Basin-Scale Hydropower and Environmental Opportunity Assessments

A framework for identifying and evaluating hydropower and environmental opportunities and linkages

Simon Geerlofs, Jerry Tagestad, Kyle Larson,
Kenneth Ham, Sara Niehus, Marshall Richmond

Pacific Northwest National Laboratory

Deschutes Basin Stakeholder Webinar

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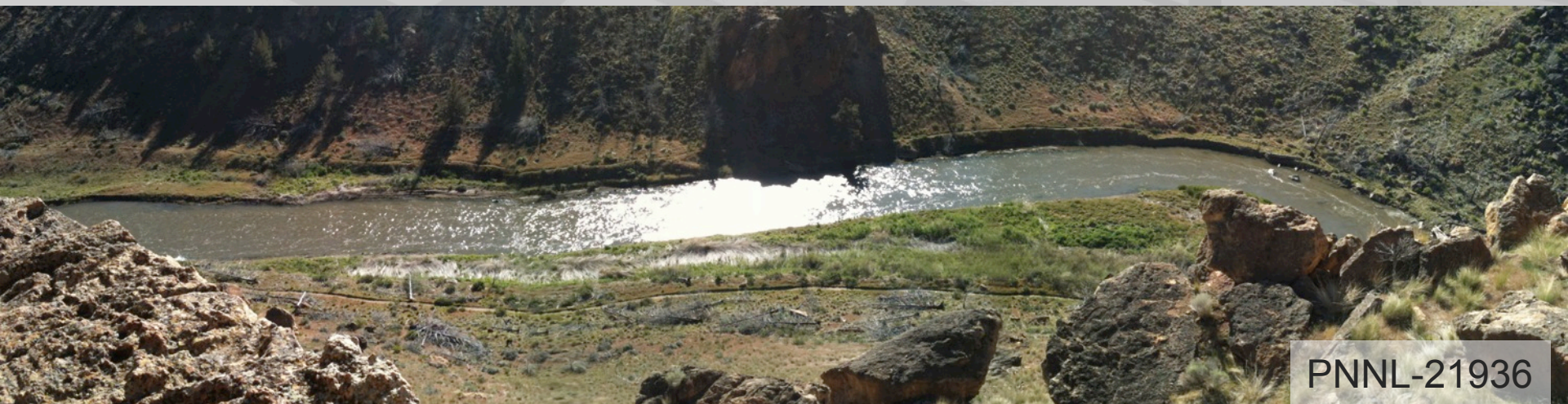

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Acknowledgements

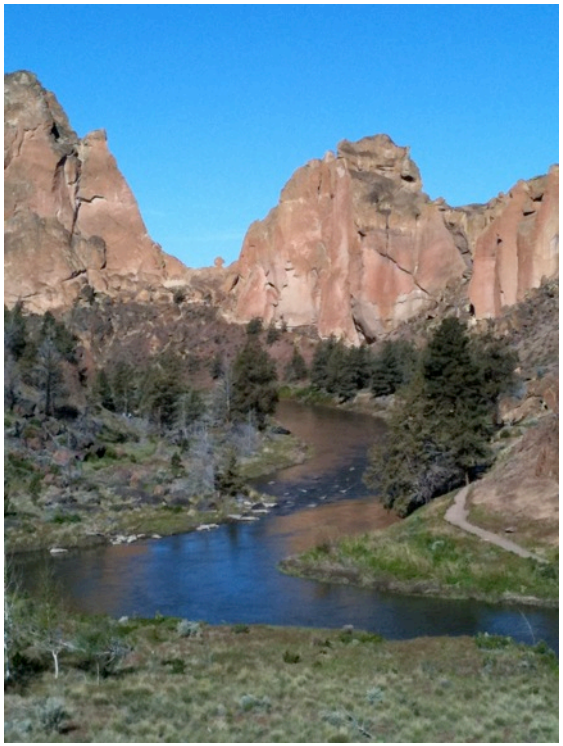
We'd like to acknowledge support for this project from the Department of Energy, Wind and Water Power Technology Office, as well as our partnership with the US Army Corps of Engineers and the Bureau of Reclamation, through the Sustainable Hydropower MOU.

The help and support from Deschutes Basin stakeholders and our national steering committee.

And the contributions of our technical team at PNNL and ORNL

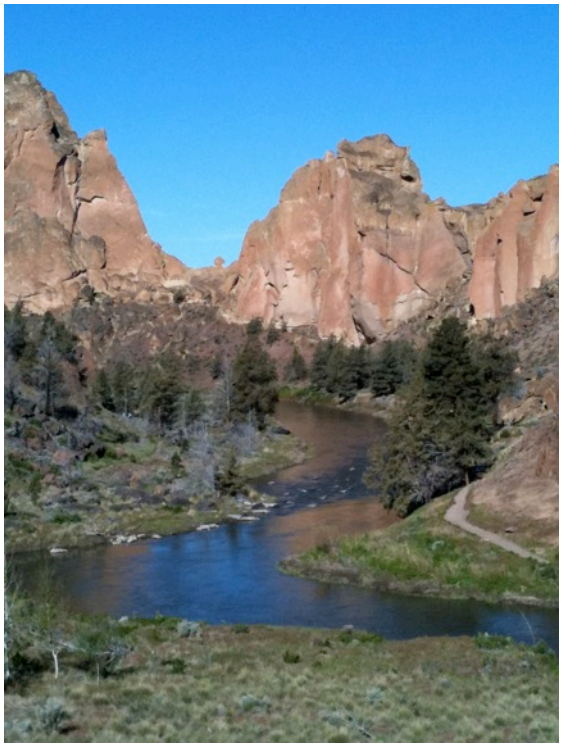
Introduction

- Webinar Goals
- Basin Scale Opportunity Assessment Overview
- Deschutes Pilot Assessment Process



Webinar Goals

- Webinar housekeeping—
  - Phone/computer on mute
  - type questions in to chat box
  - Webinar will be recorded
  - presentations available
  - If you're having trouble with computer audio, dial in:
    - 866-528-1882 code: 8189027
- Context (Simon Geerlofs)
- RiverWare Model—a flexible planning tool (Sara Niehus)
- Interpretation of modeling results (Kenneth Ham)
- Facilitated discussion



1. Basin Scale Opportunity Assessment Overview

- Can we increase hydropower ***and*** improve environmental conditions within a given river basin?

Hydropower MOU

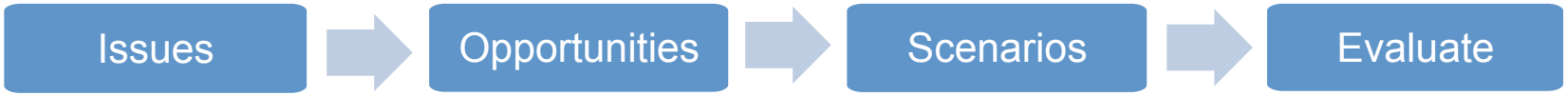
MOU for Hydropower among DOE, DOI and DOA

- Signed in March 2010, MOU highlights 7 key areas for interagency collaboration.
  - Assessments of energy generation potential and analysis of potential climate change impacts to energy generation at federal hydropower facilities
  - Exploring opportunities for collaboration across entire river basins to increase generation and improve environmental conditions
  - Green Hydropower Certification
  - Federal Inland Hydropower Working Group
  - Joint development and demonstration of advanced technologies
  - Renewable Energy Integration and Energy Storage
  - Facilitate permitting for federal and non-federal projects at federal facilities

Summary of work in the Deschutes

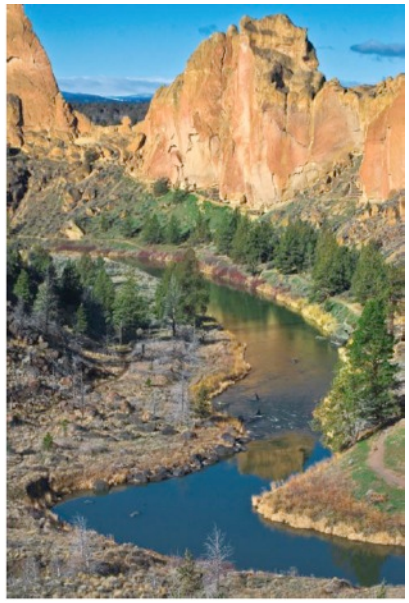
- Spring, 2011—Site visit and meetings with environmental community, irrigators, and PGE.
  - Crooked and Upper Deschutes: Bowman, Wikiup, Juniper Ridge, Ponderosa, PRB
- Late Summer, 2011—Bend stakeholder workshop
  - 48 stakeholders
  - Opportunity identification
  - Research agenda
- October, 2011—Preliminary Assessment Report
- February, 2012—Seattle modeling workshop with Bureau, OWRD, and DRC
- July, 2012—Site visit II: Scenario scoping with “Logistics Committee”
- Feb1, 2013—Second stakeholder workshop—Preliminary Results
- Feb-July—RiverWare validation
- September presentation at Small Hydro Workshop in Bend
- Final Report under review—January, 2014
- Webinar to share final results more broadly (today)
- Evaluation interviews in Spring
- Products available at basin.pnnl.gov

2. Deschutes Pilot Assessment Process

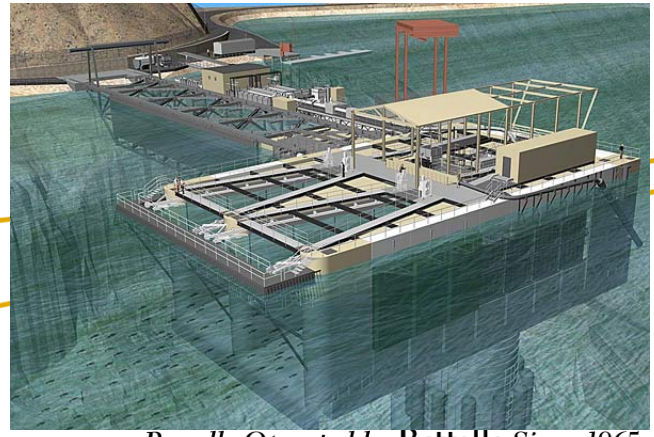


Deschutes Step 1

Identify environmental issues (2011)



- Water quality, instream habitat, fish passage, natural storage, floodplain, protection status, etc.
- High-level scoping fed by stakeholder engagement and review of existing assessments
- Focus on reach-specific opportunities related to changes in hydrologic regime
  - Upper and Middle Deschutes River
  - Tumalo and Whychus creeks
  - Lower Crooked River



Deschutes Step 2

Identify reach-specific opportunities to help address environmental issues (2012)

An opportunity is a proposed change to the operation or management of the river system that is expected to provide some benefit

- Enhance flow (timing, magnitude, duration, conservation)
- Restoration (riparian health, bank stability, stream complexity)

- Key assessments
  - *Deschutes Subbasin Plan* (NPCC 2004)
  - *Upper Deschutes Subbasin Assessment (UDWC 2003)*
  - *DWA Instream Flow in the Deschutes Basin: Monitoring, Status, and Restoration Needs* (Golden & Aylward 2006)

Deschutes Step 3

Identify hydro opportunities (2011)

- Powering non powered dams
  - BOR facilities, municipal facilities, opportunities related to irrigation reservoirs
- New small hydro in irrigation canals and conduits
- Flow shaping to maximize hydro value—Pelton-Round Butte
- Existing BOR, NUID, COID assessments and stakeholder interviews

Deschutes Step 4

Evaluate Hydropower Opportunities (2012-13): ORNL Technical and Economic Feasibility Assessment

