SW-GW INTERACTION AND CROSS-FLOW FOR RUN 13

Presentation to GMA 12

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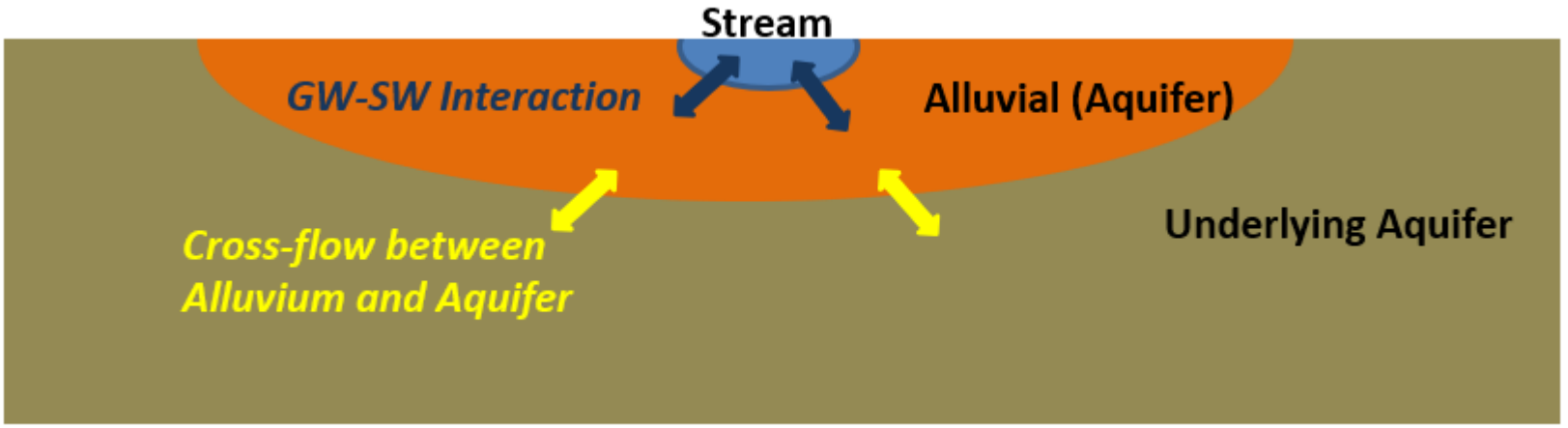
Outline for Discussion of Run 13

- GW-SW Interaction
  - Colorado River
  - Brazos River
  - Limitation on model results (Sept, 2020 slides)

- Cross-Flow Between Aquifers
  - Sparta
  - Queen City
  - Carrizo
  - Calvert Bluff
  - Simsboro
  - Hooper

Schematic of Water Budget



Alluvium Interaction

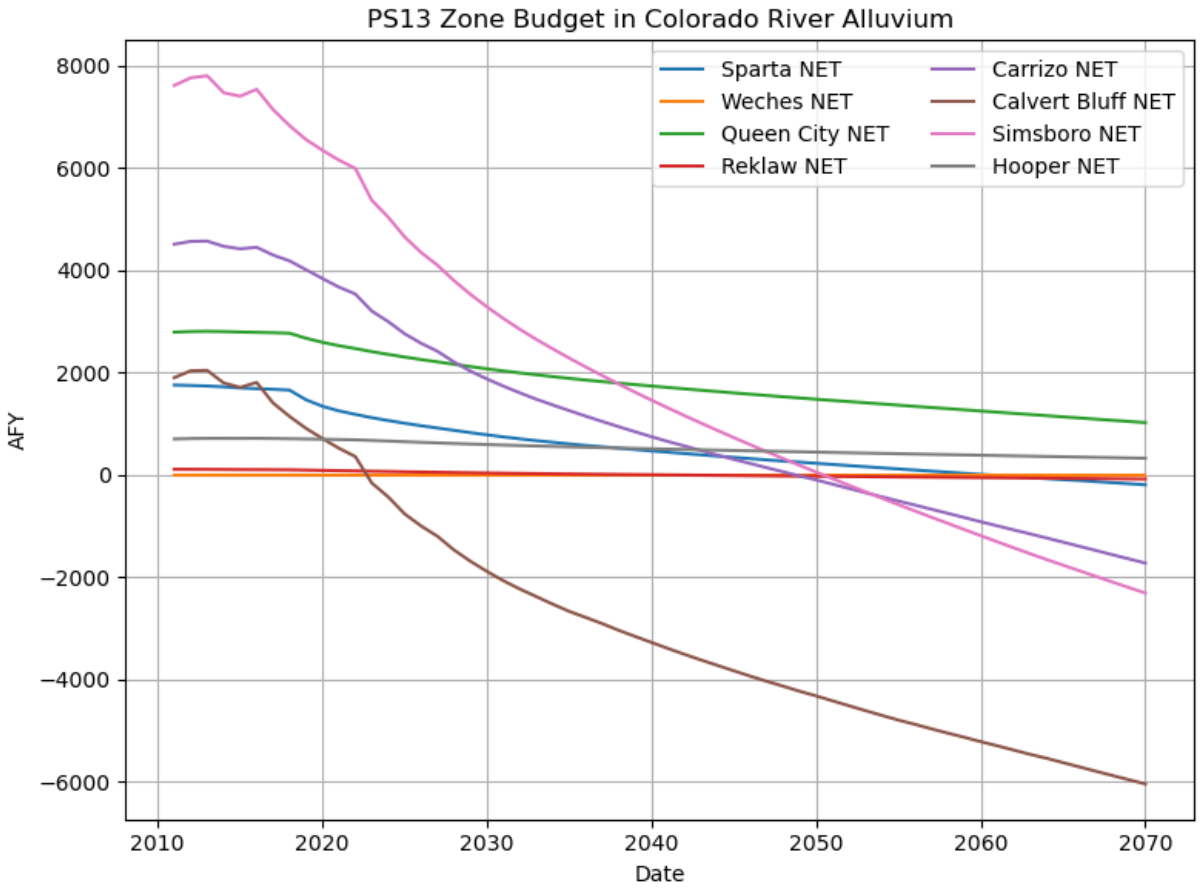
From a water budget perspective, a negative number is a loss from the alluvium

Negative numbers can be a loss to the river (river is gaining)
And, negative numbers can be a lost to an underlying aquifer

Aquifer Cross-Flow: Colorado River Alluvium

Aquifer	2011 Aquifer-Alluvium Exchange (afy)		
	Inflow	Outflow	Net
Sparta	2,240	-485	1,756
Weches	0	-22	-22
Queen City	3,390	-600	2,790
Reklaw	143	-36	107
Carrizo	6,098	-1,586	4,512
Calvert Bluff	4,360	-2,461	1,899
Simsboro	10,631	-3,012	7,620
Hooper	1,131	-431	700
Total	27,995	-8,631	19,363

Aquifer	2070 Aquifer-Alluvium Exchange (afy)		
	Inflow	Outflow	Net
Sparta	895	-1,091	-196
Weches	0	-22	-22
Queen City	1,889	-869	1,020
Reklaw	43	-127	-84
Carrizo	1,302	-3,031	-1,729
Calvert Bluff	706	-6,758	-6,051
Simsboro	4,913	-7,229	-2,316
Hooper	913	-590	323
Total	10,661	-19,716	-9,055

