Fillmore and Piru Basins
Groundwater Sustainability Agency

FPBGSA Stakeholder Workshop 3
Groundwater Model and Water Budget

Senior Groundwater Modeler
Jason Sun, PhD, PE
December 9, 2020

United Water
CONSERVATION DISTRICT

- Expert Panel Review
- Historical Water Budget
- GW Model Water Budget

Expert Panel History

- In spring 2016, the UWCD model was making progress. The Groundwater Department decided to hire external experts to review the UWCD model while the model was being calibrated
- Several rounds of reviews took place in 2016, 2017 and 2018
- UWCD released the 2018 UWCD model in July 2018
- UWCD expanded the 2018 model into the river basins in 2019-2020
- The expert panel reviewed the 2020 UWCD model in March, June and August 2020

Expert Panel

- Sorab Panday, Ph.D.
  - Member of the National Academy of Engineering (NAE)
  - Lead author of MODFLOW-USG
  - USGS MODFLOW development

- Jim Rumbaugh
  - Co-author of a popular MODFLOW GUI software, Groundwater Vistas
  - Exposed to numerous groundwater models in U.S.

- John Porcello, Registered Geologist

  Developed groundwater models in the western United States.
  Developed groundwater models in Santa Clarita area

Expert Panel Review Process

- UWCD staff gave presentations to the panel on the model development
- UWCD provided:
  - Conceptual model information
  - All the data including water level, pumping records,…
  - Numerical MODFLOW model input and output files
- The panel spent days to weeks to pore through the GW model in each review
- Expert panel reviewed the model documentation
- Expert panel will continue to review the UWCD model in the future.

Goals

- Model construction

  Boundary conditions, stresses (pumping, recharge,…), grid spacing, time steps, numerical convergence,…

- Model calibration

  Water level residuals, spatial biases, water level over time,…

- Defensible model

  Consistent with industry practice

  Appropriate use of MODFLOW packages

  Consistent with the conceptual model

  Good calibration

External Panel Review

- The expert panel concludes that "… finds the 2018 model to be a well-designed and well-calibrated tool,…provides a newly robust and detailed method of evaluating how the multiple aquifers in the region behave…

- The expert panel concludes that "… The 2020 model calibration to both heads and stream flows is **very good**, especially considering the size of the model grid cells compared to stream dimension in these three basins that have been added to the model … the three of us believe that the model replicates the historically observed conditions quite well during the calibration period. Accordingly, the United Water District team should feel proud of the current model. "

UWCD Model is Battle-Tested

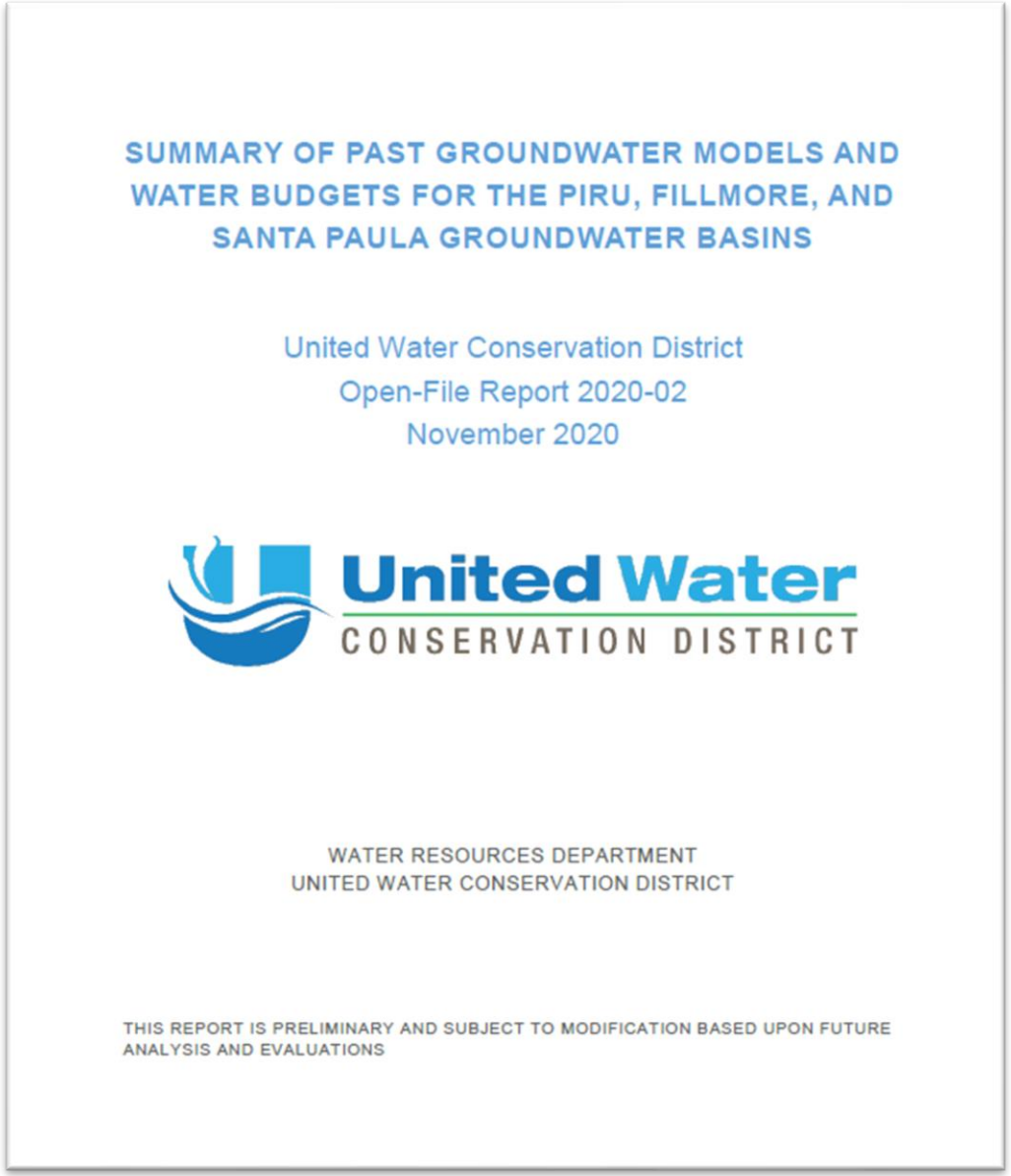
- The UWCD models have been reviewed internally by UWCD surface water hydrologists and hydrogeologists
- The UWCD models have been reviewed externally by an expert panel composed of nationally recognized modelers (Dr. Sorab Panday, Mr. Jim Rumbaugh, and John Porcello).
- The 2018 UWCD model was reviewed by Stanford professor, Dr. Daniel Tartakovsky
- The 2018 UWCD model was scrutinized in litigations

Historical Water Budget

- The historical water budget was INDEPENDENTLY reviewed and prepared by Dr. Zach Hanson
- The numerical groundwater model was built independently from the historical water budget

United Water Report Detailing Prior Investigations

- Summary of Past Groundwater Models and Water Budgets for the **Piru, Fillmore**, and Santa Paula Groundwater Basins
- Finalized November 2020
- PDF copy available on the FPBGSA website:
  - https://www.fpbgsa.org/gsp/gsp-tech-memos-and-documents/



Range of Historical Water Budget Components

Majority of values extracted from:
DWR (1956) or Mann (1959)

With other references being:
CH2M HILL (2004, 2005)
CH2M HILL/HGL (2008)
LWA and others (2015)
DBS&A and RCS (2017)

	Piru Basin			Fillmore Basin	
Budget Components (AFY)	**Lower**	**Upper**		**Lower**	**Upper**
Inflows					
Subsurface underflow	240	18,800		12,570	111,210
Stream Percolation	6,400	61,850		1,790	49,130
Precipitation Recharge	190	20,200		470	54,200
Mountain Front Recharge	2,620	2,620		3,530	3,530
Managed Recharge	0	11,800		--	--
Local Wastewater Treatment Percolation Ponds	210	210		1,040	1,040
Imported	0	5,840		4,900	11,770
Outflows					
Subsurface underflow	12,570	111,210		3,900	30,910
Rising groundwater	0	37,800		6,030	48,200
Consumptive use*	6,450	15,000		20,590	36,200
Exported	2,200	6,450		0	5,160
Change in Groundwater Storage**	**-19,600**	**44,600**		**-20,170**	**49,300**

*Of applied water and precipitation on basin (including phreatophytes)

**Reported changes in annual storage (not calculated from inflows and outflows presented here)

(Source: UWCD, 2020)

Prior Investigations Historical Water Budget Components

Table E-1: Chronology of hydrologic investigations which contributed water budget components related to Santa Clara River Valley groundwater basins (Piru, Fillmore, and Santa Paula).

Entity	Year Published	Reference	Budget Components Provided?	Representative Years
California Department of Public Works, Division of Water Resource[1]	1933	DWR, 1933	All, various	1927 - 1932
California State Water Resources Board[1]	1956	DWR, 1956	All, various	1936 - 1951
John F. Mann and Associates	1959	Mann, 1959	All, various	1936 - 1957
California Department of Water Resources	1974	DWR, 1974a	Piru, subsurface inflow	1956 - 1967
Law/Crandall Inc.	1993	Law/Crandall, 1993	Fillmore, subsurface outflow	1956 - 1990
United States Geological Survey	2003	Reichard and others, 2003	Fillmore, subsurface outflow	1984 – 1993
CH2M HILL	2004	CH2M HILL, 2004	Piru, subsurface inflow	1980 - 1999
CH2M HILL	2005	CH2M HILL, 2005	Piru, subsurface inflow	1980 - 2005
CH2M HILL/ HydroGeoLogic Inc; HydroMetrics (United-sponsored analysis)	2008	CH2M HILL/ HGL, 2008	Piru and Fillmore, subsurface inflow	1975 - 2005
HydroMetrics (United-sponsored updates)	2015	LWA and others, 2015	All, various	1996 - 2012
Steve Bachman	2015	Bachman, 2015	Fillmore, subsurface outflow	1947 - 2014
Daniel B. Stephens and Associates, Inc/ Richard C. Slade and Associates LLC	2017	DBS&A and RCS, 2017	Fillmore and Santa Paula, various	1999 - 2012

[1]One of the predecessor agencies to California's current Department of Water Resources (DWR). DWR was formed in 1956 with legislation that simultaneously dissolved the Water Project Authority and Division of Water Resources within the Department of Public Works as well as took over duties of a reconstituted State Water Resources Board (DWR, 2020).

