RiverWare Planning Model for Deerfield and Pactola Reservoir System

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BARR

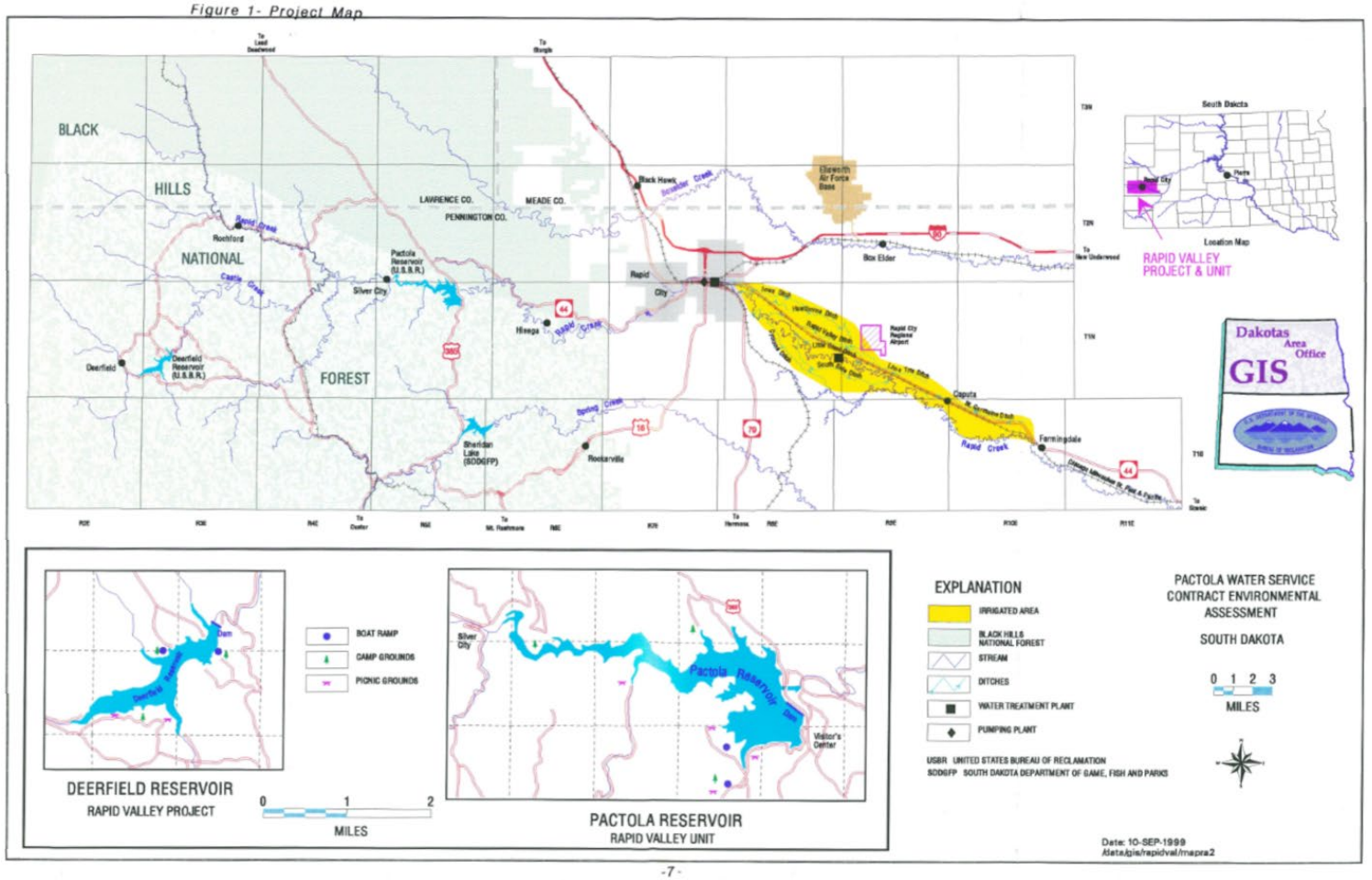
PWRE PRECISION WATER RESOURCES ENGINEERING