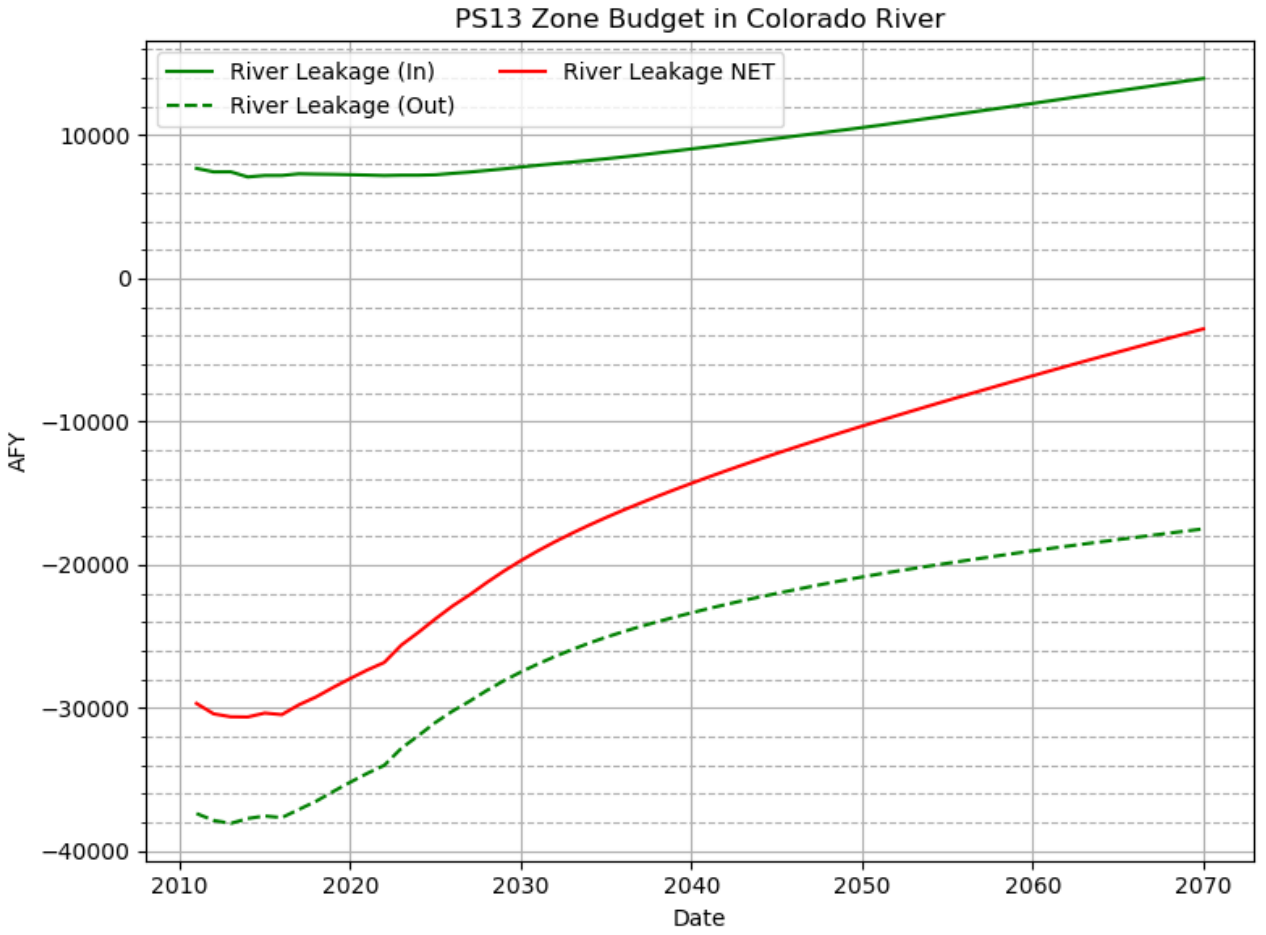


- Outflow is from alluvium to aquifer
- Inflow is from aquifer to alluvium
- Net: Positive – flow from aquifer to alluvium
  Negative- flow from alluvium to aquifer

SW-GW Interaction: Colorado River Alluvium

2011 River-Alluvium Exchange (afy)		
Inflow	**Outflow**	**Net**
7,688	-37,376	-29,688

2070 River-Alluvium Exchange (afy)		
Inflow	**Outflow**	**Net**
13,972	-17,494	-3,522

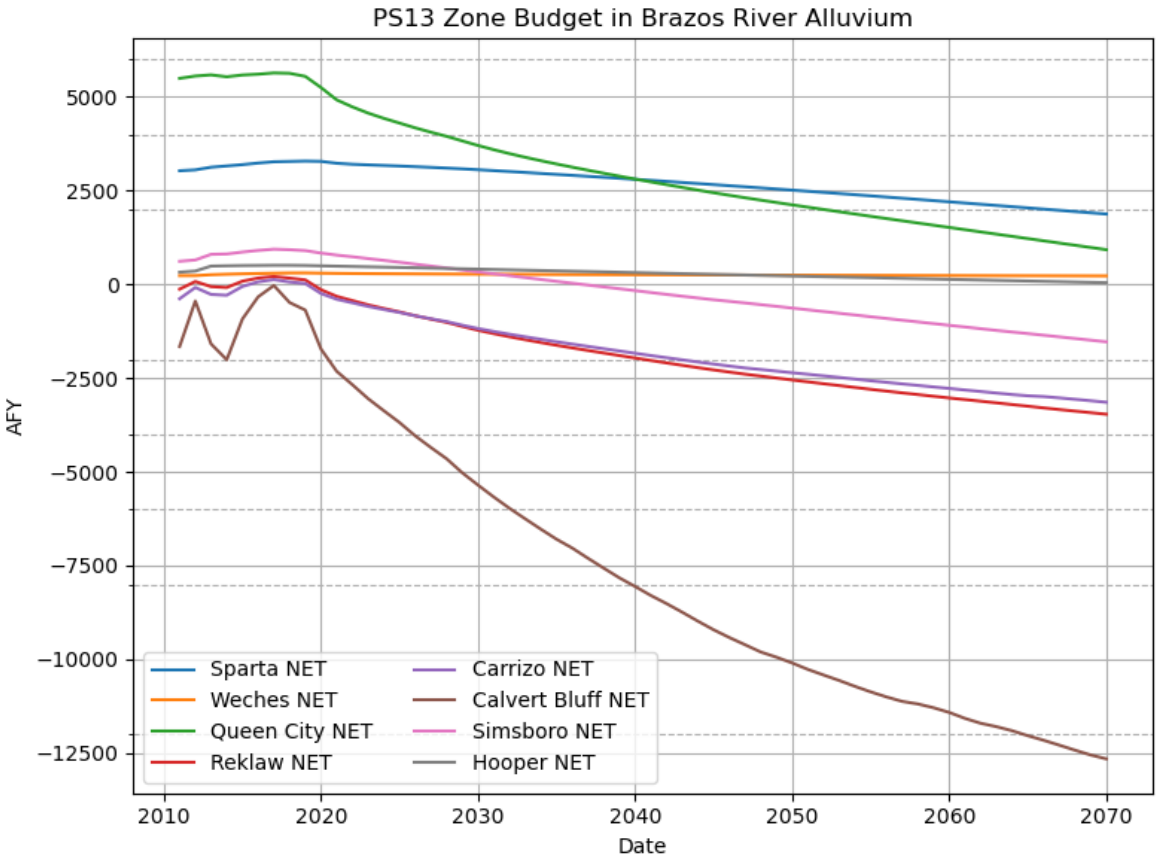


- Outflow is from alluvium to river
- Inflow is from river to alluvium
- Net: Positive – flow from river to alluvium
  Negative- flow from alluvium to river