(Source: UWCD, 2020)

GW Model Water Budget

Piru basin

	GW Model Water Budget			Historical Water Budget		
Inflows	Average	Min	Max	Lower	Upper	Data Review
Subsurface underflow	5,000			240	18,800	Subsurface underflow
Stream Percolation	40,500	18,000	75,500	6,400	61,850	Stream Percolation
				0	37,800	Rising groundwater
Recharge	10,500	4,000	27,000	190	20,200	Precip Recharge
				0	11,800	Managed Recharge
Mountain Front Recharge	6,500	1,500	14,000	2,620	2,620	
Outflows						
Subsurface underflow	46,000	31,000	54,000	12,570	111,210	Subsurface underflow
Pumping	12,500	8,000	18,000	6,450	15,000	Consumptive use
ET	5,000	2,500	10,000			

Unit: ACRE-FEET ANNUALLY

Fillmore basin

	GW Model Water Budget			Historical Water Budget		
Inflows	Average	Min	Max	Lower	Upper	Data Review
Subsurface underflow	46,000	31,000	54,000	12,570	111,210	Subsurface underflow
Stream Percolation	1,500	-39,500	23,000	1,790	49,130	Stream Percolation
				6,030	48,200	Rising groundwater
Recharge	17,000	11,040	25,000	470	54,200	Precip Recharge
				1,040	1,040	WWTP Percolation
Mountain Front Recharge	8,000	3,000	14,500	3,530	3,530	
Outflows						
Subsurface underflow to SP	19,000	15,500	22,000	3,900	30,910	Subsurface underflow
Pumping	46,000	33,000	59,500	20,590	36,200	Consumptive use
ET	12,000	3,500	20,000			

Unit: ACRE-FEET ANNUALLY

Questions/ Comments

Piru

Inflows	Average	Min	Max	Lower	Upper	Data Review
Subsurface underflow	5,000			240	18,800	Subsurface underflow
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				0	37,800	Rising groundwater
Recharge	10,500	4,000	27,000	190	20,200	Precip Recharge
				0	11,800	Managed Recharge
Mountain Front Recharge	6,500	1,500	14,000	2,620	2,620	
Outflows						
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Fillmore

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Fillmore and Piru Basins
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FPBGSA Stakeholder Workshop 3

Groundwater Model Technical Session

Senior Groundwater Modeler

Jason Sun, PhD, PE

December 9, 2020

United Water
CONSERVATION DISTRICT

- Model Validation
- Groundwater Model Input Parameters

2016-2019 Dataset

- Monthly precipitation data
- Pumping records
- Stream flow and diversions
- Surface water import/delivery
- Water level data
- WWTP discharges

The above data collection was made possible by Dr. Zach Hanson, FCGMA, cities, and other agencies/organizations

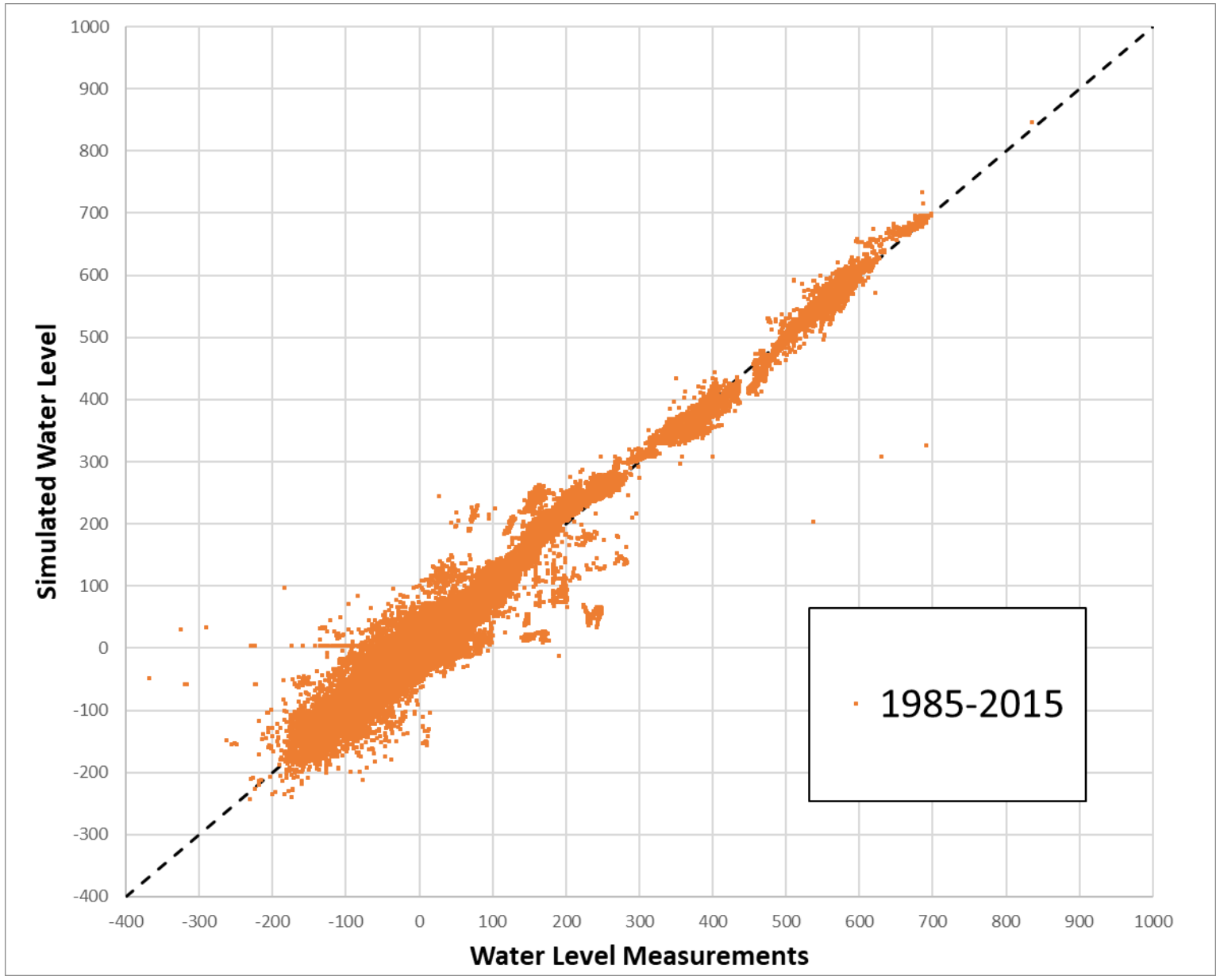
Model Validation

- The GW model remains well calibrated with the 2016-2019 groundwater level data

- The UWCD hydrologist has reviewed the surface water result and concluded the 2016-2019 surface water validation is good

Scatter Plot

- The overall comparison shows no significant outlier data points in 2016-2019
- The model validation is good