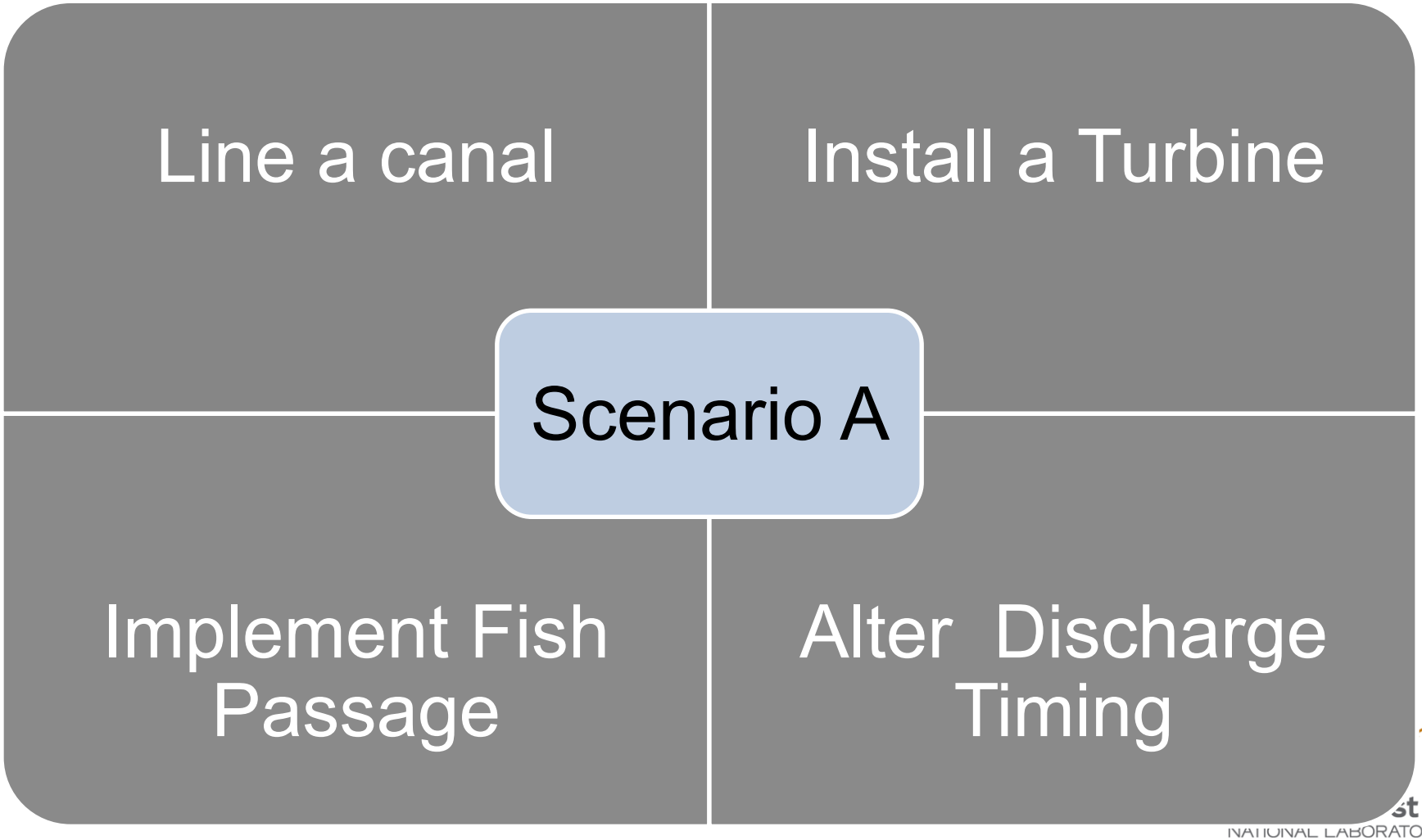
- Hydropower Energy and Economic Assessment (HEEA) Tool
  - Generate flow and power duration curves
  - Determine turbine design flow, net head, and technology type
  - Calculate monthly and annual power generation to determine design power capacity
  - Estimate project costs
  - Perform benefits and economic evaluations
- 14 NPDs and 15 irrigation canal/conduit sites
  - Four NPD sites feasible (Wickiup, Bowman, North Canal Diversion, Ochoco)
  - Four canal sites feasible (Mile 45, Haystack canal, 58-11, 58-9)
  - 19 MW capacity, 78 Gwh per year
- Power functions incorporated into PNNL RiverWare model

Zhang et al. TECHNICAL AND ECONOMIC FEASIBILITY ASSESSMENT OF SMALL HYDROPOWER DEVELOPMENT IN THE DESCHUTES RIVER BASIN. June 2013. ORNL Technical Report.
http://info.ornl.gov/sites/publications/Files/Pub44168.pdf

3. Integrate and evaluate opportunities through scenarios

….A scenario is a set of opportunities that depend on a common resource

A Scenario is a Set of Opportunities



Deschutes Scenario Scoping

- Increase minimum flow below Wickiup Dam during the non-irrigation season from 25 cfs (baseline) to 350 cfs in ~75 cfs increments
- Simulate water conservation measures by reducing baseline irrigation demand by 5 and 10 percent

Modify timing and amount of instream flow in upper Deschutes to benefit fish, water quality, and other ecological processes

Analyze power benefits under modified flow scenarios

Assess risk to irrigation under modified flow scenarios

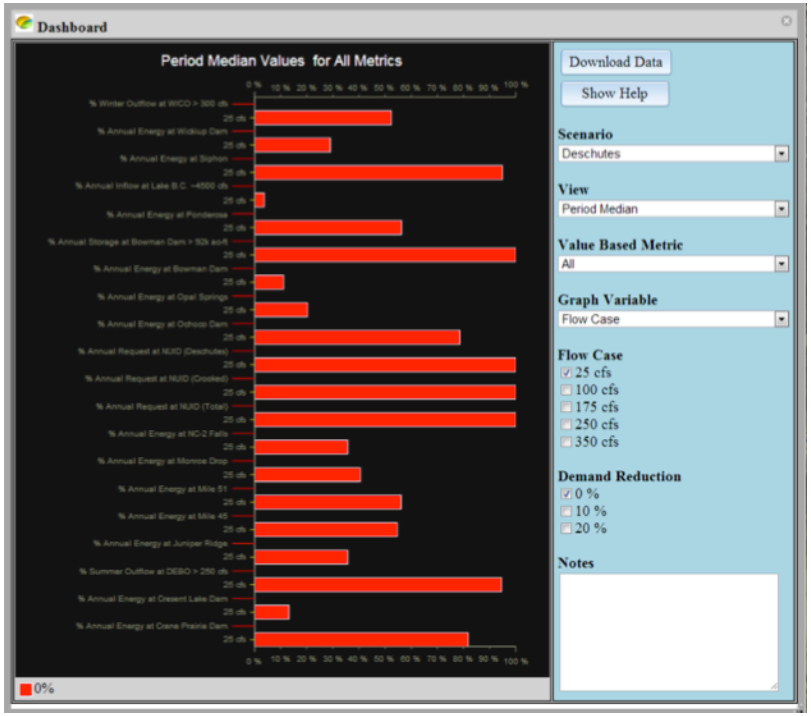
Model Implementation

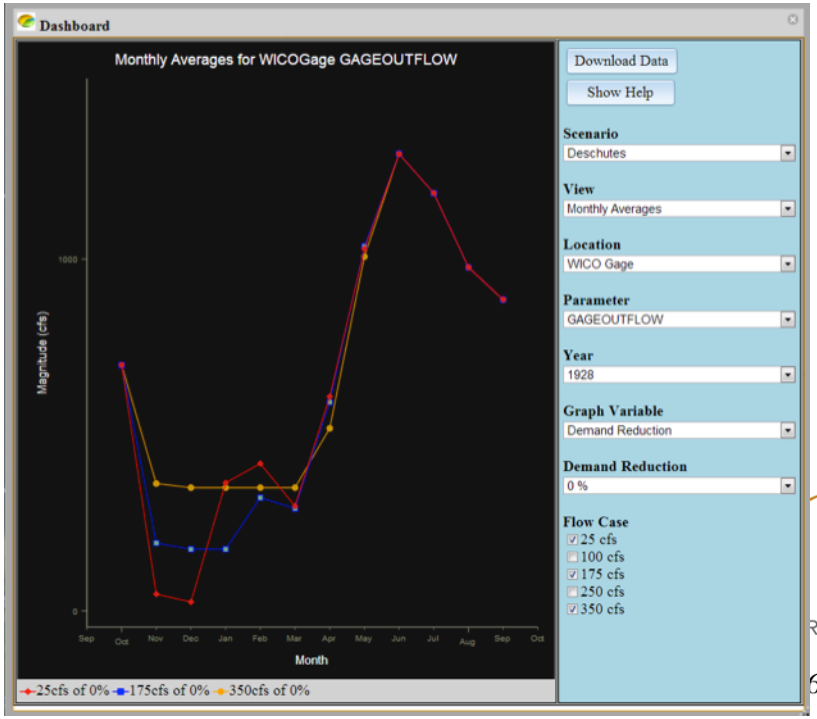
- Combinations of scoping variables are implemented in a mass-balance river model to simulate different management scenarios

Demand Reduction Levels

Flow Cases	0%*	5%	10%
25*	25, 0%	25, 10%	25, 20%
100	100, 0%	100, 10%	100, 20%
175	175, 0%	175, 10%	175, 20%
250	250, 0%	250, 10%	250, 20%
350	350, 0%	350, 10%	350, 20%

4. Visualize data to support collaborative decision making…more from Sara on this…





Application of RiverWare to Deschutes Basin Opportunity Assessment

Sara Niehus and Marshall Richmond

Hydrology Group, Environmental Directorate

Richland, WA

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Our Modeling Collaborators

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- OWRD – Kyle Gorman, Jonathan La Marche, and Jeremy Griffin
- USBR – Jennifer Johnson
- CADWES – Edith Zagona and David Neumann

What is a Model and Why are we using them?

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- *Models are a replication of reality to explore complex, expensive, or dangerous alternatives to proposed scientific questions*
- *The best Models are the most accurate representations of reality*
- *RiverWare is a Model to visualize and explore many management options to aid in understanding entire basin impacts*

Flight Simulator

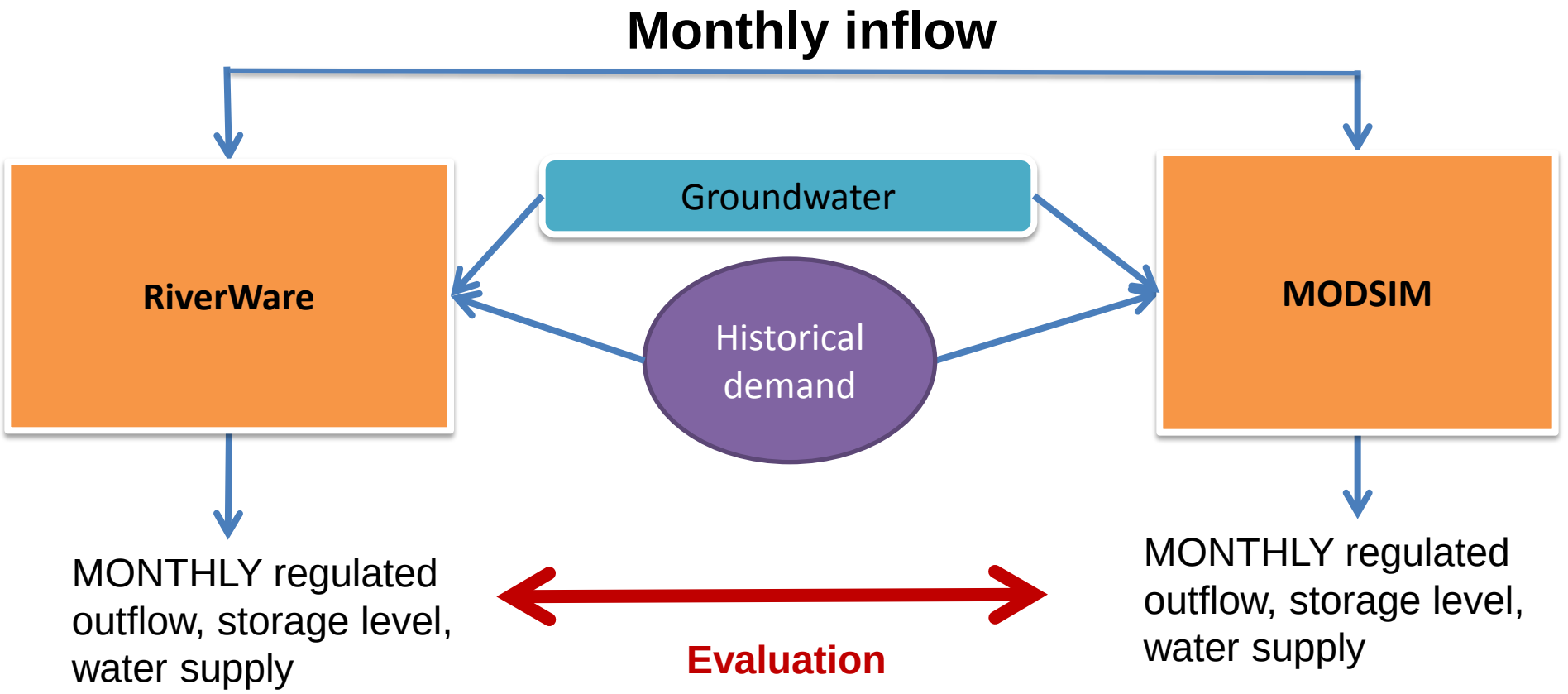
Deschutes Case Study Outline

- Background
- Modeling Strategy
- Model Inputs
- Infrastructure and Configuration
- Model Evaluation
- Model Outputs
- Model Outcomes