Aquifer Cross Flow: Brazos River Alluvium

Aquifer	2011 Aquifer-Alluvium Exchange (afy)		
	Inflow	Outflow	Net
Sparta	3,415	-382	3,033
Weches	234	0	234
Queen City	5,717	-221	5,496
Reklaw	192	-318	-126
Carrizo	274	-656	-382
Calvert Bluff	2,345	-4,001	-1,656
Simsboro	984	-367	617
Hooper	351	-25	326
Total	13,514	-5,970	7,544

Aquifer	2070 Aquifer-Alluvium Exchange (afy)		
	Inflow	Outflow	Net
Sparta	2,761	-883	1,878
Weches	230	-3	228
Queen City	3,013	-2,086	927
Reklaw	15	-3,478	-3,462
Carrizo	13	-3,155	-3,142
Calvert Bluff	151	-12,806	-12,655
Simsboro	318	-1,849	-1,531
Hooper	310	-264	46
Total	6,813	-24,523	-17,711

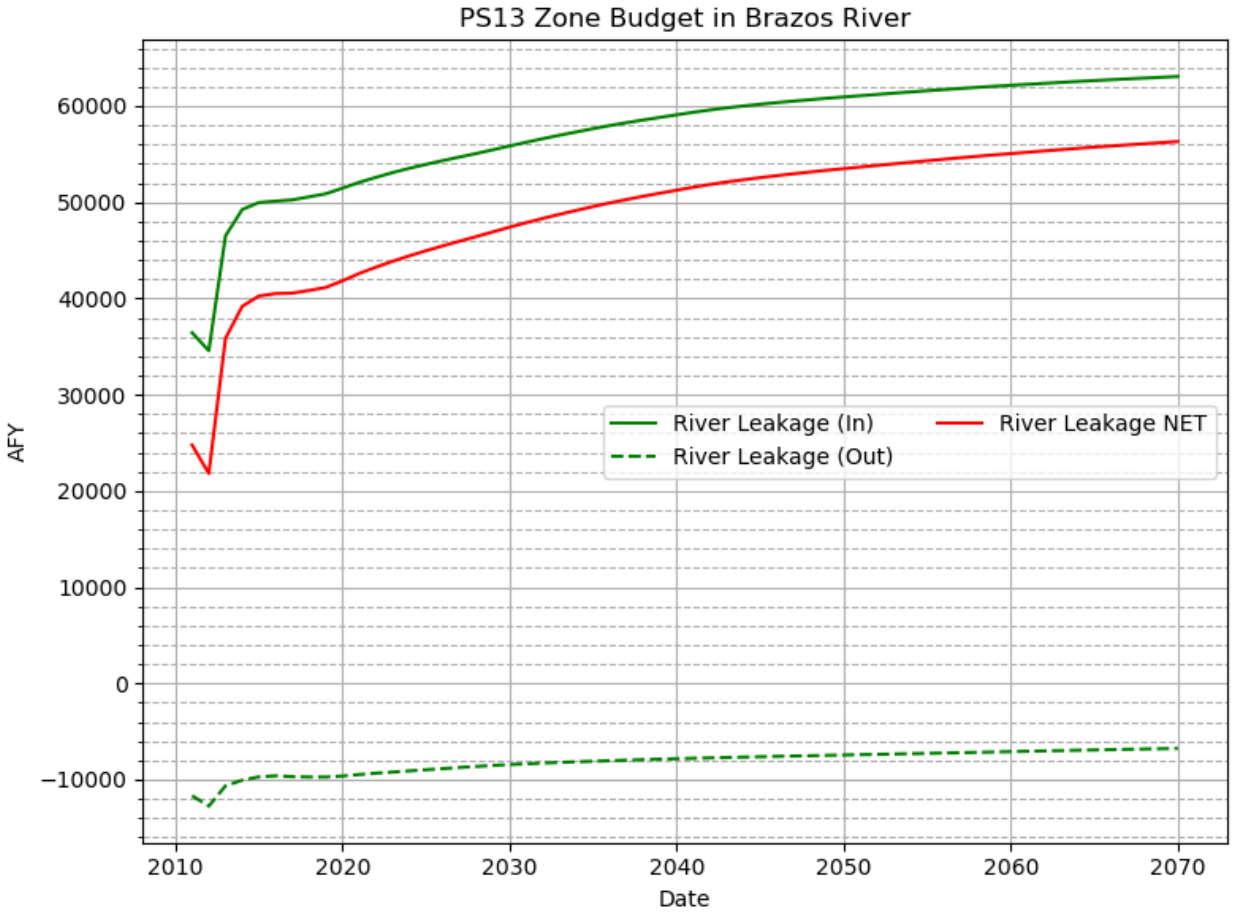


- Outflow is from alluvium to aquifer
- Inflow is from aquifer to alluvium
- Net: Positive – flow from aquifer to alluvium
  Negative- flow from alluvium to aquifer

