Memorandum

To: URGWOM Technical Team Members
Date: January 25, 2021
Subject: Notes of the January 19, 2021 URGWOM Technical Team Meeting

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These notes summarize the salient matters discussed during the January 19, 2021 Upper Rio Grande Water Operations Model (URGWOM) Technical Team meeting. The meeting began at 9:00 am and was conducted as an on-line collaboration hosted by the Corps of Engineers using the Corps' WebEx account. All those participating introduced themselves and their names and affiliation are listed on the last page of these meeting notes.

Meeting agenda topics include a report on the implementation of deep aquifer objects and model calibration of the middle Rio Grande, the report on the simulation of Rio Chama Acequia depletions, an update on RiverWare improvements and enhancements and general updates on ongoing URGWOM related activities from the Corps of Engineers, the Bureau of Reclamation, the Interstate Stream Commission and the US Geological Survey.

John and Nick presented to the Team a report on calibration of the Middle Rio Grande model potion following implementation of the new aquifer objects. After a brief background presentation on existing conditions, Nick summarized the implementation of 95 new aquifer objects. The data used to establish the deep groundwater heads used in the new objects are based on the 2019 USGS Middle Valley and the 2005 Shafike Socorro Basin MODFLOW models and the MODFLOW model grids are mapped to the RiverWare objects. The hydraulic characteristics of the aquifer formations were averaged in a vertical direction and the model fluxes were summed and input into the RiverWare model. These fluxes include recharge, basin infiltration and groundwater pumping.

John described the work that Hydros performed in the process of setting up the model calibration runs after the aquifer objects were added, including assigning the groundwater level data to the correct object. The calibration was performed using both automated methods (PEST, parameter estimation tool) and manual calibration methods. The calibration parameters were described which included riverbed and drain conductivity. The period of record used in the analysis is 1990-2010 and the calibration parameters were adjusted to match the historic flow at six URGWOM reach river gages. John presented the results of the calibration efforts to date in a series of charts and hydrographs depicting simulated surface flow and groundwater level data in comparison to historic records. The results of the model calibration and document will be submitted by Hydros to the Corps who will, with the assistance of Intera and Tetra Tech, review the implementation of the groundwater objects and the calibration.

Nick presented some limitations and conclusions drawn from calibration study, including:

- The model simulated drain operation is such that they do not really function as a drain, but shows that the drains actually function as a residual of the water balance in each reach;
- The Atrisco siphon object tries to take all of the water through the siphon which does not reflect actual operations and the historic drain flow in the Atrisco reach cannot be used to calibrate this reach of the model;
- There may be some "circularity" in the way riverside drains are simulated in that the riverside drains intercept surface water seepage from the river, and the riverside drain then discharges to the river and the cycle is repeated.
- The Canal Seepage rates are fixed, and it would help the calibration process to assign variable seepage rates, providing there is documentation to support the assignment of the variable seepage rates.
- The URGWOM model is simulating approximately twice the amount of recharge used in the MODFLOW models; the reason for his discrepancy is uncertain.

Carolyn suggested that Nick and John check with Nabil before any changes are made to the way the model simulates the groundwater-surface water interaction.

Nick also outlined the limitations imposed in implementing the aquifer objects in lieu of the using the deep aquifer heads provided by the MODFLOW model, including the simplification of nine horizontal layers into two layers in Riverware; reducing about 1,000 MODFLOW cells to 95 URGWOM objects and moving from the application of seasonal time-step to daily time step used in URGWOM. Overall, Nick said that they were pleased with the results of the calibration process to date.

Miller summarized the results of his investigation into the way URGWOM simulates the depletion of the Acequias diverting from the Rio Chama downstream of Abiquiu Dam. Currently, the simulation of the Acequias is based on a fixed annual total diversion of 52,800 acre-feet and a return flow of 15,843 acre-feet (30% return flow). Actual diversion and return flows were determined to compare to the current model simulation.

Acequia diversion date were downloaded from the NMOSE web page and reviewed and compiled. Data from the Alcalde weather station (NM Climate Center) were used to compute reference ET, and the Keller Bliesner software application Effective Precipitation was used to compute the CIR. Cropping pattern was based on the 2017 USDA NASS crop data for Rio Arriba County and the total acreage was based on the values given in the 2009 Rio Chama Watermaster Report, reduced by 6.5% to account for fallow acreage. The computed CIR was based on the Potential ET which was reduced by 20% to account for reduction in water use due to poor soil conditions, farm management practices, insects, etc. The investigation's conclusion is that the average annual diversion over the 2012-2020 period was about 38,300 acre-feet and the return flow was 28,300 acre-feet (68% return flow as percent of diversion). Miller will

circulate copies of the Rio Chama Report for review and comment by Technical Team members, and the Report will be posted on the myUSGS web page.

David reported to the Team on upgrades to RiverWare as requested by the Corps or the Bureau, including:

- Adding the ability to easily open multiple object account summaries which makes it easier to reconcile objects;
- Allow for multiple accounts of Rio Grande water types including changes to the accounts. Carolyn reported that this change was requested to allow for the accounting of multiple Rio Grande (native) water accounts in Abiquiu Reservoir.
- Implementation of changes to allow for the editing of data in SCT tables. David reported that this task was completed ahead of schedule and under budget, which may allow for the completion of additional tasks.

Lucas updated the Team on the following Bureau of Reclamation activities:

- In the Rio Grande Basin Study, additional global climate change models have been run to provide additional data; a simplified version of the Santa Fe River has been added to the URGWOM model being used in this study, including accounting of Water under Rio Grande Compact Articles VI and VII and the simulation of an exchange of water between the Buckman Direct Diversion and Cochiti Lake recreation pool San Juan-Chama project water. This simulation of the Santa Fe River is working and Lucas will meet with the City of Santa Fe to discuss further. Lucas will report back to the Team on this matter at one of the next two meetings.
- Reclamation is now able to directly move National Weather Service model run traces into the HDB database via the NWS web page.
- Paleoclimate model runs have been completed and are ready for inclusion into the report being prepared by Reclamation for submittal to the Congress.
- The 2021 Accounting model has been set up and two items of note observed by Reclamation in the 2021 model include that the monthly time step were changed to daily and that there was a problem identified with the Caballo Reservoir area-capacity relationship, which have been resolved. Marc reported that the Corps Reservoir's elevation-area-volume tables were updated for each reservoir project to ensure consistent increase in area or capacity with stage (no flat spots in the curve). Scripts were also modified or deleted as necessary.
- The Bureau's collaboration with NCAR has resulted in the use of the SUMMA hydrologic modelling approach to estimate the volume and timing of snowmelt runoff. Forty-nine traces of seasonal snowmelt runoff forecasts were compared with historic hydrographs generated in URGWOM. Reclamation will be testing the new NCAR approach with the normal NRCS runoff forecasts starting in March, 2021.

The NMISC had no updates on URGWOM related activities to report.

Dave M. reported that the USGS had no matters to bring before the group during this meeting.

Marc Sidlow announced that he intends to retire in May, 2021 after a 38 year career with the Corps of Engineers.

The next regular meeting of the Technical Team is scheduled for February 9, 2021 at 9:00 am, which will also be an on-line collaboration.

The meeting adjourned at approximately 10:15 am.

ATTENDANCE LIST
URGWOM TECHNICAL TEAM MEETING
January 19, 2021

NAME	REPRESENTING
Dave Moeser	USGS
Marc Sidlow	USACE
Phillip Carrillo	USACE
William Miller	Southwest Water Design/USACE Contractor
Mike Brown	Tetra Tech/USACE Contractor
Carolyn Donnelly	Bureau of Reclamation
Lucas Barrett	Bureau of Reclamation
Jerry Melendez	Bureau of Reclamation
Brian Westfall	Keller Bliesner Engineering / BIA Contractor
David Neumann	CADSWES
Nick Mander	Hydros Consulting
John Craven	Hydros Consulting
Ashenafi Madebo	Colorado Division of Water Resources
Zhuping Sheng	Paso del Norte Watershed Council
Delbert Humberson	International Boundary and Water Commission

URGWOM Tech Team

MRG Calibration

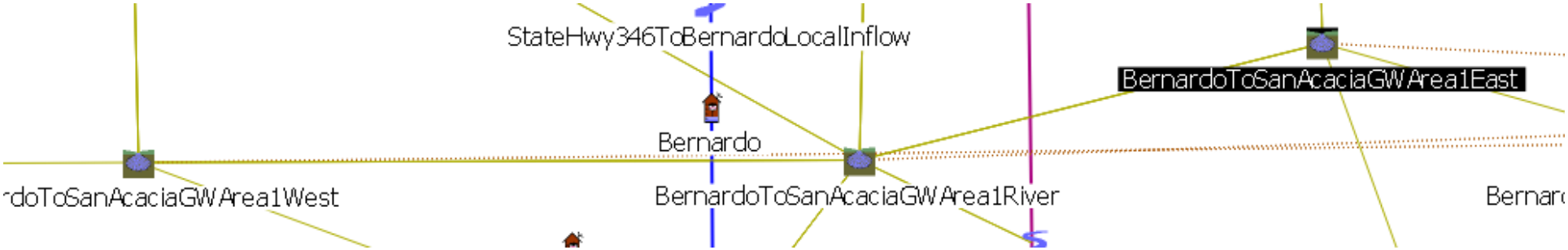
John Craven and Nick Mander
Hydros Consulting Inc.
January 19, 2021