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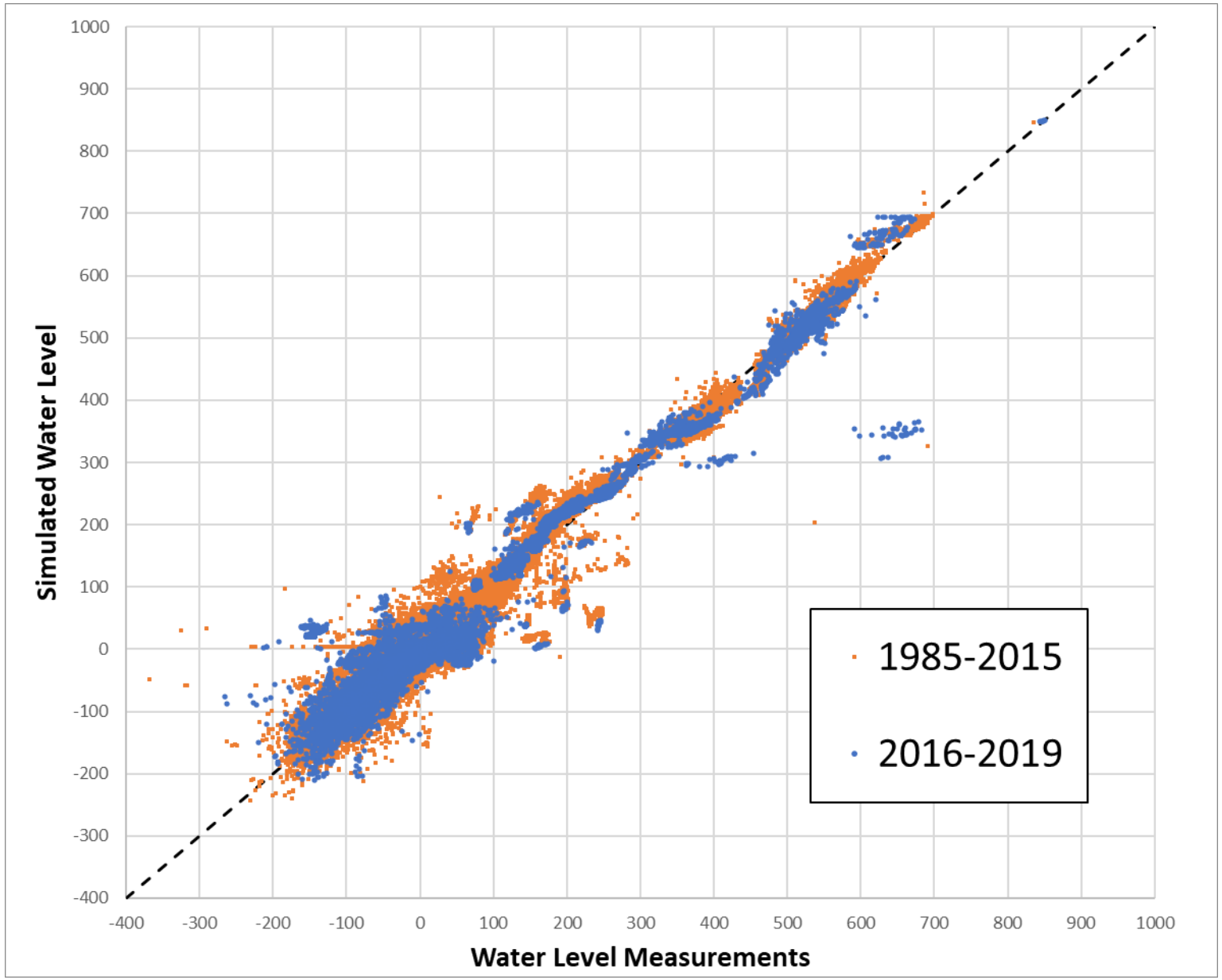
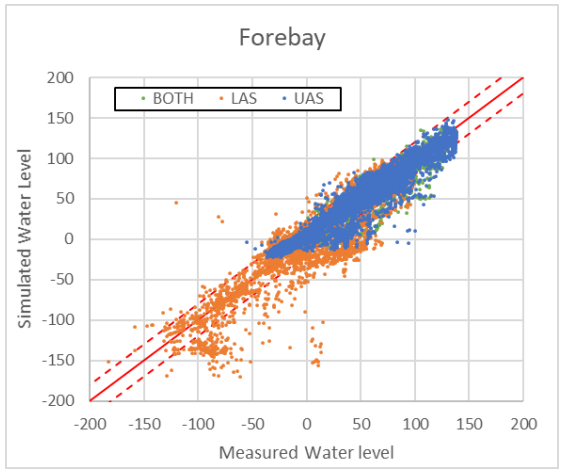
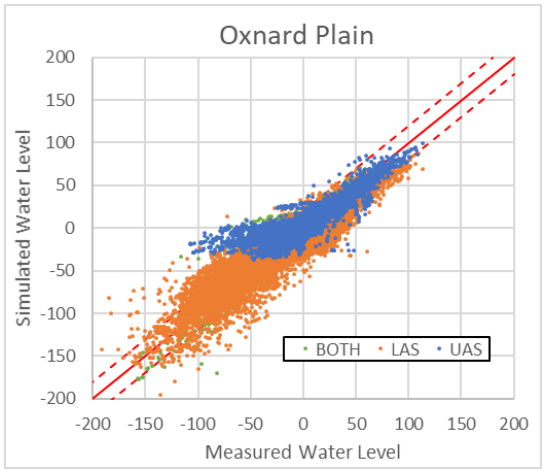
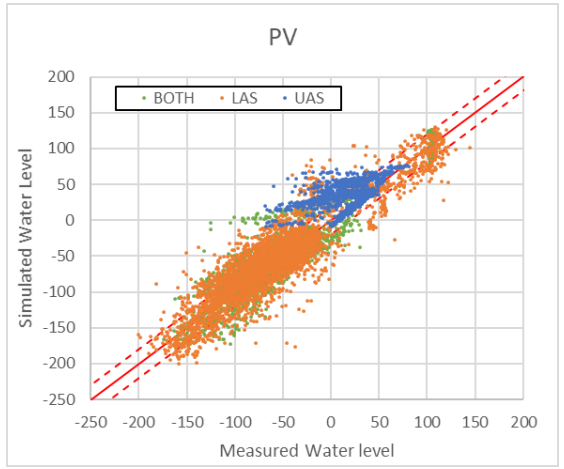
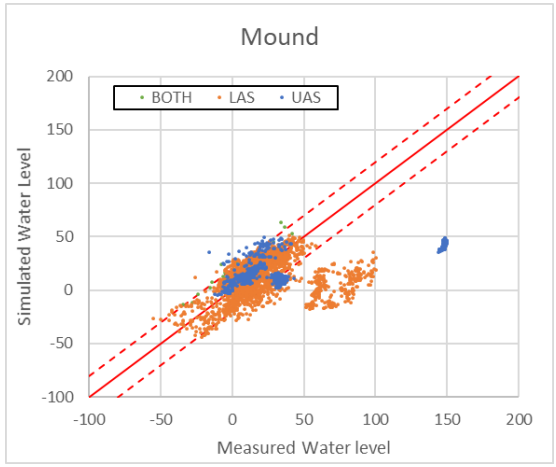


