Center for Advanced Decision Support for Water and Environmental Systems (CADSWES)
UNIVERSITY OF COLORADO **BOULDER**

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# Deep Aquifer Modeling within an Operations and Planning Decision Support Tool on the Rio Grande River, New Mexico


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2023 RiverWare User Group Meeting August 29-30, 2023

# Application: Upper Rio Grande

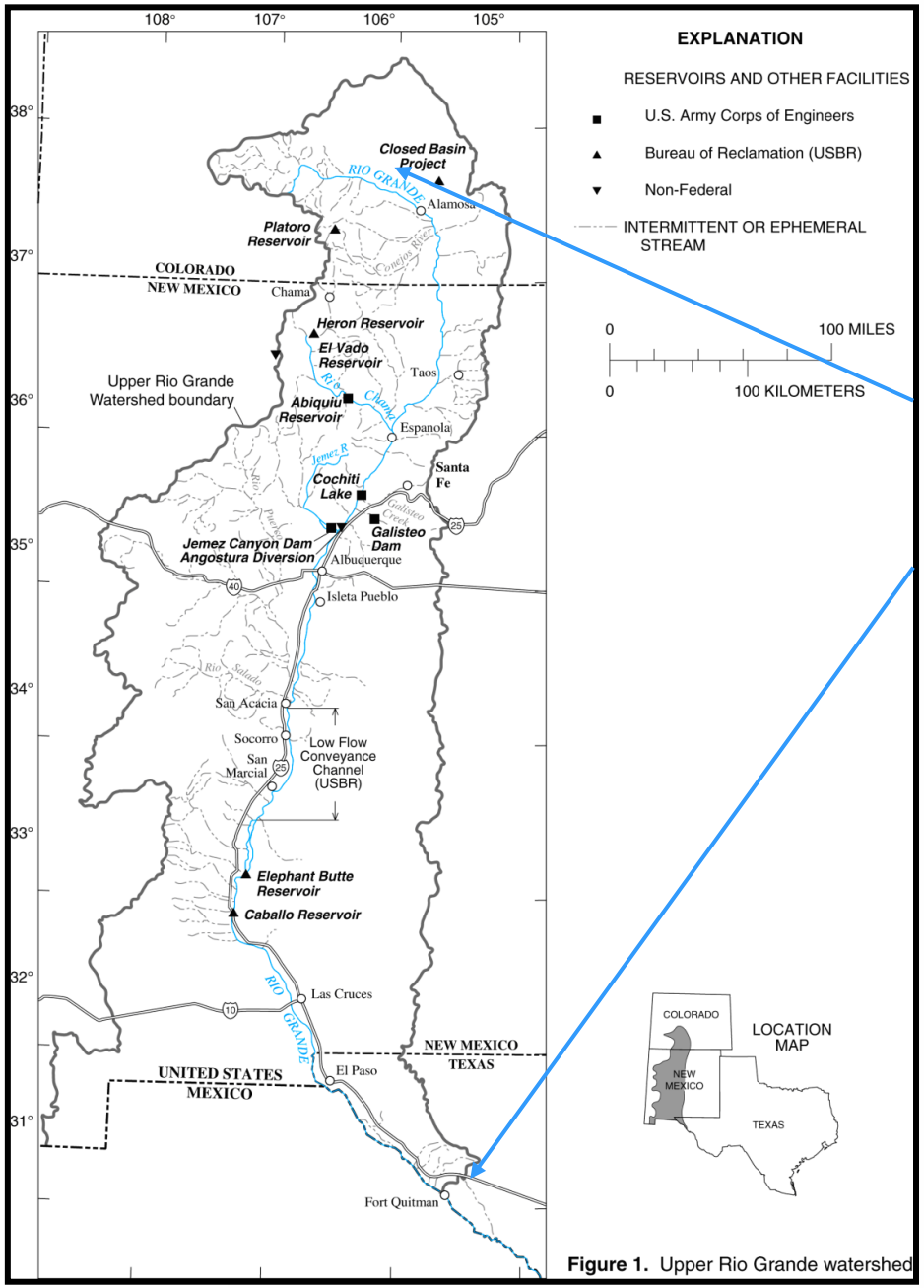
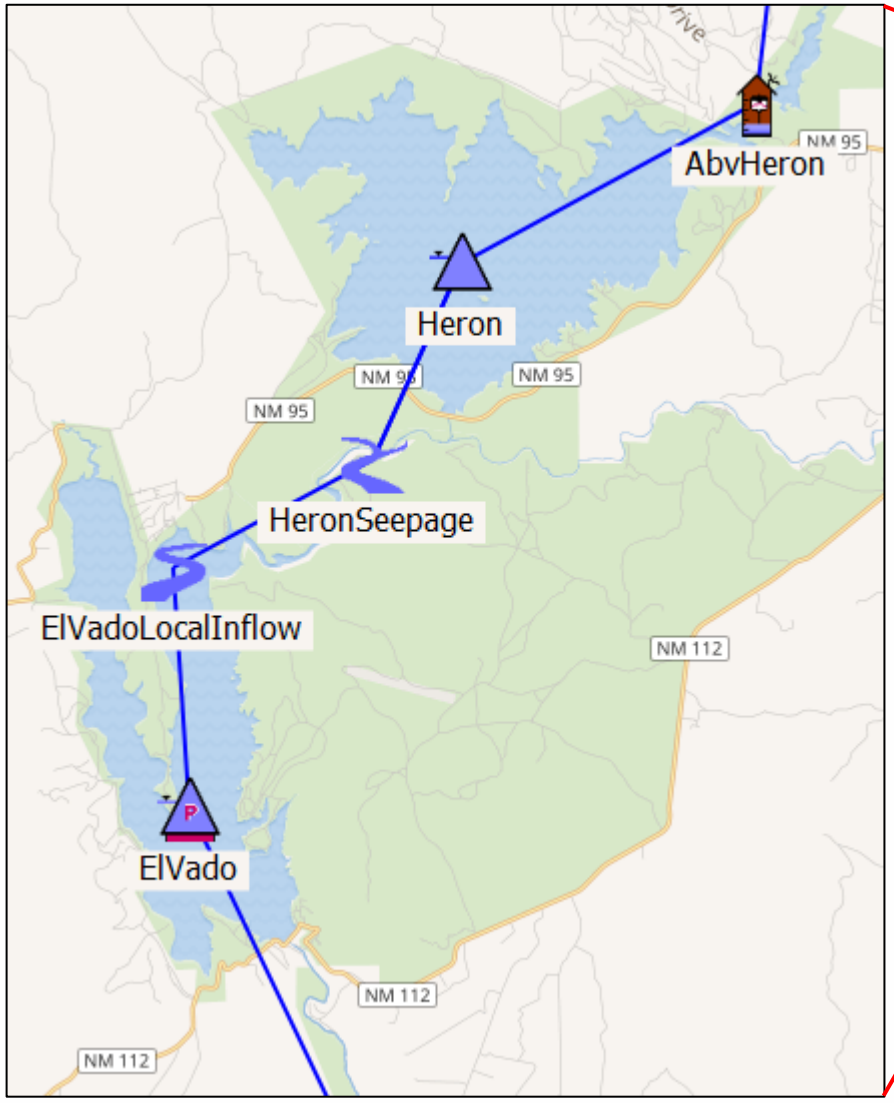


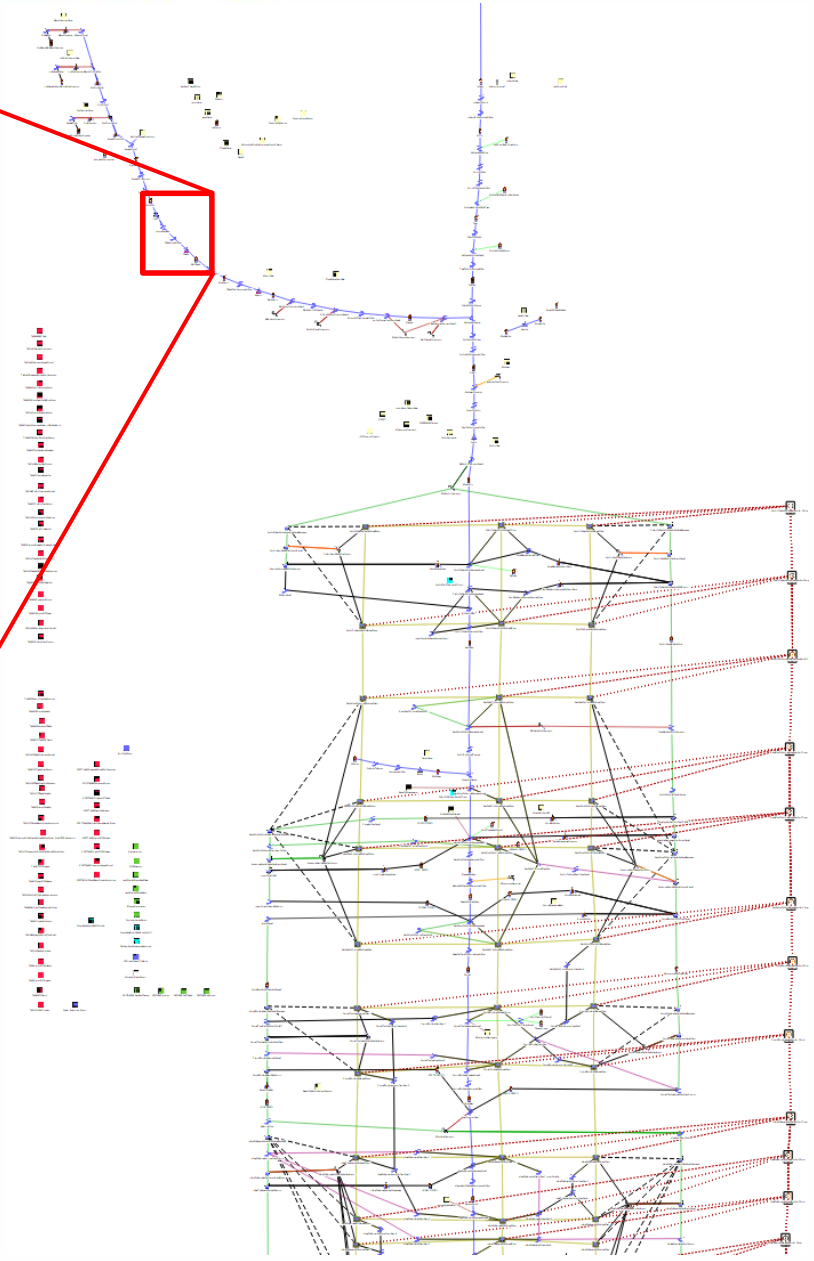

Figure 1. Upper Rio Grande watershed

Colorado to
Ft. Quitman, Texas

Upper Rio Grande Water Operations Model (URGWOM)