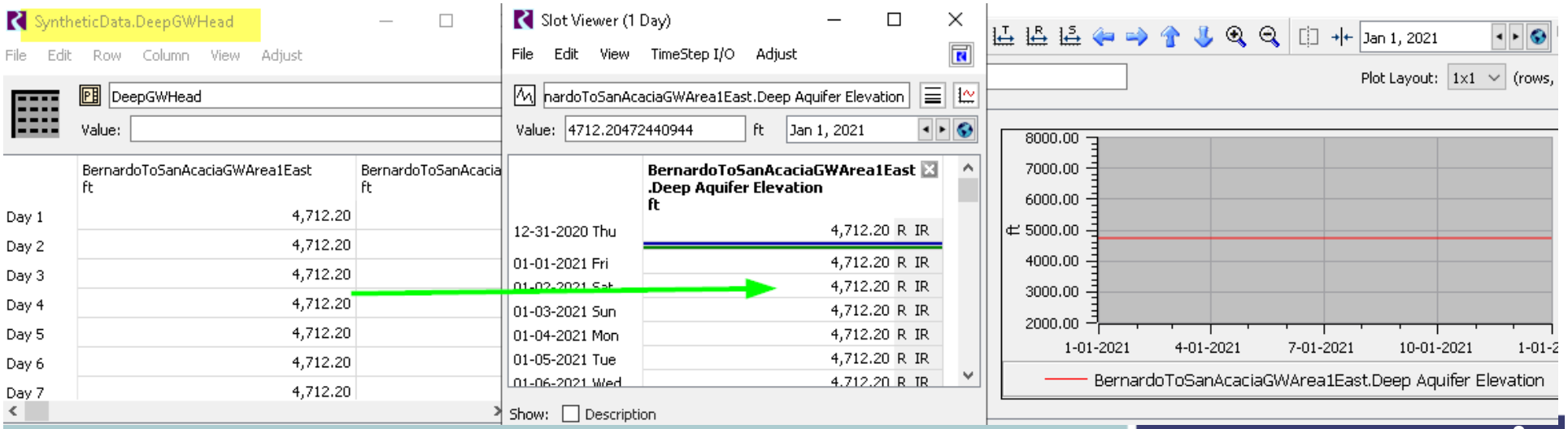
Outline

- Background
- Model Updates
- Groundwater Model Data Extraction
- RiverWare Model Calibration
- Recommendations
- Limitations

Background

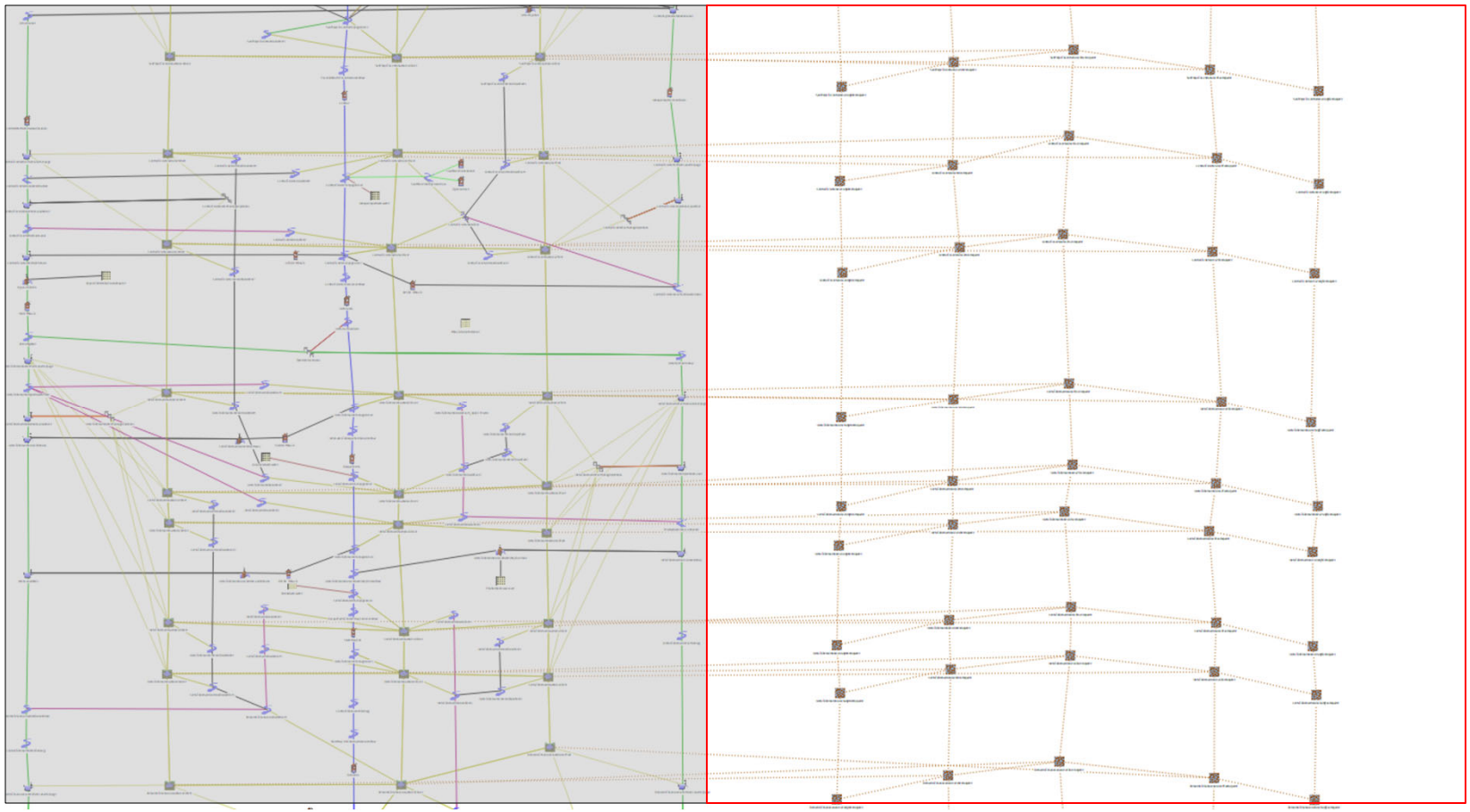
- URGWOM currently uses input Deep Aquifer Heads
- Used by RiverWare to compute flux between shallow and deep aquifer, which isn't explicitly modeled In URGWOM





URGWOM Model Updates

- USACE tasked Hydros with explicitly modeling Aquifer objects in MRG in URGWOM
- Added 95 Aquifer objects:

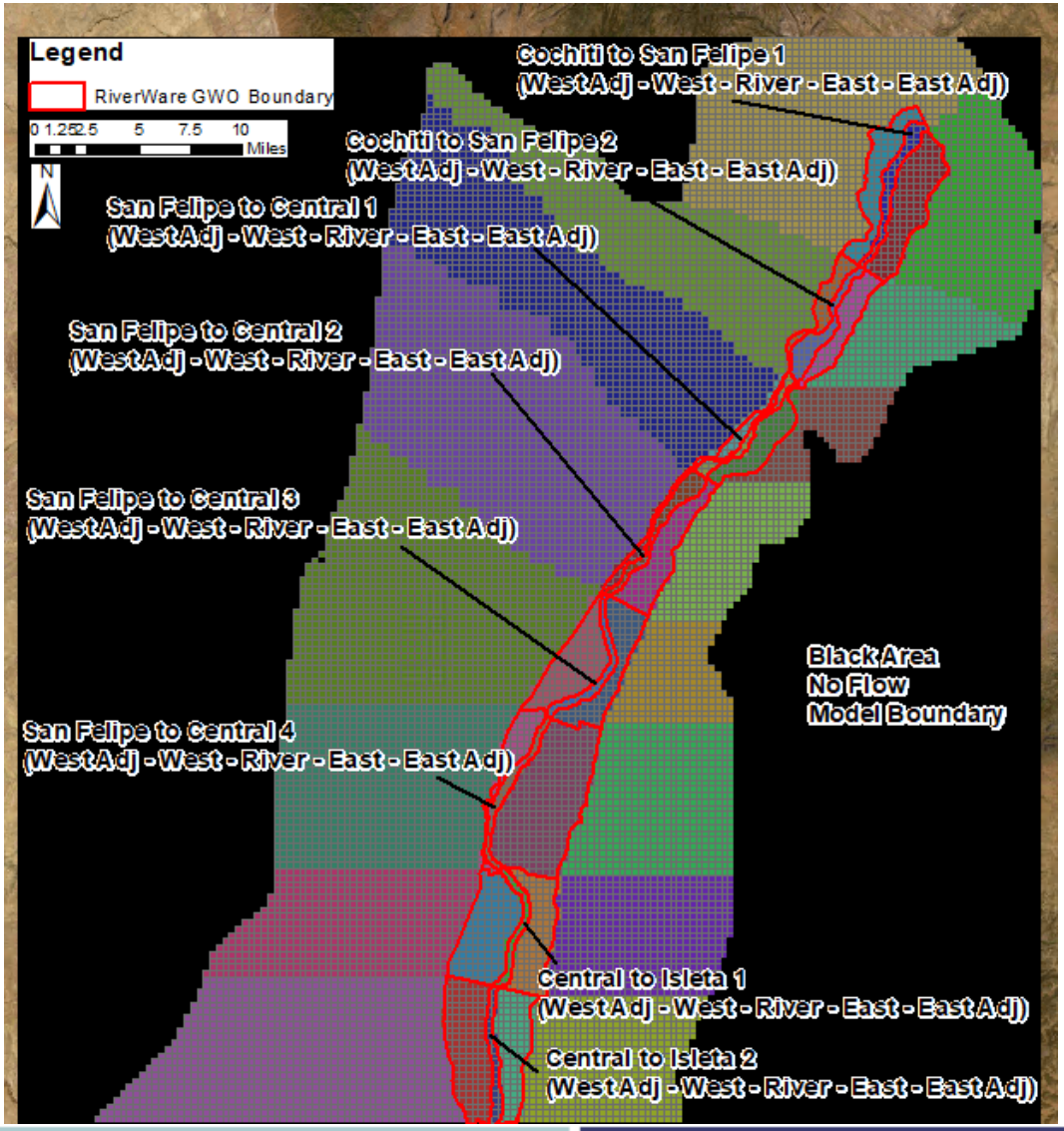


Groundwater Model Data Extraction

- Using existing MRG shallow alluvium areas, extracted data from two MODFLOW models
  - Meyers et al., 2019 (USGS) – Cochiti to Bernardo
  - Shafike, 2005 (NMISC) – San Acacia
- Averaged aquifer properties over the vertical layers, within each of the delineated objects
  - Hydraulic conductivity, layer thicknesses, storage coefficients
- Summed fluxes over the vertical layers, within each of delineated objects
  - Aquifer recharge, aquifer M&I pumping, mountain front recharge
  - Fluxes are inputs to the RiverWare model for each GWO
- Head timeseries for each GWO, shallow/deep, used for calibration
- Aquifer extends further than shallow alluvium—also extracted data for "Adjacent" areas

Groundwater Model Data Extraction

- Groundwater Model cells were mapped to the RiverWare Groundwater Objects
- Groundwater model inputs, aquifer properties, and heads were extracted



Groundwater Model Data Extraction

Reach	Object	Annual Average 1990 -2010 (acre-feet)									
		Recharge				Basin Inflow		Pumping			
		Mntn-frnt	Septic	Sewer	Irrigation *	Shallow	Deep	Shlw M&I	Deep M&I	Shlw Dmstc	Deep Dmstc
Cochiti To San Felipe	Area 1 East	0	26	0	708	0	0	0	-52	0	-46
	Area 1 East Adj.	5250	18	0	0	0	3771	0	0	0	-34
	Area 1 River	0	5	0	315	0	0	0	0	0	-8
	Area 1 West	0	13	0	531	0	0	0	-16	0	-28
	Area 1 West Adj.	0	27	0	57	0	11542	0	-7	0	-43
	Area 2 East	0	8	0	357	0	0	0	0	0	-18
	Area 2 East Adj.	56	11	0	0	0	1171	0	-8	0	-17
	Area 2 River	0	3	0	275	0	0	0	0	0	-7
	Area 2 West	0	7	0	183	0	0	0	0	0	-14
	Area 2 West Adj.	190	47	0	324	0	12640	0	0	0	-71

- Example table of Annual Average groundwater model fluxes extracted and input to the MRG RiverWare Model
- Full table is provided in the documentation

MRG RiverWare Model Calibration

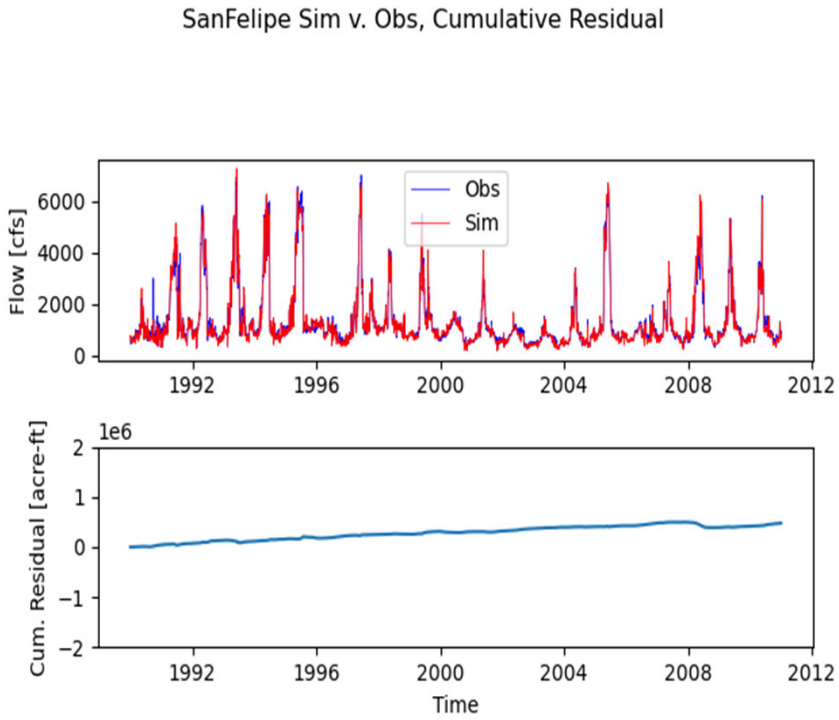
- Calibration focused on the shallow and deep aquifer objects, river seepage objects, and drain objects.
  - Used a combination of automated (PEST) and manual calibration
- Calibration parameters:
  - shallow alluvium hydraulic conductivity, aquifer conductance, river hydraulic conductivity, and drain hydraulic conductivity
- Calibration period: 1990-2010
- Calibration targets:
  - 6 river gage flows (observed data), and average heads extracted from the groundwater models (modeled data)

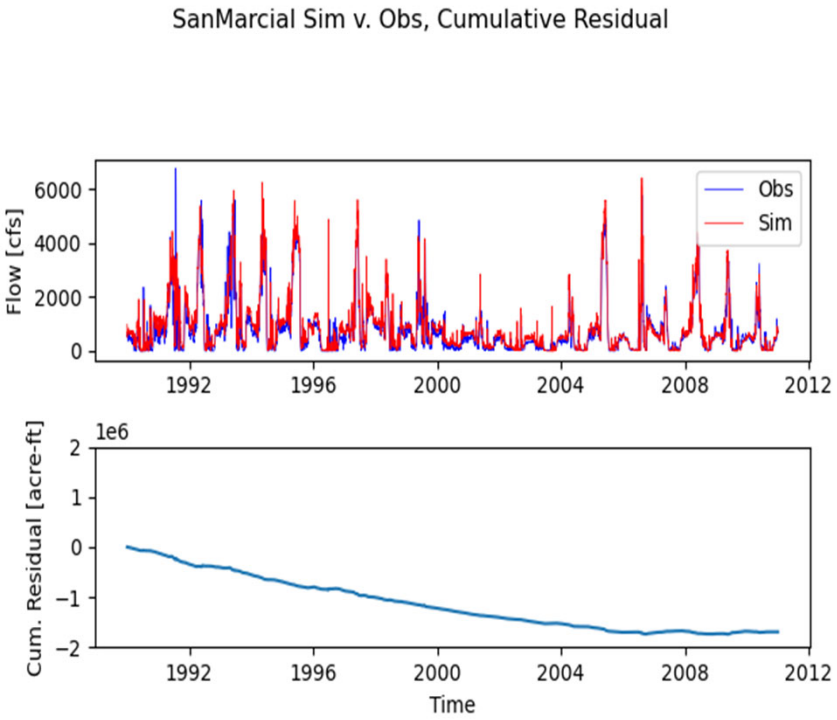
Calibration Results: Streamflow Gages

Streamflow Gage Name	RMSE [cfs]	Mean Error (ME) [cfs]	PBIAS [%]	Nash-Sutcliffe (NSE) [-]	Median Difference [cfs]	Low Flow Median Difference [cfs]
Central	245	-125	-11%	0.96	119	-42
Escondida	196	39	5%	0.94	-16	-17
San Felipe	145	-31	-2%	0.98	39	n/a
San Marcial	283	112	14%	0.92	-101	-63
State Hwy 346	183	-47	-6%	0.96	30	-19
US Hwy 380	232	50	7%	0.93	-73	-65