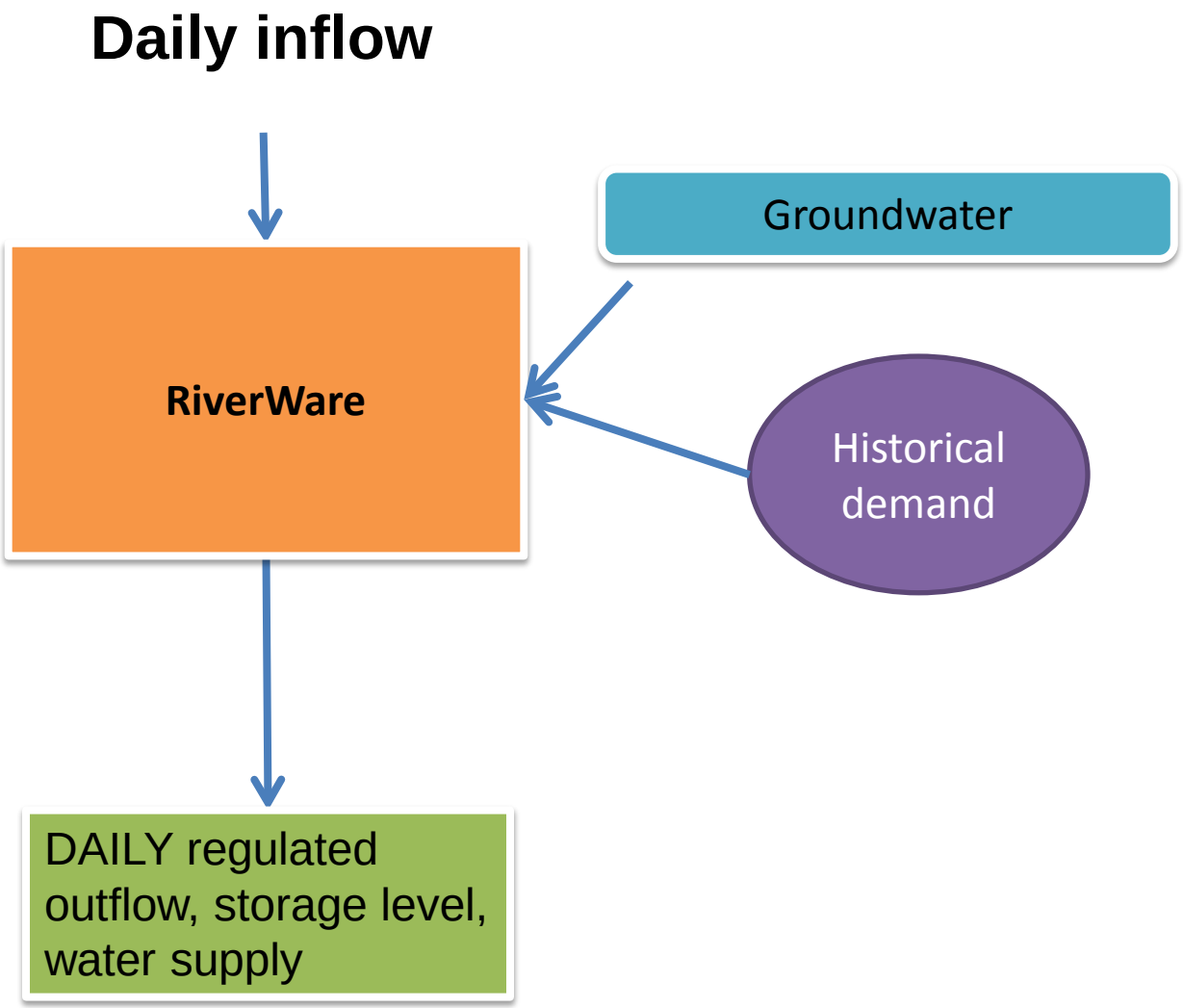
Background - WHY RIVERWARE?

- Current capabilities: MODSIM Deschutes model was completed in 2013
  - Monthly hydrologic inflow and groundwater returns
- Capabilities RiverWare offers
  - Modeling transparency
  - Daily time scale
    - Environmental assessment
    - Hydropower
  - Water accounting
  - Groundwater application
  - Flexible coding for operations
  - Data-centered design for model update ease
  - Wide use and recognition
    - Entire Colorado River and Rio Grand Basins
    - Truckee River Basin

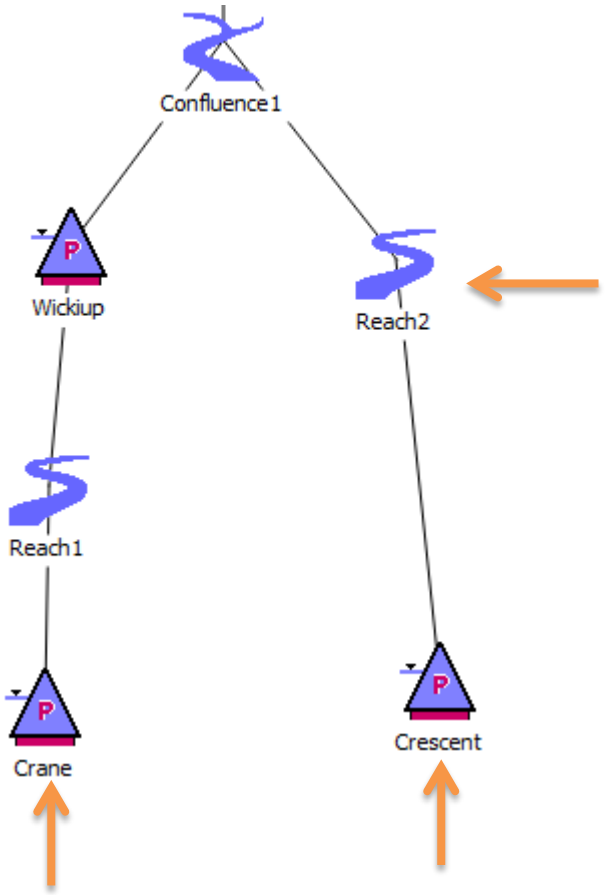
Modeling Evaluation Strategy



Modeling Scenario Strategy

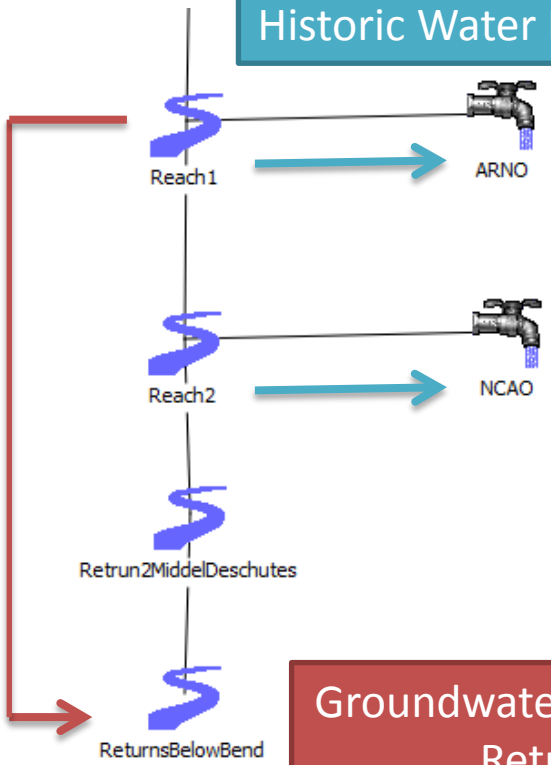


RiverWare inputs from external data or models



Inflow from MODSIM

Historic Water Diversion



Groundwater Losses and Returns

Model Infrastructure

- Existing hydropower capacity:
  - Opal Springs, Siphon, Juniper Ridge, and Ponderosa
- Proposed hydropower capacity:
  - Crane Prairie, Wickiup, Crescent Lake, Bowman, Ochoco, Monroe Drop, Mile 45, Mile 51, and NC-2 Falls
- Diversion/Water Users:
  - 31 diversions from Arnold, Central Oregon, North Unit, Ochoco, Three Sister, Swalley, Lone Pine and Tumalo irrigation district
  - 72 Aggregated water rights accounts
    - 60 in stream flow
    - 12 Project Storage
- Pumping Stations:
  - Ochoco Relift and Barnes Butte

Reservoir Storage Evaluation

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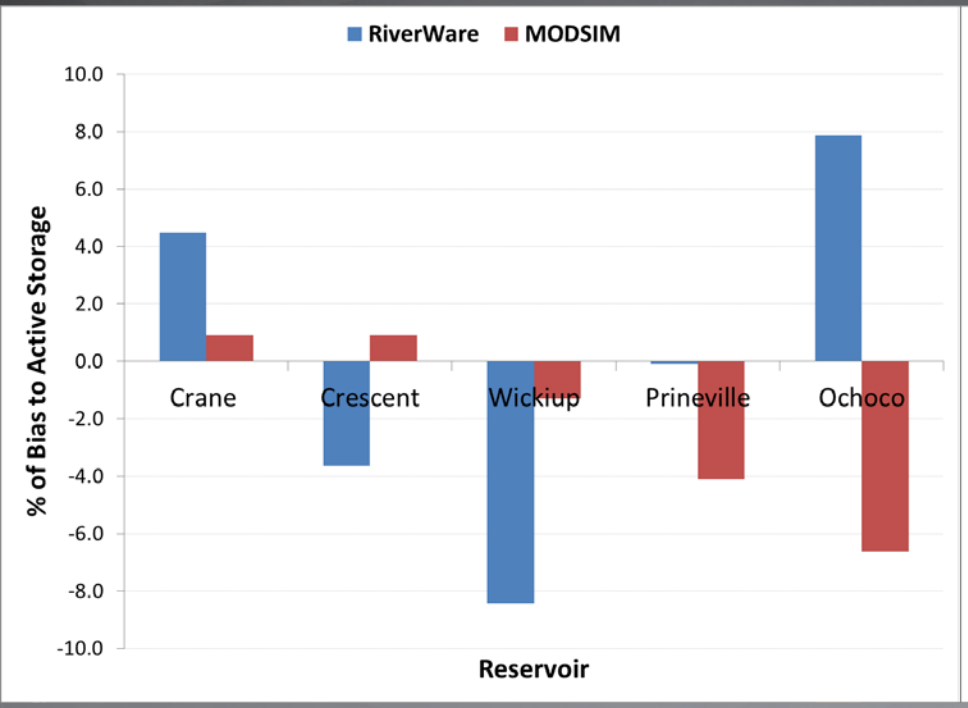

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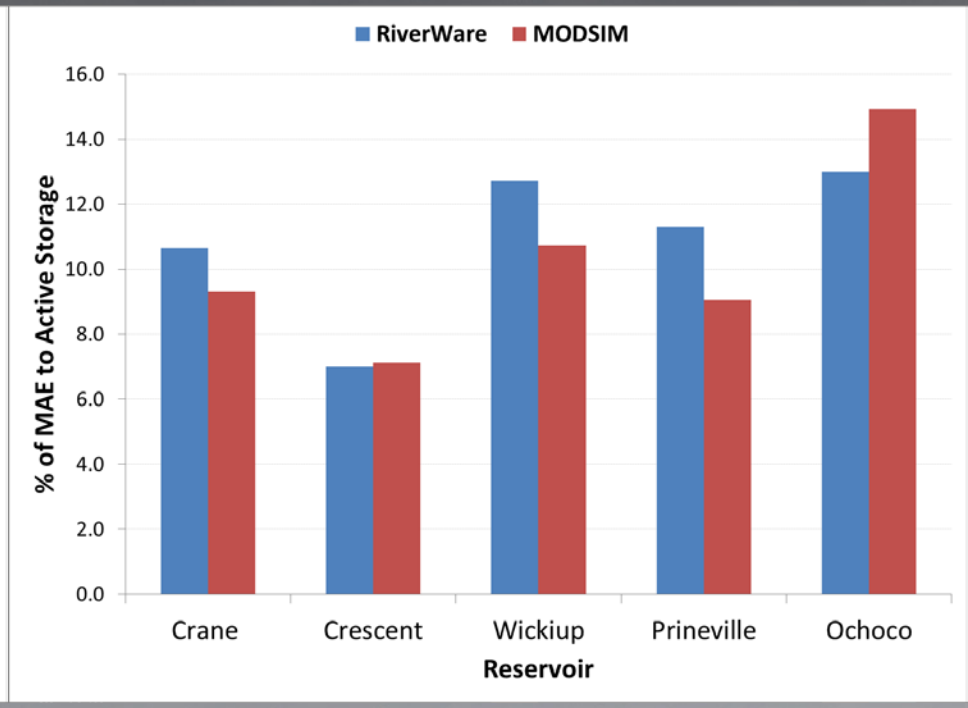

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Storage Evaluation– Crescent Reservoir Storage 1985 to 1990