1985 - 2015

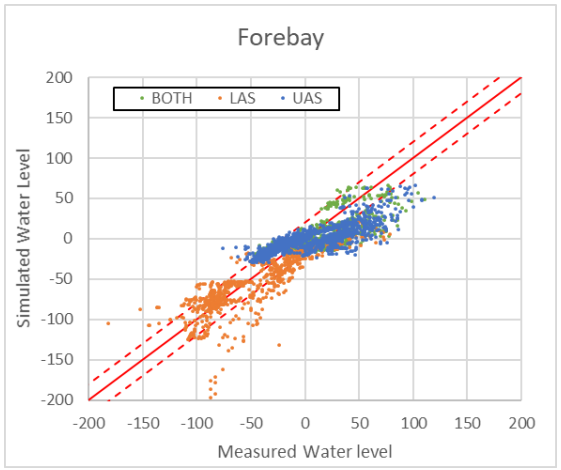


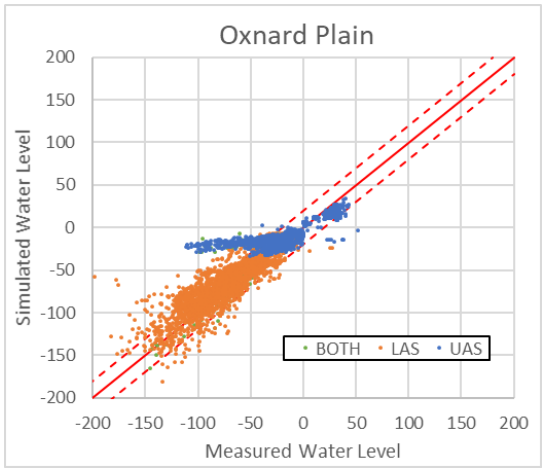


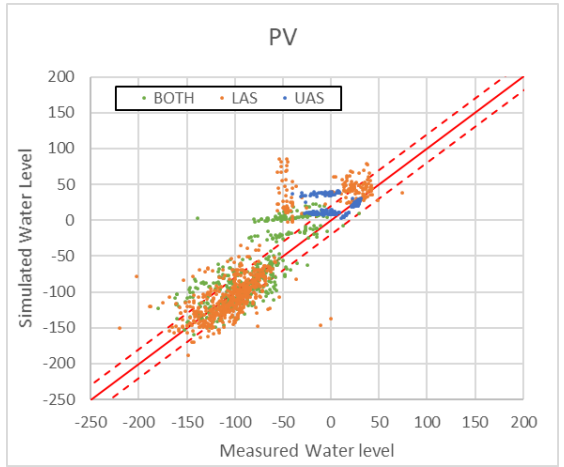


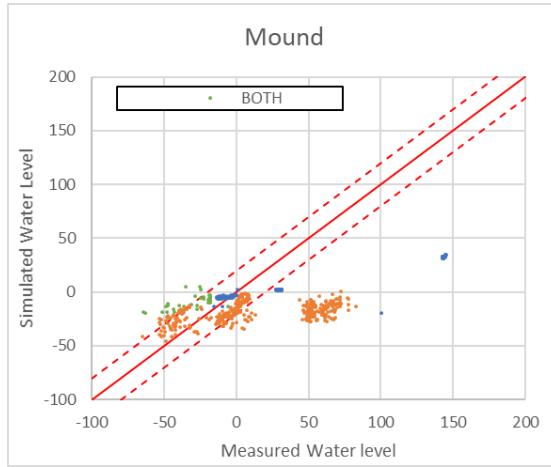


2016 - 2019

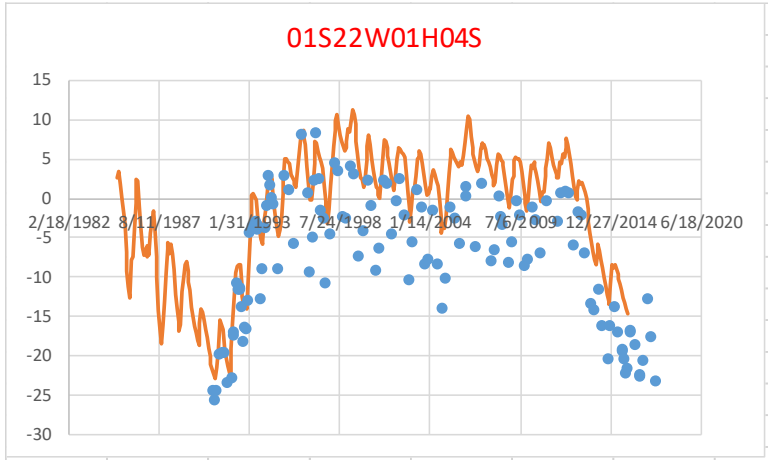


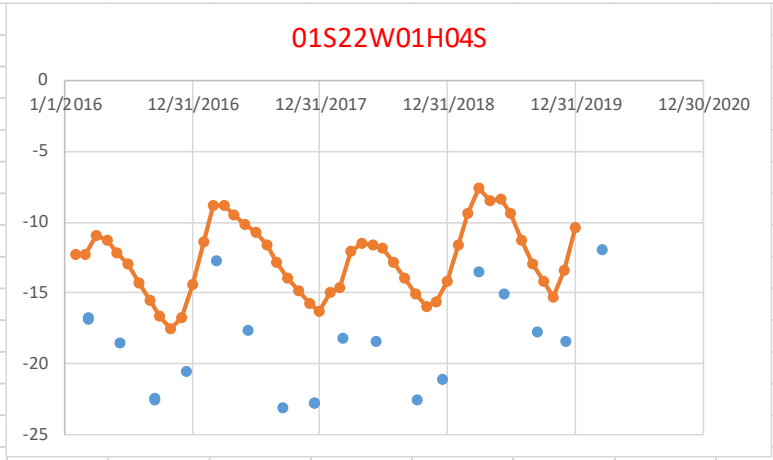






Oxnard Plain





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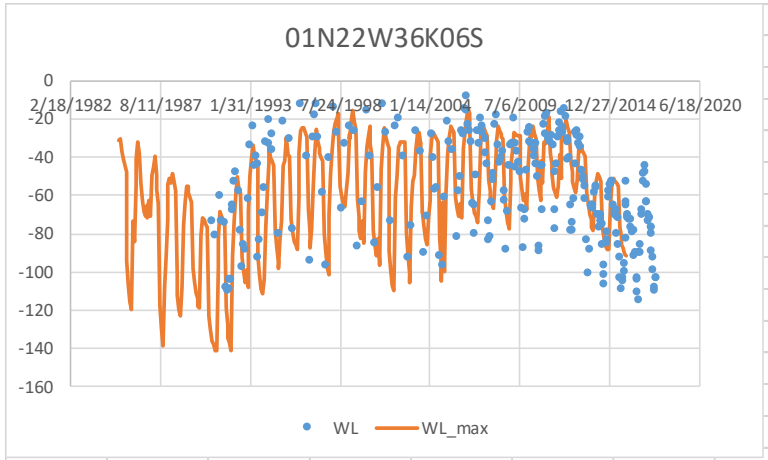
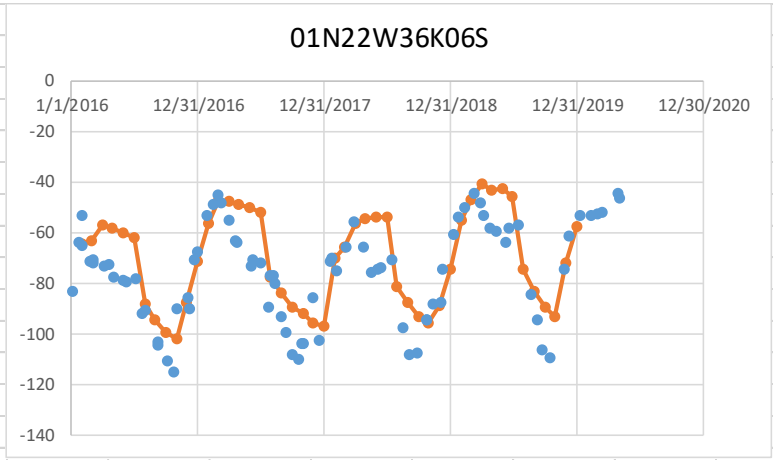
01S22W01H04S	3	3	-5.3	6.0	5.3
01S22W01H04S	5		-5.2	6.0	5.3
	G.S.	9.126	OBS #	119	

01S22W01H04S	180	0	200	0	200
01S22W01H04S	3	3	-6.1	6.2	6.1
01S22W01H04S	5		-5.9	6.1	5.9
	G.S.	9.126	OBS #	19	

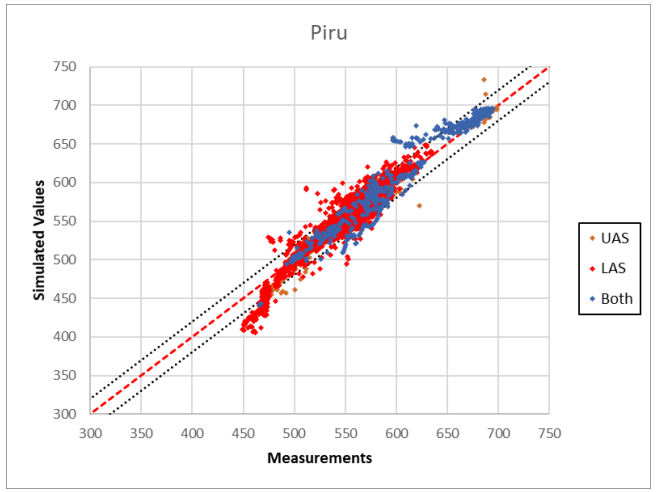


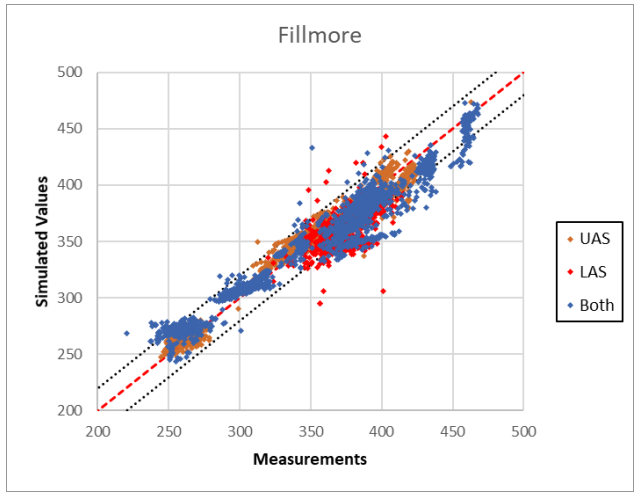


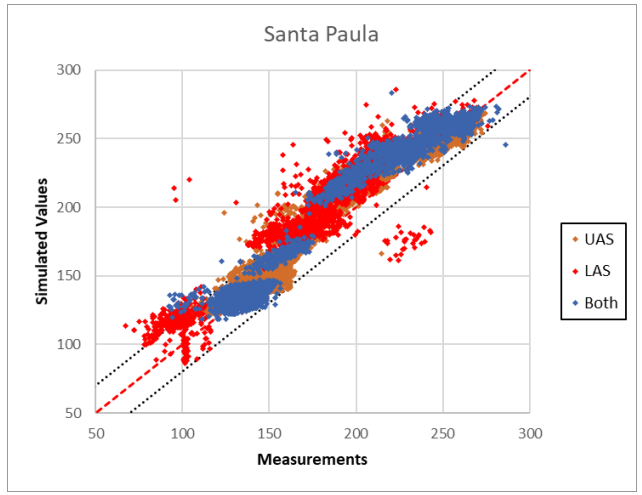
01N22W36K06S	540	0	580	0	580
01N22W36K06S	9	11	1.7	15.8	12.6
01N22W36K06S	7		1.4	15.8	12.5
	G.S.	9.735	OBS #	237	