SW-GW Interaction: Colorado River Alluvium

2011 River-Alluvium Exchange (afy)		
Inflow	**Outflow**	**Net**
36,441	-11,674	24,767

2070 River-Alluvium Exchange (afy)		
Inflow	**Outflow**	**Net**
63,070	-6,758	56,312

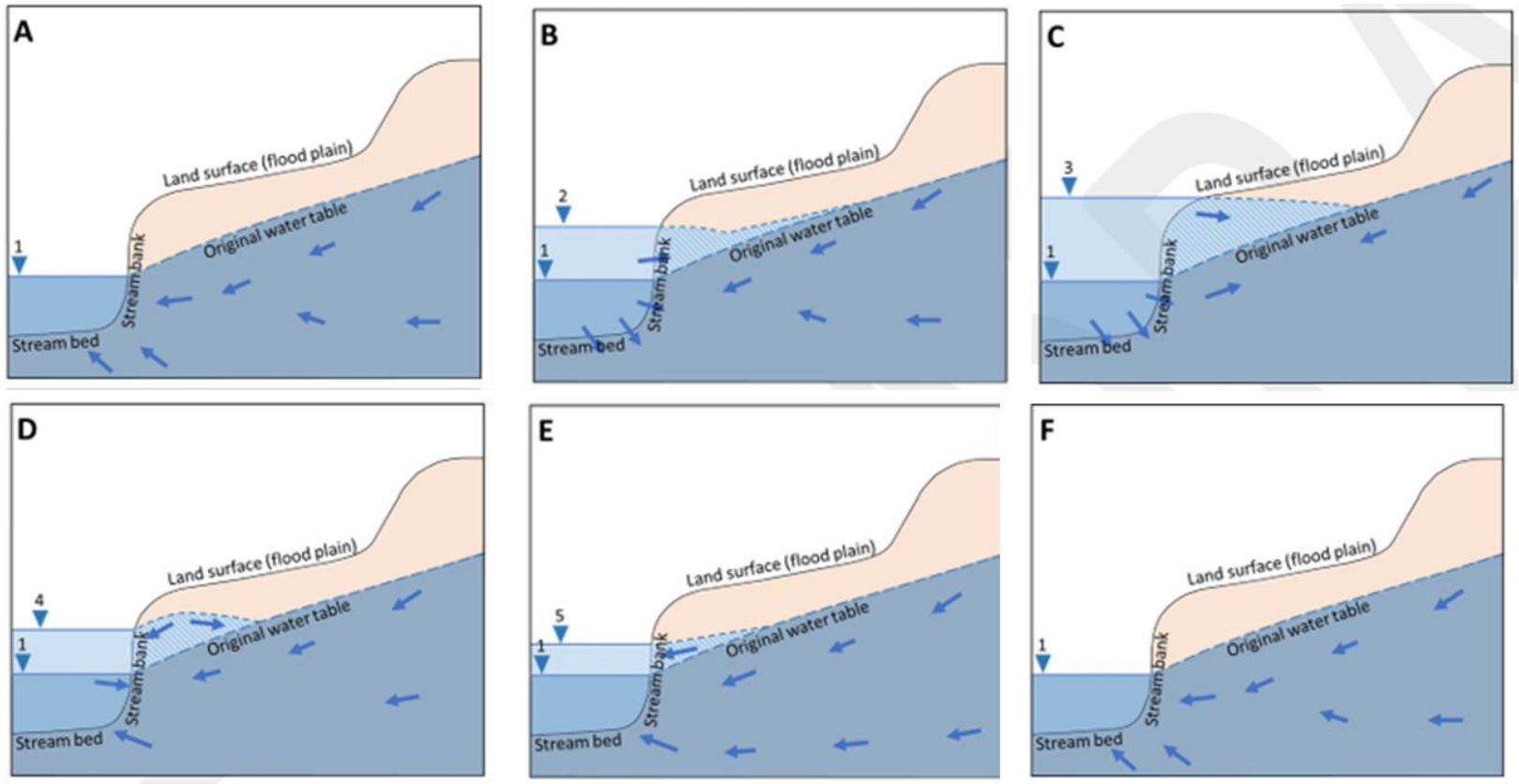


- Outflow is from alluvium to river
- Inflow is from river to alluvium
- Net: Positive – flow from river to alluvium
  Negative- flow from alluvium to river

Application of the BRAA and SP/QC/CW GAMs for Simulating GW-SW Exchange

- Strengths
  - GAMs include shallow ground flows zones and inclusion of alluvium underlying the stream bed
  - GAMs have grid refinement near streams to improve representation of river cells and wells
- Short-comings
  - Input data and calibration targets are based on time intervals of 1-year
  - Algorithms and time intervals do not adequately capture temporal dynamics associated with changing river elevation, and overbank/bank storage associated with flood events
- Assessment for Establishing DFCs for GW-SW Exchange
  - Given careful application and analysis, GAMs are suitable for developing some qualitative relationship between pumping and GW-SW exchange
  - GAMs are less reliable for prediction of GW-SW exchange for river tributaries than for main river reach

Schematic of Bank (alluvium) Storage and Bank (alluvium) Flow



Bank storage also include storage resulting form flooding of alluvium that leads to retention and recharge of runoff and river water

Summary of SW-GW Exchange Simulated from 2010-2070 for Stream-Alluvium Interactions

- GAMs have been developed to include shallow flow system that includes alluvium for Colorado Rivers and Brazos Rivers
- GAMs have not yet been updated to accurately simulate the important transient and dynamic nature of GW-SW exchange
- Insufficient field data exists to accurately provide a framework for interpreting GAM results and assessing importance of bank storage
- GAMs results indicate that large increases in pumping will reduce the amount of groundwater that flows from the alluvium to the rivers

Potential Impact of Bank Flow on Baseflow

- As discussed by Freeze and Cherry (1979), bank storage effects and bank flows can complicate the process of defining and determining baseflow.
- Bank storage refers to the variable amount of water stored temporarily in the stream banks during rising flood stage (Todd, 1955).
- Bank flow is the release of bank storage back to the stream that occurs following the high rivers stage that occurs during a flood.
- This study by Rhodes and others (2017) involved the analysis of water levels and water quality in the Brazos River and groundwater in Burleson County. Over a four-month post-flood event period, they estimated that 96% of the groundwater that flowed to the Brazos River from the aquifer was from bank storage.
- Despite being potentially important to characterizing SW-GW interactions, bank flow and bank storage is not recognized in TCEQ rules and is not computable using WAMs and GAMs.

SUMMARY OF KEY ENVIRONMENTAL ISSUES

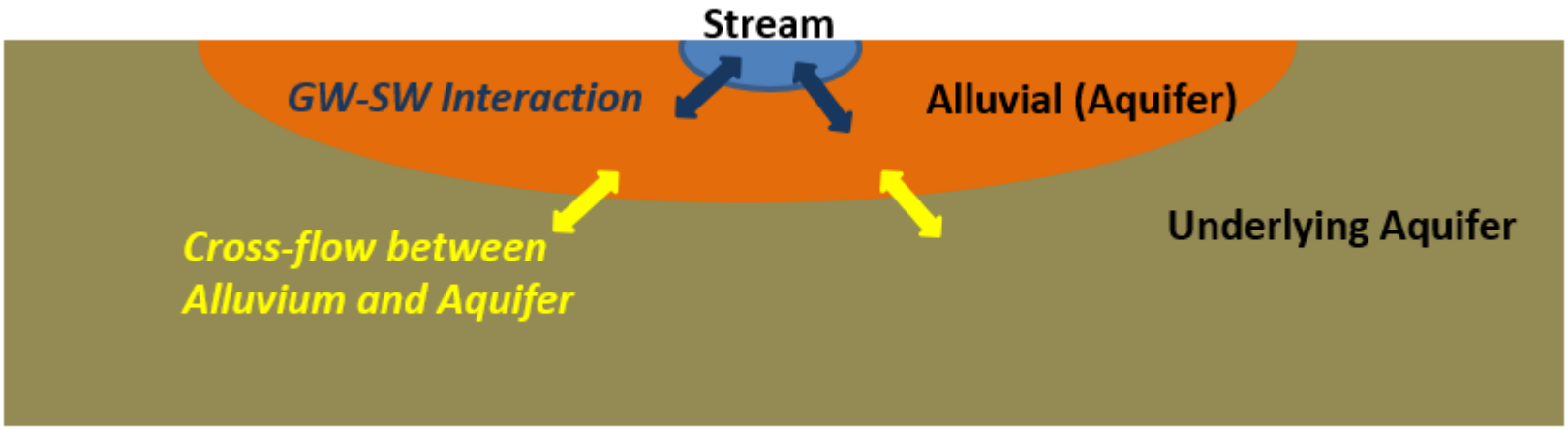
- TCEQ Environmental Instream Flow program is set up to protect the health of the Colorado and Brazos Rivers . GAMS have not been demonstrated as suitable for quantitative GW/SW analysis