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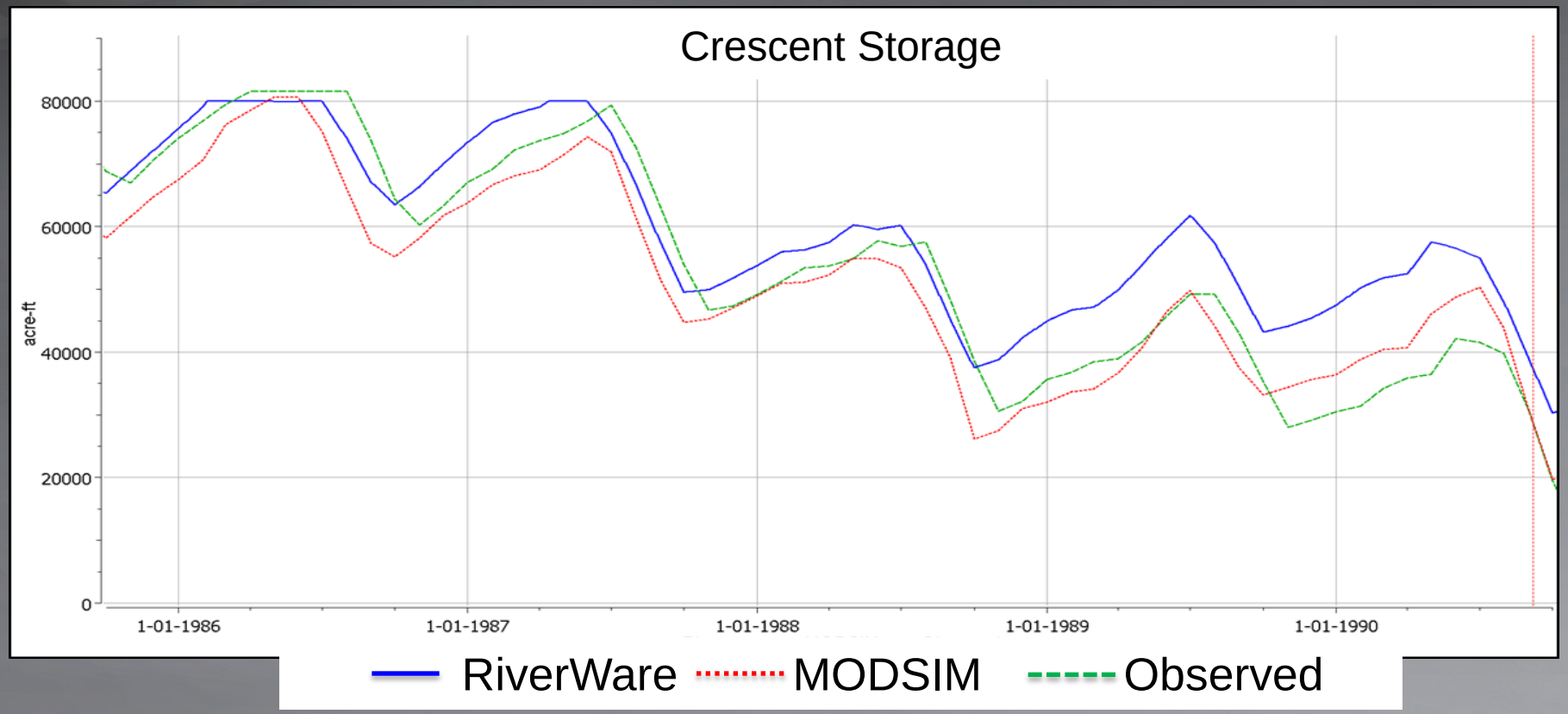

Reservoir Outflow Evaluation

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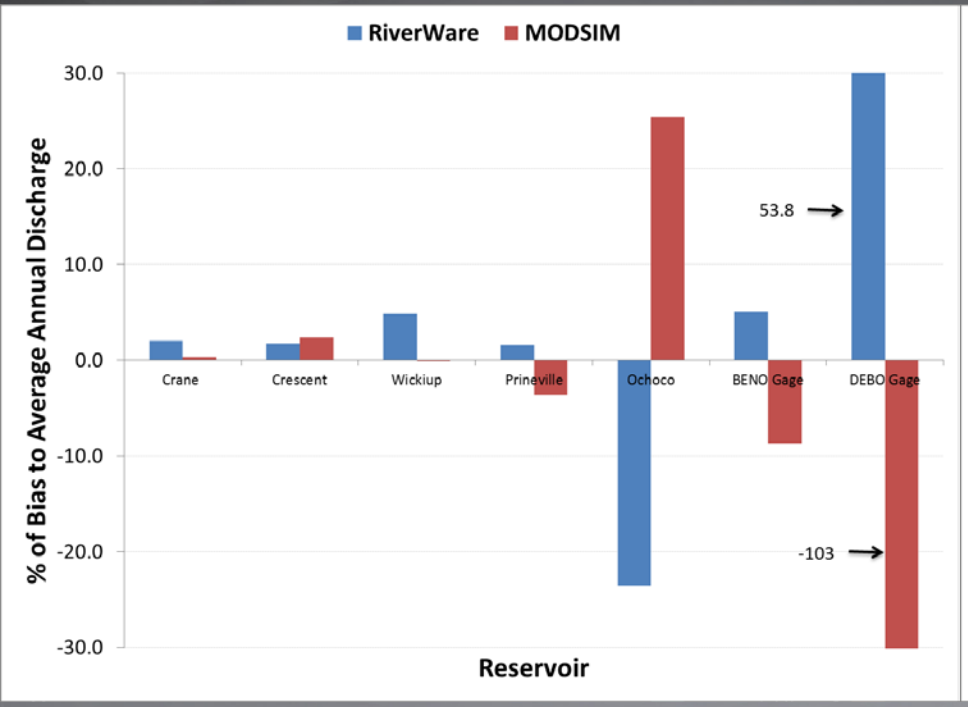

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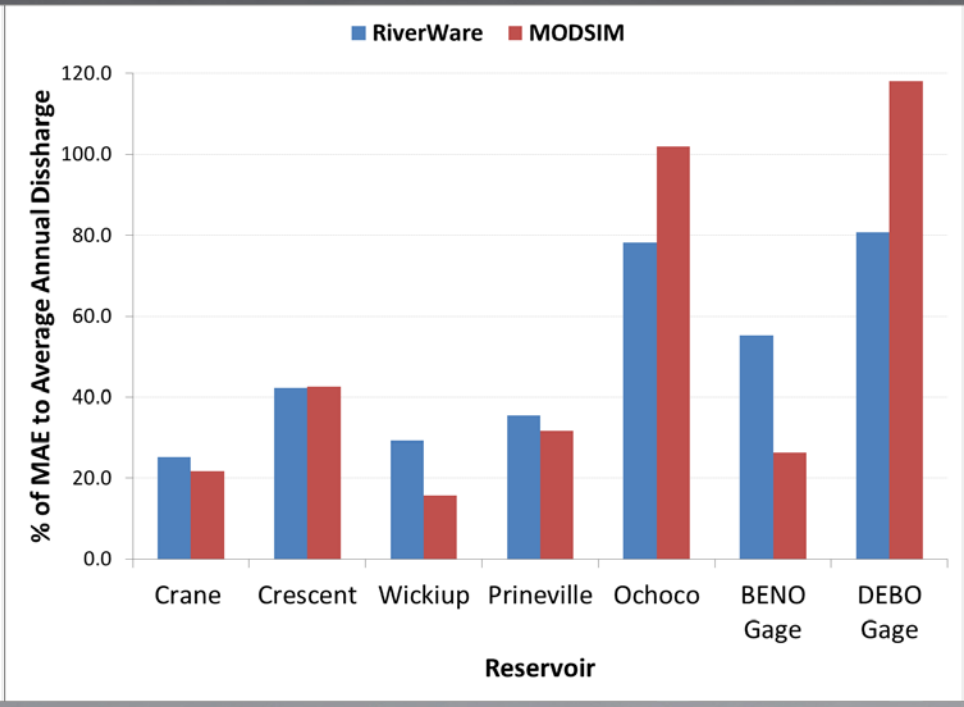

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Reservoir Outflow Evaluation – Crescent Reservoir

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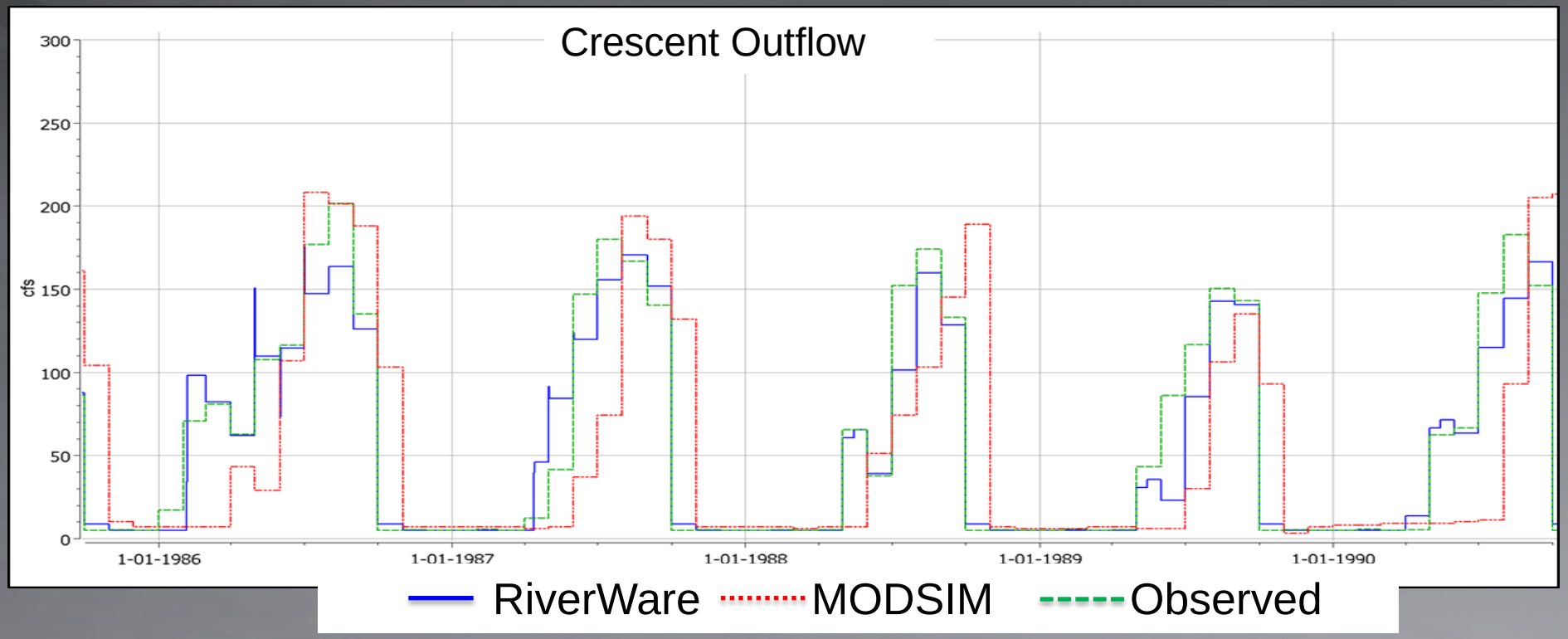

NUID simulated irrigation diversion – which water was used?