# URGWOM RiverWare Model



# Sample Rio Grande Reach

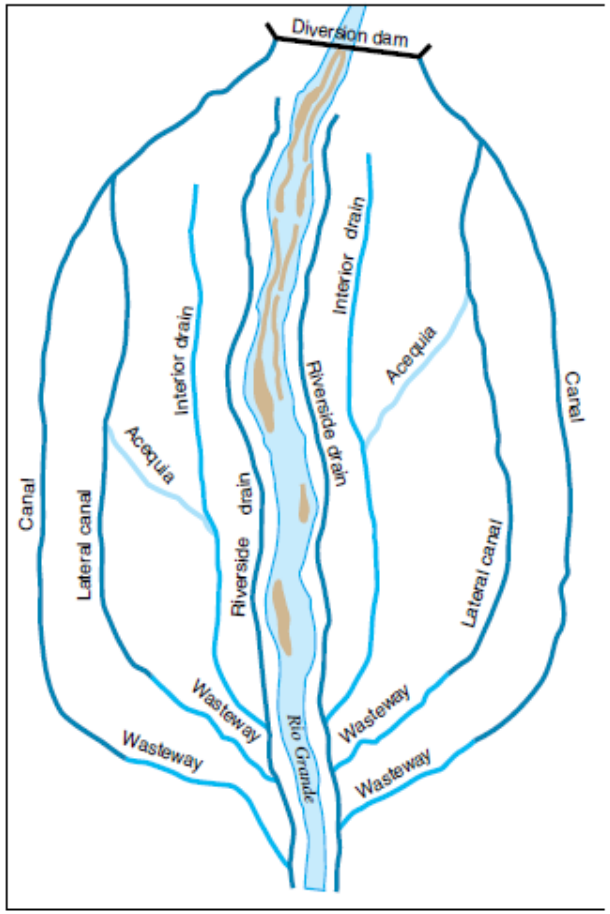
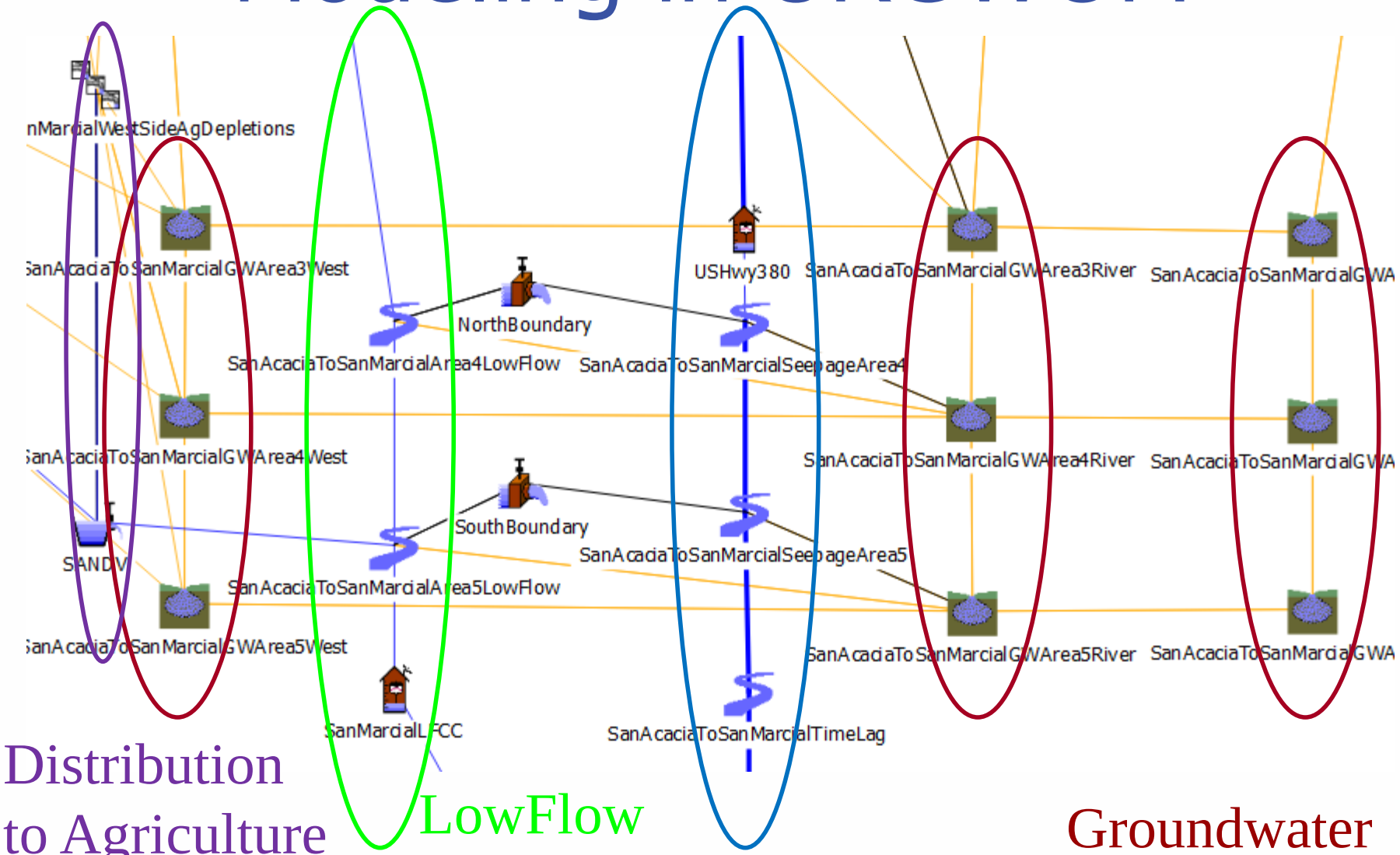



***Figure 4.2.**—Schematic diagram of the inner valley irrigation network in the Middle Rio Grande Basin.*

The middle and lower valley consist of Irrigation canals, farms, drains and wasteway channels

Source: Bartolino, J.R. and J.C. Cole, 2002, Ground-water resources of the middle Rio Grande basin, New Mexico, 2002, USGS Circular: 1222