- NSE >0.9 is considered excellent
- PBIAS: generally less than +/- 10% is excellent
- Cumulative Residual plots show that RiverWare tends to be consistently high or low over time

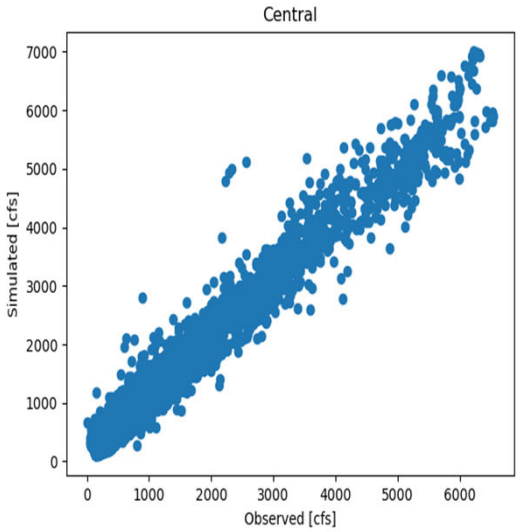
Calibration Results: Streamflow Gages

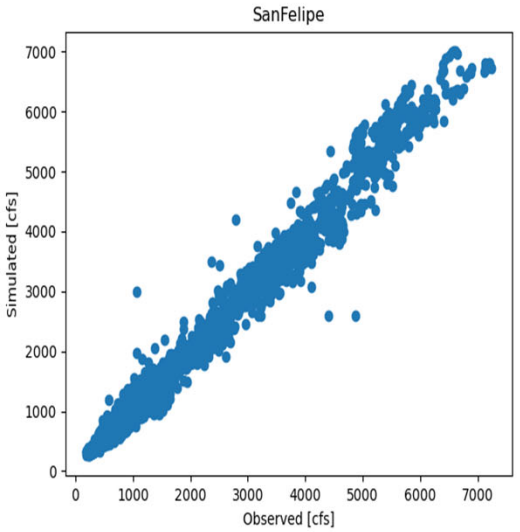


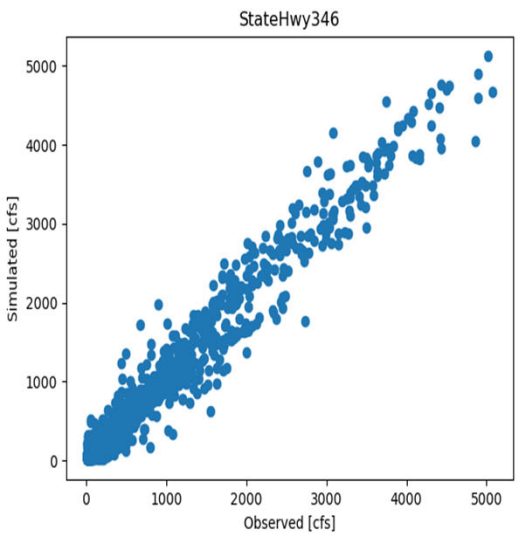


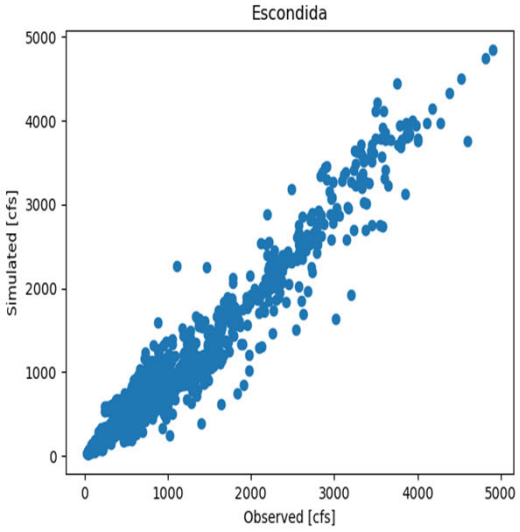
- Hydrographs and Cumulative Residual plots are provided in the documentation for each gage