- River authorities are currently managing in-stream flows in Colorado and Brazos rivers

- The evaluation river gage hydrographs by the TCEQ Instream Flow program does not quantify GW flow

- Groundwater flow into streams can be an important contributor for helping river authorities maintain critical or subsistence flows

Schematic of Water Budget

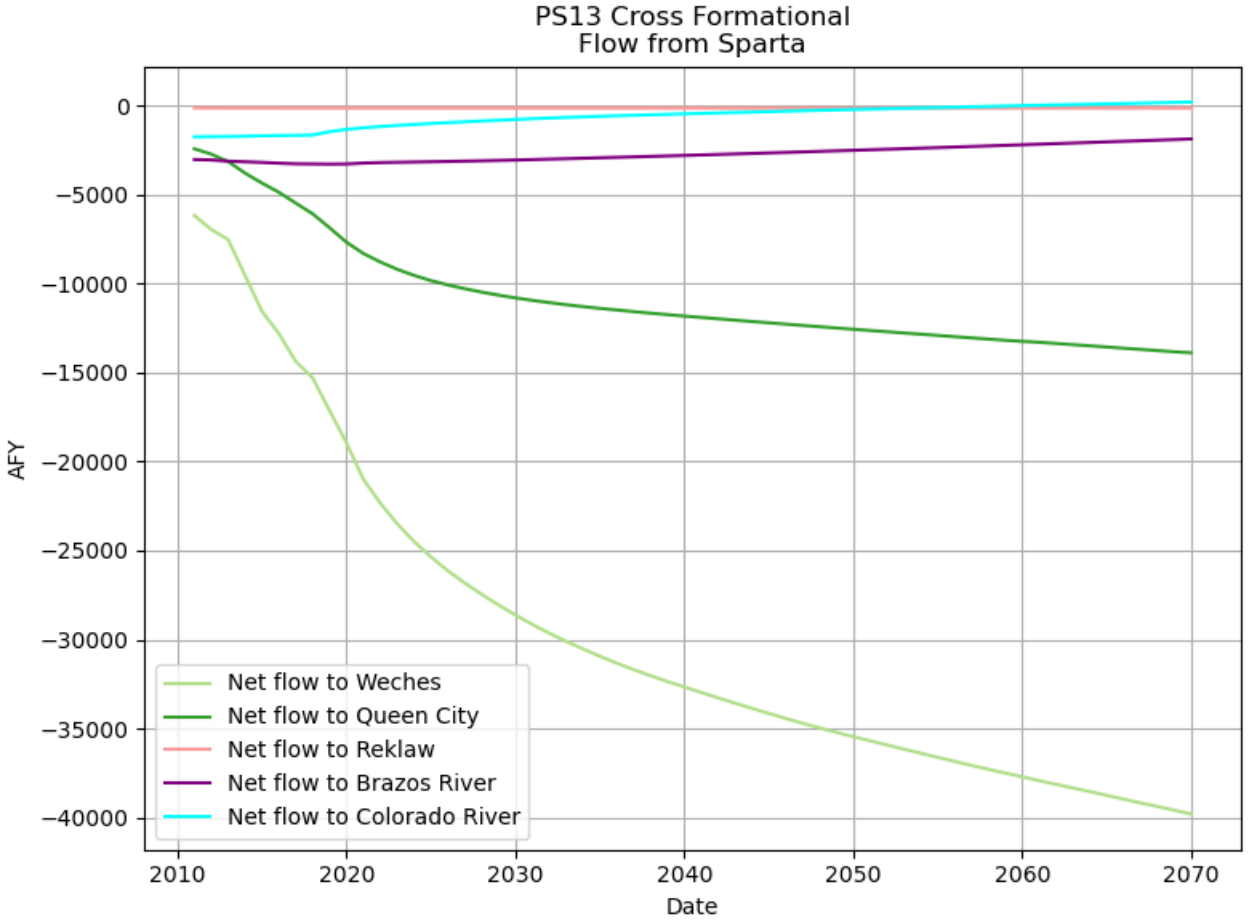


GW-SW Interaction

Flow from Aquifer to Stream is Negative
Flow From Stream to Aquifer is Positive

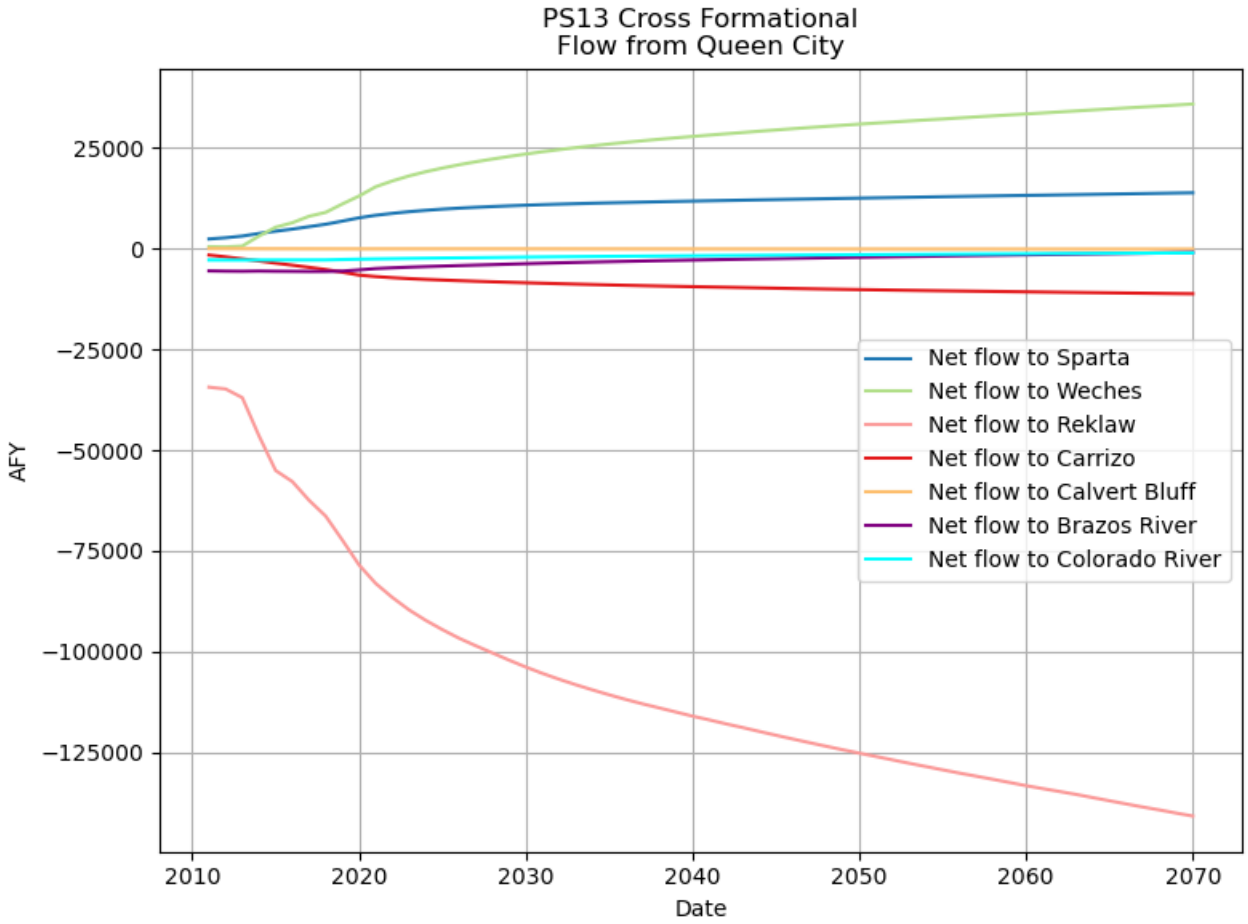
Positive Net Flow Stream Flow = Losing Stream
Negative Net Flow Stream Flow = Gaining Stream