# Modeling in URGWOM



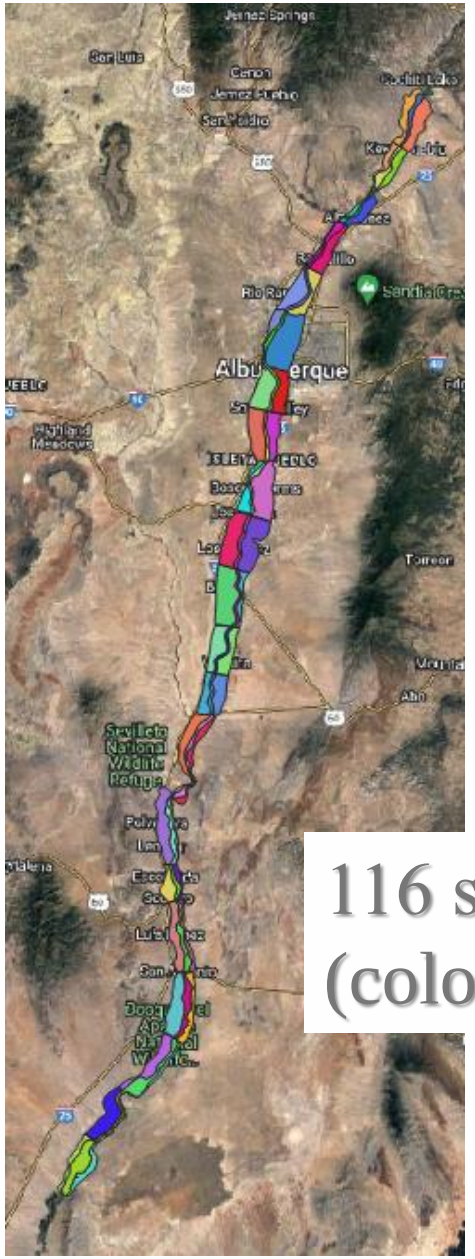

Distribution to Agriculture

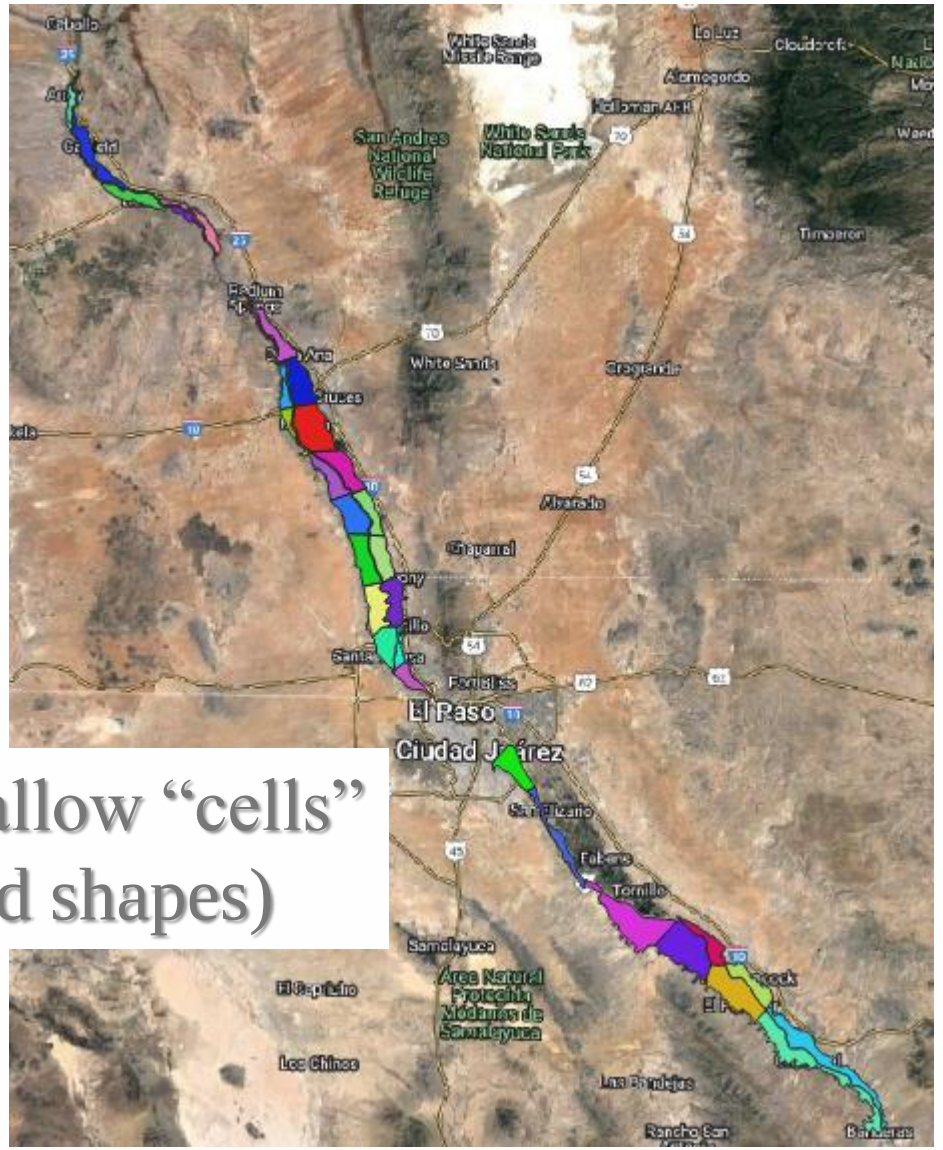
LowFlow

Main River

Groundwater Network

# Groundwater model in URGWOM




116 shallow “cells” (colored shapes)

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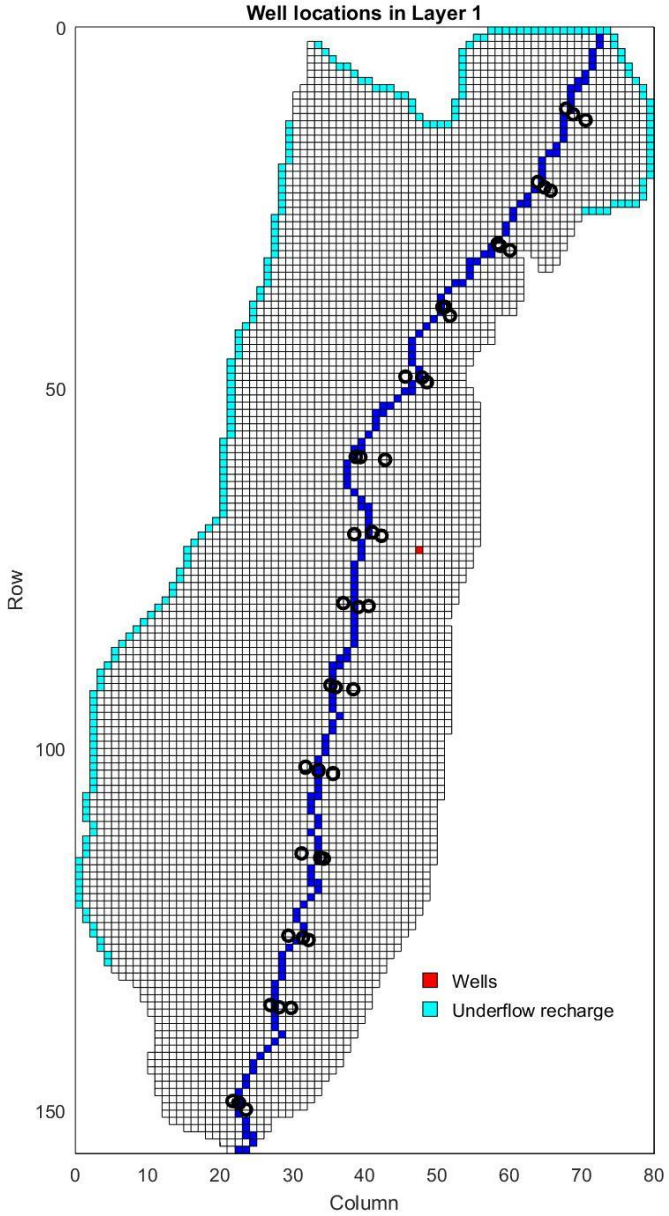
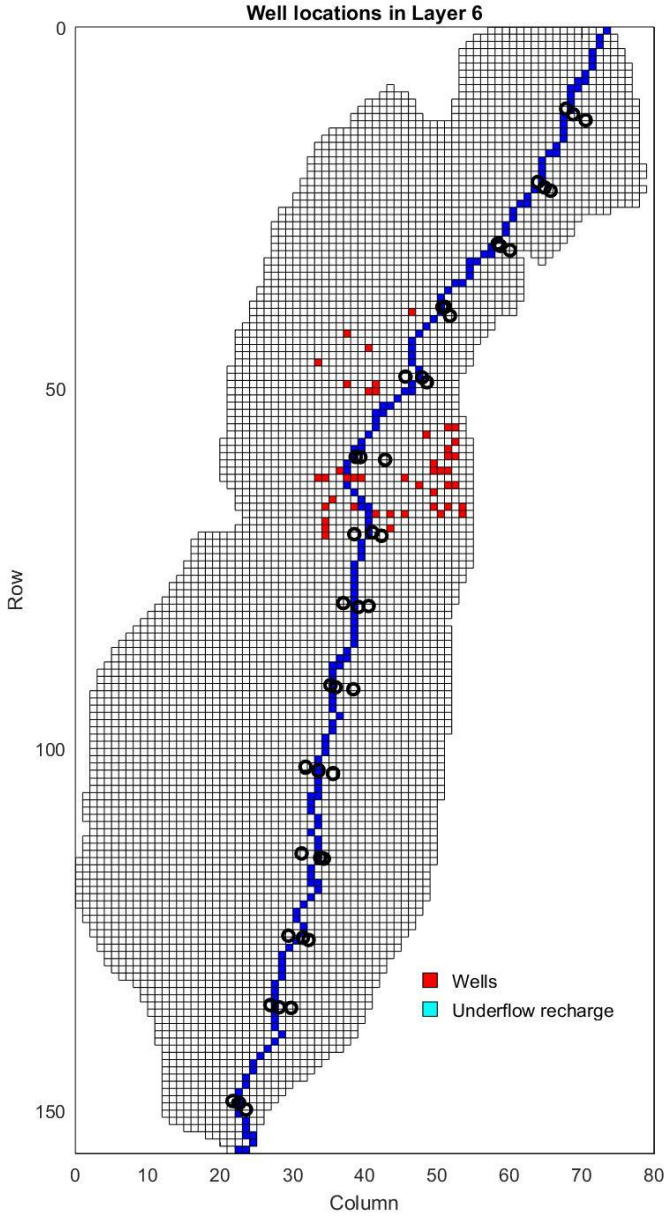
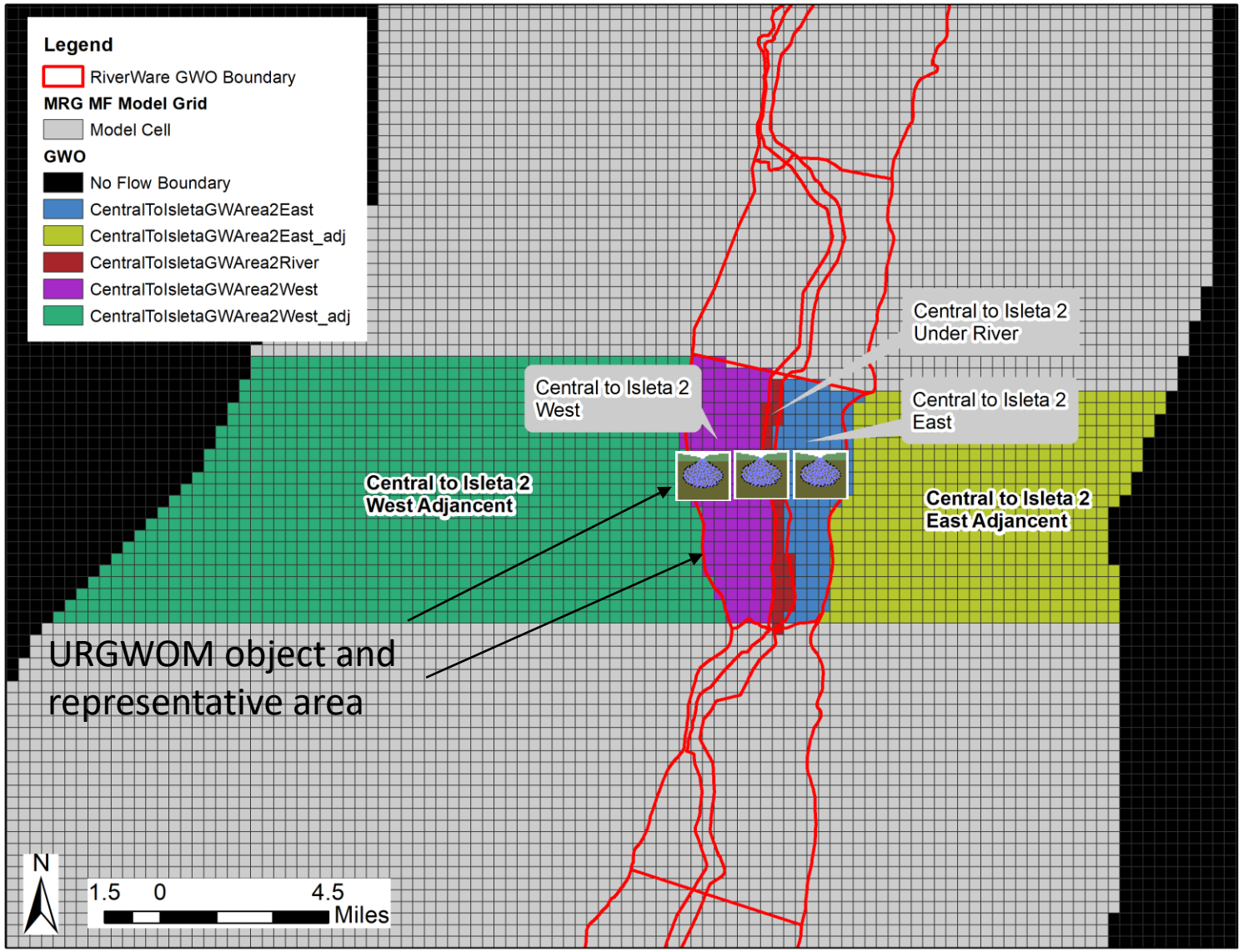
# Limitations

- Deep boundary conditions were from MODFLOW models
  - Hard to update
  - Only one trace of aquifer heads in planning runs
- Unable to answer questions like: How does a long-term drought, increased deep pumping, and/or changes to recharge rates affect the surface system?