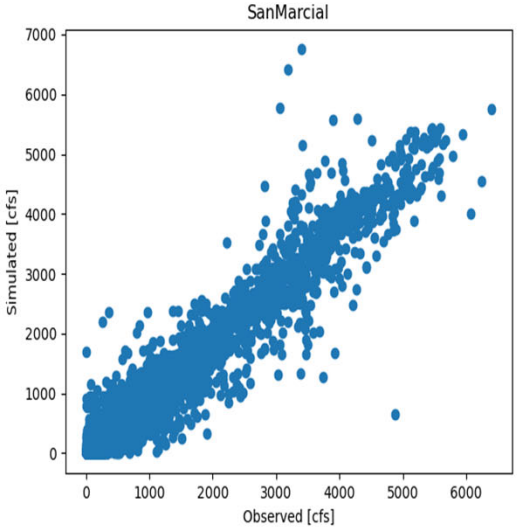
Calibration Results: Streamflow Gages

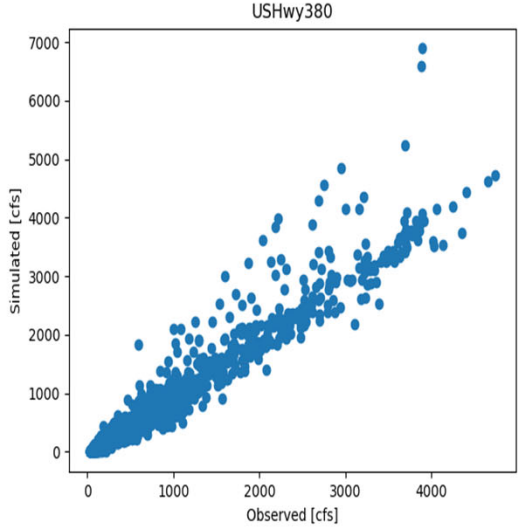






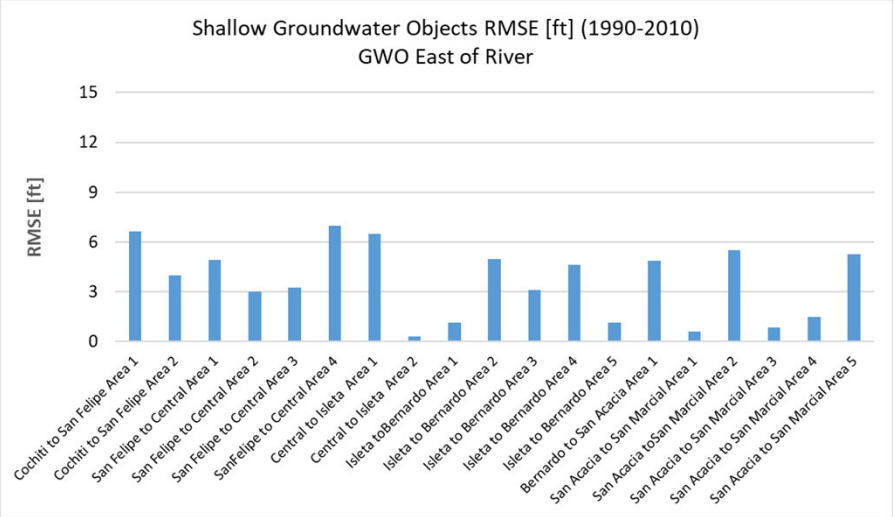


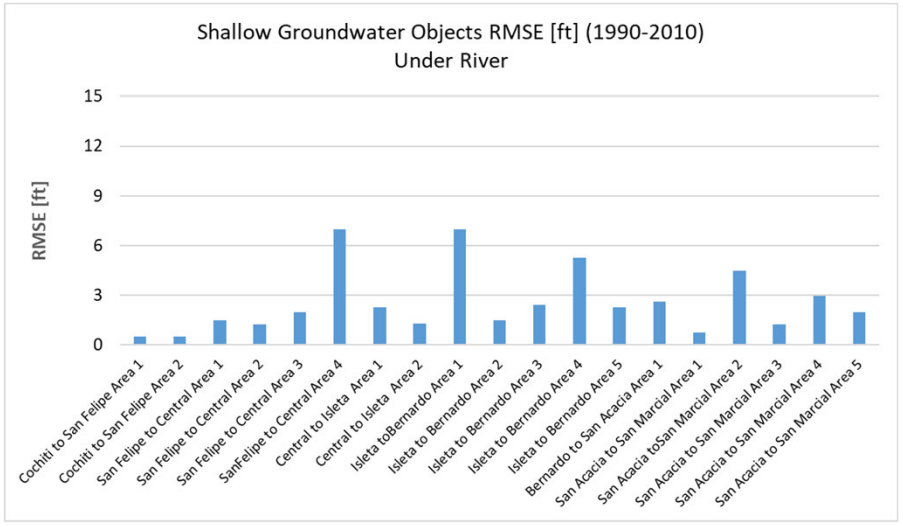


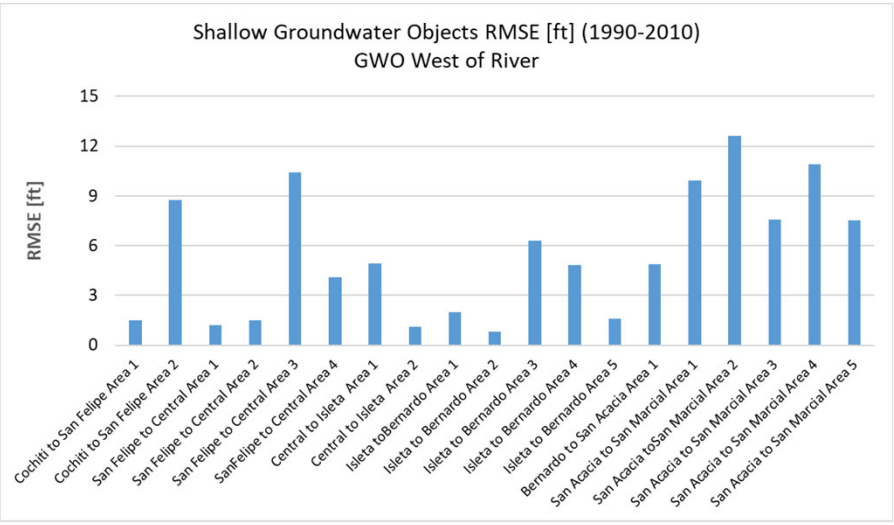


Calibration Results: Shallow Groundwater Objects

- Under River: generally <3 ft
- East: most areas ~5 ft
- West: mostly <5-6 ft, San Acacia avg. RMSE ~10 ft

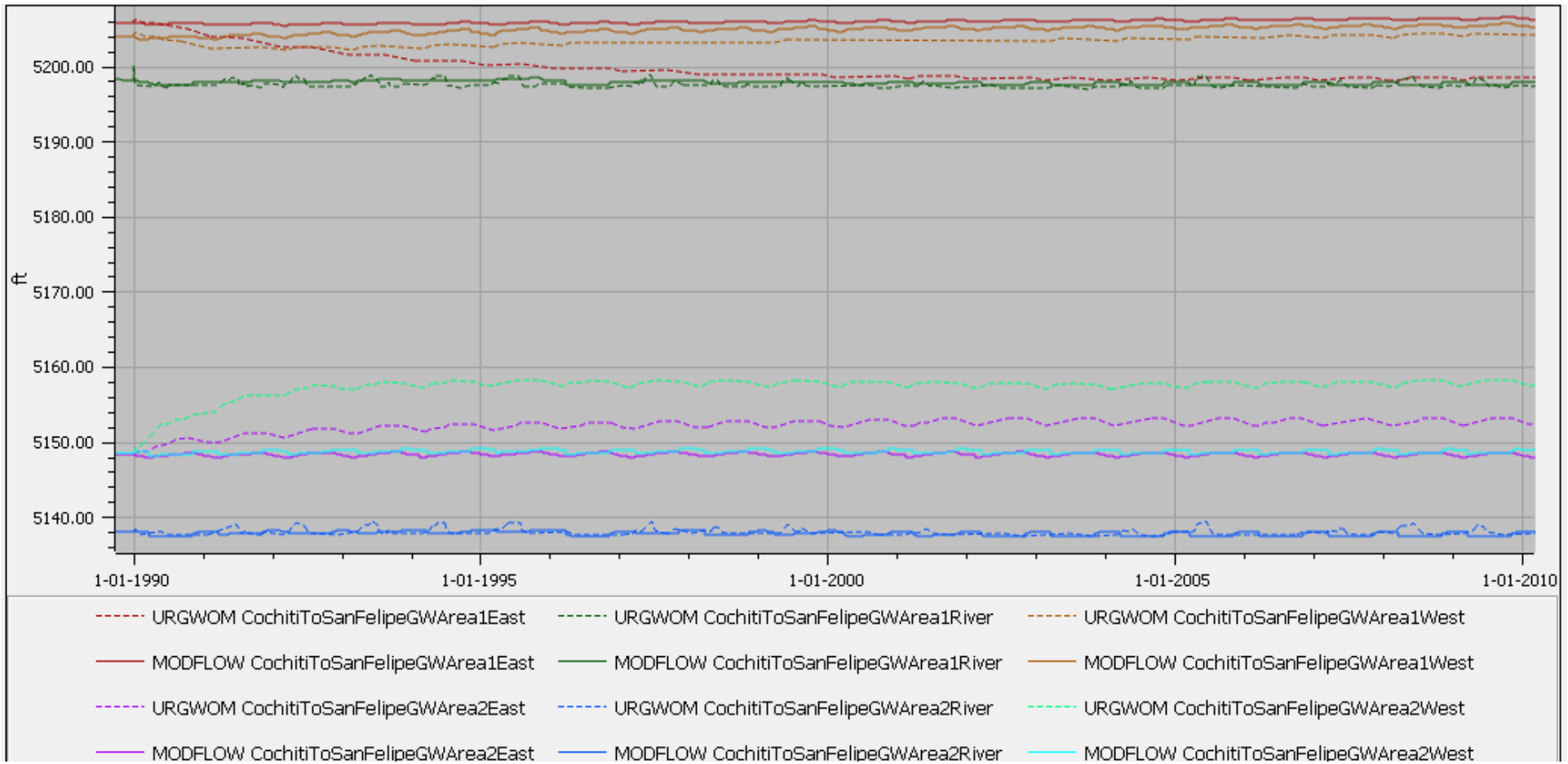






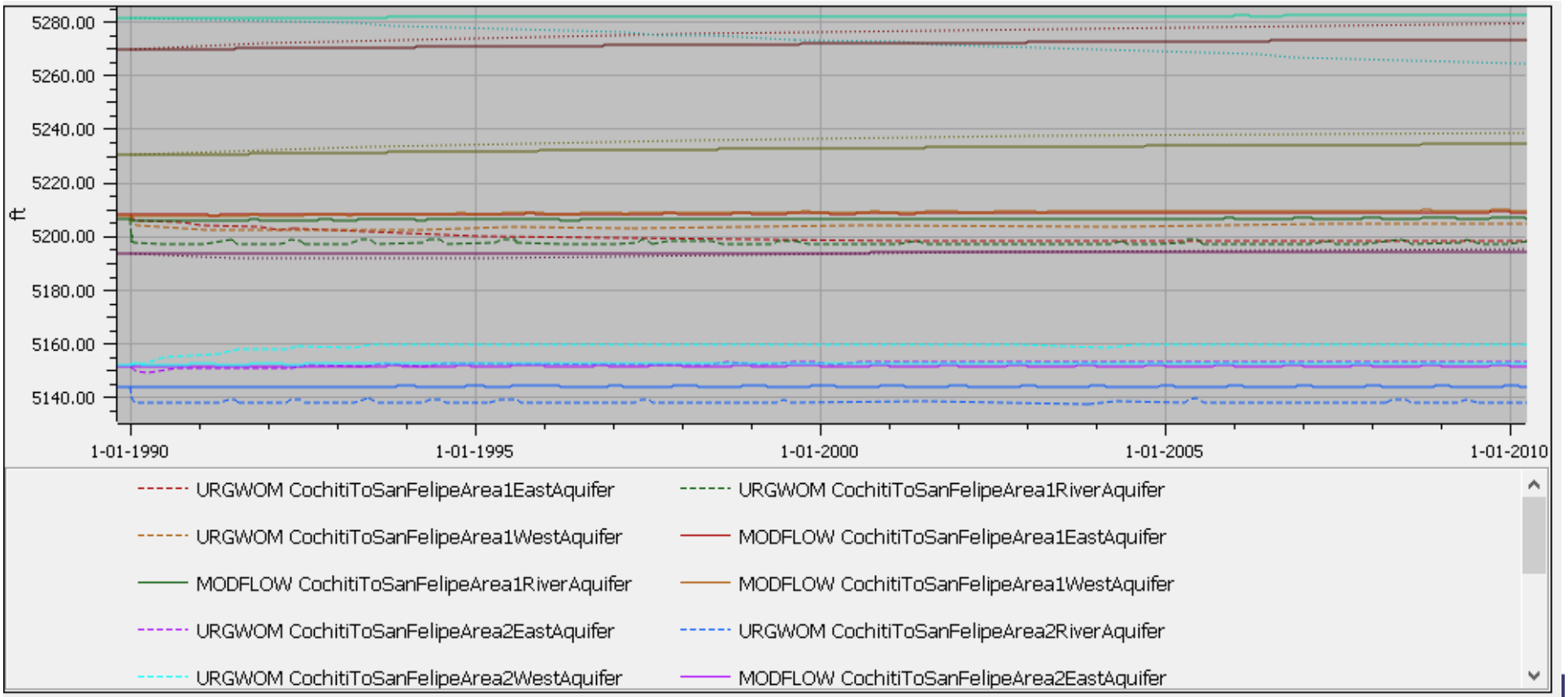
Calibration Results: Shallow Groundwater Objects