Cross-Flow Between Aquifer: Sparta



Positive values – flow into Sparta
Negative value - flow out of Sparta

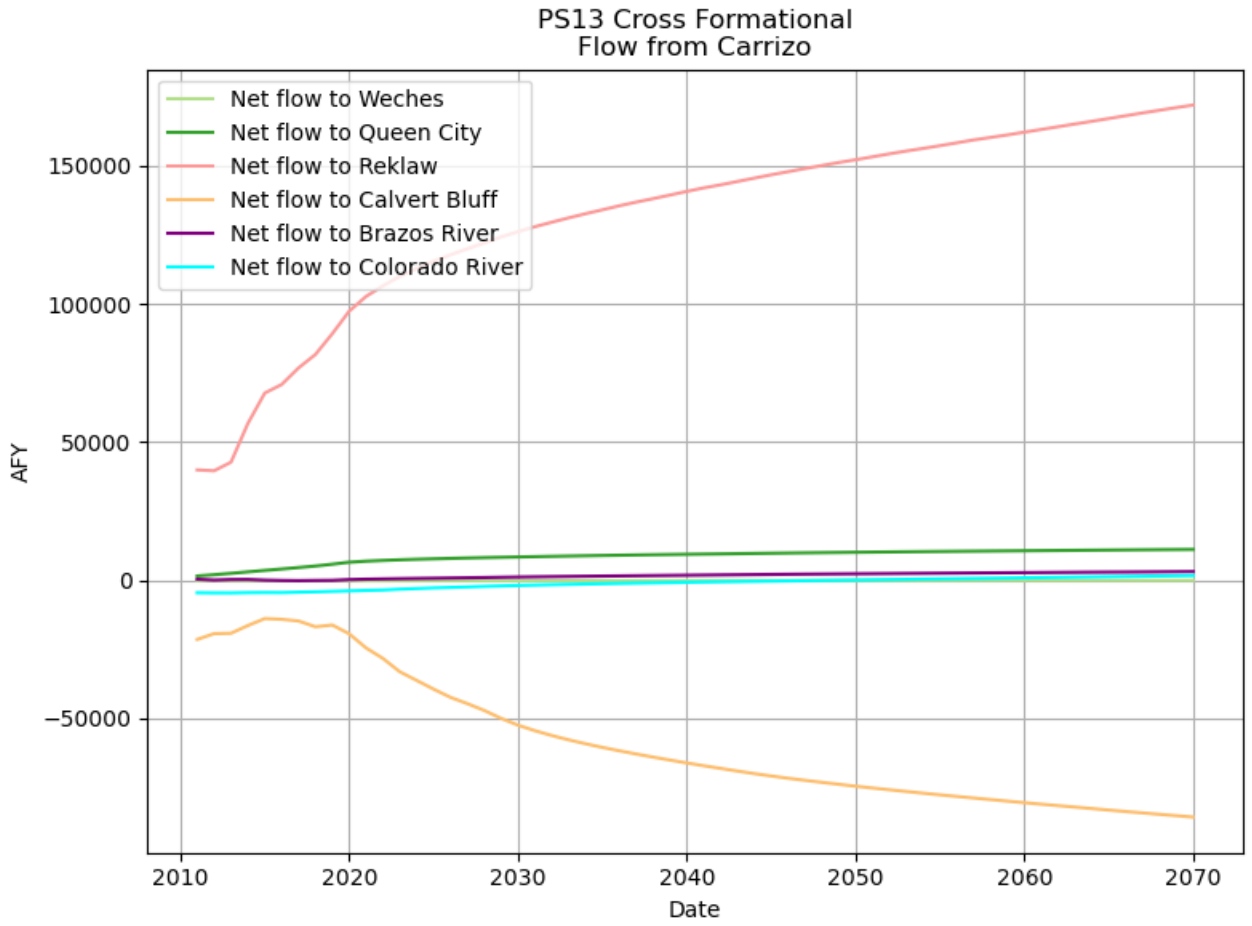
Cross-Flow Between Aquifer: Queen City



Positive values – flow into Queen City