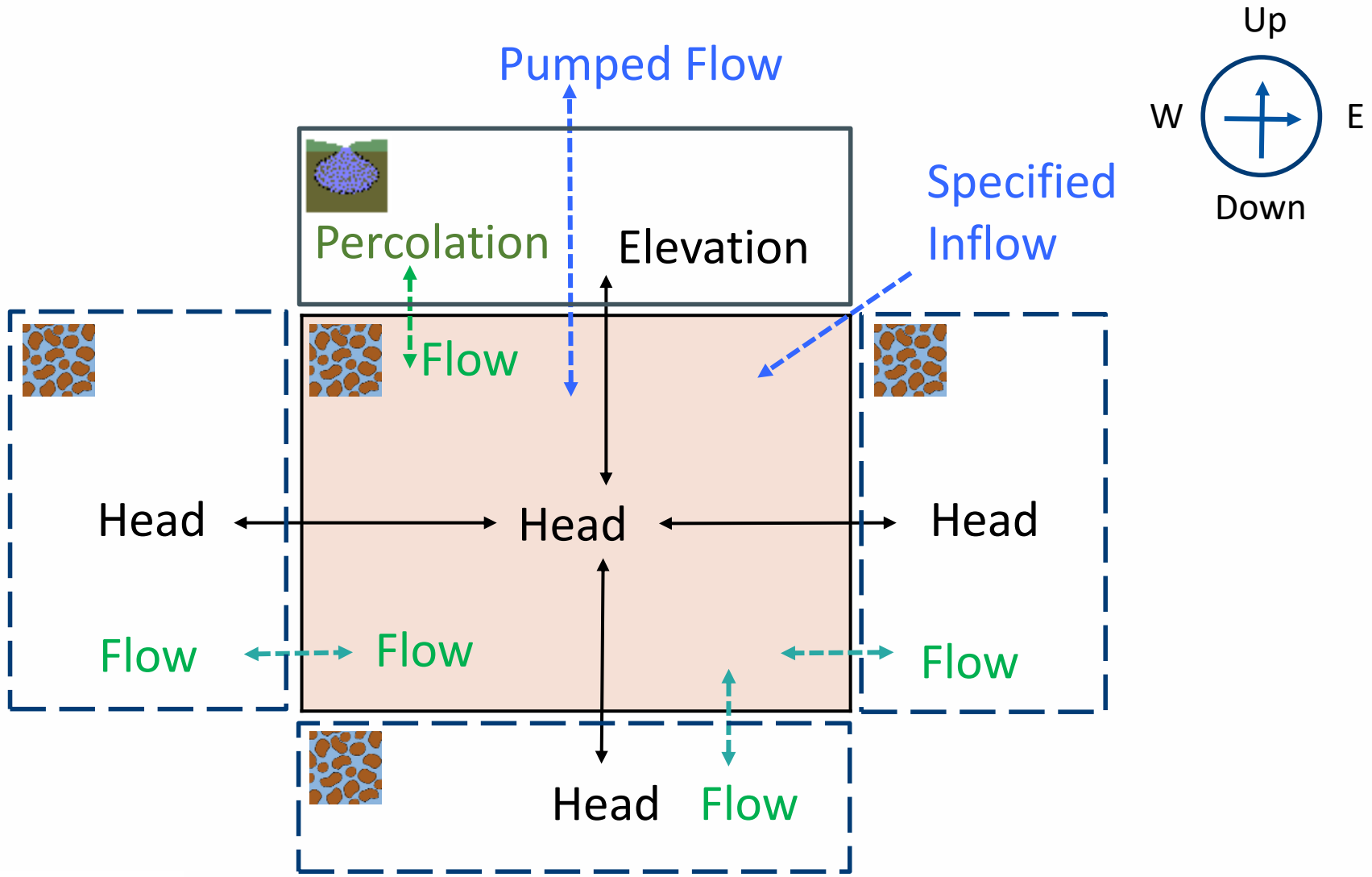

Well locations in Layer 1
Row
Column
Wells
Underflow recharge

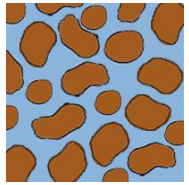

Well locations in Layer 6
Row
Column
Wells
Underflow recharge

# MODFLOW Area Aggregation



# Aquifer Connections and Fluxes





# Aquifer Object Equations

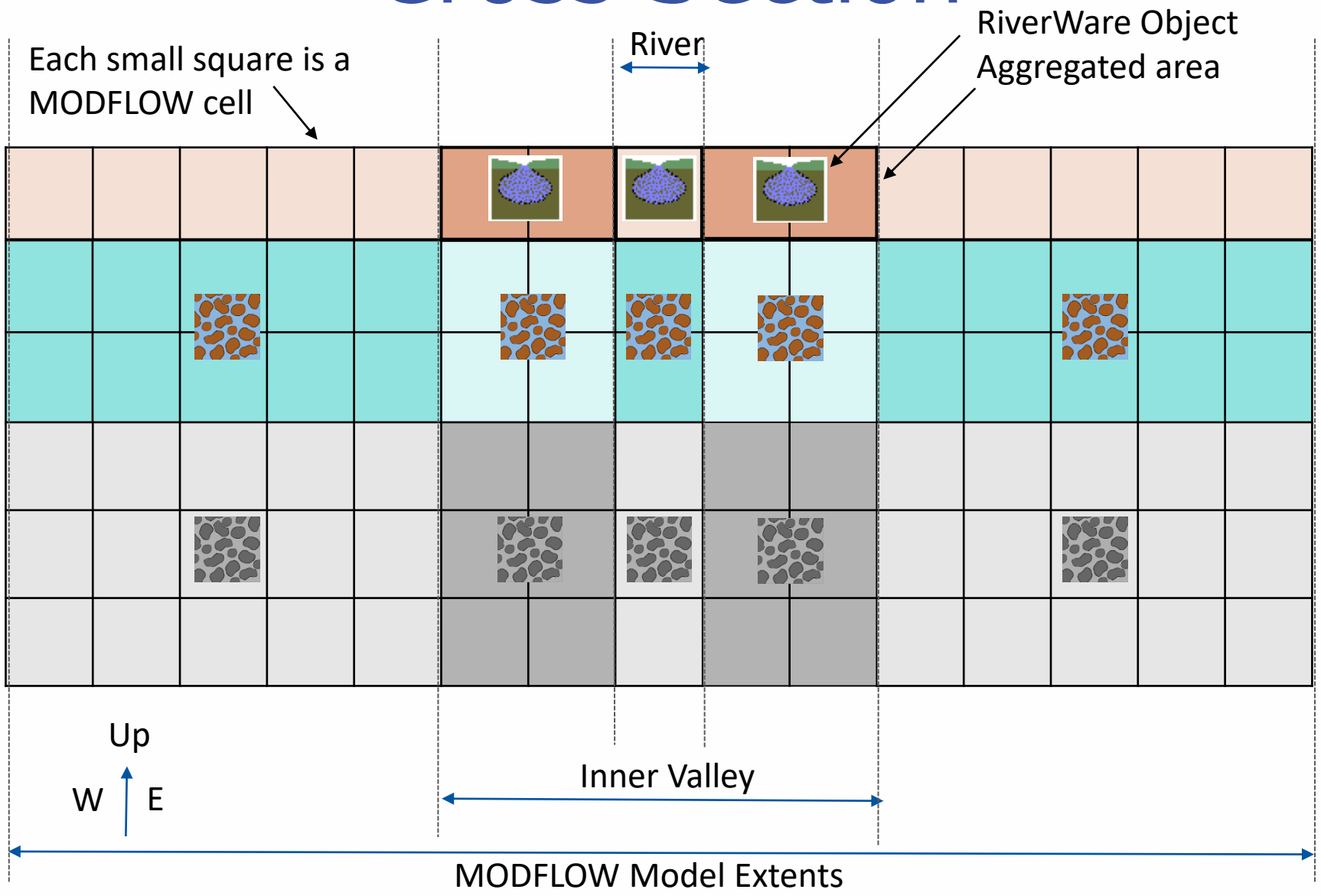
For each of six directions, i,

$$\text{Flow}_i = \text{Conductance}_i(\text{HeadPrevious}_i - \text{HeadPrevious})$$

$$\text{Storage} = \text{Storage}(-1) + \left(\sum_i \text{Flow}_i - \text{PumpedFlow} + \text{Specified Inflows}\right)\Delta t$$

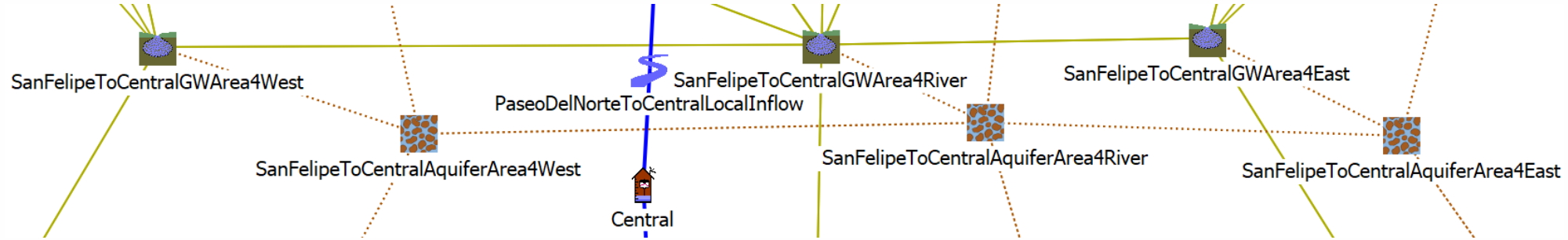
$$\text{Head} = \text{Head}(-1) + \frac{Storage - Storage(-1)}{Storativity \times Area}$$