Shallow Groundwater Aquifer RMSE [ft]				
Area	Sub-area	West	River	East
Cochiti	Cochiti to San Felipe Area 1	1.5	0.5	6.6
	Cochiti to San Felipe Area 2	8.7	0.5	4.0
San Felipe	San Felipe to Central Area 1	1.2	1.5	4.9
	San Felipe to Central Area 2	1.5	1.2	3.0
	San Felipe to Central Area 3	10.4	2.0	3.3
	San Felipe to Central Area 4	4.1	7.0	7.0



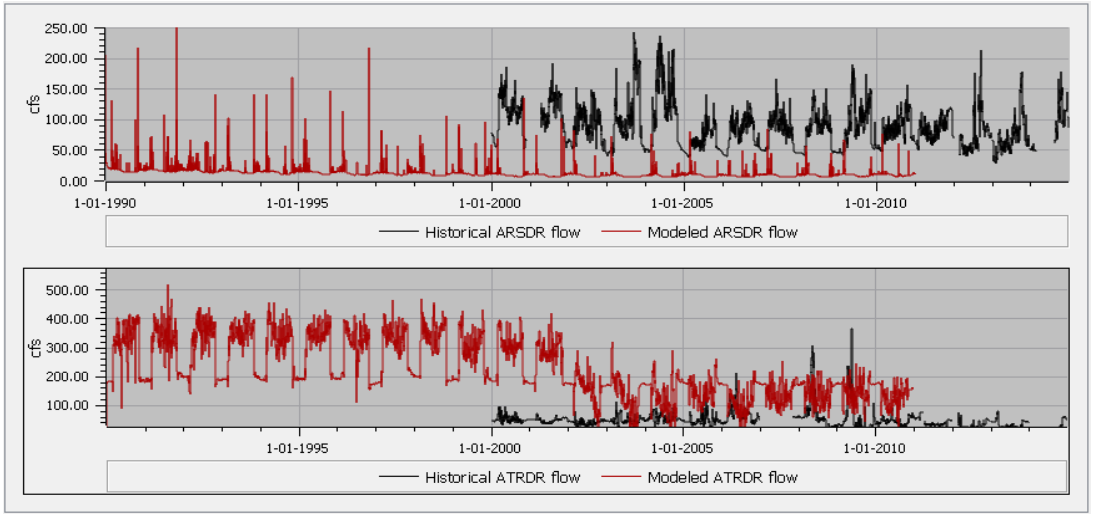
Calibration Results: Deep Groundwater Objects

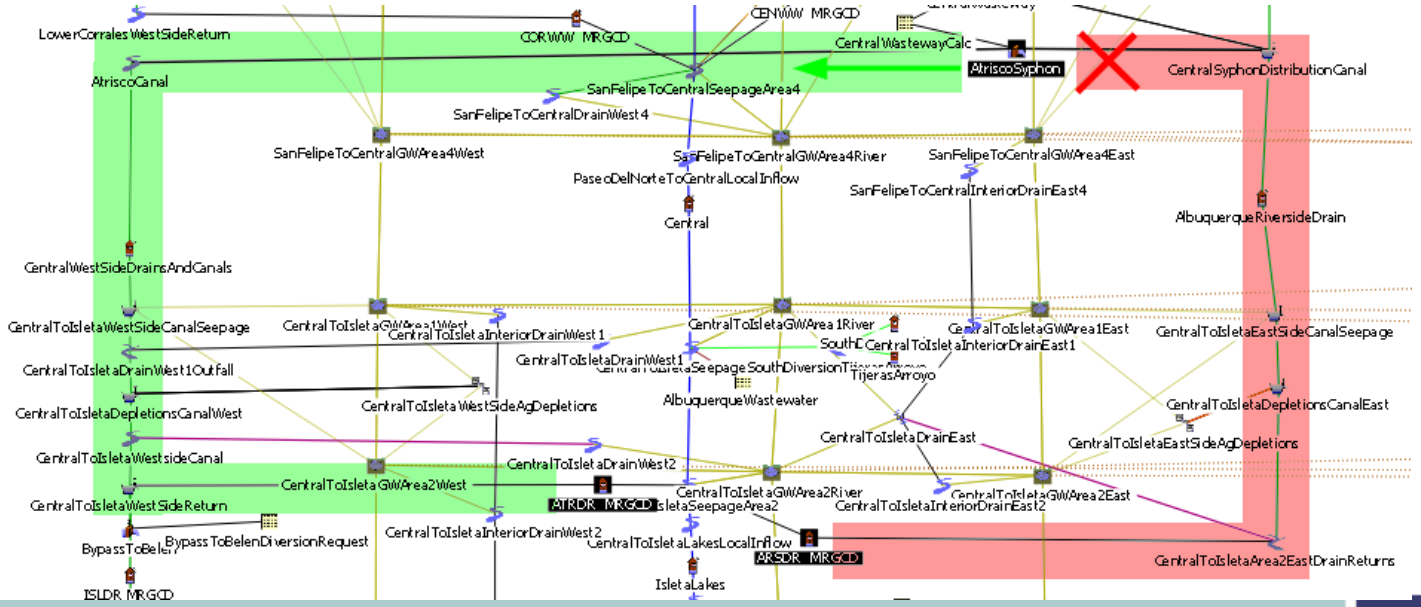
Deep Groundwater Aquifer RMSE [ft]						
Area	Sub-area	West Adj.	West	River	East	East Adj.
Cochiti	Cochiti to San Felipe Area 1	3.2	5.2	8.9	9.0	4.3
	Cochiti to San Felipe Area 2	10.8	6.5	5.9	1.1	1.0
San Felipe	San Felipe to Central Area 1	8.6	6.4	5.0	2.6	13.4
	San Felipe to Central Area 2	27.3	1.2	4.1	2.5	10.3
	San Felipe to Central Area 3	15.8	13.9	11.4	3.6	6.8
	San Felipe to Central Area 4	9.0	3.2	15.5	1.5	21.6



Recommendations

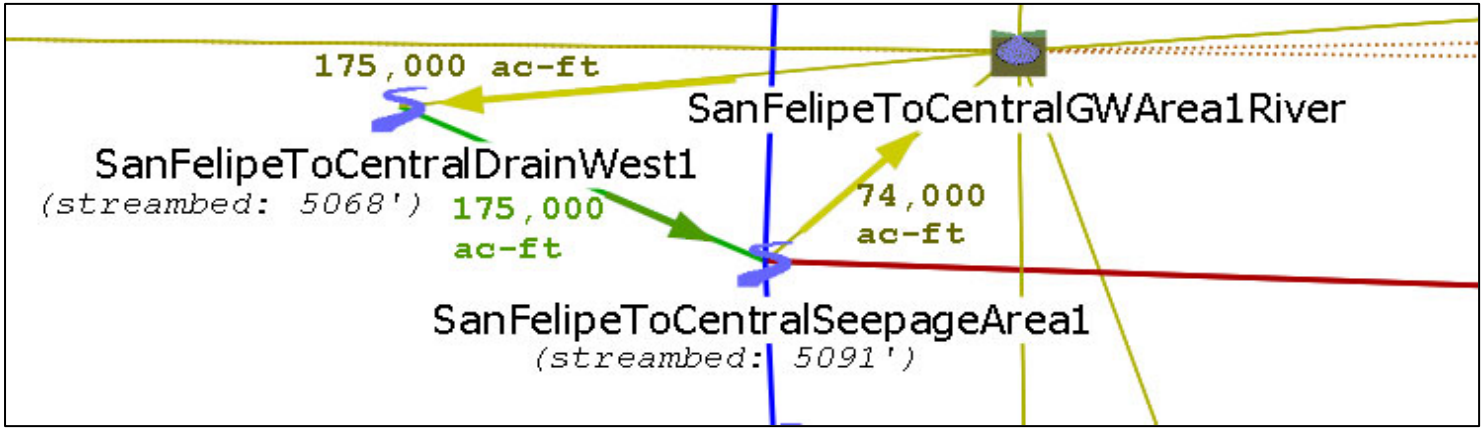
1. Investigate drains





Recommendations

1. Investigate drains (Continued)



- Riverside Drains are below the Rio Grande
- River seeps water to the Under River Object
  - Water is picked up by the drain, and routed back to the River Object
- May want to add drain flow return reach below seepage object so that the river doesn't gain water lost to the aquifer
- The current connection is circular