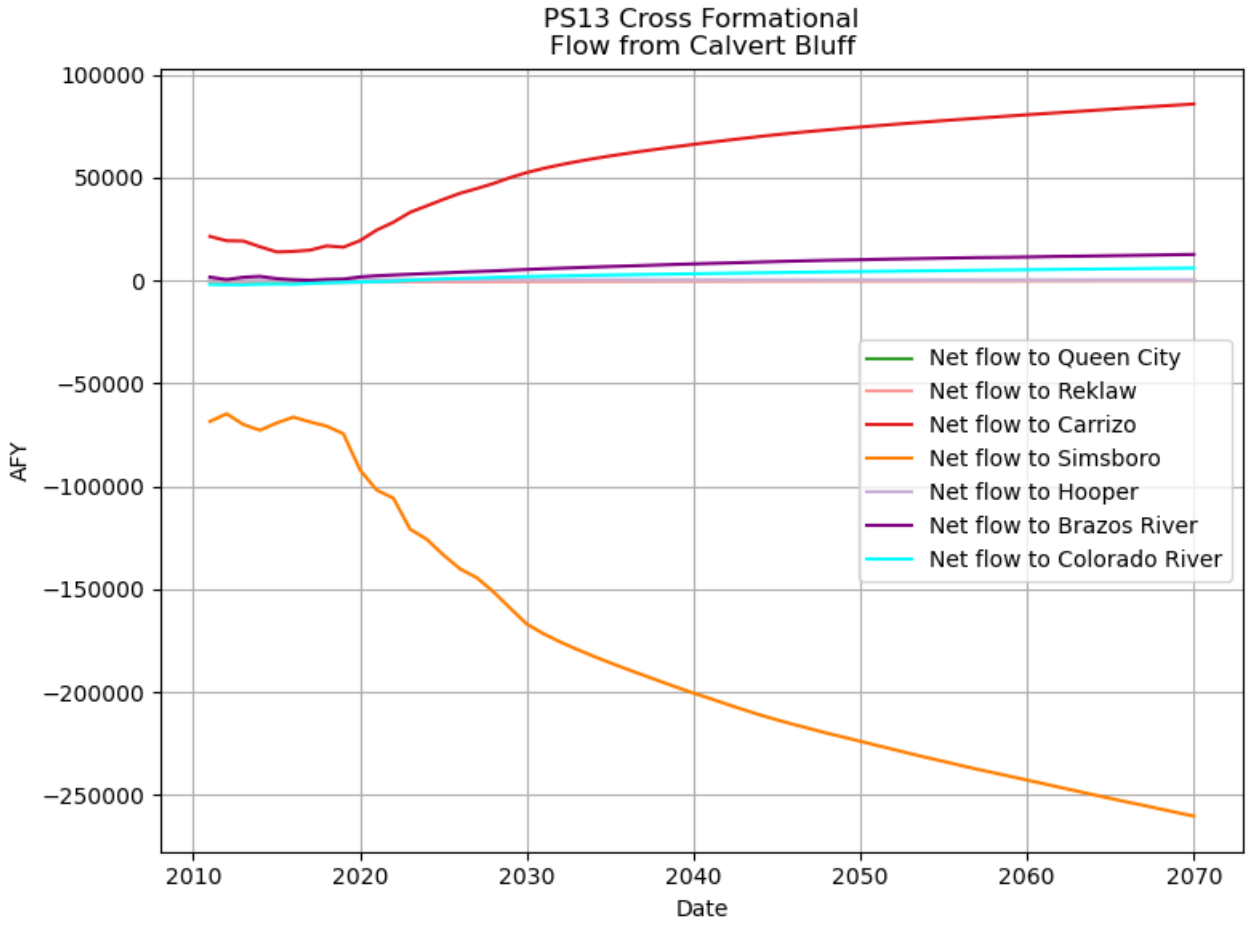
Negative value - flow out of Queen City

Cross-Flow Between Aquifer: Carrizo



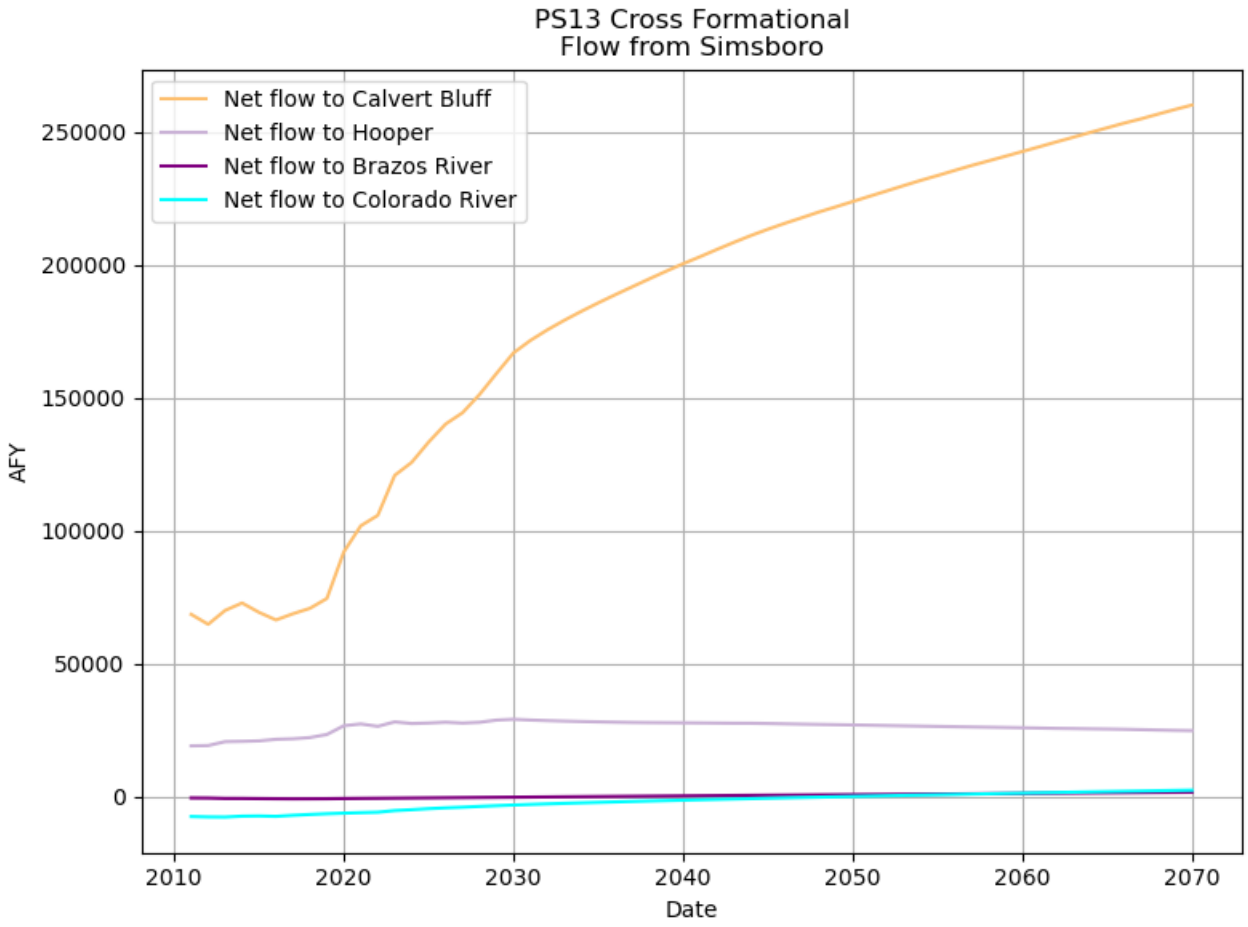
Positive values – flow into Carrizo
Negative value - flow out of Carrizo