# Cross Section



# Aquifer Object Implementation in URGWOM

## Added 185 Aquifer objects




Added recharge, and irrigation, municipal, industrial and domestic pumping from deep and shallow layers

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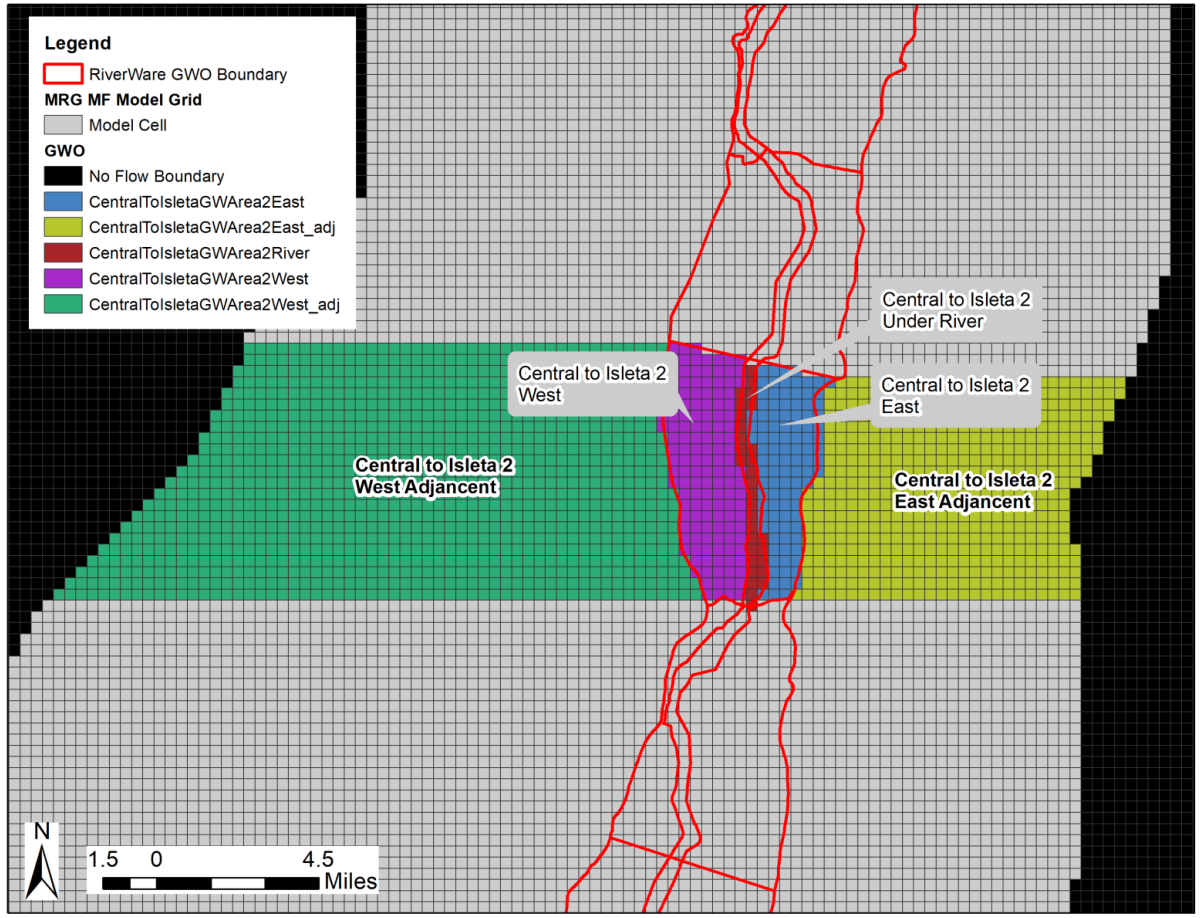
# Data from MODFLOW models

- Aquifer parameter data
- Pumping and recharge data
- Aquifer Head data




Cochiti to San Acacia: Meyers (USGS) et al., 2019
San Acacia to San Marcial: Shafike (NMISC), 2005
Caballo to Mesilla: NMISC 2011 Mesilla Bolson model
El Paso to Hudspeth: USGS 2003 Hueco Bolson model

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# Calibration Process

- 219 total calibration targets
  - Match historical USGS gage flows
  - Match averaged aquifer heads from MODFLOW models
- Calibration period: 1975-2014
- Parameters were calibrated using PEST software
  - 395 total calibration parameters

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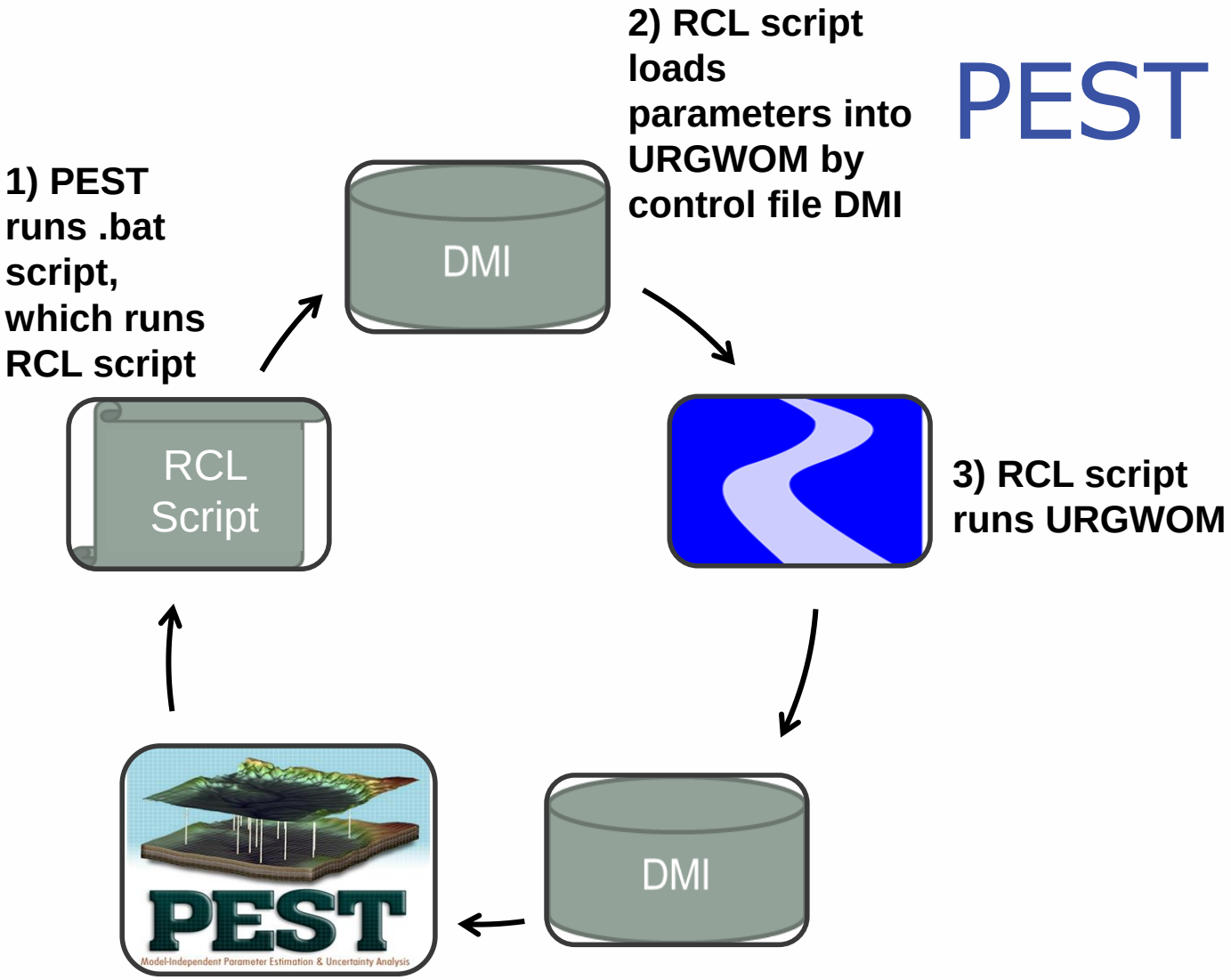
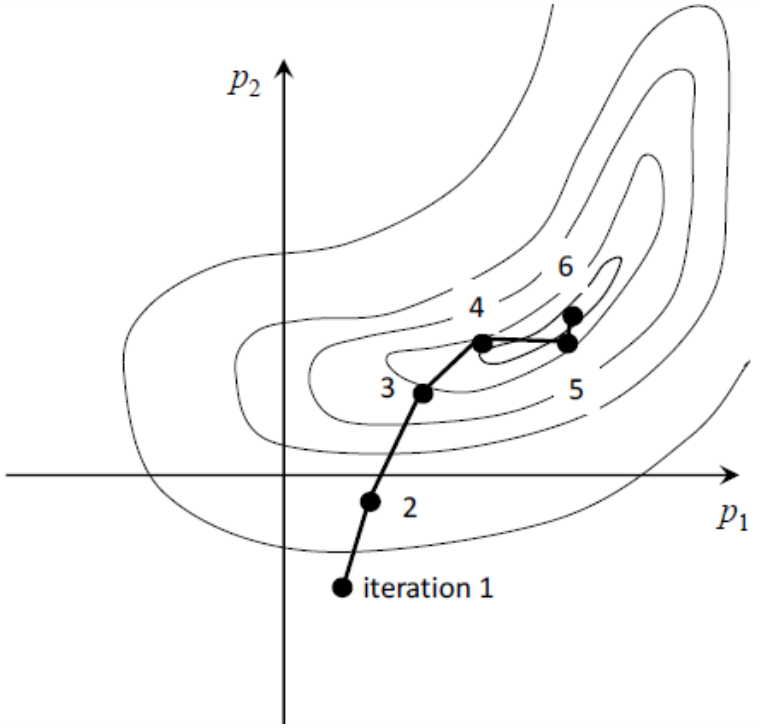
PEST
Model Independent Parameter Estimation & Uncertainty Analysis