Recommendations

2. Investigate and calibrate canal seepage
   - Canal seepage is a simple, fixed percentage
   - Not included in calibration

3. Irrigation Recharge
   - The RiverWare model simulates approximately twice as much irrigation recharge to the aquifer than the MRG MODFLOW model
   - The volume of irrigation recharge is a function of available water supply, crop demand, and irrigation efficiency.
     - Min efficiency currently set to 50%
     - Groundwater return flow fraction currently set to 95%

Limitations

- Calibrating model (URGWOM) based on another model (MODFLOW)
- Model simplifications
  - Aggregating 9-layer MODFLOW model to 2-layer RiverWare model
  - Aggregating 1000's of MODFLOW cells to 95 URGWOM aquifer objects
  - Disaggregating seasonal stress periods from MODFLOW into daily URGWOM model

UPPER RIO GRANDE WATER OPERATIONS MODEL

REPORT TO TECHNICAL TEAM

January 19, 2021

RIO CHAMA ACEQUIAS

DIVERSION AND DEPLETION ANALYSIS

william j. miller
ENGINEERS

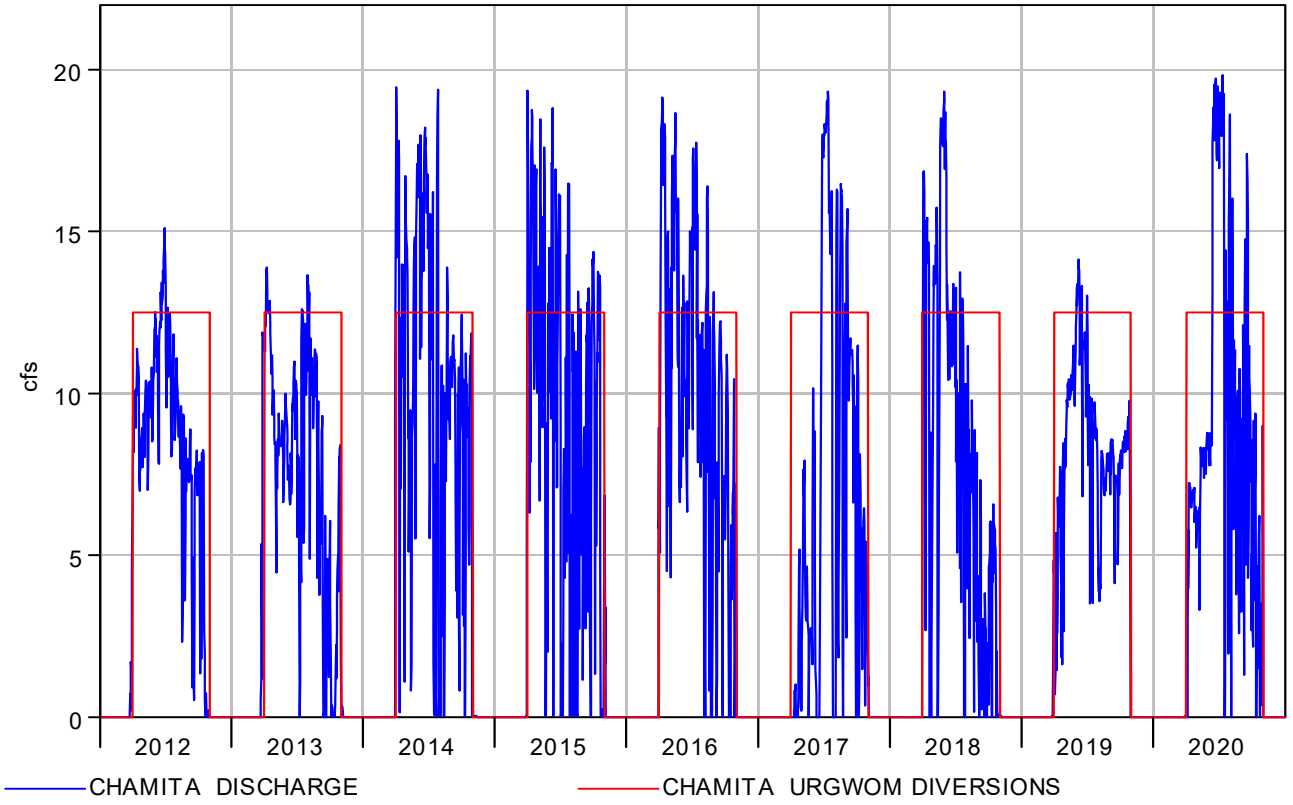
UPPER RIO GRANDE WATER OPERATIONS MODEL
REPORT TO TECHNICAL TEAM
January 19, 2021
RIO CHAMA ACEQUIAS
DIVERSION AND DEPLETION ANALYSIS

1. The current URGWOM physical model simulation of Acequias diverting from the Rio Chama below Abiquiu Dam assumes a constant diversion rate based on each Acequia water right and a return flow of 30%.
2. This presentation describes the data, methods and assumptions used in compiling diversion data and computing Rio Chama Acequia depletions to update the model simulation and database and improve the model reliability in the reach between Abiquiu Dam and Espanola.
3. Records of Rio Chama Acequias diversion data for the are collected by the NMOSE and records for the period 2012-2020 are used in this analysis.
4. Climate data from the Alcalde weather station used to estimate crop consumptive use using the Hargreaves Samani method
5. 2017 NASS cropping pattern and 2009 crop total acreage used in this analysis

RIO CHAMA ACEQUIAS BELOW ABIQUIU RESERVOIR

ACEQUIA NAME	LENGTH (mi.)	IRRIGATED AREA (Ac.)	URGWOM MAX DIVERSION RATE (cfs)	URGWOM MAX DIVERSION RATE (af/yr)	URGWOM RETURN FLOW (af/yr)
Salazar	4.9	487	13	5,492	1,648
Hernandez	3.9	583	12.5	5,281	1,584
Chamita	3.8	717	12.5	5,281	1,584
Chili	3.4	281	8	3,380	1,014
Martinez y Duranes	7.5	539	12.5	5,281	1,584
Rio de Chama	3.9	381	11	4,647	1,394
Manzanares y Montoya	1.1	41	1.5	634	190
Martinez	1.8	139	4	1,690	507
Tierra Azul	3.6	176	7	2,957	887
Ferran	2.5	130	4	1,690	507
Mariano	2.1	121	4	1,690	507
Valentine Martinez	0.6	21	1	422	127
Quintana	0.8	31	1	422	127
La Puente	3.0	177	5	2,112	634
Gonzales	1.4	211	6	2,535	760
Jose Pablo Gonzales	4.7	521	16	6,760	2,028
Winfield Morton	1.0	90		-	-
Abeyta Trujillo	3.9	236	6	2,535	760
		4882		52,811	15,843

RIO CHAMA ACEQUIAS BELOW ABIQUIU RESERVOIR DIVERSION DATA



RIO CHAMA ACEQUIAS BELOW ABIQUIU RESERVOIR

Acequia Depletion - Cropping patterns along Rio Chama
Acreage used in analysis: 4,482 acres

	Percent of Total		
Crop	1961 Hydrographic Survey	ET Toolbox	USDA-NASS Rio Arriba County (2017)
Alfalfa	22.5	30.0	55.0
Hay and Pasture	39.1	40.0	40.0
Orchard	10.7	30.0	2.0
Corn	10.7	--	1.0
Grain	6.4	--	--
Garden	4.0	--	2.0
Fallow	6.6	--	--

RIO CHAMA ACEQUIAS BELOW ABIQUIU RESERVOIR

Diversion and return flow summary

ACEQUIA	Average annual diversion (af)	Average annual depletion (af)	Average annual return flow (af)	Return flow as % of diversion
ABEYTA TRUJILLO	1,742	491	1,252	72%
CHAMITA	3,700	1,491	2,210	60%
CHILI	2,227	584	1,643	74%
FERRAN	380	270	110	29%
GONZALES	669	439	231	34%
HERNANDEZ	5,042	1,212	3,831	76%
J. P. GONZALES	4,569	1,083	3,486	76%
J. V. MARTINEZ	1,237	289	949	77%
LA PUENTE	1,215	368	847	70%
MANZANARES MONTOYA	271	85	186	68%
MARIANO	1,187	251	936	79%
MARTINEZ-DURANES	5,010	1,120	3,889	78%
QUINTANA	255	64	191	75%
RIO DE CHAMA	4,508	792	3,715	82%
SALAZAR	4,129	1,012	3,117	75%
TIERRA AZUL	2,064	366	1,698	82%
VALENTINE MARTINEZ	85	44	42	49%
	38,293	9,961	28,332	68%

RIO CHAMA ACEQUIAS BELOW ABIQUIU RESERVOIR

Acequia diversion and depletion study results summary

	Current URGWOM	This study
Irrigated acreage (ac.)	--	4,482
Average Annual Diversion (af)	52,811	38,293
Depletion (af)	36,968	9,961
Return flow (af)	15,843	28,332
Return flow (%)	30	68

Recommendations:

- Update URGWOM database with diversion and return flow data based on recorded diversion and computed CIR.
- Update local inflow file and URGWOM database.
- Delete these Acequias from model and database:
  - Martinez Duranes #2
  - Monastery
  - Skull Ranch
  - Winfield-Morton

Questions?