01N22W36K06S	540	0	580	0	580
01N22W36K06S	9	11	-7.1	11.8	9.8
01N22W36K06S	11		-6.9	11.7	9.8
	G.S.	9.735	OBS #	78	

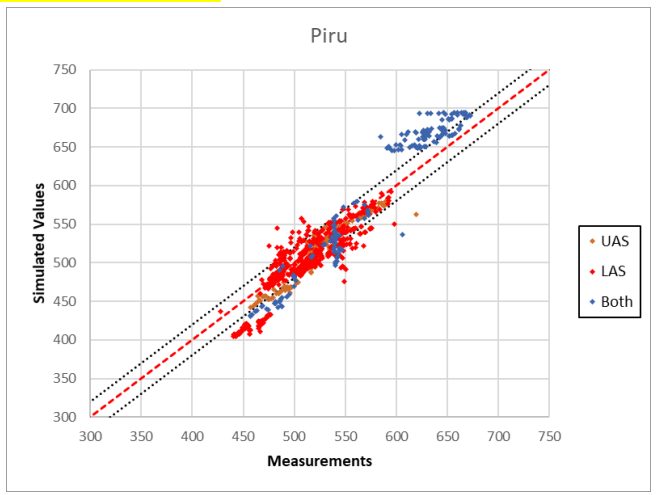
1985 - 2015

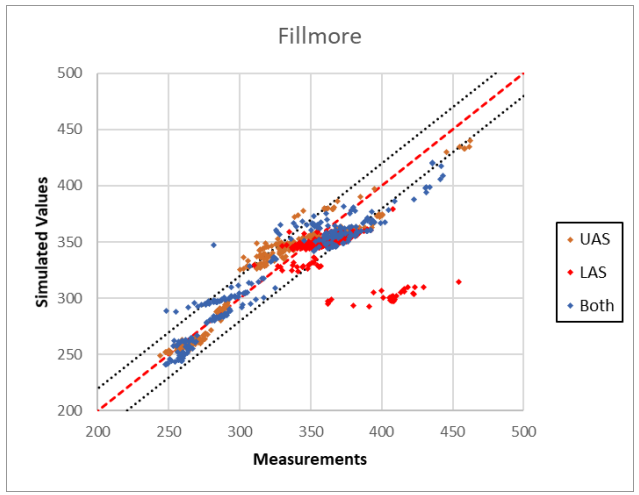


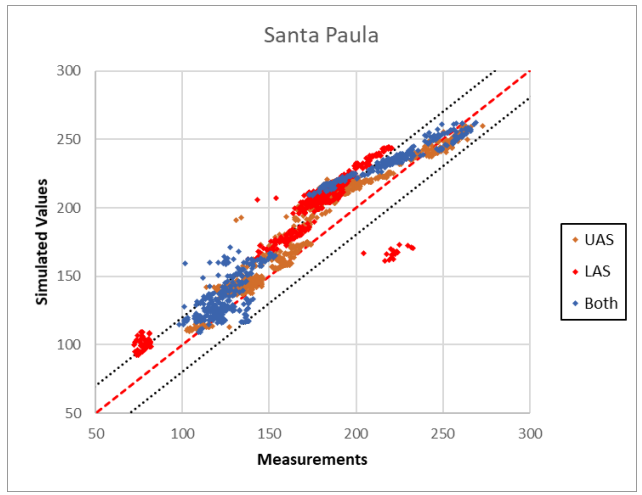




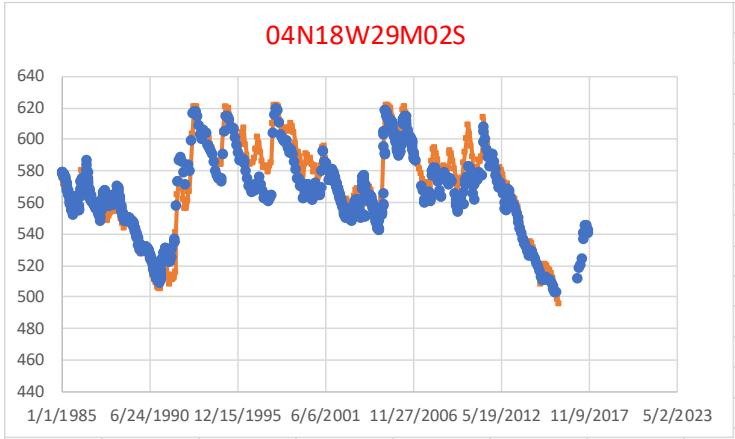
2016 - 2019

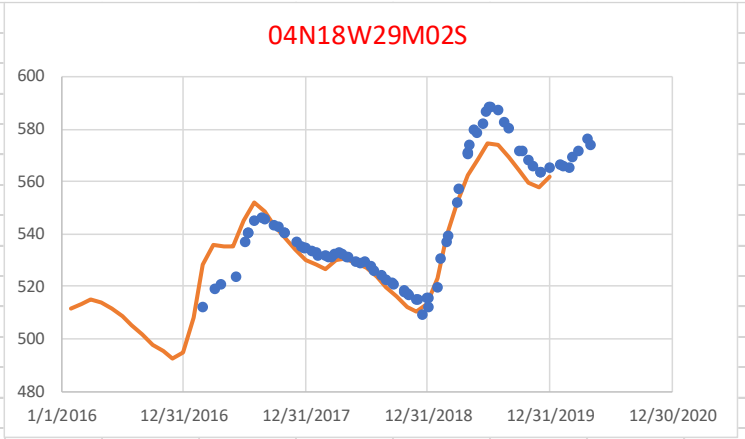






Piru





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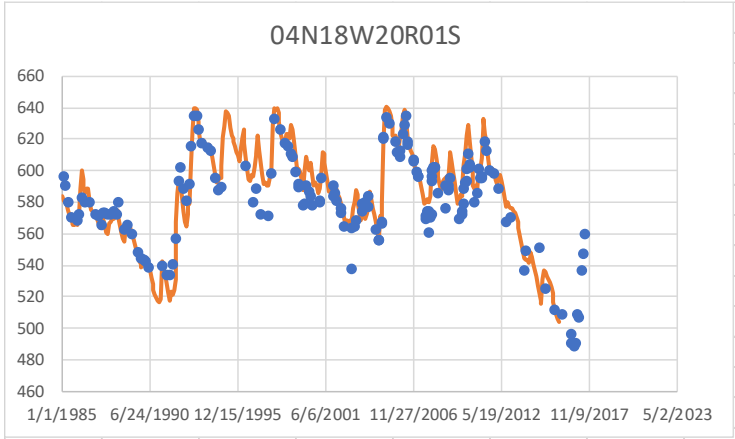
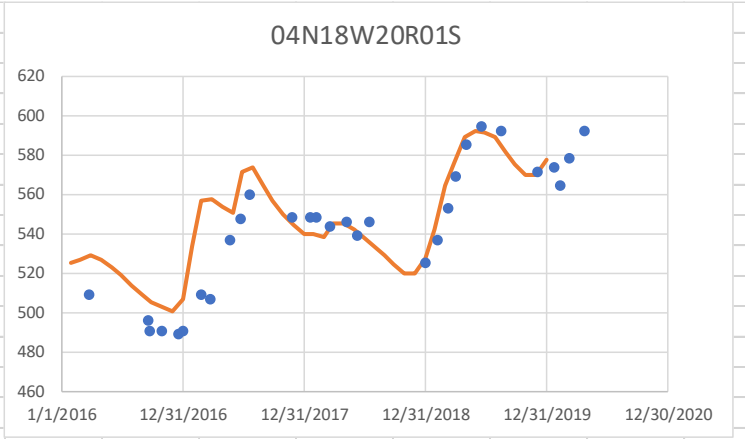
04N18W29M02S	3			-4.4	8.5	6.8
		G.S.	635.856	OBS #	932	

		0	0	0	142	-142
04N18W29M02S	1	5		2.6	7.0	5.6
04N18W29M02S	4			2.6	7.0	5.6
		G.S.	635.856	OBS #	74	





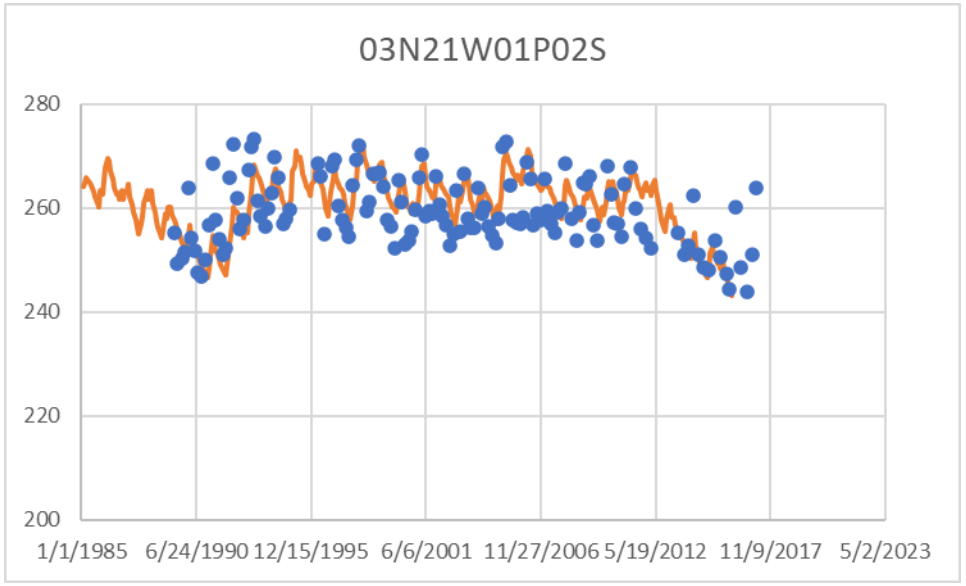
		190	0	319	0	364
04N18W20R01S	7	7		-6.2	11.3	9.1
04N18W20R01S	7			-6.2	11.3	9.1
		G.S.	677.229	OBS #	163	

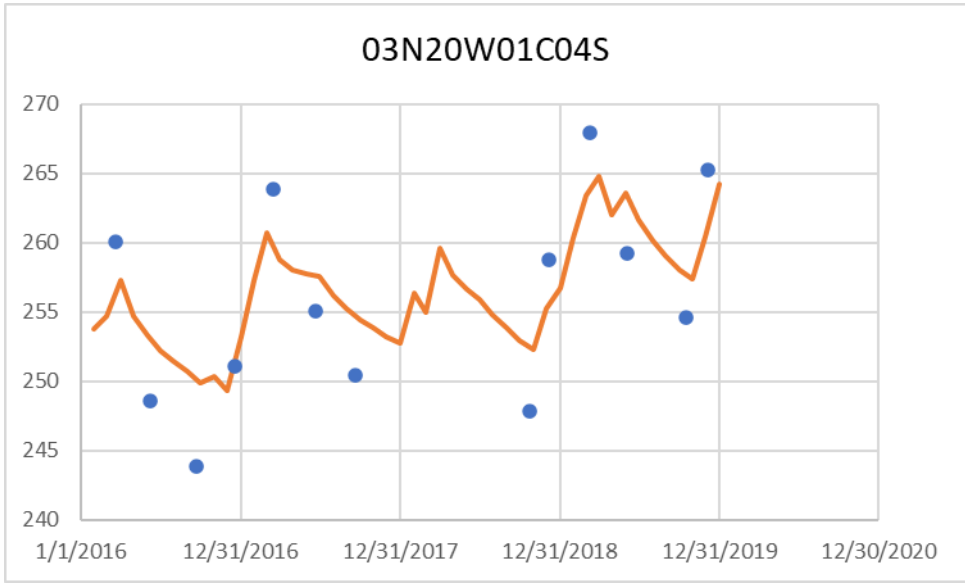
		190	0	319	0	364
04N18W20R01S	7	7		-9.2	17.2	12.6
04N18W20R01S	7			-9.2	17.2	12.6
		G.S.	677.229	OBS #	26	