The Project

- Led by West Dakota Water Development District (WDWDD), funded through a Bureau of Reclamation (Reclamation) WaterSMART cooperative agreement
- **Goal:** explore reservoir operations that better serve a large group of partners (Reclamation, the City of Rapid City (City), WDWDD, irrigators, and others)
- **Secondary goal:** provide a framework for operations model development
- Barr and PWRE partnership: PWRE providing guidance on the model build, Barr connecting the model to real-life operations, scenario analysis, and partner communication
- Project is ongoing through 2027

The System

- Deerfield Reservoir on Castle Creek, Pactola Reservoir 28 river miles downstream on Rapid Creek, operated in tandem
- Municipal supply for Rapid City and Ellsworth Air Force Base
- Environmental flows, flood control, recreation, irrigation, and senior water rights calls
- Built on a Master's thesis from South Dakota Mines



The Problem

- Operations historically run on experience: institutional knowledge, spreadsheets, and precedent
- Things are changing:
  - City needs to protect supply for a growing population
  - Channel downstream runs low too often; many stakeholders negotiating over the same finite supply
- Without a model, there's no means to examine modified operations to better serve users nor justify a modification to operations
- Large basins get compacts, Records of Decision (RODs), and Environmental Impact Statements (EISs) due to scale forcing the rules onto paper
- Smaller systems tend to run on precedent - many systems in the country operated like this one

The Solution:

Create a model that is more a transparent box rather than a black box.

The model needs to be a partner, a tool, for the operator rather than an oracle. But what does that look like?

The Operator-Modeler Experience

- 13 years operating Navajo Dam, a Colorado River Storage Project (CRSP) unit, as the hydrologic engineer
- As a Modeler
  - San Juan River Daily Operations Model
  - Operations support for San Juan River components of CRMMS, 24-Month Study, MTOM, CRSS (Reclamation, Colorado River Models)
- As a Client or Subject Matter Expert
  - New Mexico's administration and planning model (Hydros)
  - Reclamation's San Juan River Recovery Implementation Program Model (PWRE)
  - San Juan Basin Climate Change Model studies (SNL, LNL)
- Supported non-technical operators of other water management systems
- Perspective from both sides of the table: recognize gaps, bridge operations and modeling staff, catch problems early in both directions

One Model, Two Hats

- No operator(s) present
- Runs 500 hydrologic traces start to finish, unattended (facilitated by RiverSMART)
- Sweeps 672 operating scenarios
- Hands stakeholders a tradeoff space
- Where policy is soft, assumption required
- Transparency in the planning process requires special rules

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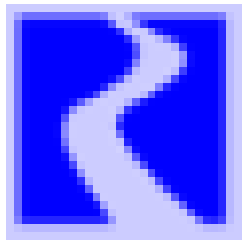

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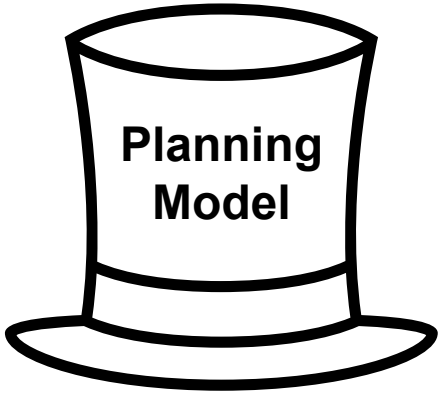

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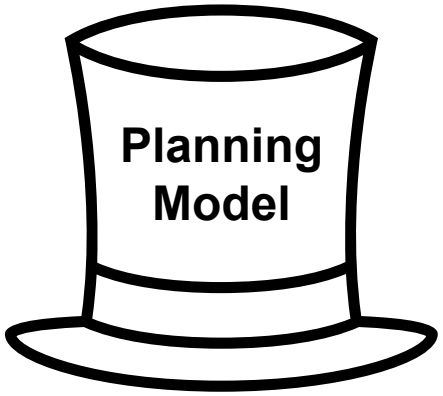