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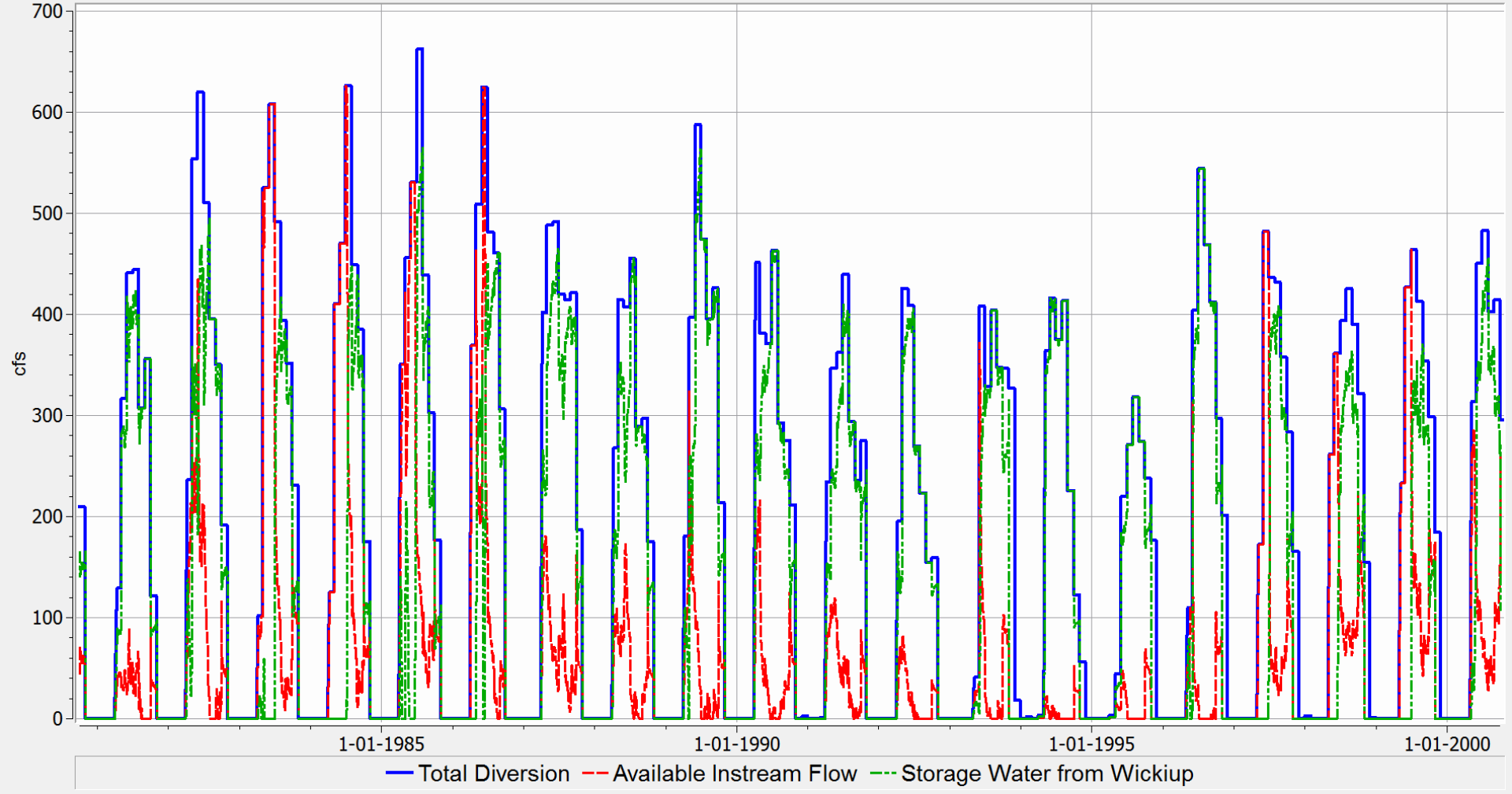

RiverWare Modeling Evaluation Summary

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- What works well in RiverWare?
  - Most reservoir outflows and storage are preforming similar to MODSIM
  - Water Diversion: Project vs. Instream Allocable flow
  - Hydropower estimation
- What can be Improved?
  - Ochoco Inflow inputs
  - Groundwater return inputs at and below DEBO gage
  - Fine tuning of reservoir operations

Model Outputs

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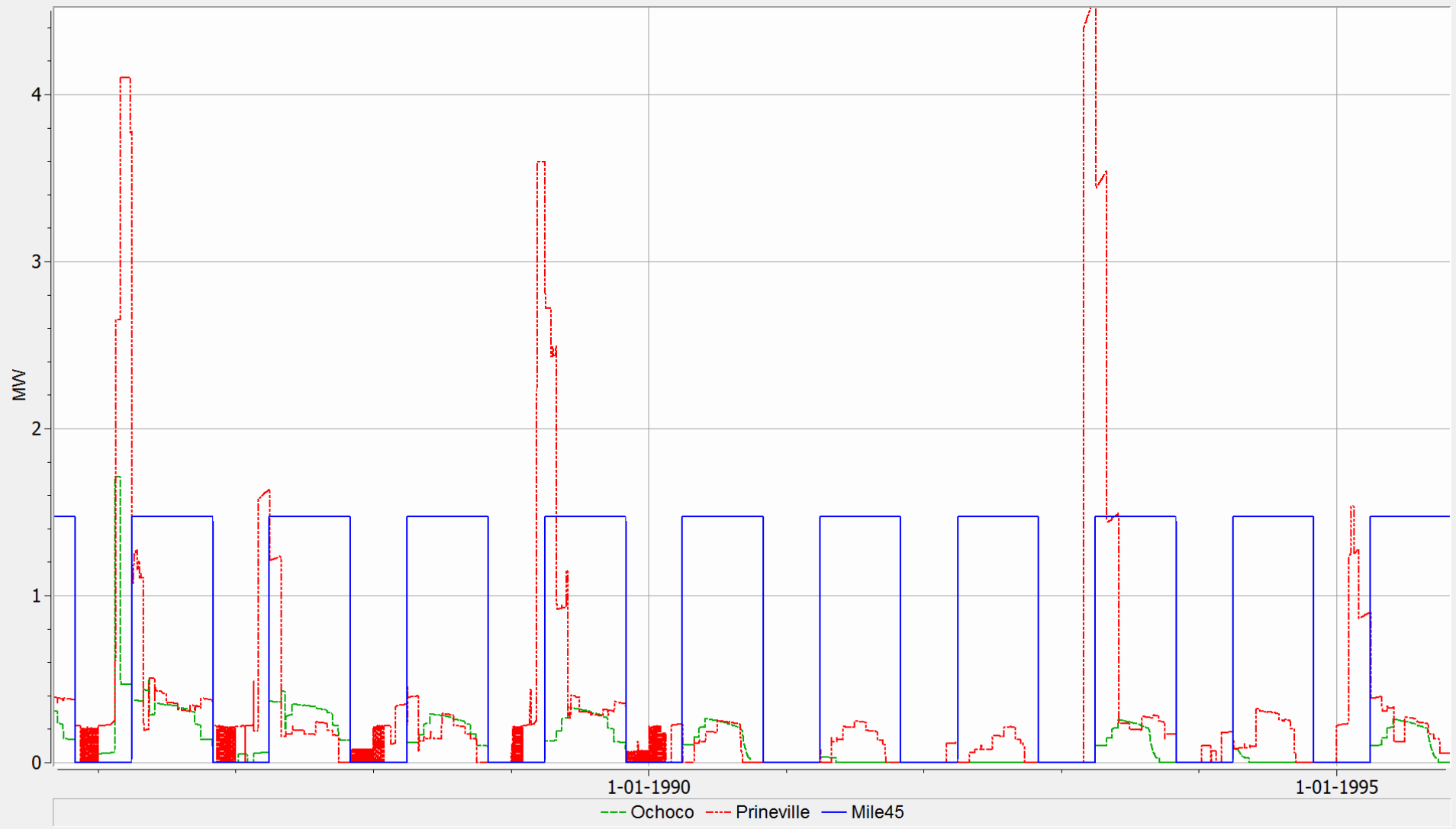
- Reservoir Storage and Outflow 
- Stream Discharge 
- Water Diversion
  - RiverWare Simulated vs. Historically Observed
  - What water is used: Storage vs. Instream 
- Hydropower
  - Potential Megawatt Generation

RiverWare Output of Potential Hydropower



Simulated Potential Hydropower

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	Riverware Calculated Generation with 1980 - to 2000 hydrologic history		
Hydropower Site	Avereage (MW)	Max (MW)	Average energy generation per year (MWh)
Crane	0.11	0.40	955
Wickiup	3.89	6.71	34,124
Crescent	0.08	0.42	707
Ochoco	0.19	2.15	1,646
Prineville	0.56	5.08	4,898
Monroe Drop (NUID)	0.27	0.45	2,329
Mile 45 (NUID)	0.87	1.47	7,608
Mile 51 (NIUD)	0.63	1.07	5,542
NC2 Falls (COID)	0.99	3.62	8,658

Deschutes stakeholder driven scenario case

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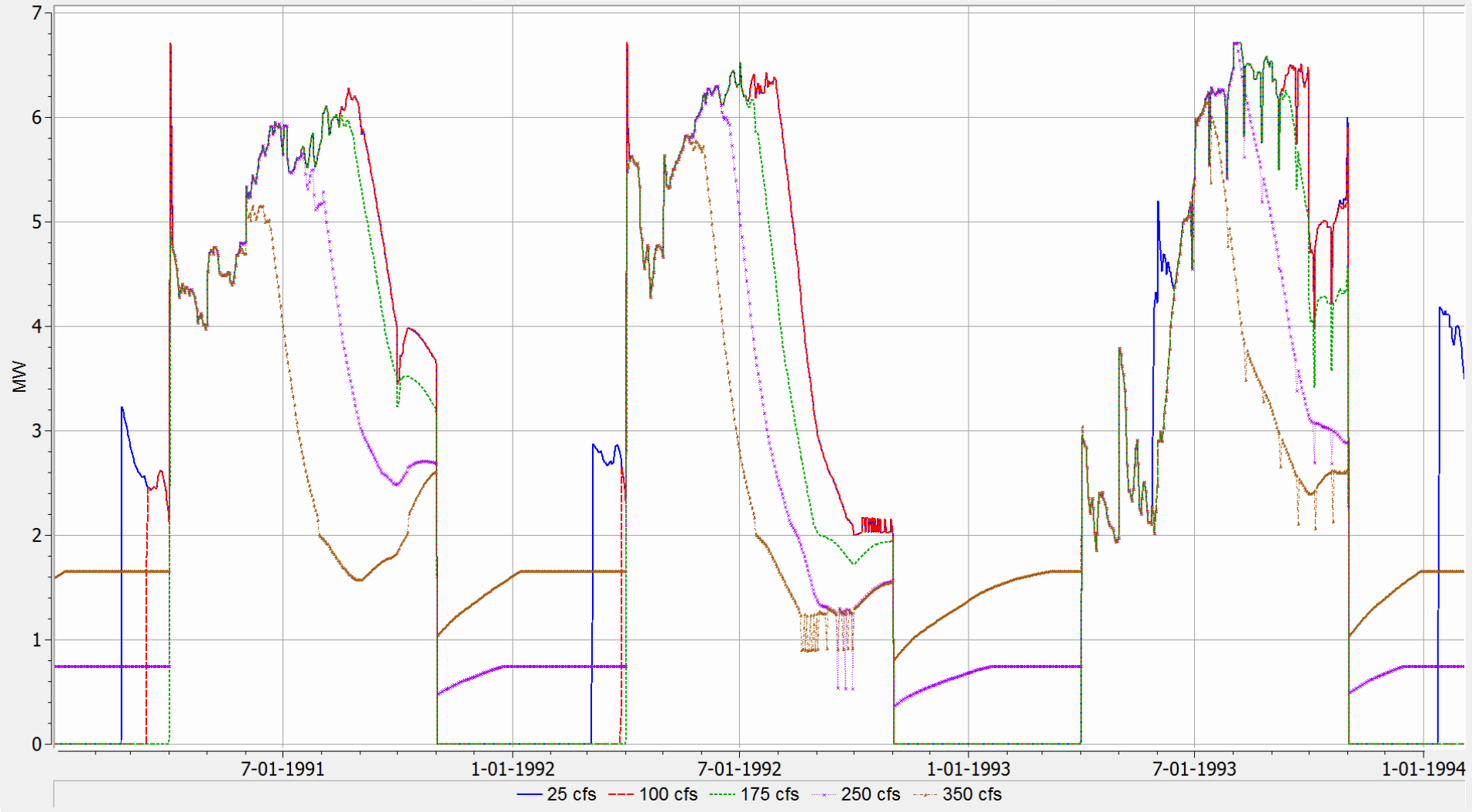
- Wickiup Minimum Outflow (cfs)
  - 25
  - 100
  - 175
  - 250
  - 350
- Water supply reduction for NUID (%)
  - 0
  - 5
  - 10

Wickiup Power Production with Various minimum flows – 0% Water Reduction



Deschutes RiverWare Outcomes

- Water supply reductions throughout the basin affect:
  - Instream flows
  - Water users
  - Reservoir Storage/Outflow
- Site specific power potential
- Operation minimum out of Wickiup outflows affect:
  - Hydropower generation capacity at Wickiup and downstream hydropower location
  - Available in stream and project water for many diversions

What benefits to the basin does this RiverWare model provide

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- Investigate proposed planning:
  - How will environmental, water use, operations and hydropower potential all be impacted
  - Run many potential case to find out when can all interests be met
- How will climate change effect our basin and what stress will we encounter?

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Thank you!

Questions?