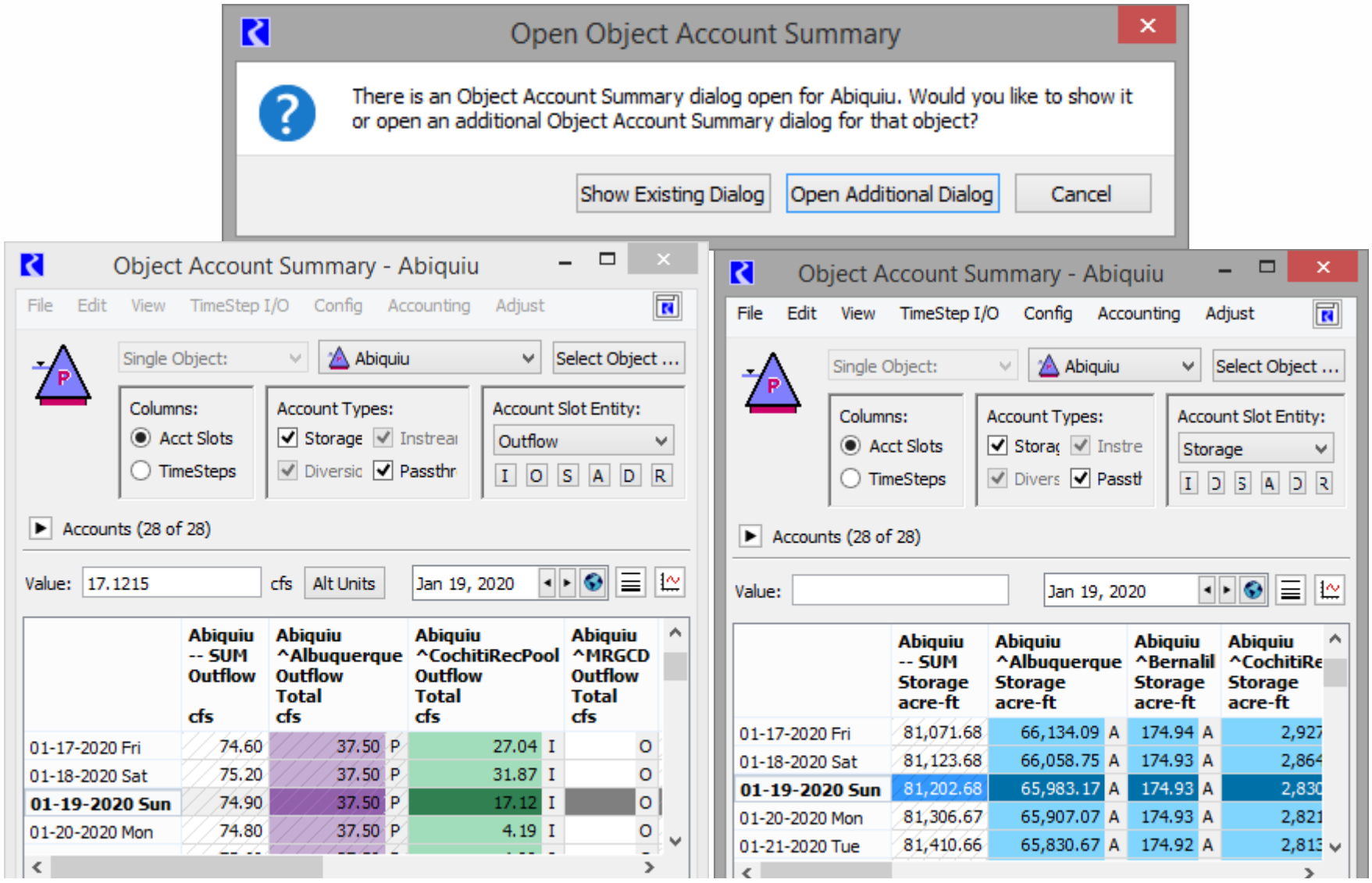
RiverWare Updates for USACE and Reclamation

Presenters: David Neumann

URGWOM Tech Team Meeting

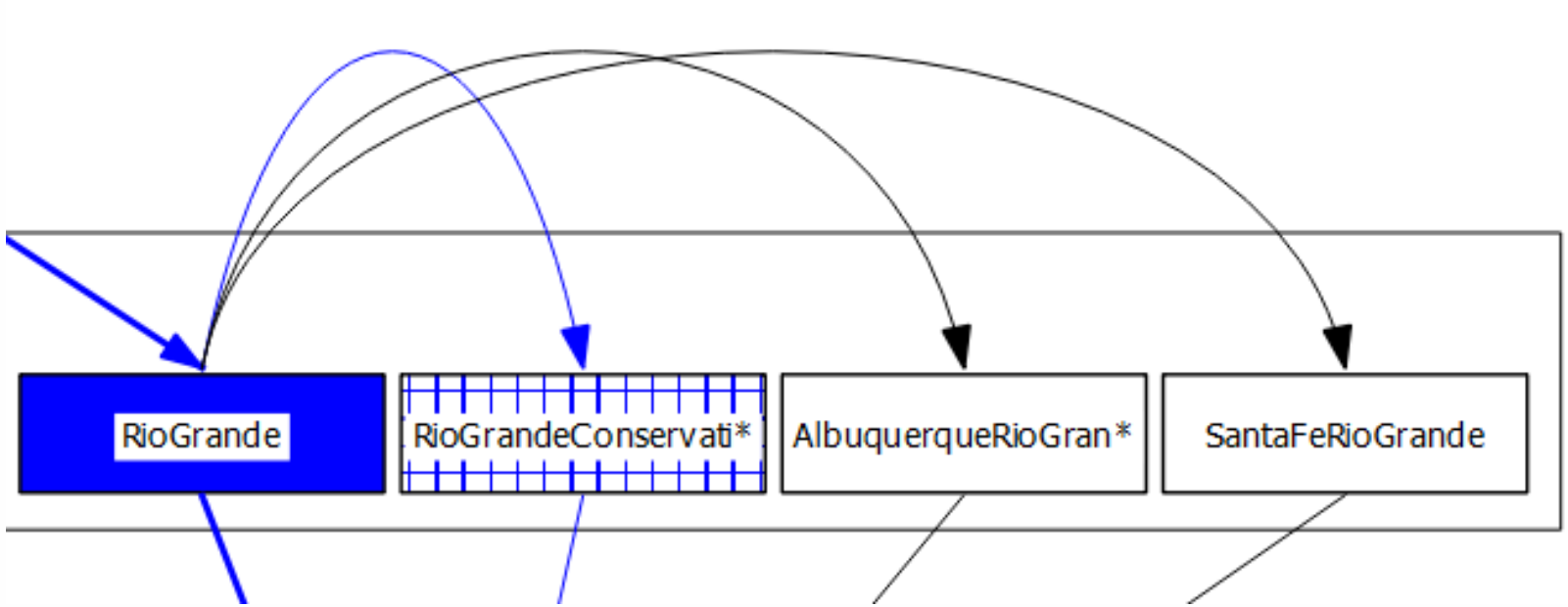
January 19, 2021

Easily open multiple Object Account Summary



Rio Grande Conservation Accounts

- Allow multiple accounts of Water Type “RioGrande”



- Required changes to the

  Reservoir Account Gain Loss category /

  Abiquiu, Cochiti and Jemez Gain Loss

Loss Equations

$$\textbf{RioGrandeConservationAccounts Total Gain Loss} = totalRioGrandeGainLossTemp \times \left(\frac{\text{RioGrandeConservation.Storage(t-1)} + RGConservInVol - RGConservOutVol}{totalRioGrandeStorage + totalRioGrandeLossTemp} \right)$$

$$\begin{aligned}\textbf{RioGrande.Gain Loss} = {} & (Reservoir.\text{Storage} - totalSanJuanStorageSum) \\ & - \text{RioGrande.Storage(t-1)} \\ & + (-\text{RioGrande.Inflow} - RGTransfersInSum) \times Timestep \\ & + (\text{RioGrande.Outflow} + RGTransfersOutSum) \times Timestep \\ & - \text{RioGrandeConservation.StorageSum} \\ & + \text{RioGrandeConservation.Transfers In Sum} \times Timestep \\ & - \text{RioGrandeConservation.Transfers Out Sum} \times Timestep \\ & - \text{Accumulated Permanent Sediment}\end{aligned}$$

Undo data edits on the SCT

- Funding by Reclamation and USACE
- Status:
  - Design and prototype complete
  - Implementation underway
- ~30 ways to edit data on the SCT!

- On track to finish within budget