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RiverWare Model

- Operator(s) present during the simulation
- Where the planning model made assumptions, make checks, show relevant information, and ask for input
- Touchpoints for operator(s) - Alerts and decisions during the simulation; checkpoints and decisions outside of the simulation
- Developed from and driven with the planning model framework

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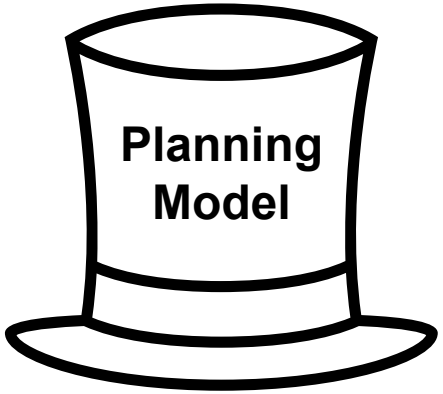

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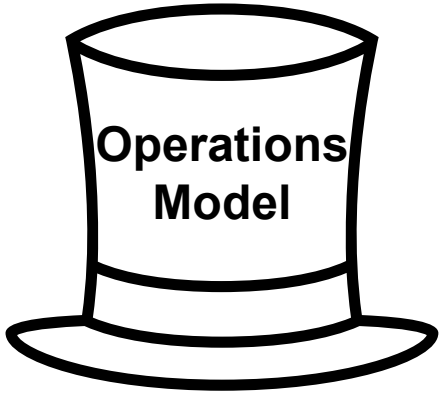

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Hurdle 1: implicit Versus Explicit Logic

The traditional approach

- Operations based on institutional knowledge, spreadsheets, and precedent
- Policy not written in a procedural form because there was no reason
- Logic is…*fuzzy*

A hands-off model needs rules that are complete, explicit, and consistent

Four kinds of logic discovered

- *Written and operative:* guide curves, minimum releases, flood control tables
  - Documented and implementable
- *Written, but not consistent:* minimum releases modified based on accounting that isn't explicitly computed and tracked
- *Written, but undefined:* drought operations require “prolonged drought” – no criteria specified in documentation
- *Not written anywhere:* Handling negative storage accounts – Reclamation's pool ran negative Dec 2024 to Apr 2025
  - Real, correct, but how to handle appears in no documentation

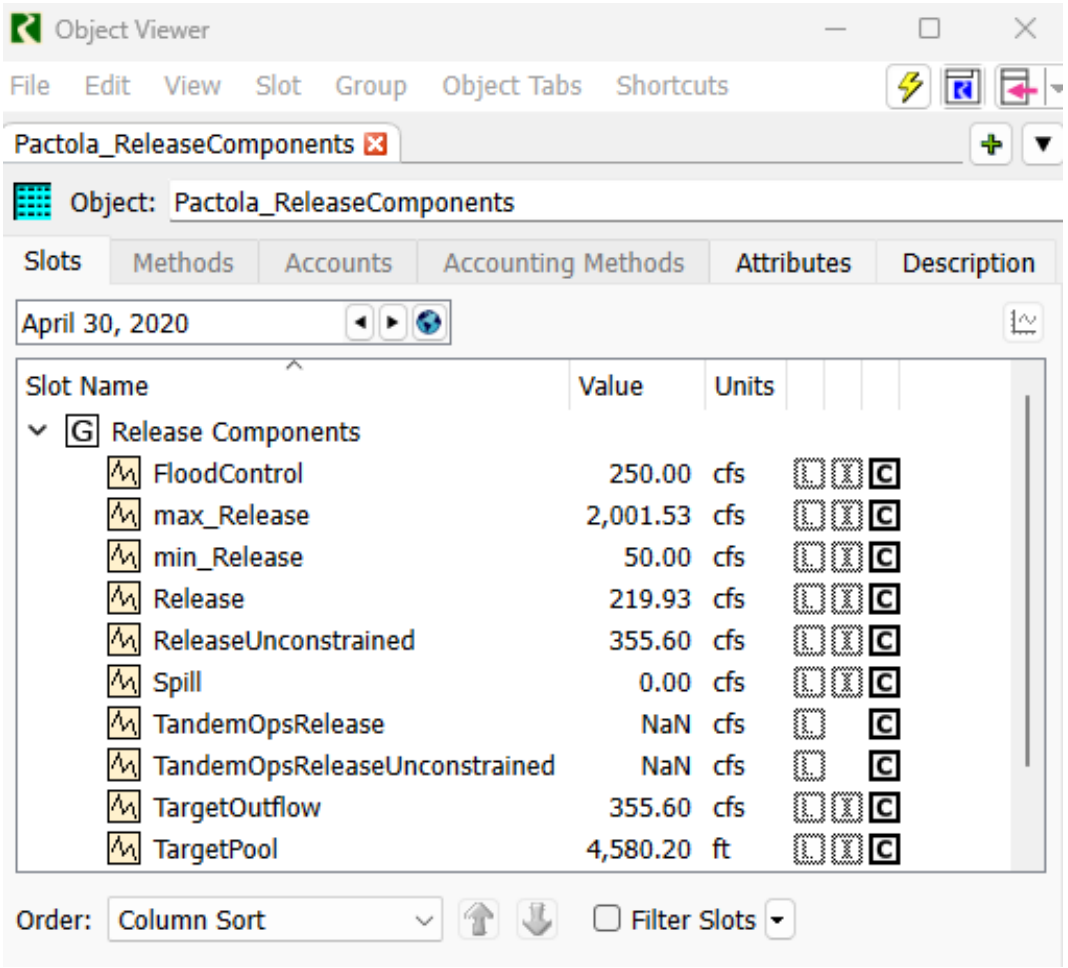
Hurdle 2: Constructing the Reservoir Release

