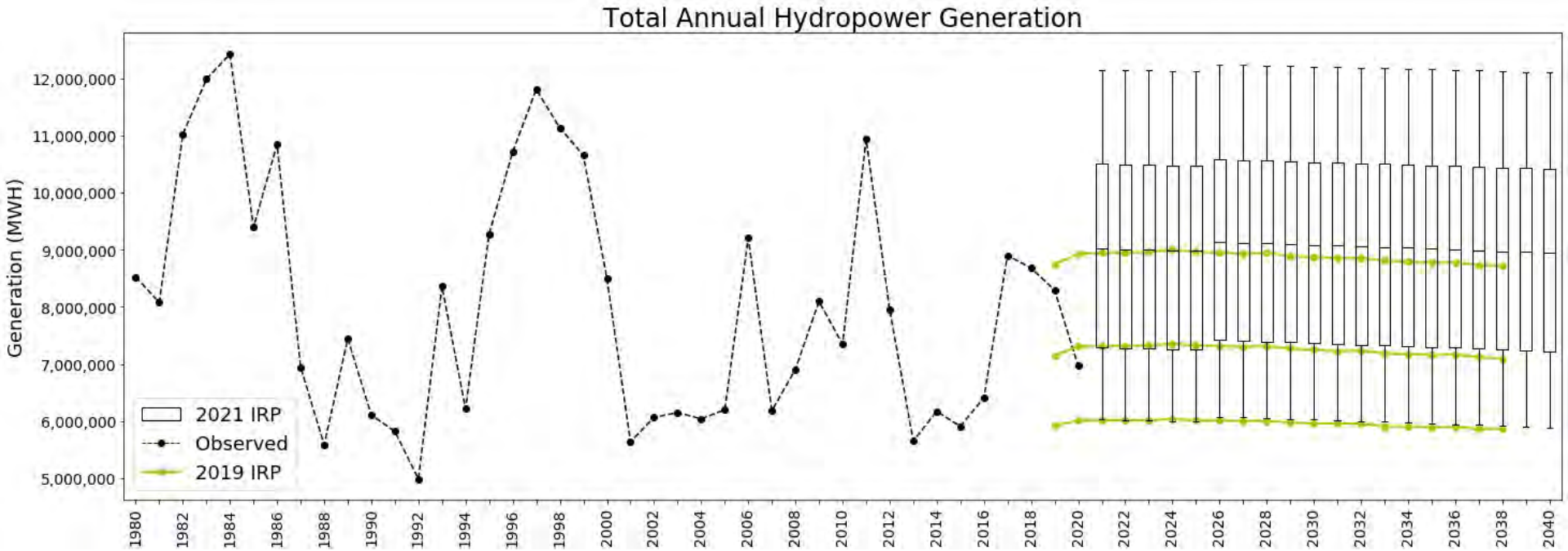


Brownlee Results

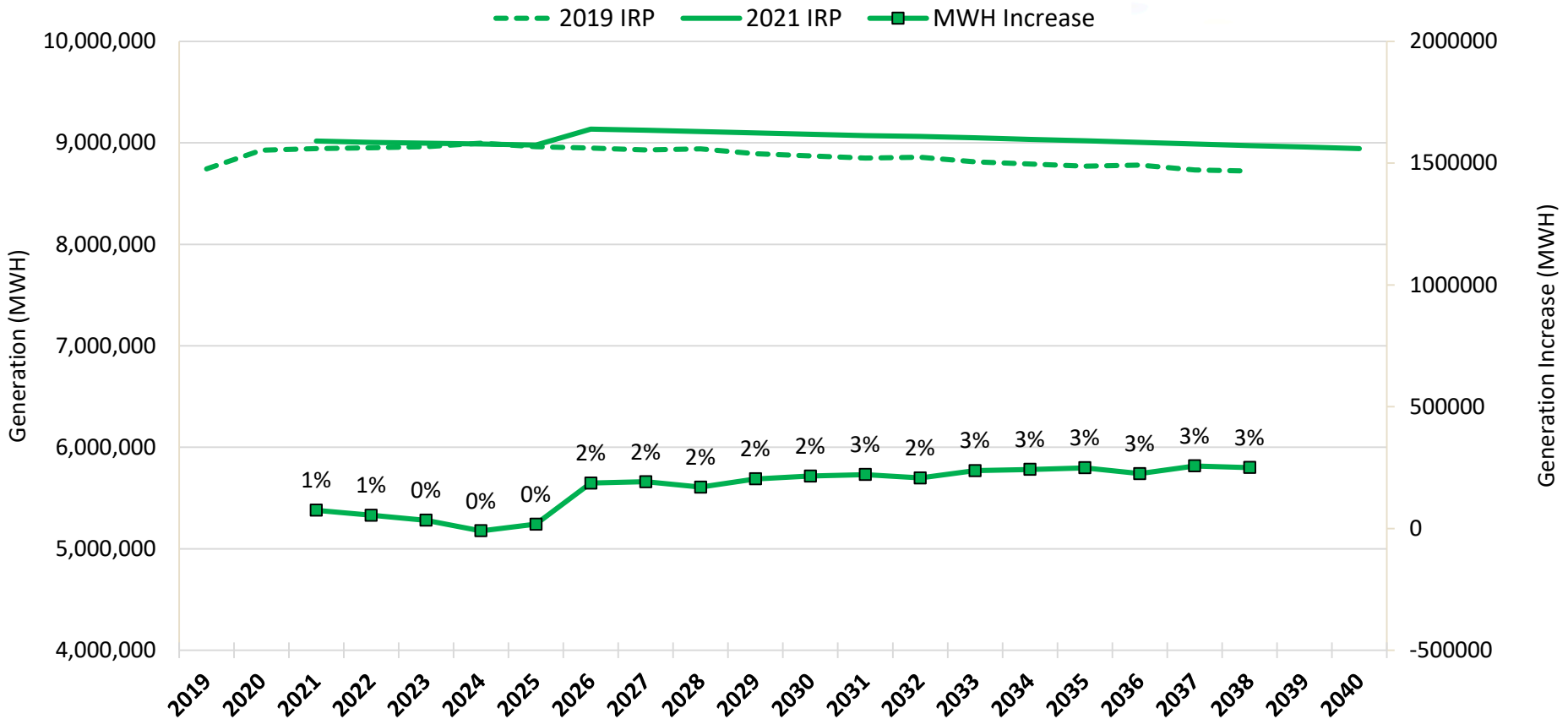


Planning Generation Results