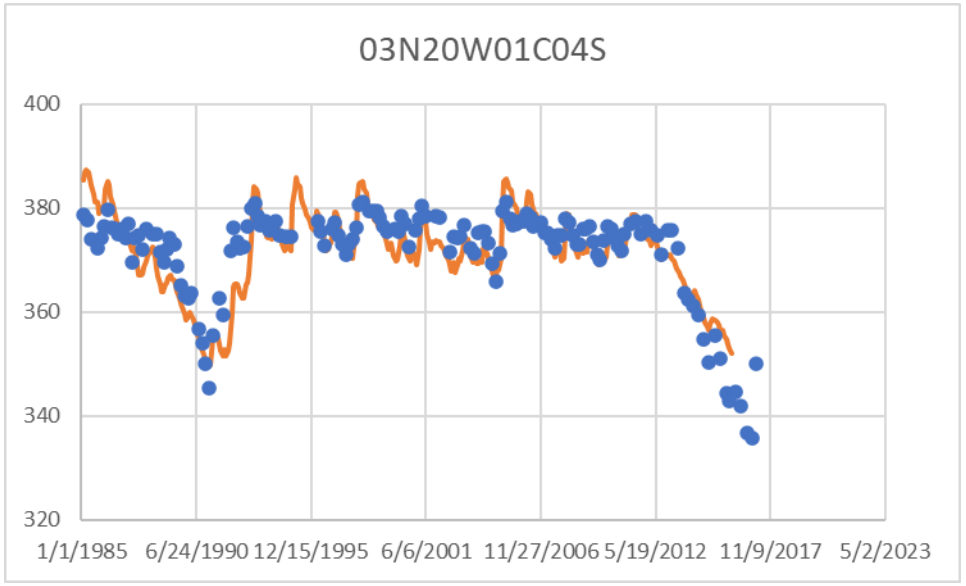
1985-2015

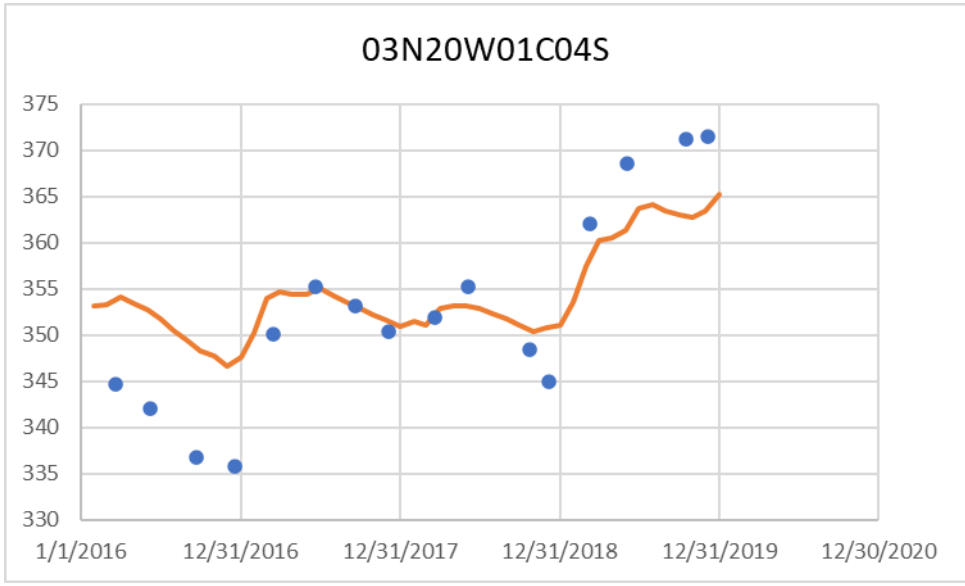
2016-2019

Fillmore



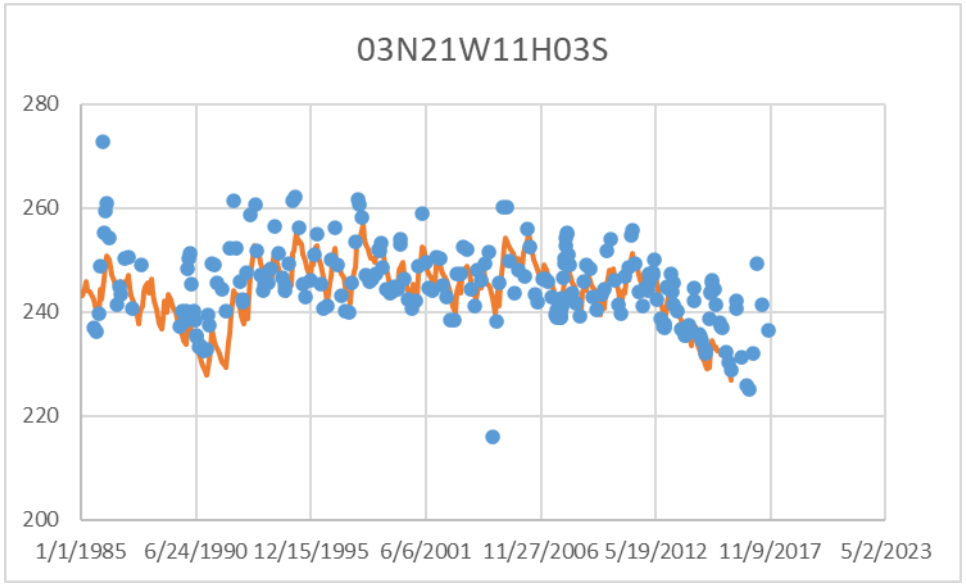




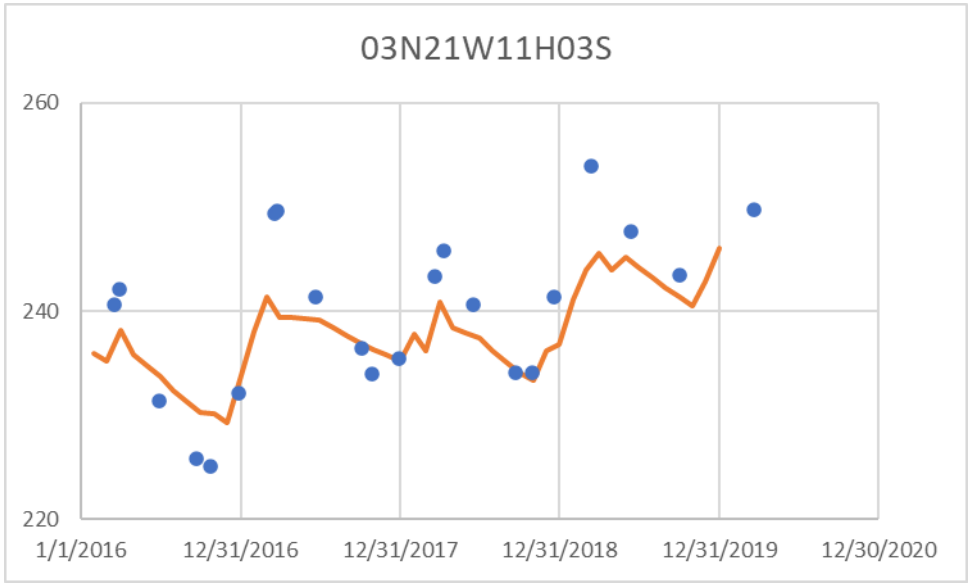


Santa Paula

1985-2015

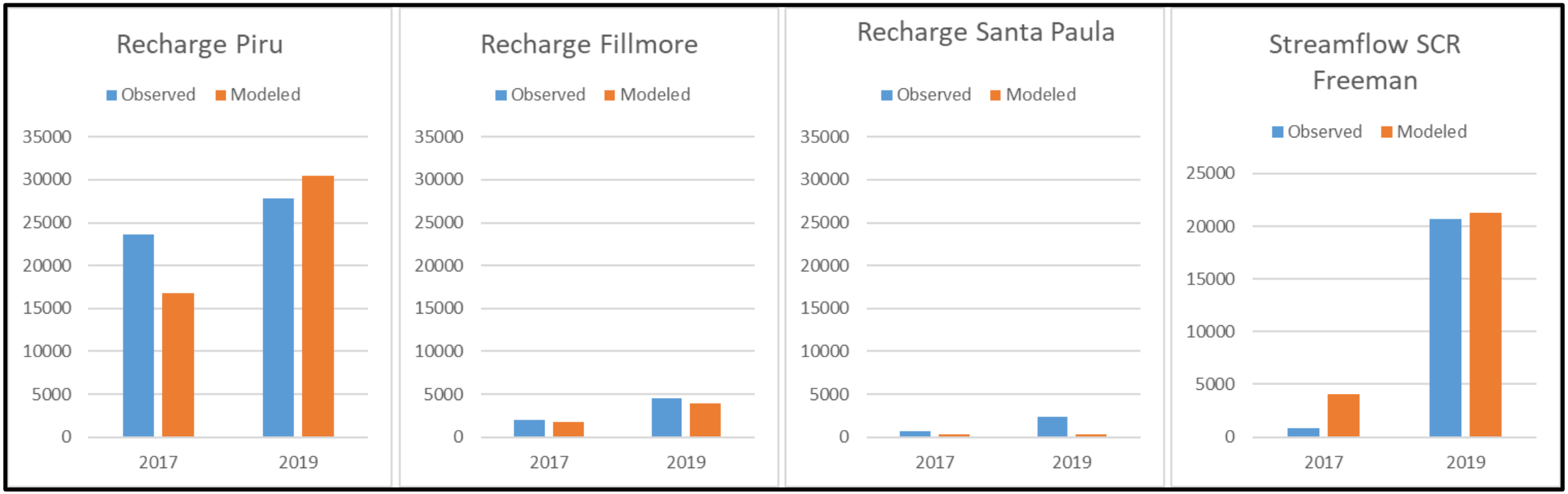


2016-2019

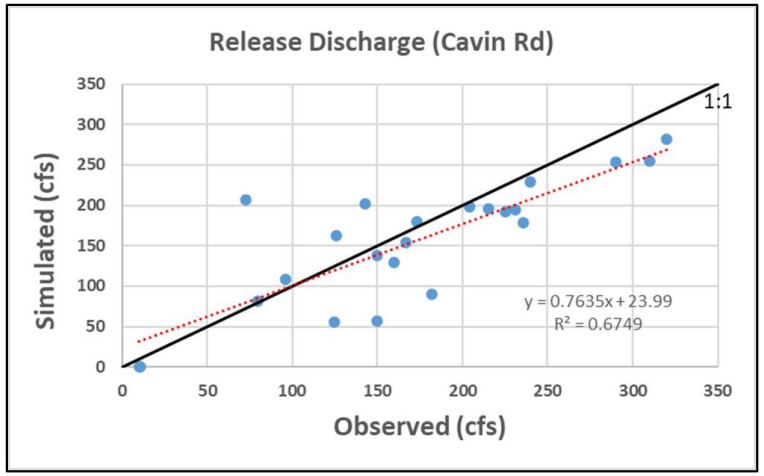


Surface Water

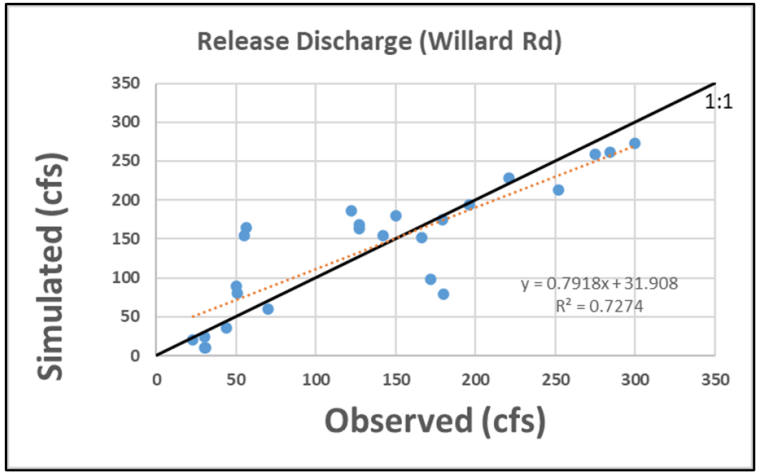
There were 2 releases (2017 and 2019) by UWCD



