

Great Plains Regional Office Reservoir Operations Activities

Presented by: Patrick J. Erger February 1, 2018



Clark Canyon Reservoir, Montana

Background

- Reclamation does not have an agency-wide or Region-wide standard reservoir operations methodology
- Models Include:
 - 1. RiverWare
 - 2. MODSIM
 - 3. ROMS
 - 4. Cal-Sim
 - 5. Custom Spreadsheets
- Databases:
 - 1. Hydromet
 - 2. HDB
 - 3. HAR
 - 4. Spreadsheets
 - 5. Access databases
- Forecasts: NRCS, NWS, USACE, Local (e.g., "Horse Head") inform Reclamation official forecast
- Methods may be different within the same basin (Bighorn)



Horse head on 5/16/16. Informs Bighorn forecasters on peak runoff timing date.

Project Goal:

- Develop a Great Plains Region-wide operations system.
- The system should be robust, transparent, and easily implementable by Area Office reservoir operators
- Four components:
 - Operations models which support risk-based decision making utilizing RiverWare in an attempt to optimize reservoir operations
 - Enhanced forecasting methods, including ensembles
 - Enhanced operational decisionmaking methods
 - Modern database of record



Schematic of idealized reservoir operations system.

Benefits of a good reservoir operations system

- **1.** Reduction in staff labor;
- 2. Skills are transferrable between modelers/hydrologists;
- 3. Risk-based decision making based on stochastic rather than deterministic hydrology
- 4. System optimization:
 - **1.** Increased hydropower revenue;
 - 2. Decreased water shortages;
 - 3. Enhanced fisheries benefits;
 - 4. Decreased litigation risk.
- 5. Operational transparency
 - **1.** Decreased litigation risk;
 - 2. Enhanced ability to defend decisions under litigation;
 - 1. Enhanced stakeholder relationships.



Canyon Ferry Dam, Montana

Desired traits of Reservoir Operations System

- 1. Easily repeatable tasks are automated (e.g., storing physical and accounting data in database);
- 2. Robust streamflow forecasting (i.e., streamflows represent the probability distribution);
- 3. Modeling can easily examine a wide variety of operational scenarios and hydrologic traces;
- 4. Operational transparency-e.g., quick and effective reporting to stakeholders
- 5. Archiving data driving decision making process

Optimization-making reservoir operations as fully effective as possible.

Example: Maximizing hydropower generation while fulfilling water user contracts and protecting Indian trust responsibilities as well as enhancing fisheries conditions in the Bighorn Basin. Reclamation also maximizes the efficiency of its labor while optimizing reservoir operations.



Bighorn Mountains, Montana



Yellowtail Dam, Montana

Modeling Platform

- RiverWare utilized as modeling platform
- RiverWare is extensively used throughout Reclamation, USACE, TVA, BPA, others
- Planning models exist for Upper Missouri and Milk/St. Marys River Basins
- RiverWare facilitates ensemble model runs
- Allows quick examination of large number of potential inflow scenarios



Moving from deterministic to probabilistic forecasting: one step toward optimization



This requires a change in mindset for operators, stakeholders, and management

Incorporating forecasts

- Missouri River Basin River Forcast Center (MRBRFC) part of NWS generates ensembles which are easily incorporated-daily streamflow traces
- Seasonal (NRCS monthly & daily, USACE, Reclamation) must be disaggregated
- Forecast traces stored in database of record and linked to RiverWare operations model
- Model output saved to database of record following runs



Current modeling efforts

- Upper Missouri Basin Impacts Assessment/Basin Study
- Upper Missouri Operations models Canyon Ferry, Tiber, Clark Canyon
- St. Marys/Milk Basin Study Update
- Bighorn Reservoir:
 - Review of operating criteria
 - Operations model
- Future efforts:
 - WYAO?
 - Integrated Bighorn Basin model?
 - North Platte model?
 - NKAO?
 - Republican River model?



Upper Missouri Basin Impacts Assessment

• Study Partners:

- Bureau of Reclamation, Montana Department of Natural Resources and Conservation
- Assistance from US Geological Survey (Northern Rocky Mtn.) (unique to this study)
- Assess historical and projected water supply and demand
- Analyze how the basin will respond to water supply and demand projections

Missouri Headwaters Basin Study

- Study Partners:
 - Bureau of Reclamation, Montana Department of Natural Resources and Conservation
- Includes stakeholder involvement to identify adaptation strategies to be evaluated in the modeling framework established by the Impacts Assessment
- Develop adaptation strategies to reduce any identified imbalances
- Evaluate adaptation strategies, findings, and recommendations as appropriate



RiverSmart Study – Example Showing Marias River Basin Adaptation Strategies





So when a hydrologic system has strong decadal persistence, how do we contextualize change and natural variability in short observational flow records?

> Greg Pederson: USGS Justin Martin: MSU

 \mathbf{H}

Streamflow from tree rings - How does this work?

Ring widths and streamflow both integrate the effects of precipitation and evapotranspiration, as mediated by the soil, over the course of the water year.







Paleo Record showing relative drougths from around 800-1999 Volume Difference From Long Term Average [acre feet] Cumulative Drought Deficits - Ruby River near Twin Bridges 0.0 ↔ 10⁰ -5.0↔10⁵ 1268-1281 1422-1426 Bowl .0 ↔10⁶ Dust -1.5 ↔10⁶ 1300 800 900 1000 1100 1200 1400 1500 1600 1700 1800 1900 2000 year Ruby EOM Storage (AF) 2020s 2050s 2080s 30000 20000 10000 Jan Feb Mar Apr Jun Jul Jul Sep Sep Nov Dec Jan Feb Mar Mar Mar Jun Jun Jun Nov Nov Feb Mar May Jul Jul Aug Sep Oct Month 2020s 2050s 2080s 600 -Inflow (cfs) 400 -200 . Apr Jun Jul Aug Sep Oct Nov Jan Feb Mar Apr May Jun Jun Jul Aug Sep Oct Feb Mar Jun Jul Sep Oct Nov Jan Feb Mar Dec Dec Jan Month 2020s 2050s 2080s WD -WW --3 -5 Scenario -5 2 1 1 CT -2 -5 HW HD -8 -8 _4 -8 Change in Annual Median Inflow (days) WD HW СТ ww HD

Sample Results from Upper Missouri Basin Impacts Assessment illustrating changes in reservoir storage and inflow, comparing climate change and paleo events.

• Current forecasting efforts

- Creating regional statistical forecasting software
- GPRO will issue a forecast for Big Hole at Melrose this spring
- Automating retrieval of MBRRFC ensemble forecasts
- Enhancing representation of depletions between Boysen/Buffalo Bill and Bighorn Reservoirs
- Future efforts
 - Region-wide statistical forecasts
 - Issue guidance on using statistical forecasting software
 - Implementing ensemble forecasts on all RiverWare models

Updating the Database of Record

- Any new database should:
 - Utilize DECODES
 - Interact with the selected modeling platform
 - Have support throughout Reclamation
- Currently working to implement a contract to perform GP region data management needs assessment.

S&T Project-Risk-based operations

- Research project examining methods to make riskbased decisions on reservoir operations
- Basin to be selected in 2018-probably Bighorn basin
- Use ensembles with operations model and estimates of allowable risk for various parameters to determine "best" operations
- Partners:
 - MTAO, TSC, CADSWES, NCAR
 - Kick-off Meeting scheduled on March 6, 2018 in Boulder, CO.

Questions Contact Info – perger@usbr.gov Phone - 406-247-7755

