Vina Subbasin
Stakeholder Advisory Committee

Basin Setting Updates:

Model Development ***Groundwater Conditions*** ***Water Budgets***

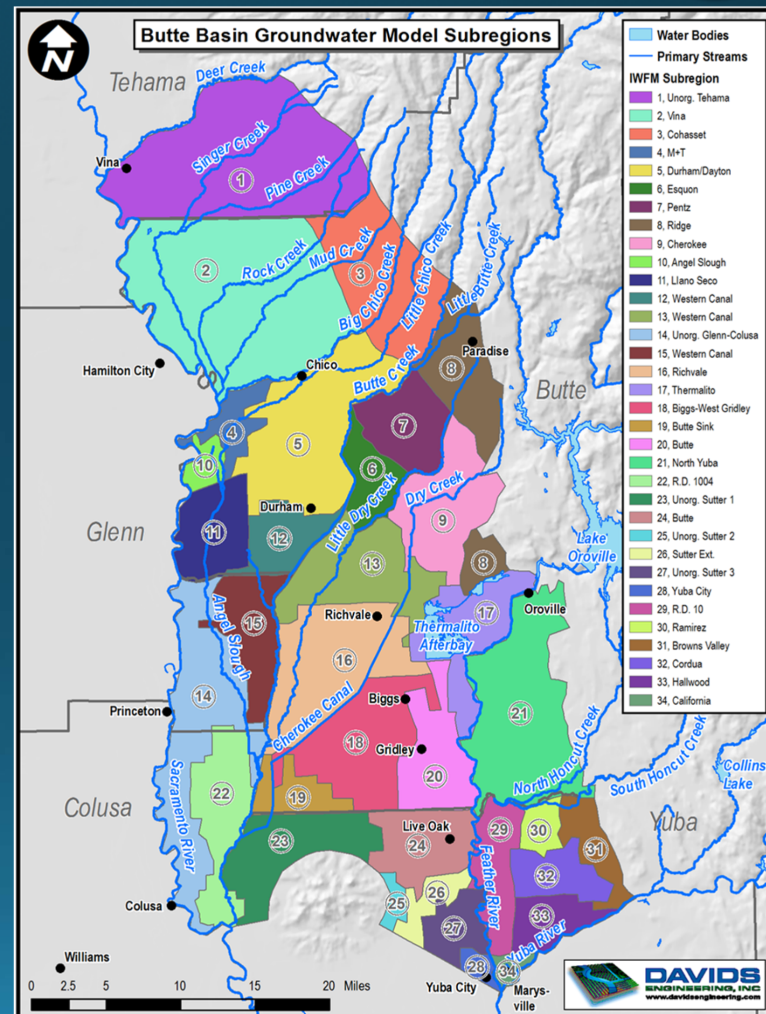
May 19, 2020

9 a.m. to Noon

Butte Basin Groundwater Model Status

Butte Basin Groundwater Model (BBGM)

- Number cruncher over time and space
  - Hydrologic processes
  - Physical properties
- Integrated Hydrologic Model meaning it includes what's happening above and below ground:
  - Land Surface System
  - Groundwater System
- Pulls together different types of data and hydrologic processes that all interact
- Used to estimate water budget numbers



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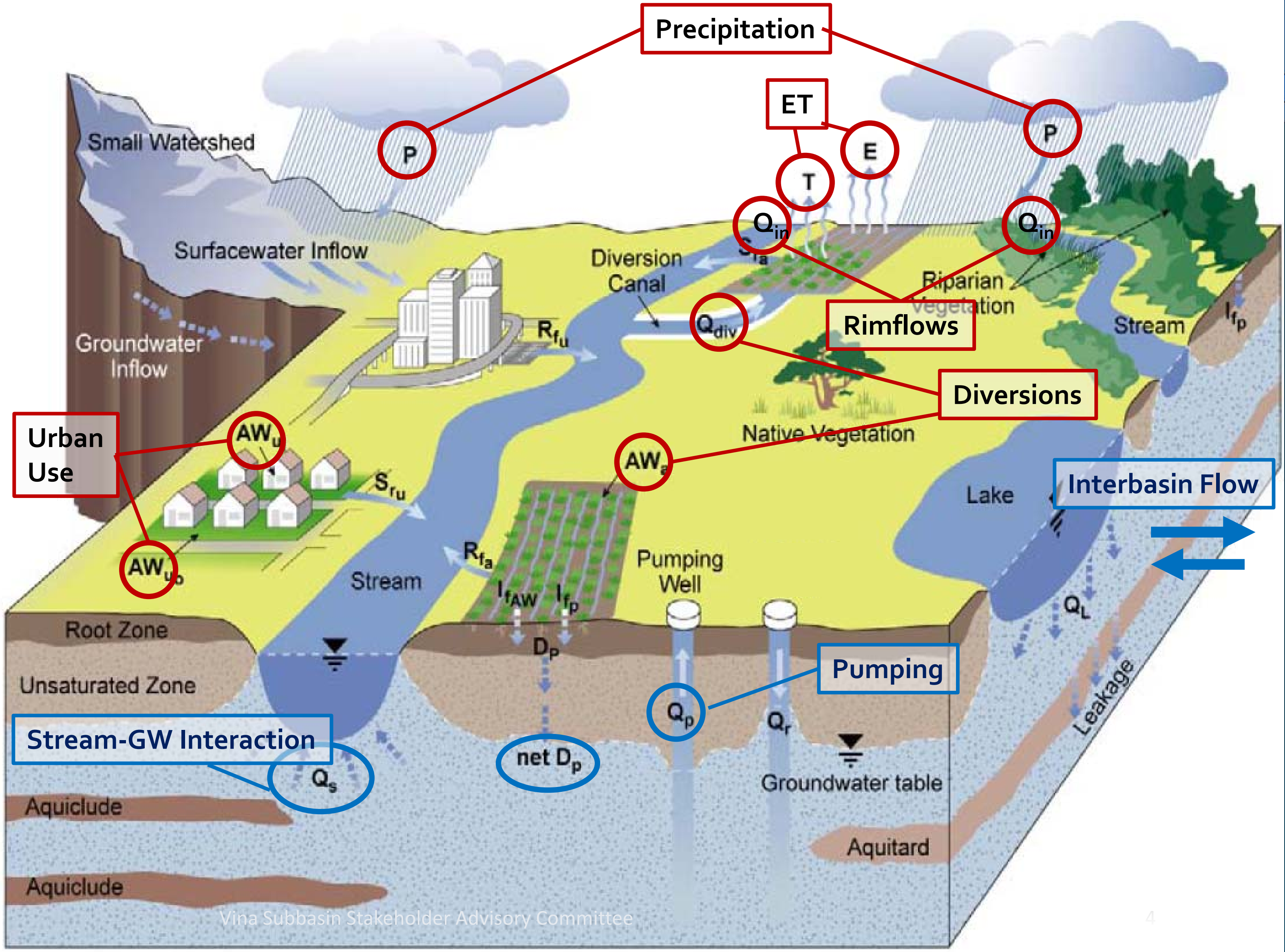
Modeled Water Budget Components