# PEST



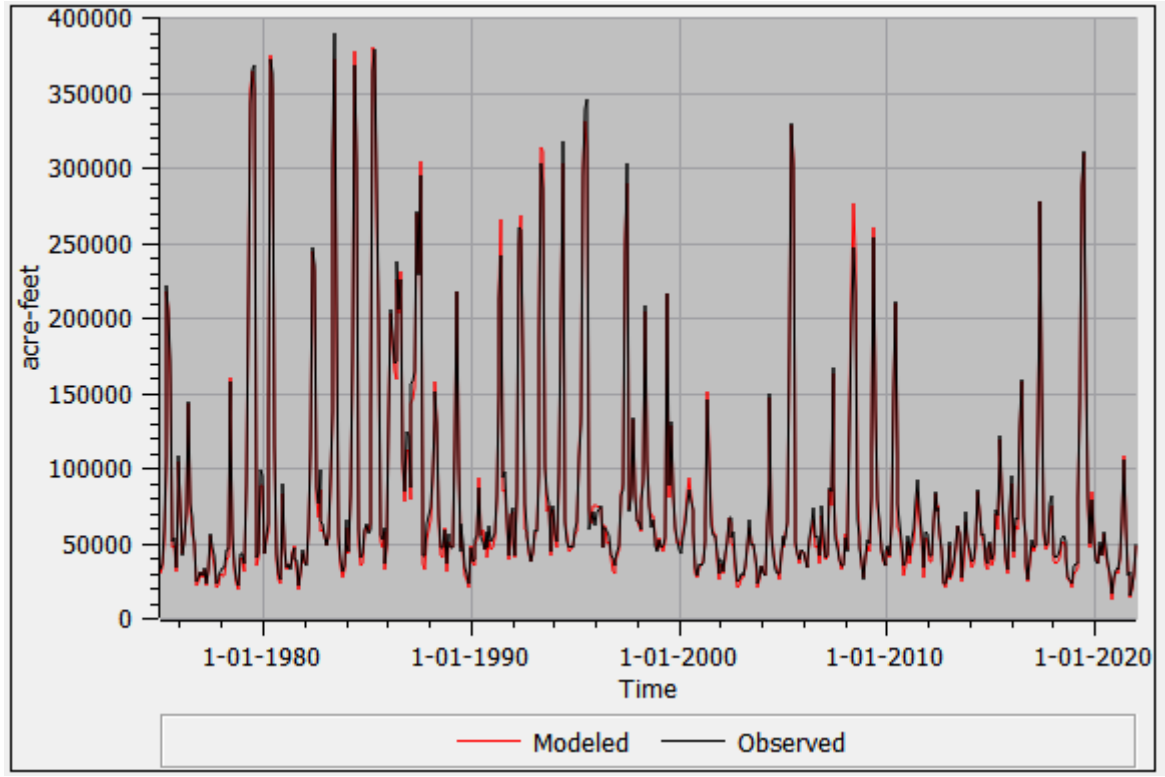




Example of PEST movement parameters values through the objective function space (contours)

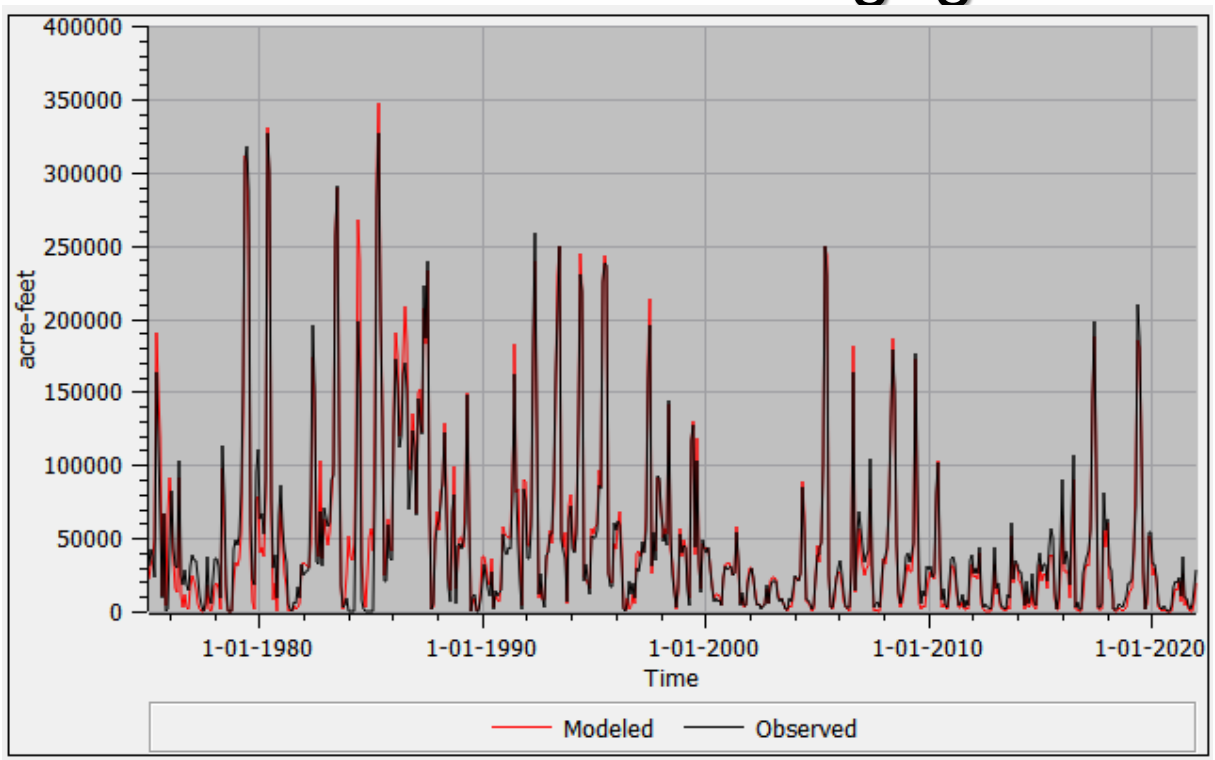
Doherty, 2015 (Fig. 5.5)

# Calibration Results

## San Felipe USGS gage




## San Marcial USGS gage




Nash Sutcliffe Efficiency > 0.92 at all calibration gages

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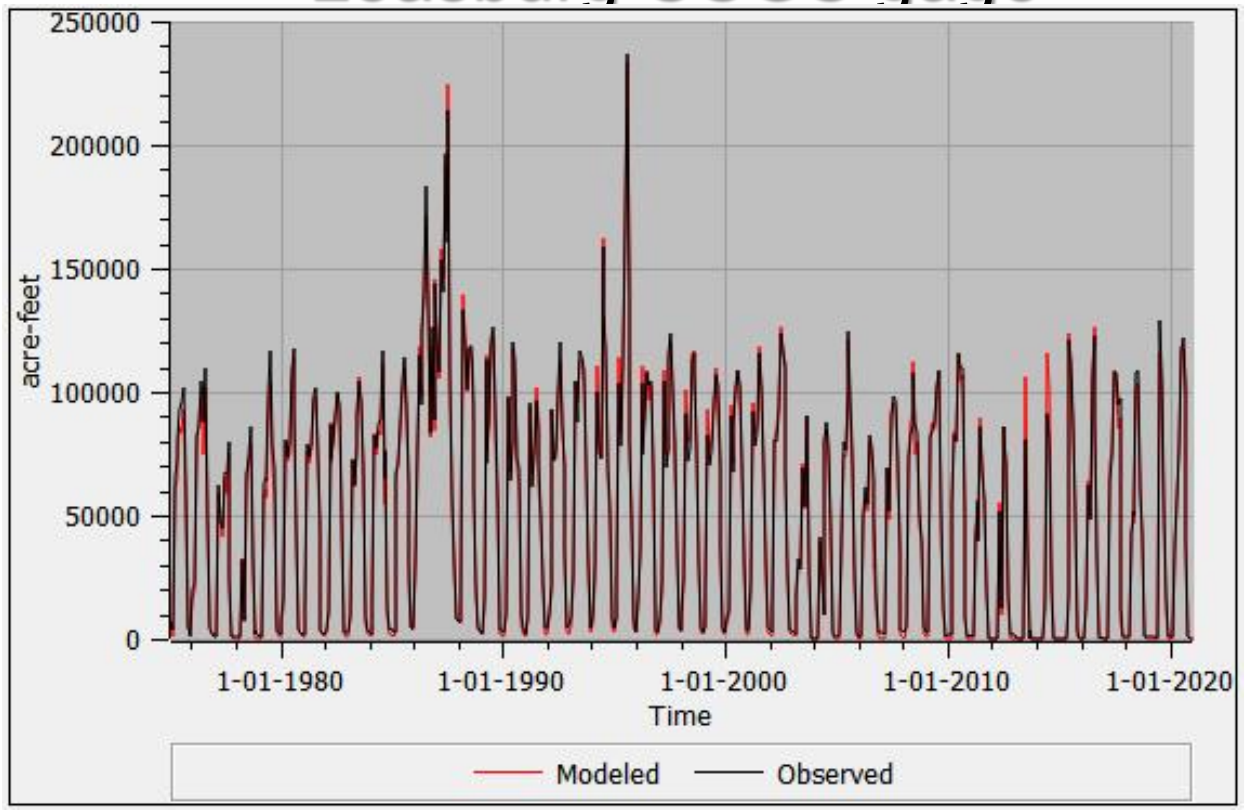
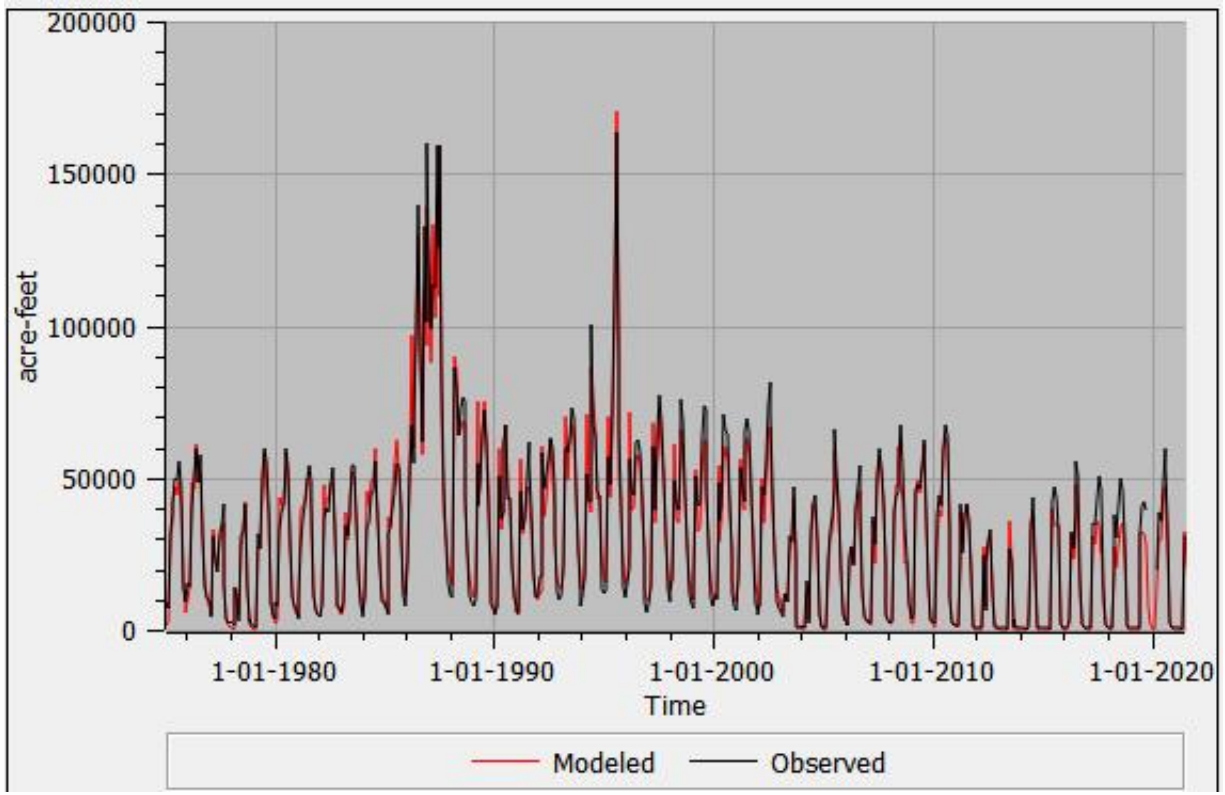
# Calibration Results