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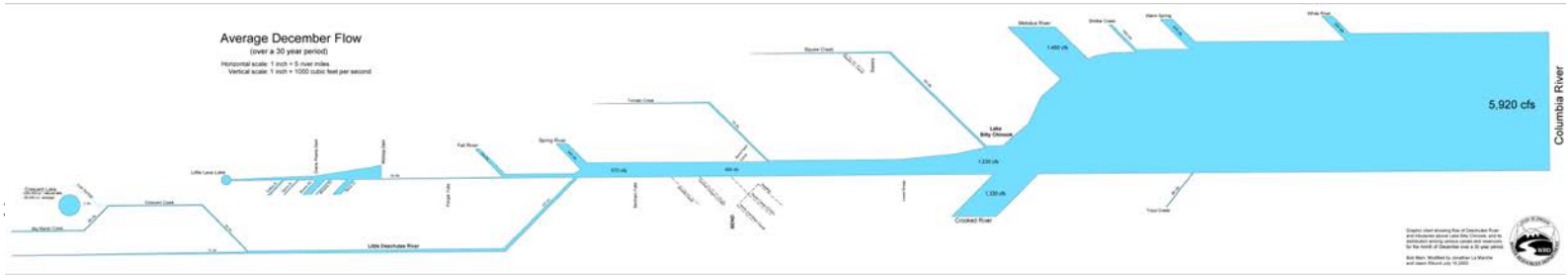
Scenario Based Modeling Results for the Deschutes River Basin

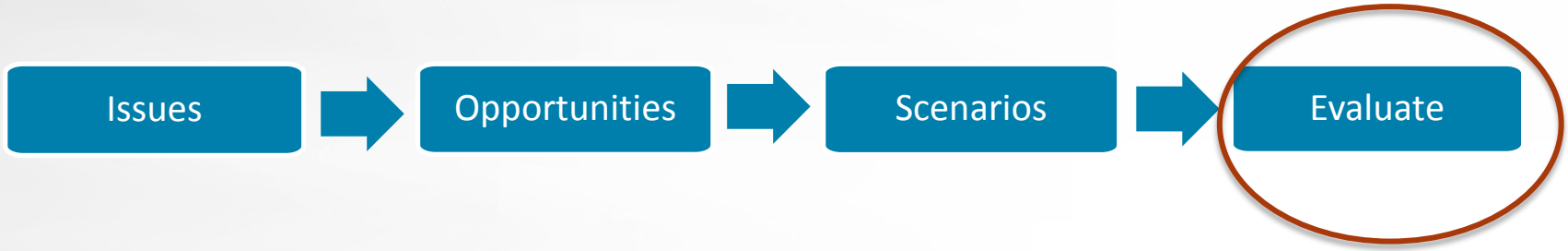
KENNETH D. HAM, PH.D.

Common Tools Create Shared Understanding of Costs and Benefits

- Deschutes Basin ModSim and RiverWare models benefited from collaborative input from multiple groups
- Those models can be operated based on a range of scenarios proposed by stakeholders
- Model output used to evaluate value-based metrics for all stakeholders
- What benefits are possible at what cost



Deschutes Pilot Assessment Process



Definitions

- **Opportunity:** a proposed change to the operation or management of the river system that is expected to provide some benefit
- **Scenario:** a set of opportunities that combine to provide a mix of benefits.
- **Scoping:** an incremental evaluation of an opportunity that reveals how the mix of benefits changes across a range of management action
- **Value-Based Metric:** a representation of an aspect of the river system that is valued by a stakeholder

A Variety of Metrics Were Defined Around Deschutes Basin Stakeholder Values

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Category	Value-Based Metric Description	Target Level	Applicable Scenario
Hydropower	Percent of potential energy generated during water year	200% of baseline	Deschutes & Crooked
	Percent of water year where inflow to Lake Billy Chinook is 4400-4600 cfs	NA	Deschutes & Crooked
Environmental	Percent of storage season (Oct 15 – Apr 15) that flow below Wickiup Dam ≥ 300 cfs	95%	Deschutes
	Percent of summer (Jun 1 – Aug 31) that Deschutes River below Bend ≥ 250 cfs	65%	Deschutes
Irrigation	Percent of NUID annual diversion request that was received	95%	Deschutes & Crooked
Recreation	Percent of water year that Prineville Reservoir storage ≥ 92,000 ac ft	NA	Crooked

Simulation Output Reveals How Scenarios Impact Values

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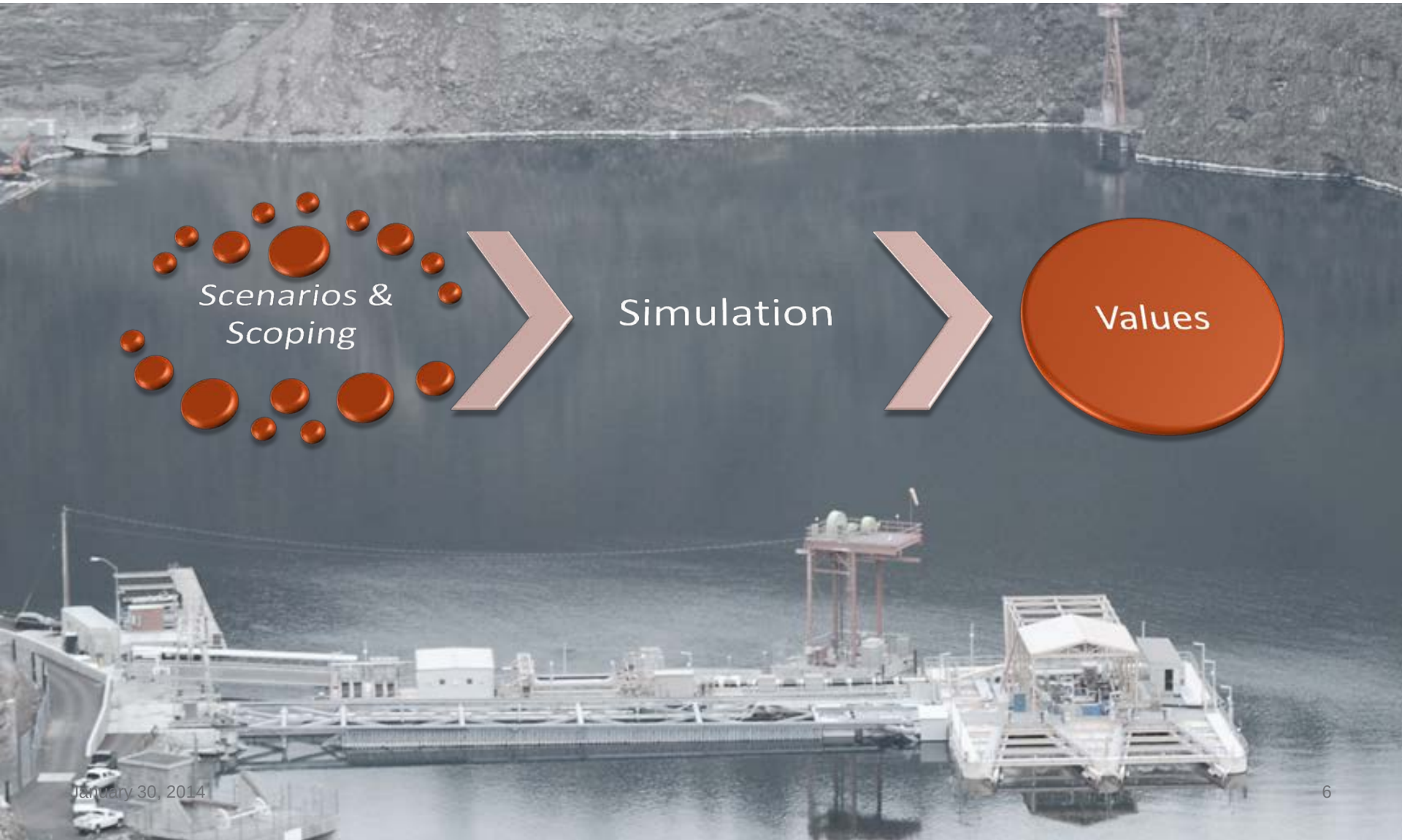

Visualization Tool Dashboard Displays Value-Based Metrics

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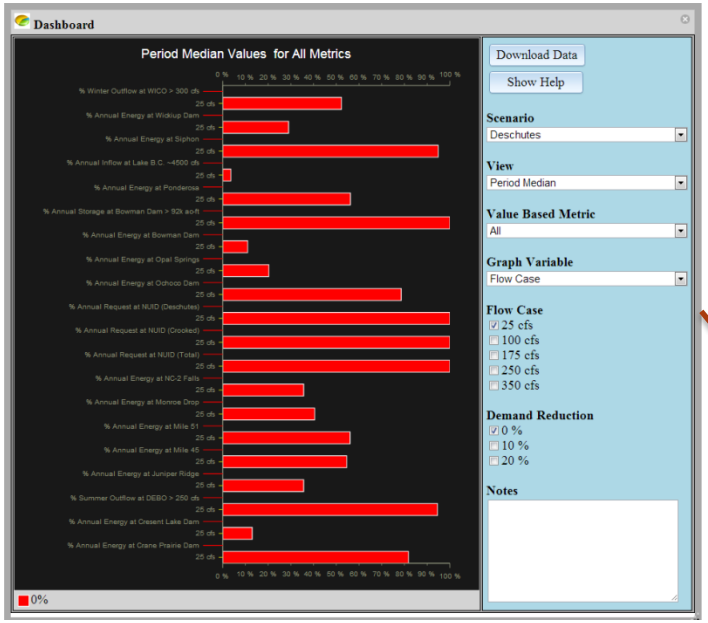
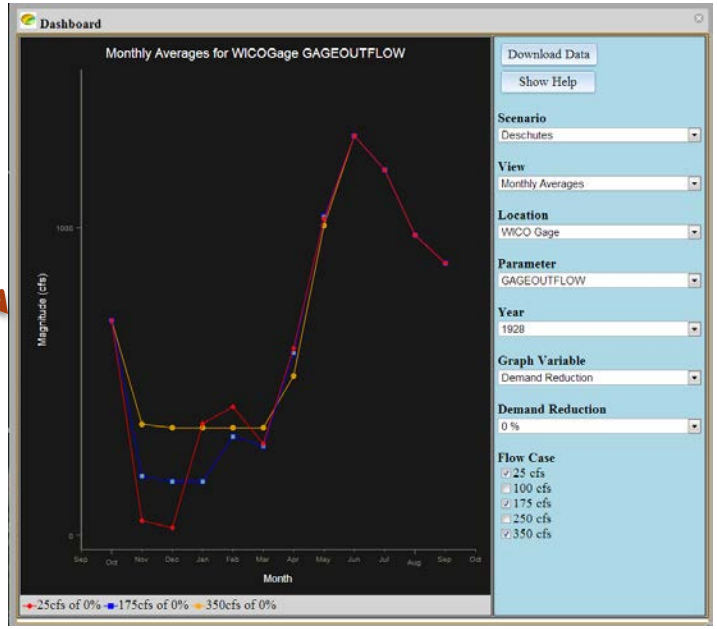
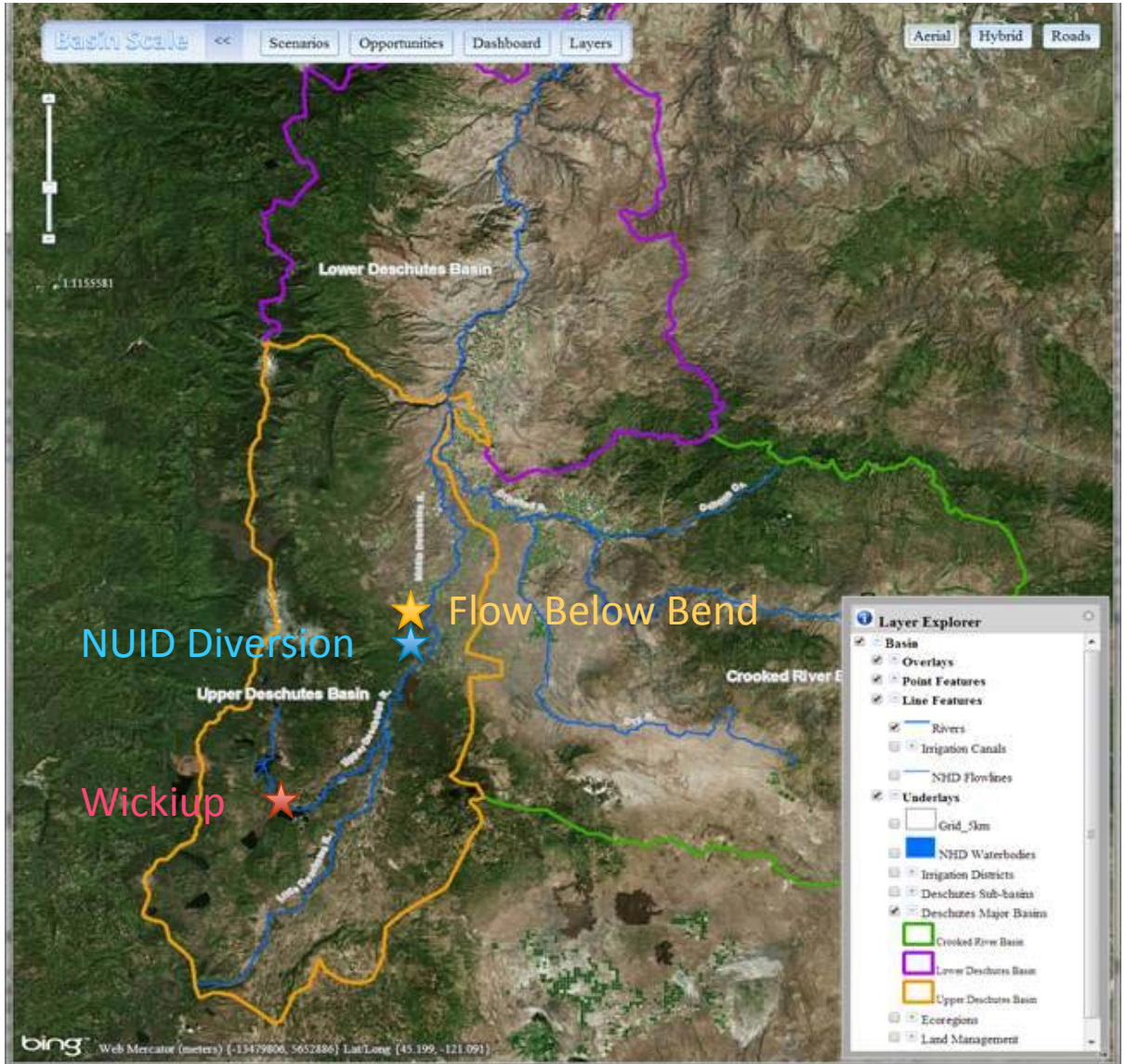
- **Visualize modeling results to help interpret how values change and facilitate discussion**