The traditional approach

- One physical outflow, several obligations:
  - Minimum release, maximum release
  - Guide curve, flood control
  - Tandem operations
  - Etc.
- The standard method is sequential: set a baseline release, then refine it with successively higher-priority rules

However

- Once higher-priority rule overrides, overridden values are gone
- Know which rule took precedent, but don't know results of other rules nor how they may have affected release
- Difficult to analyze how release got to value it did – How does one know the tradeoffs and how can one validate the targets were calculated correctly?



Solution – Release Components

Independent components

- Each release target or component computed (once) in its own rule and value assigned to its own slot
- Utilize a “Set Reservoir Releases” rule that can refire and is dependent upon component slot values
- At every timestep, the release is known and it’s easy to dissect how it arrived at that release
- Can easily examine things like: how close the system ran to flood control on days the guide curve governed, what a guide curve release would have been without outlet works constraints, etc.

Adds transparency

- Peer review asked for the explicit rule-succession trail our original rules didn't have
- The fix: helper slots recording which rule and factor's value was selected (in progress)

Planning and operational models need transparency – the model is only a partner and tool if the operator can understand its decisions

Release Components

1. “Set Reservoir Releases” rule executes first with a baseline release – no execution constraint
2. Subsequent rule determines a target/factor and assigns it to a slot – NOT HasRuleFiredSuccessfully() execution constraint
3. “Set Reservoir Releases” rule refires due to dependency on assigned slot
4. Repeat steps 2 and 3 for all targets/factors
5. Once all targets/factors have been computed, “Set Reservoir Releases” rule can be easily dissected to know why the reservoir release was what is was