Cross-Flow Between Aquifer: Calvert Bluff



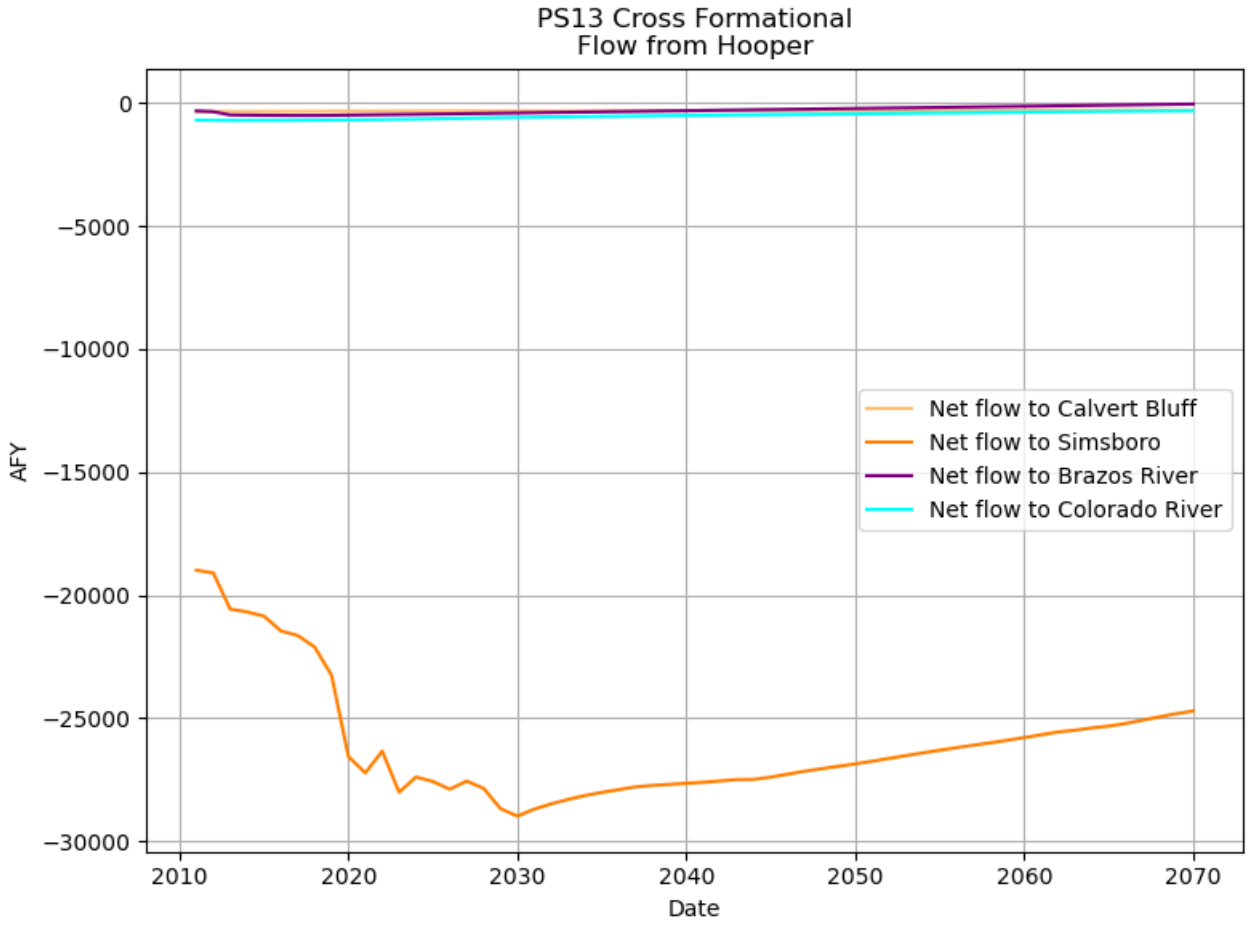
Positive values – flow into Calvert Bluff
Negative value - flow out of Calvert Bluff

Cross-Flow Between Aquifer: Simsboro

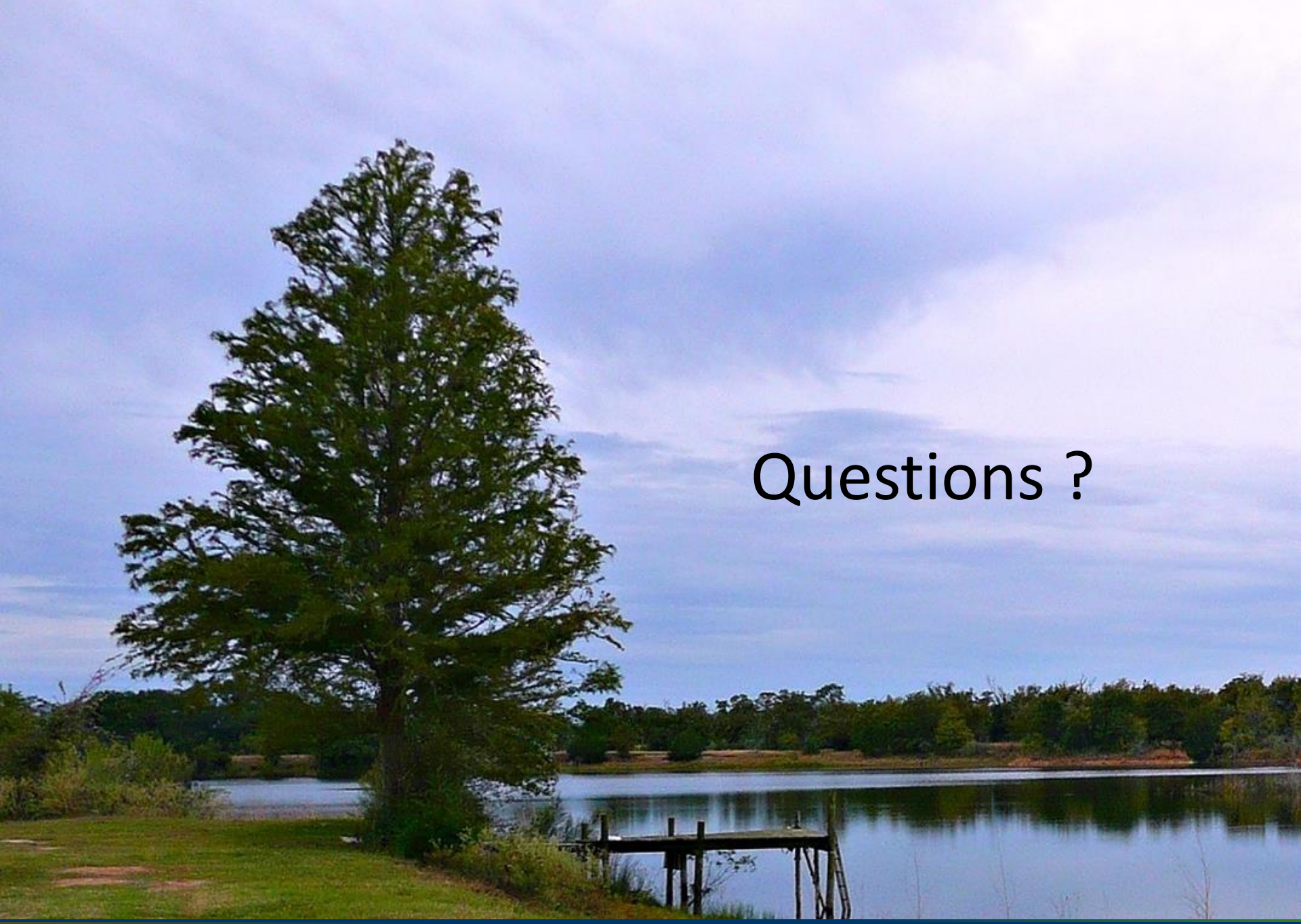


Positive values – flow into Simsboro
Negative value - flow out of Simsboro

Cross-Flow Between Aquifer: Hooper



Positive values – flow into Hooper
Negative value - flow out of Hooper


Questions ?