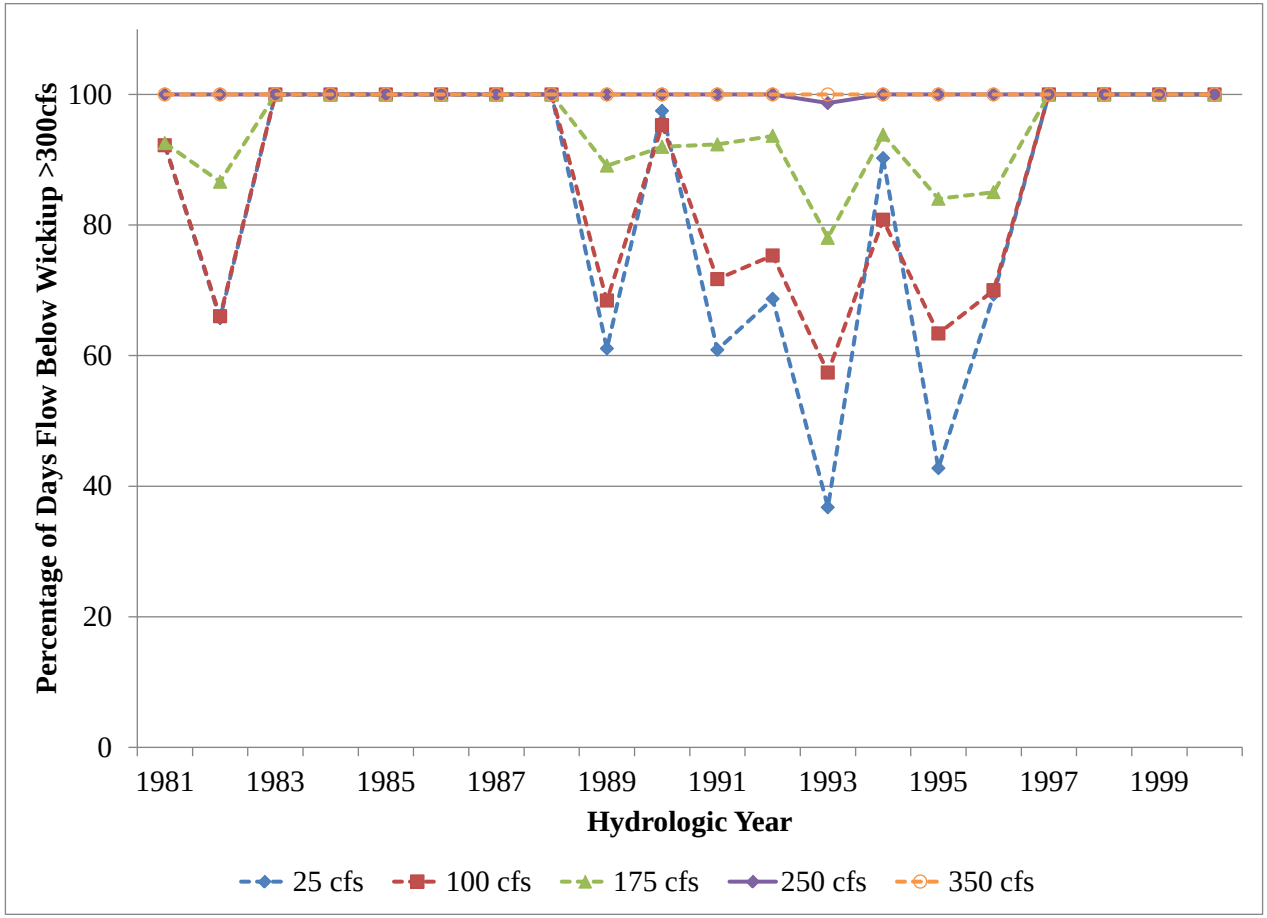




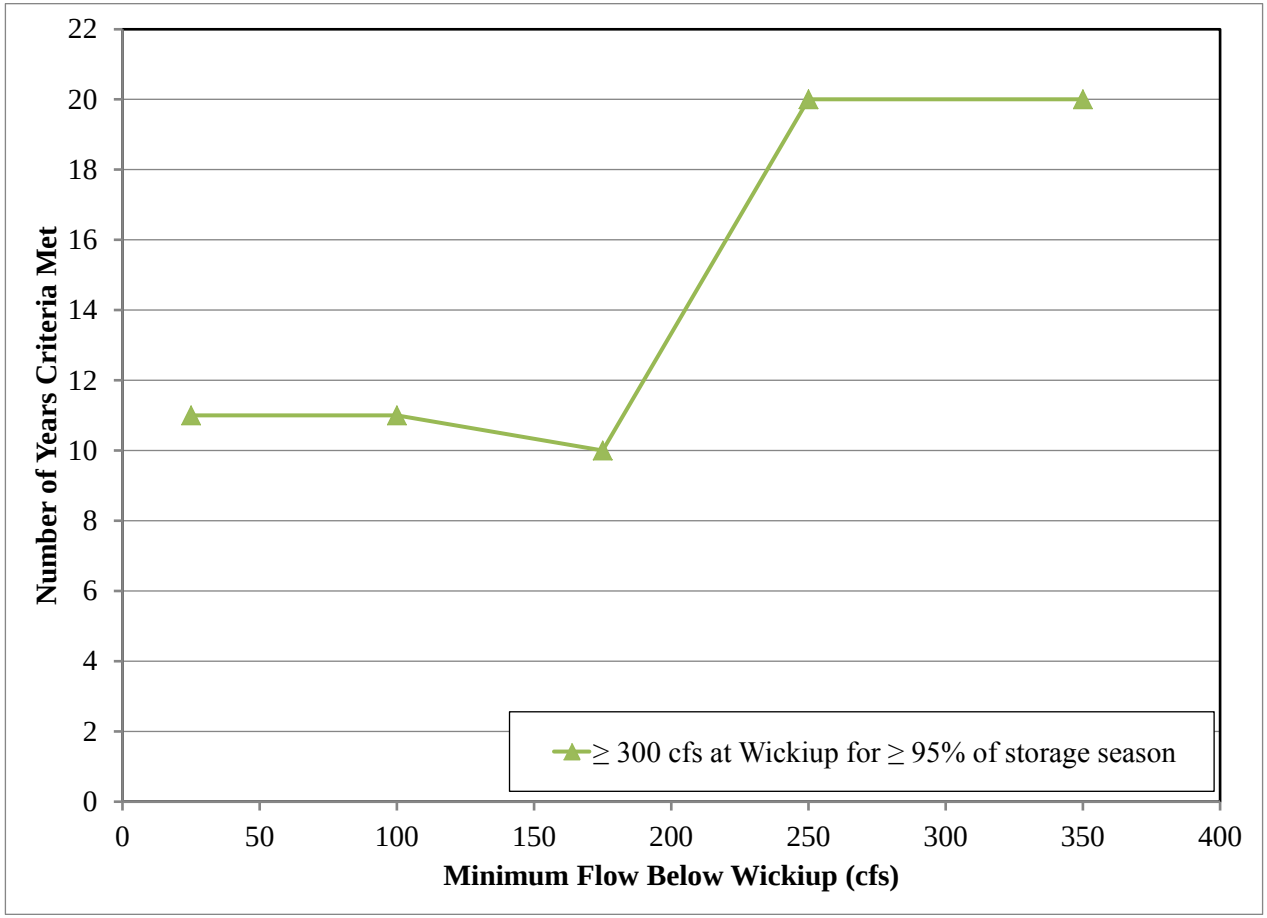
The Upper Deschutes Scenario Includes Hydropower, Environmental, and Water Use



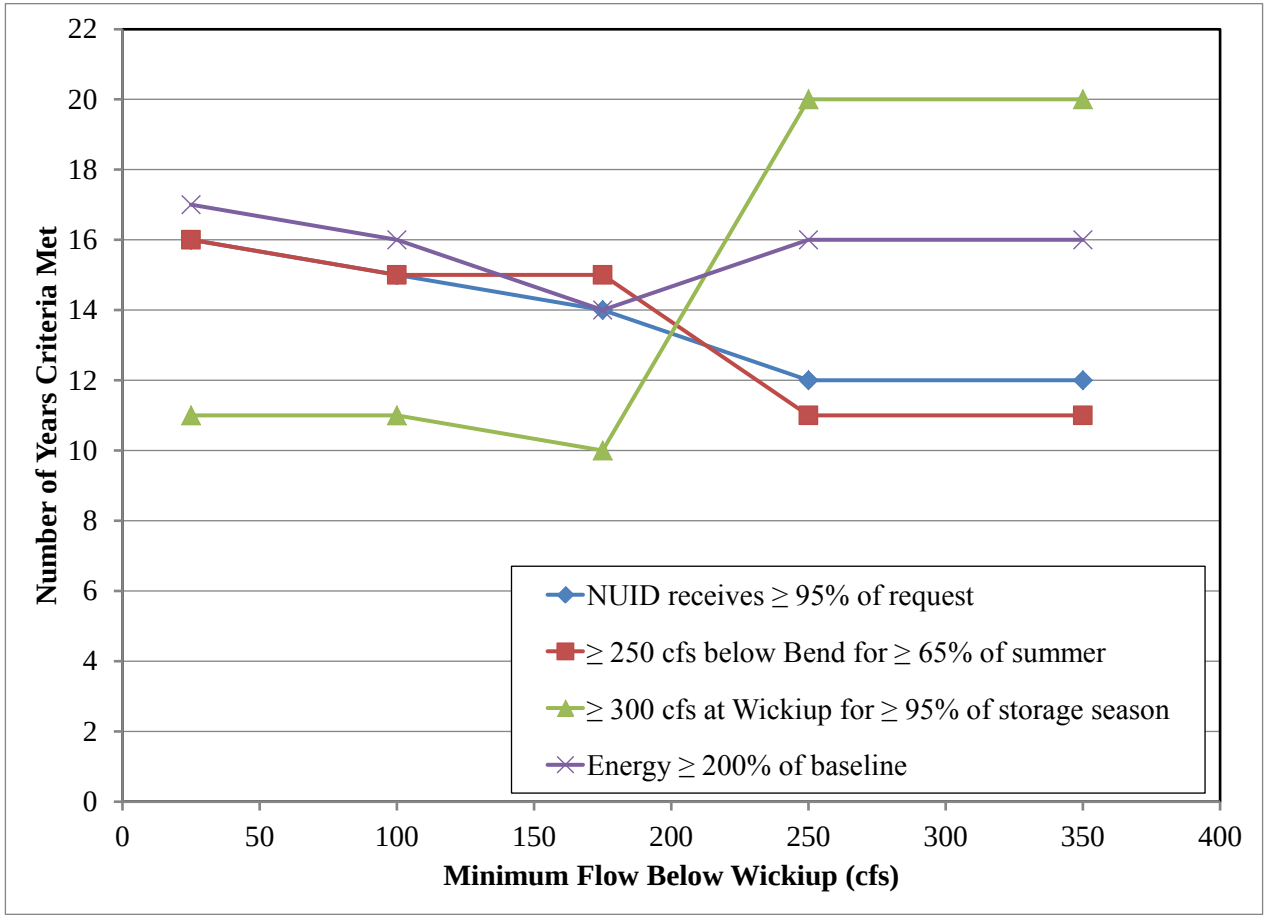
Winter Flow Below Wickiup Dam Drops Below 300cfs in Below-Average Water Years