Lessons Learned

Get everyone in the room early

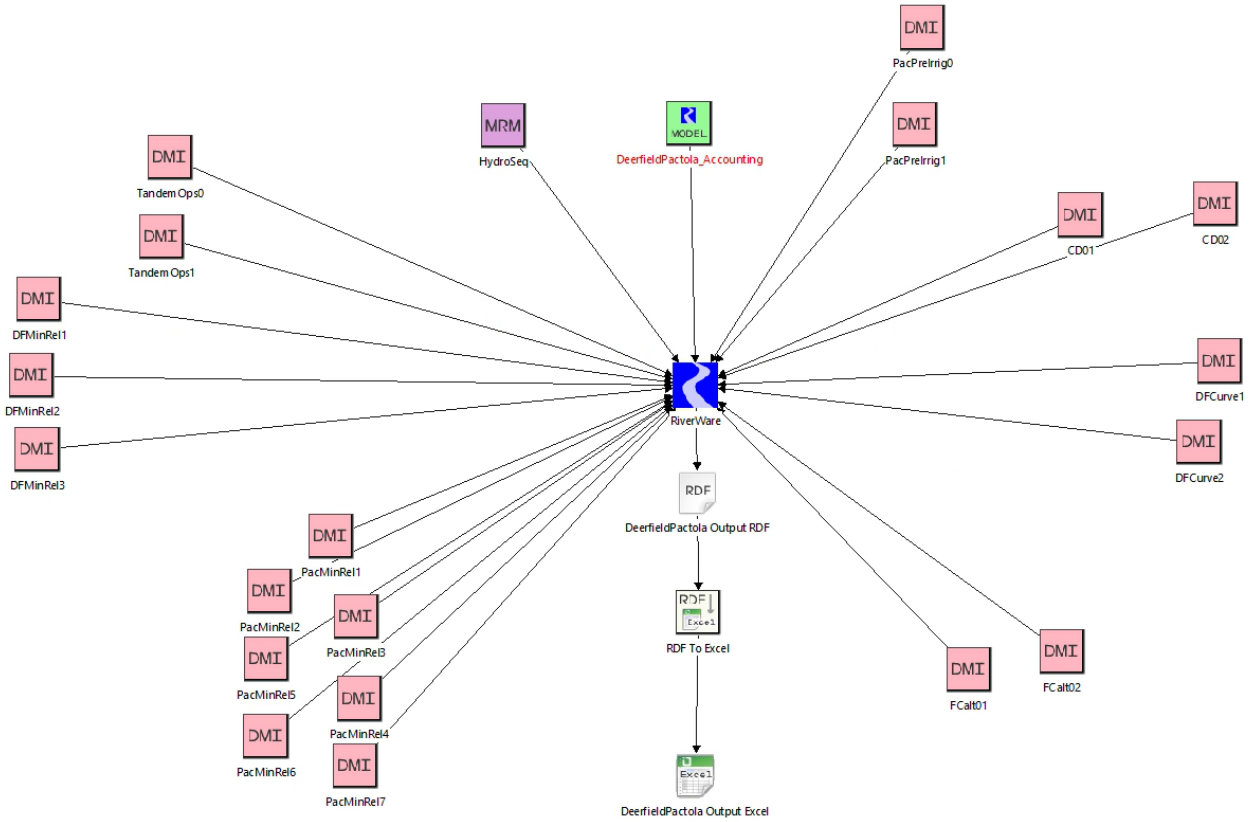
- If policy has never been made explicit, you make it explicit by getting everyone who holds a piece of it into the design conversation before the rules are written/finalized
- Design choice can be technically defensible and still hard to review. Cheap to fix in design, expensive after
- Mean everyone – not just the project proponent, but final reviewers, project partners, and the operators. Spend time upfront even for a small system (especially with a small system that has undefined parameters)
- Document, document, document; share documentation early (and don't make it too long at this stage…no one has time for that)