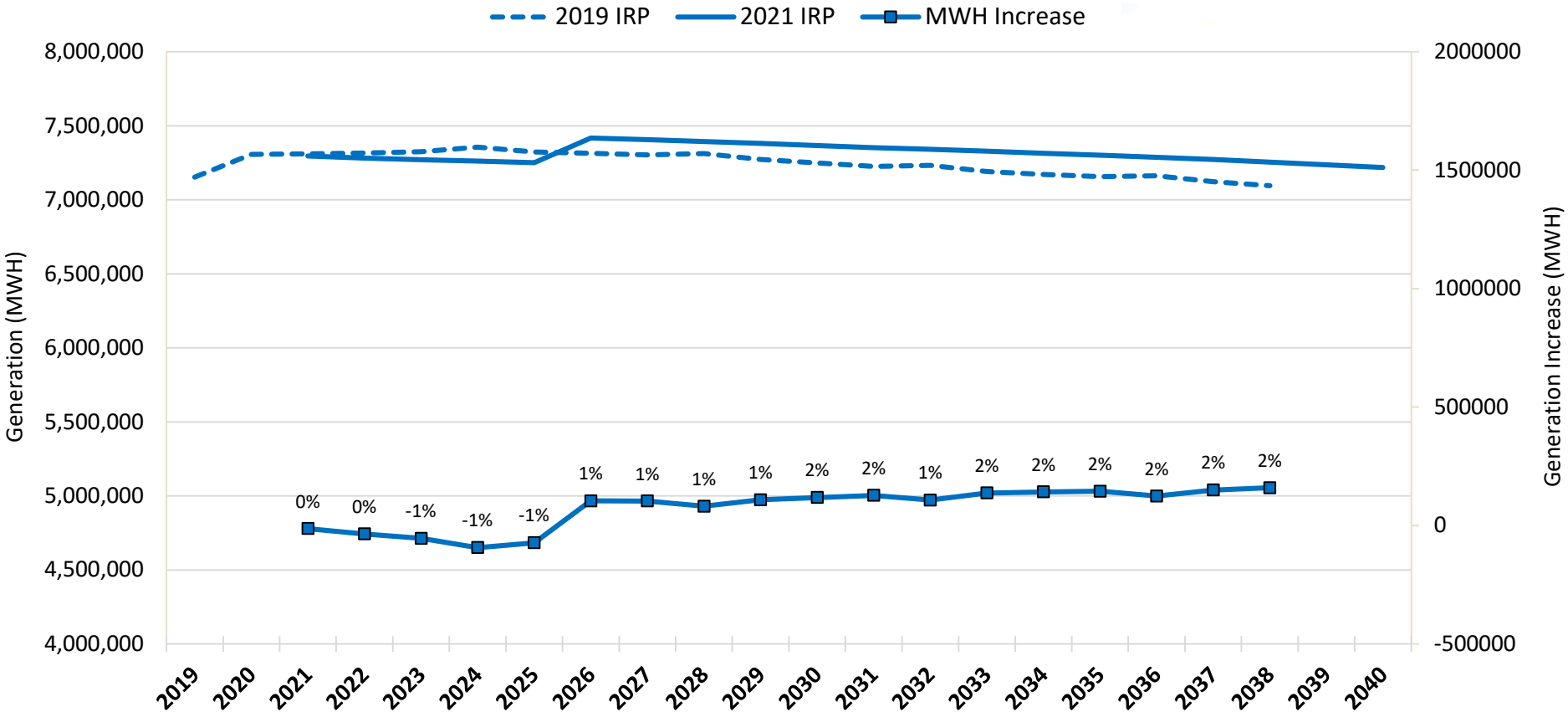
Annual Generation Results



50% Exceedance Generation



70% Exceedance Generation



90% Exceedance Generation