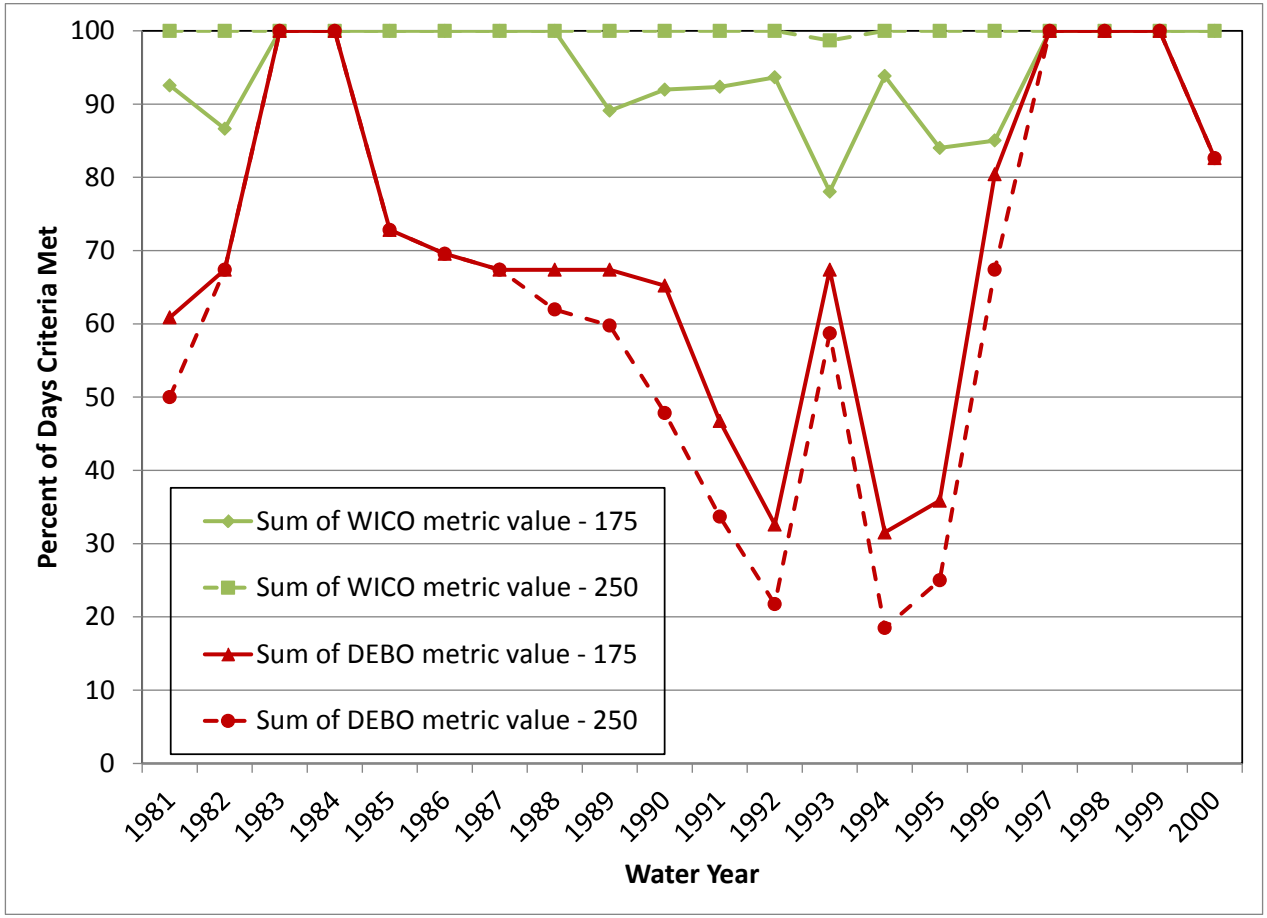
Value-Based Metrics Can be Summarized Across The 20-year Simulation Period



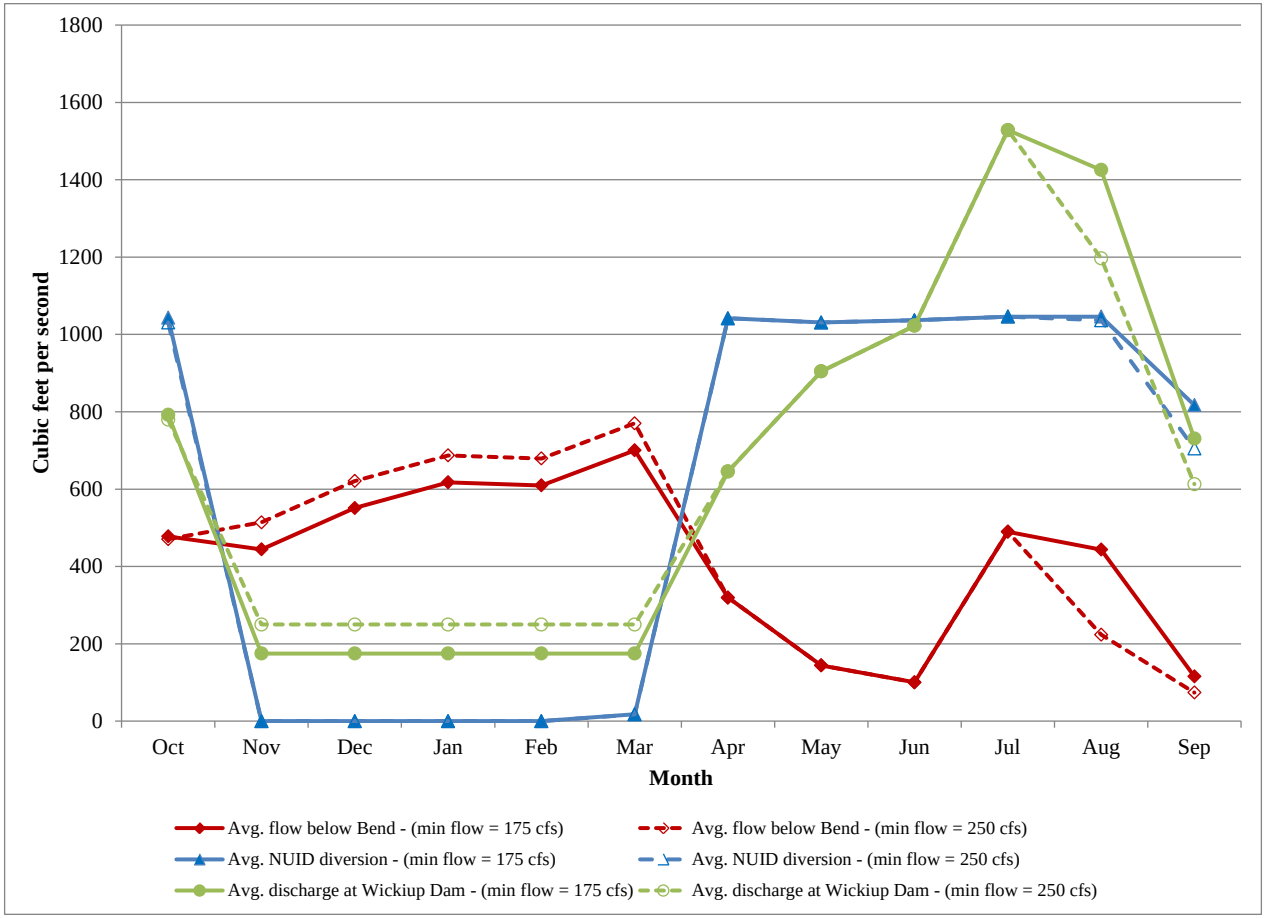
Comparing Metrics Reveals Trade-offs



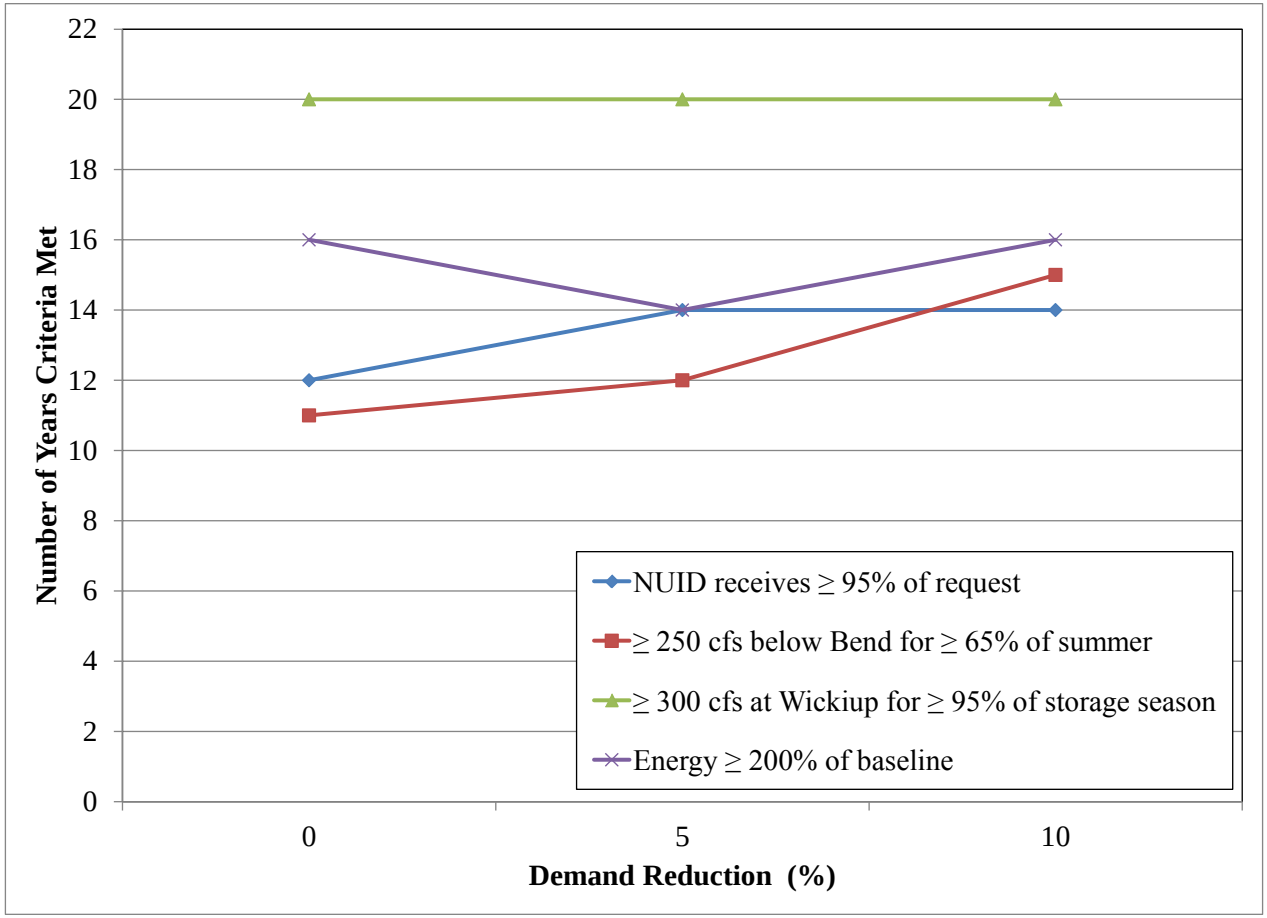
Greater Winter In-stream Flow can Decrease Summer In-stream Flow



In a Low Water Year, Higher Winter Flow Reduces Availability in Late Summer



Demand Reduction Increased the Number of Years When Metrics Met Criteria



These Explorations Provide Useful Information on How the System Responds

- Tension between water use and instream flow
  - Metrics changed rapidly between 175cfs and 250cfs
- Water use reduction helped meet criteria in moderately low water years
  - Improvements fell short of criteria in lowest years
- Tradeoffs rarely involved hydropower generation
  - Generation driven by water use and instream flow

These Tools Can Be Used to Support Discussion Among Stakeholders

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- Compare a range of potential management alternatives
- See how achieving an objective interacts with other objectives
- Identify critical areas for detailed analysis

Gary Halvorson, Oregon State Archives


Thank You
Questions?

Deschutes RiverWare Model Future

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- Model will be housed with the staff at the Bureau of Reclamation Pacific Northwest Region and PNNL

- Points of Contact for Model:

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Next Steps: Beyond the Deschutes

- Rapid high-level assessment approach—(90 day process, rather than multiple years)
  - Associate hydropower opportunities with environmental issues through a rules-based approach
  - Identify site-specific hydro/environmental interactions
  - Look beyond site specific interactions to system-scale
- Rapid assessments underway in the Roanoke, Connecticut, and Bighorn basins
- FY 14: Package tools and methodologies
  - Provide assistance for basin stakeholders wanting to use tools