Stream Flows at Basin Boundary



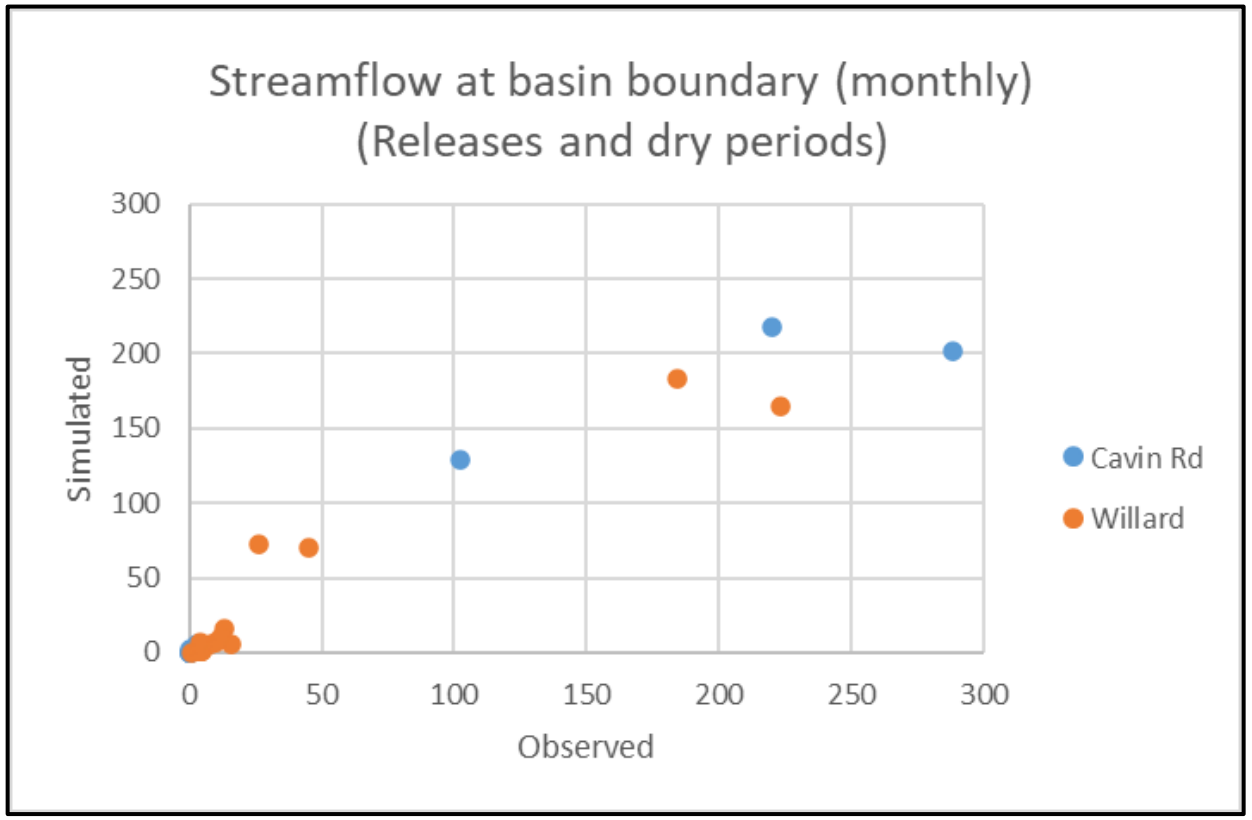
Between Piru and Fillmore Basins



Between Fillmore and Santa Paula Basins

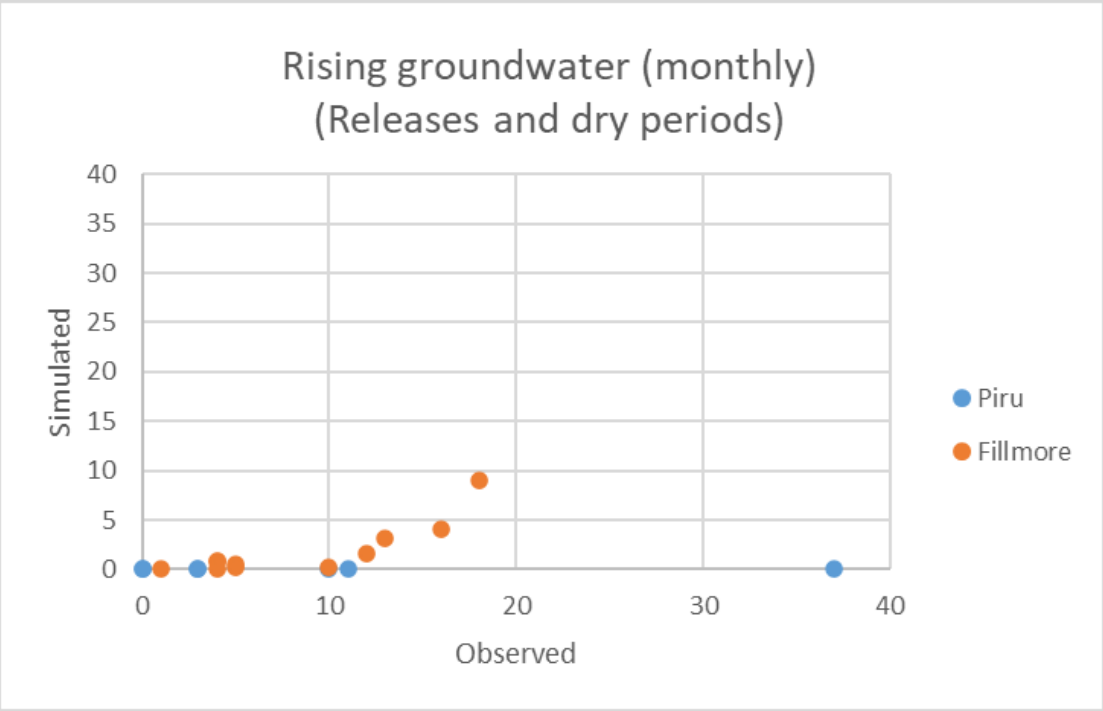
1985 - 2015

The stream flows at basin boundary are well correlated in 2016-2019



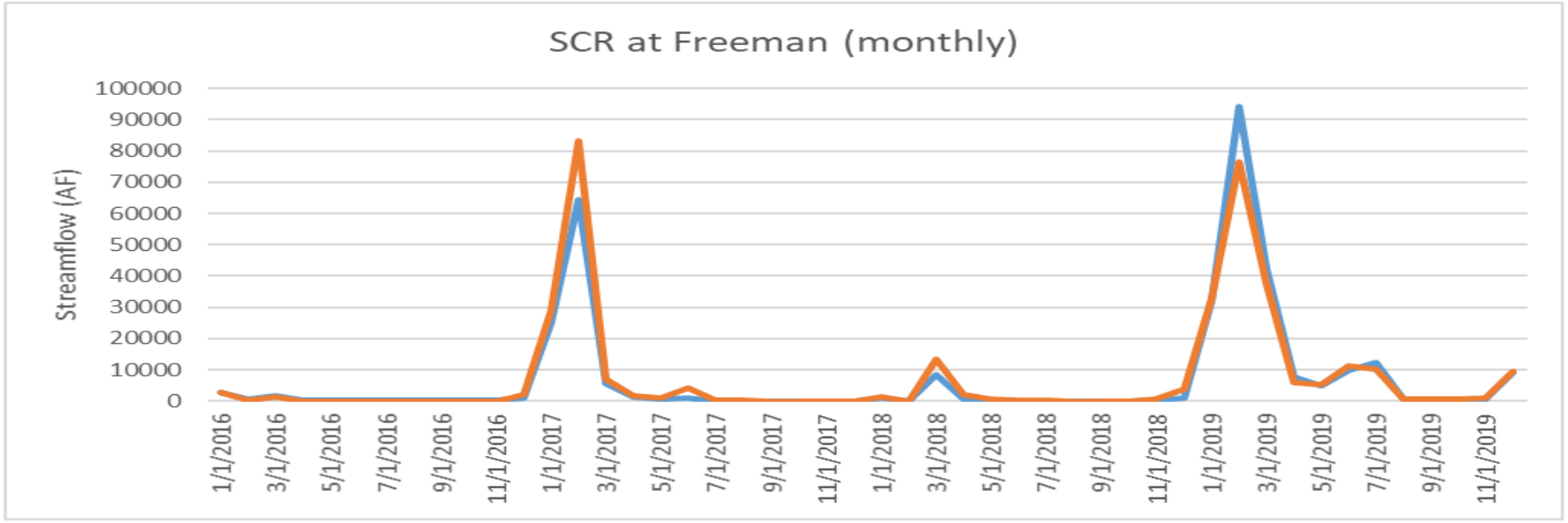
2016 - 2019

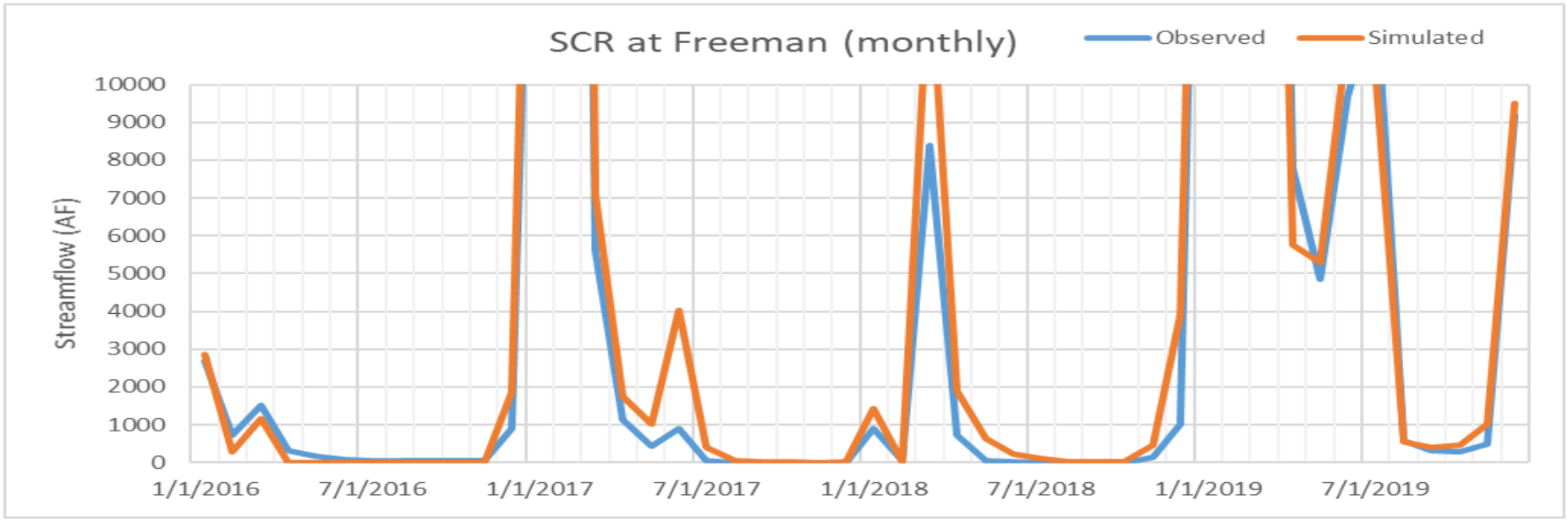
Stream Gaining/Losing



- The GW model underestimates the rising groundwater both in 1985-2015 and 2016-2019
- **The effect of underestimation** on the basin flow budget and GSP analysis is **minimal** as the stream flows at basin boundary are good
- The rising groundwater is very sensitive to the groundwater level.
- A few feet difference can change stream from rising to losing, and vice versa