Scenarios and Tradeoffs

Planning model specifics

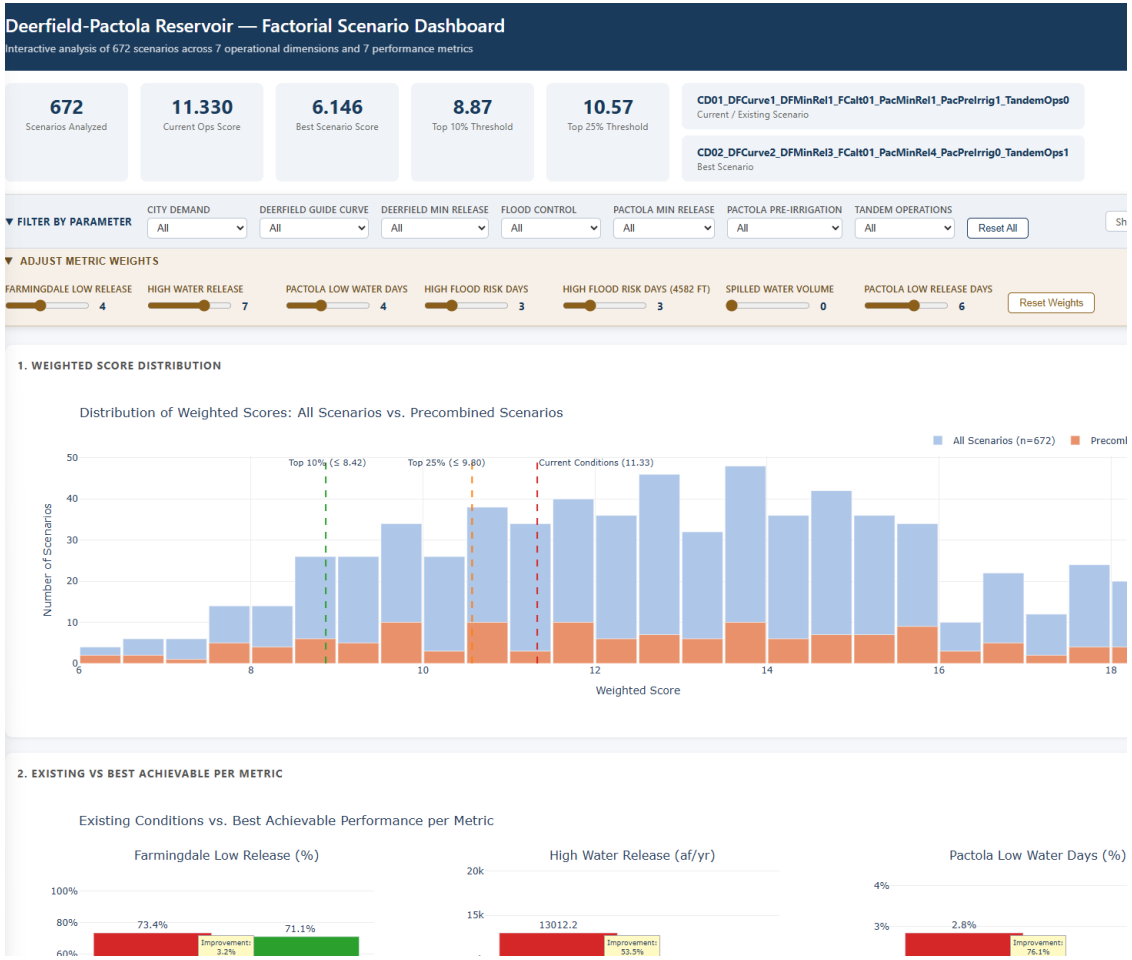
- 672-scenario factorial sweep across seven operating factors managed in RiverSMART
- Synthesized down to the viable options
- 500-trace stochastic analysis
- Tradeoff results now in front of the stakeholder group

This is manageable for a two-reservoir municipal system with a small district as lead.



Translating the Model For Partners (In Progress)

- Not all operators are technical
- Interactive dashboards built by Elise Madonna at Barr using AI-generated tooling
- Partners adjusted metric weights and watch the alternatives reorder themselves during an interactive meeting
- Everyone has a different idea of what “good” looks like for reservoir operations
- Whittle down everyone’s minimum thresholds and you’re left with no one’s favorite but something everyone can live with