## Leasburg USGS gage




## El Paso USGS gage

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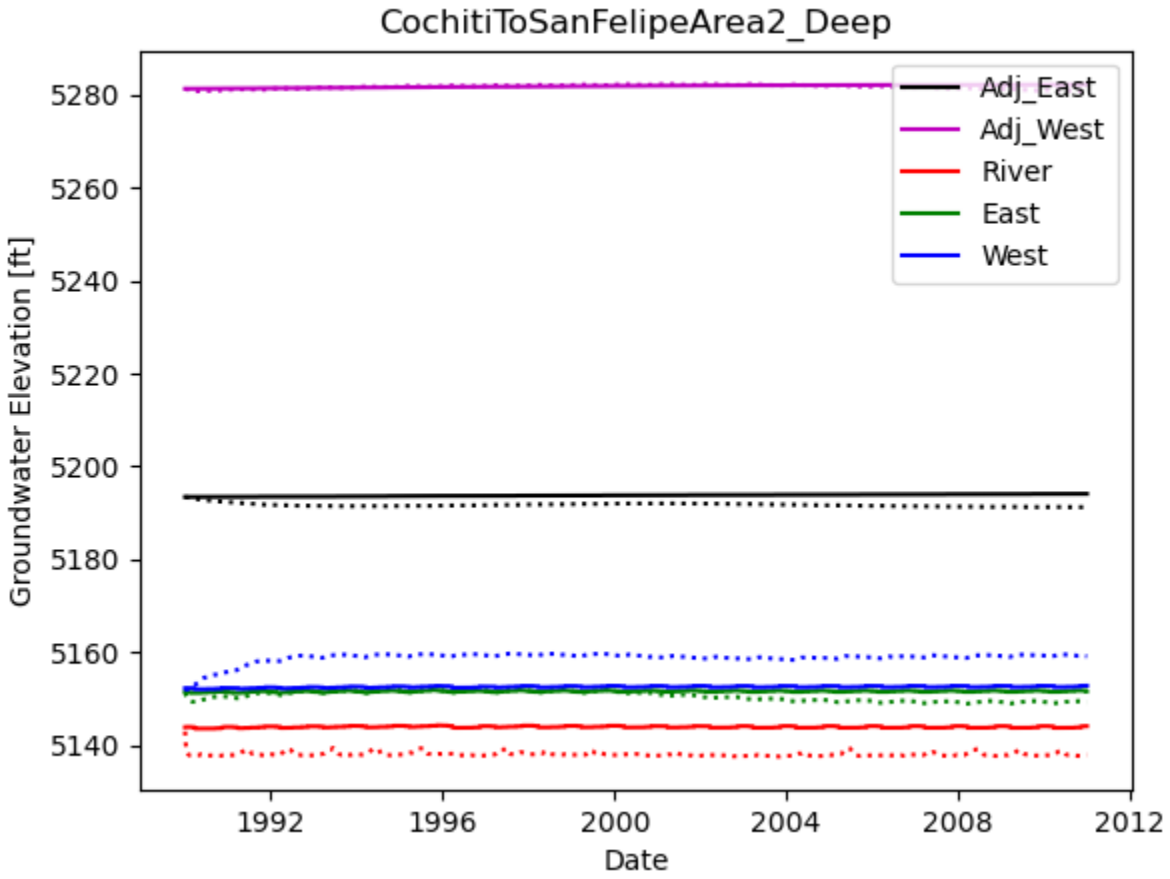
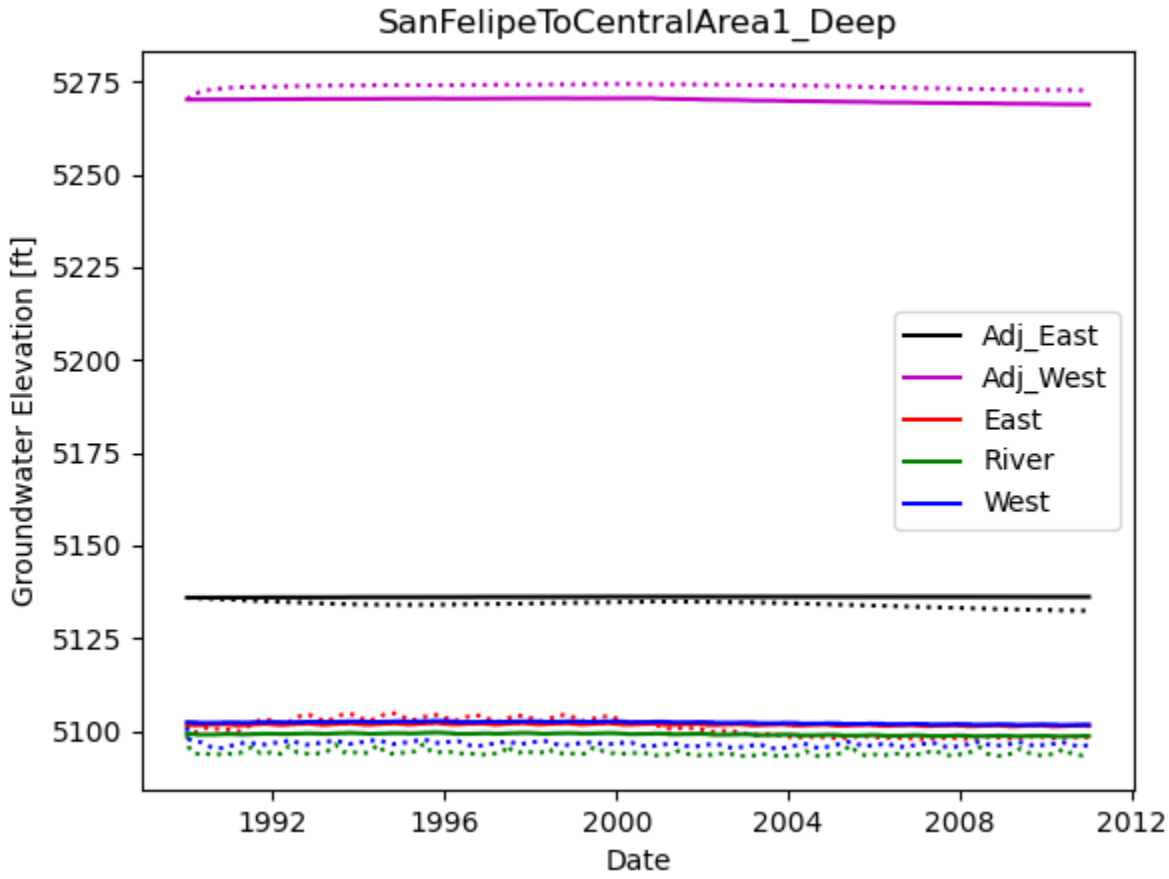
# Calibration Results