Stream Flow at Freeman Diversion

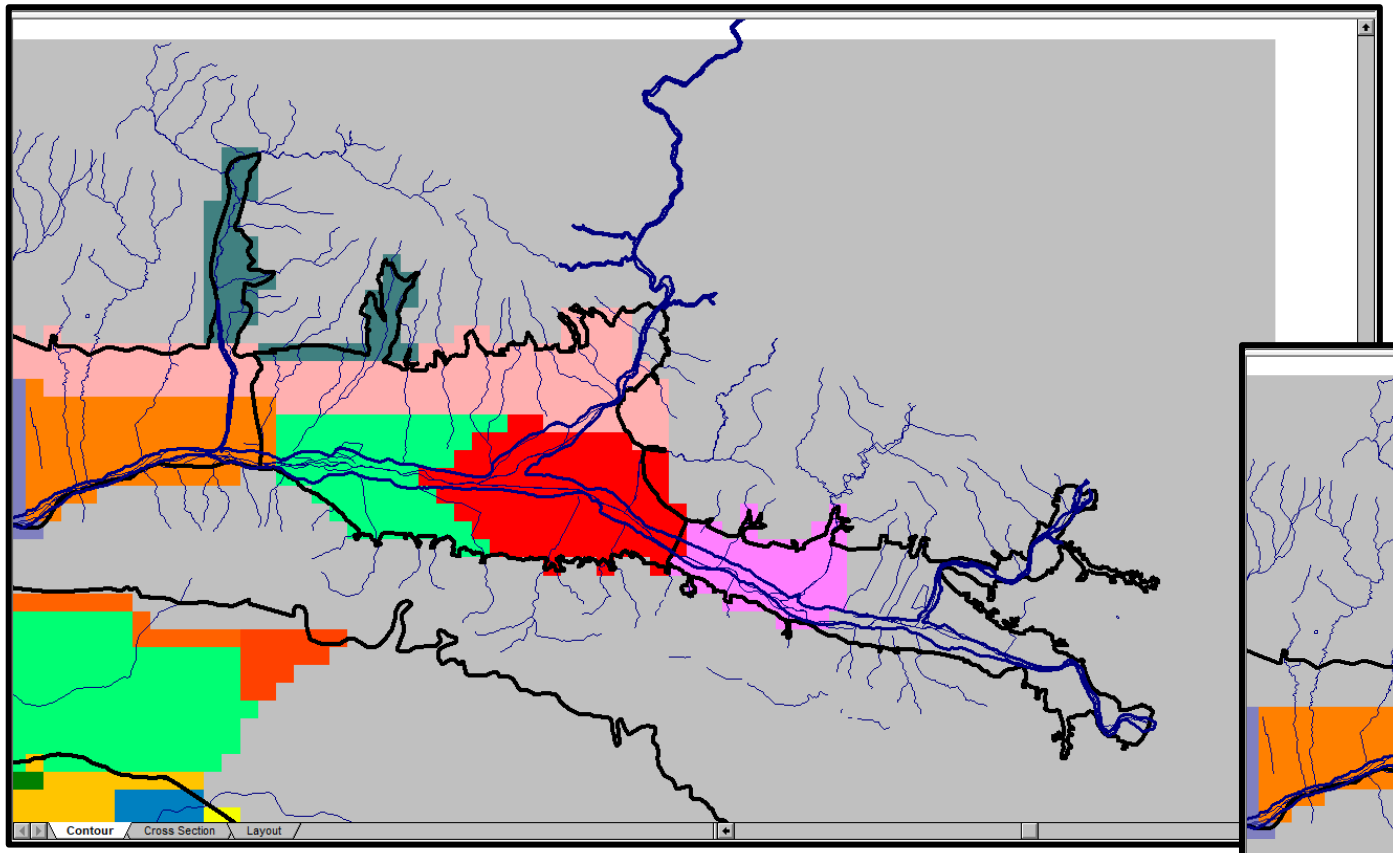


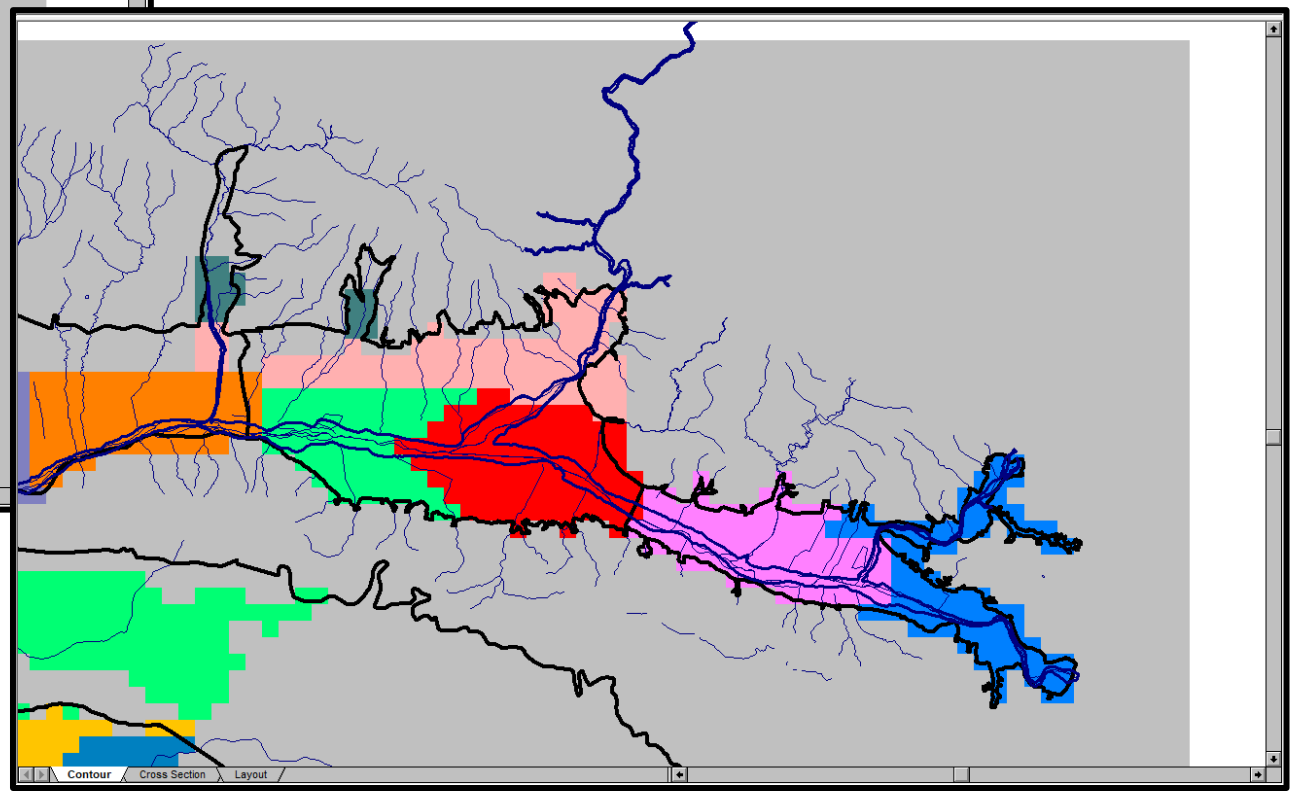


Model Validation

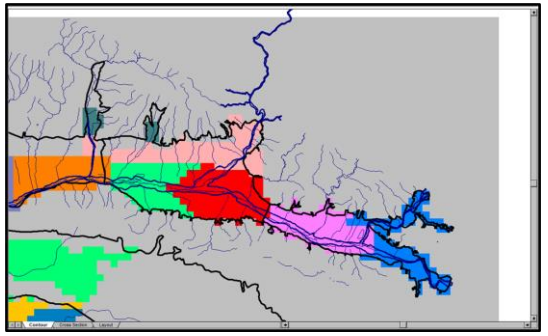
- The model validation is good. No change to the model
- The UWCD Model is now extended to 2019 (1985 to 2019)
- There are model limitations on SCR gaining/losing reaches
- The GW model is adequate for the GSP analysis

Input Parameters





Hydraulic Conductivity



Aquifer System	Hydrostratigraphic Unit	Model Layer						
A	Surficial Deposits and Colluvium	1	10	200	200	600	1200	1200
	Aquitard	2	10	100	0.1	0.1	0.1	0.1
	Recent River Alluvium	3	10	100	100	400	1200	1200
B	Aquitard	4	10	100	100	200	1000	1000
	Older Alluvium	5	10	100	100	200	1000	1000
	Aquitard	6	0.1	1	1	1	1	1
	Upper Saugus	7	5	50	100	100	200	200
C	Aquitard	8	1	1	0.01	0.01	0.01	0.01
	Lower Saugus	9	5	50	100	100	100	100
	Undifferentiated Sedimentary Deposits	10	5	50	100	100	100	100

Unit: FEET/DAY

Ongoing/Future Work

- GSP model simulations for Fillmore, Piru, and Mound GSAs
- Brackish water model simulation
- Model documentation
- Sensitivity Analysis/Uncertainty Analysis
- The groundwater model improvement will continue whenever we have better understanding or more data

Questions/Comments