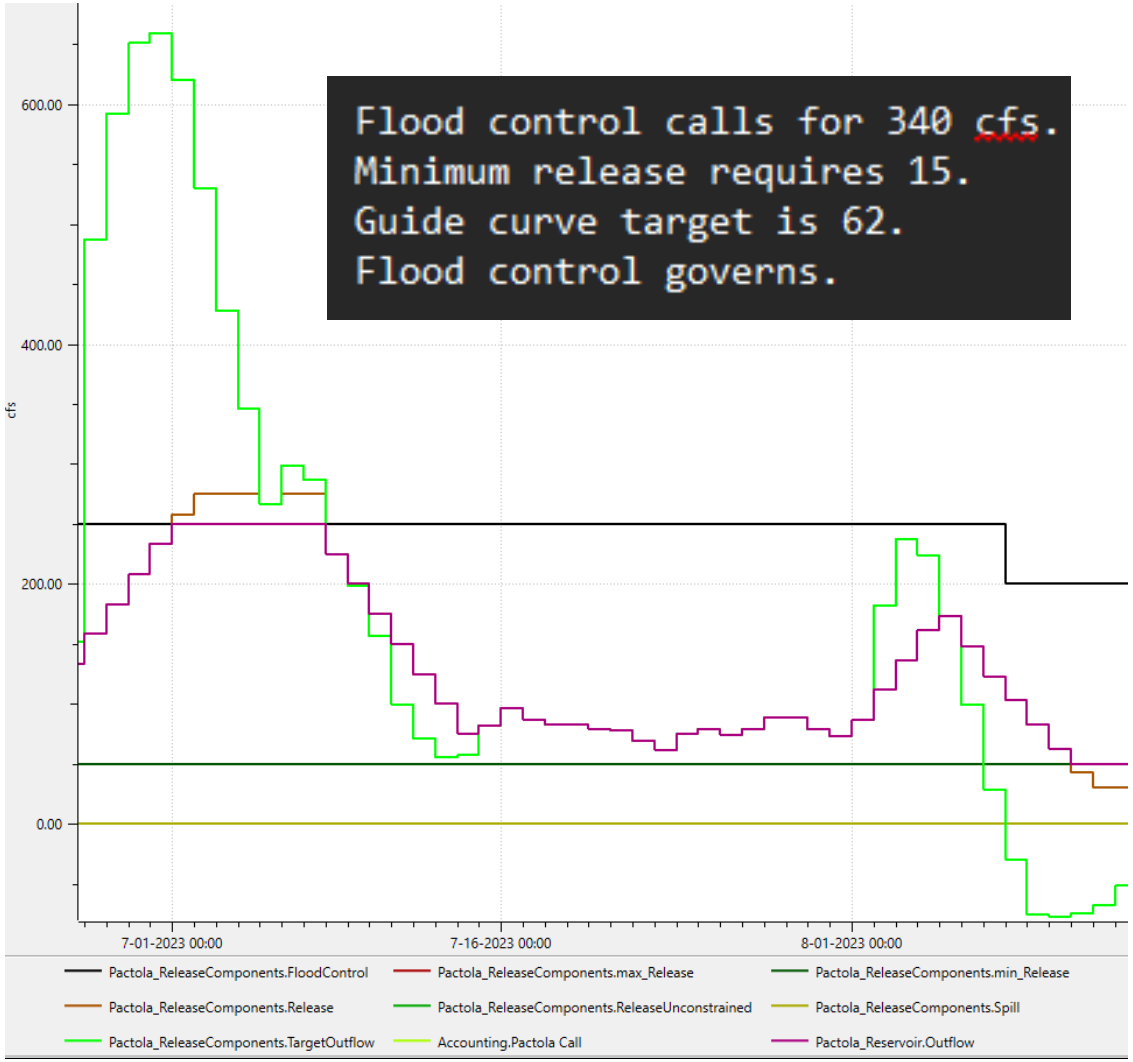
Framework for Operations (Future)

Operational payoff for the release components architecture:

Replace assumptions with touchpoints for the operator to help produce consistent, defensible results

Touchpoints are helpful for operators who have not traditionally run models

1. Helps them trust the model
2. Helps them understand what the model is doing
3. Helps them document explicit rules that reside in their heads



Framework for Operations (Future)

Keeping the Operator in the driver's seat with *fuzzy* logic decisions

A slot holding the determination and the date it was made, so the release trail reads "DPR schedule active per operator determination 2025-03-14" rather than the schedule just silently switching.

```
Reclamation pool depleted at 2025-03-14.
Minimum release schedule unchanged pending drought determination.
Confirm before the next run.
```

```
Reclamation pool is depleted.
DPR schedule also requires a prolonged drought determination
as per Accounting Narrative 30258.13

Drought determination for this run:
○ In prolonged drought (DPR)
○ Not in prolonged drought (FONSI)
```

Reclamation's peer review strengthened the model and laid the foundation for future operational use

Transparent models matter most where documentation is thinnest

Thank you!

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