Aquifer head RMSE generally less than 5 feet

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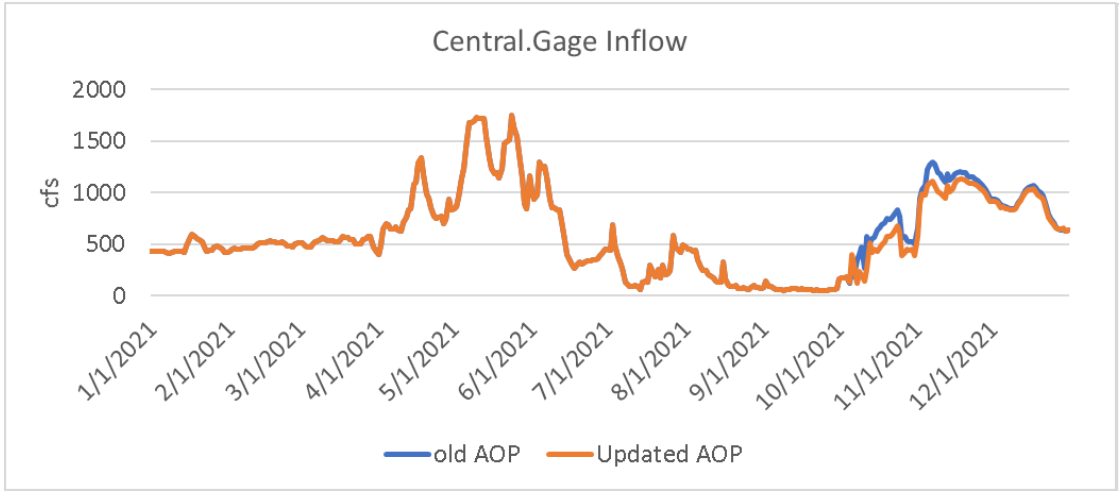
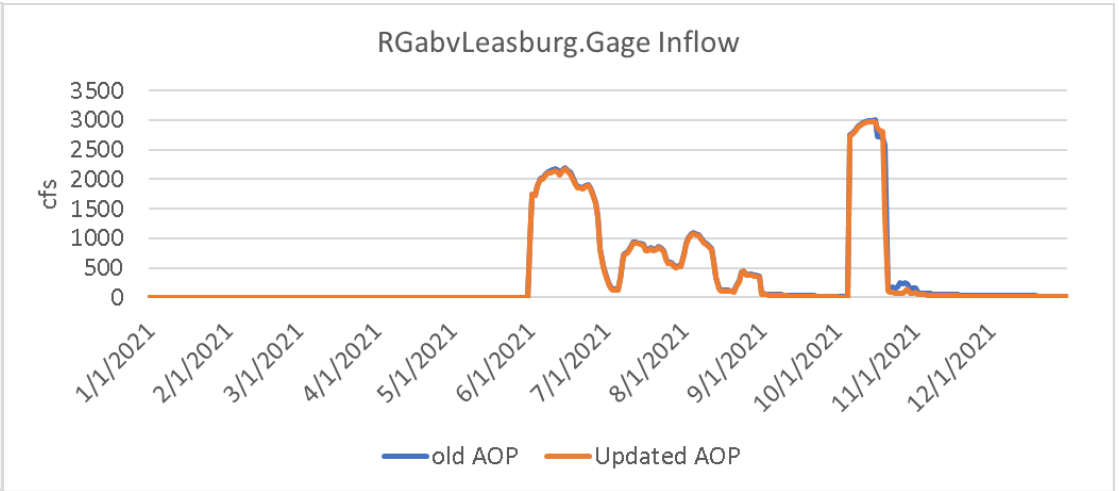
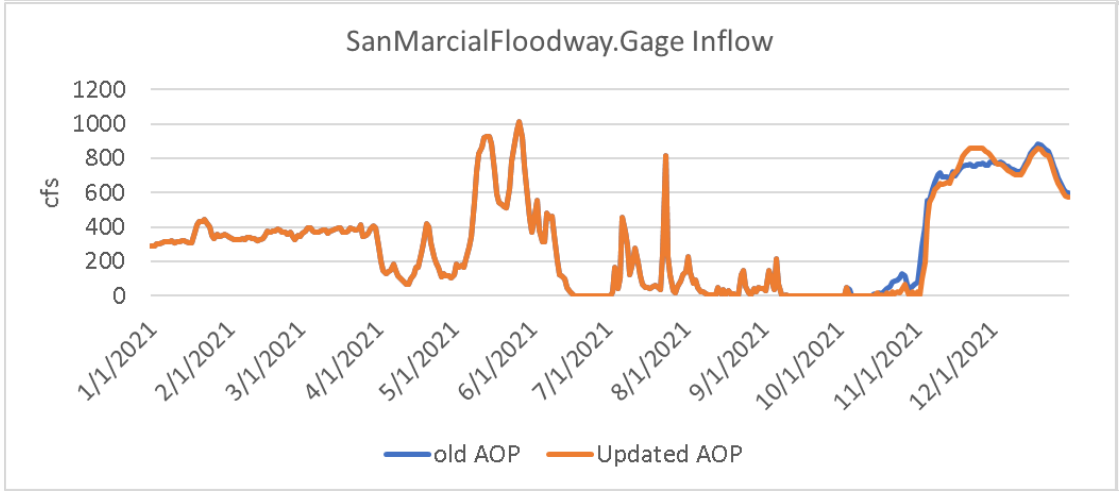
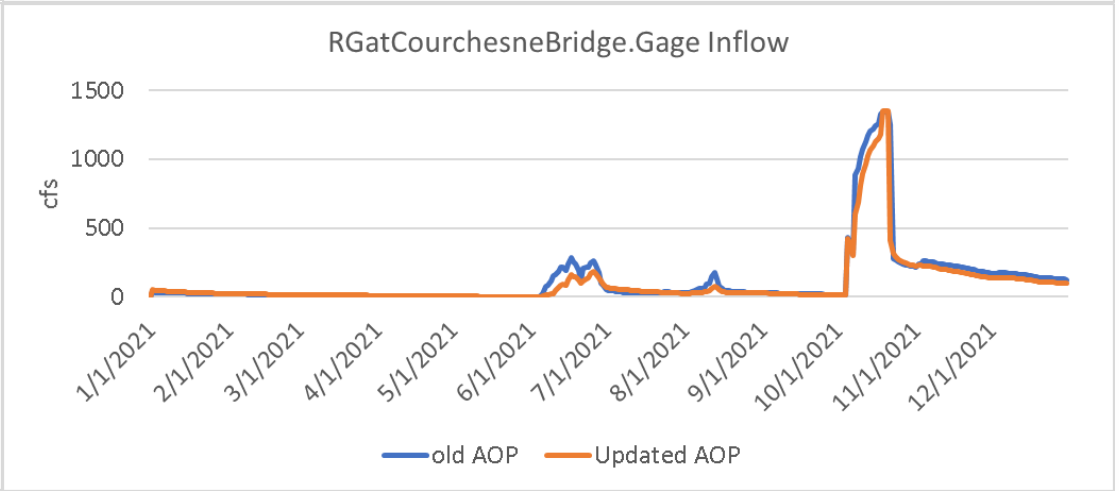
# Testing in Operations Mode

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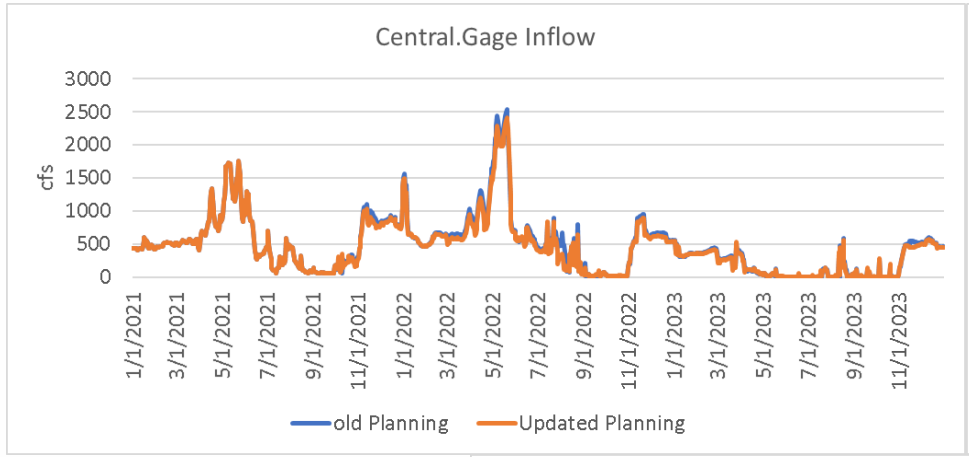
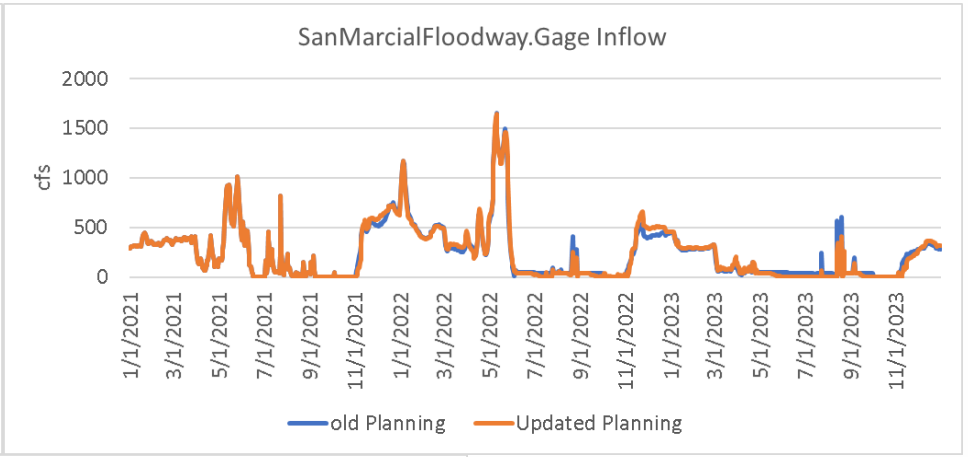
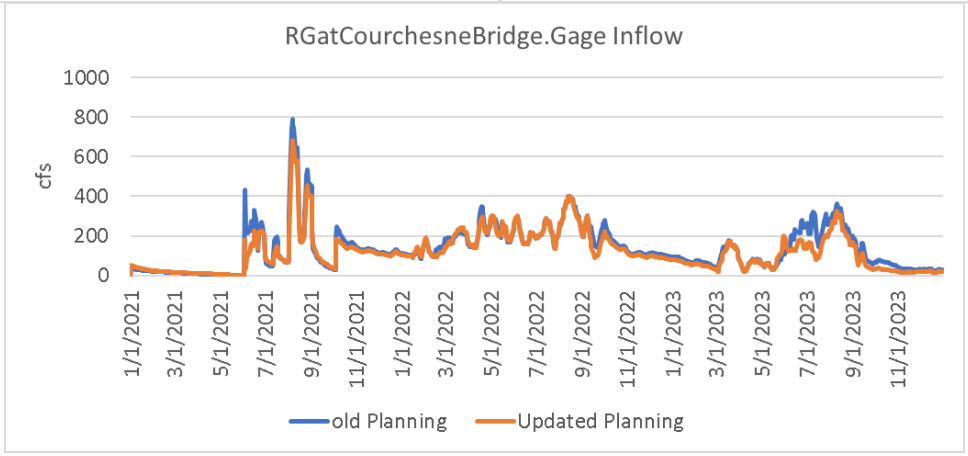
# Testing in Planning Mode

The new deep aquifer objects have a negligible effect on the current results.

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# Thank You

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