Distinction between:

- Data Input (Red)
- Model Simulated/ Estimated (Blue)



The Goal of Calibration

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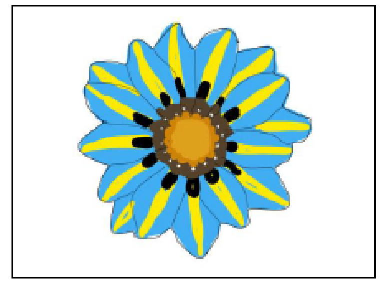
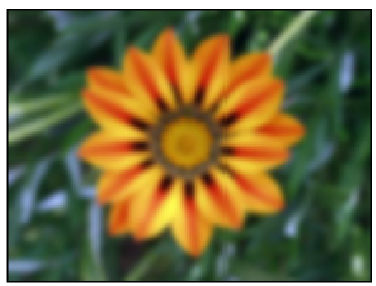
Numerical models will never match the real-world perfectly, so we look for models that are “good enough” to answer our key questions.

Real World

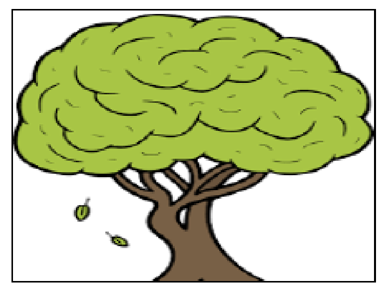
Great Model



Poor Model



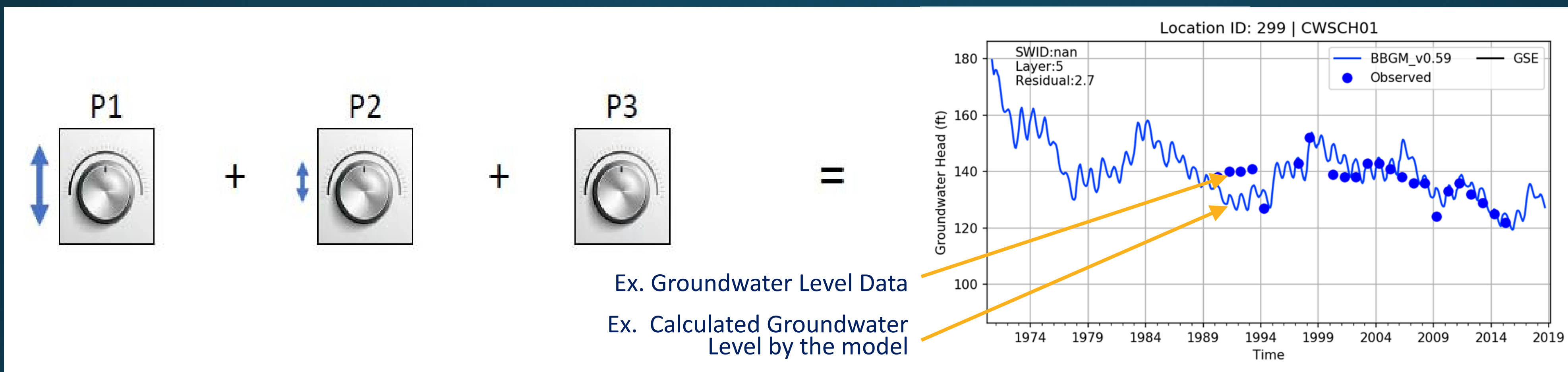
Good Model



Bad Model

Slide credit: Gus Tolley, GRA Cast November 2019

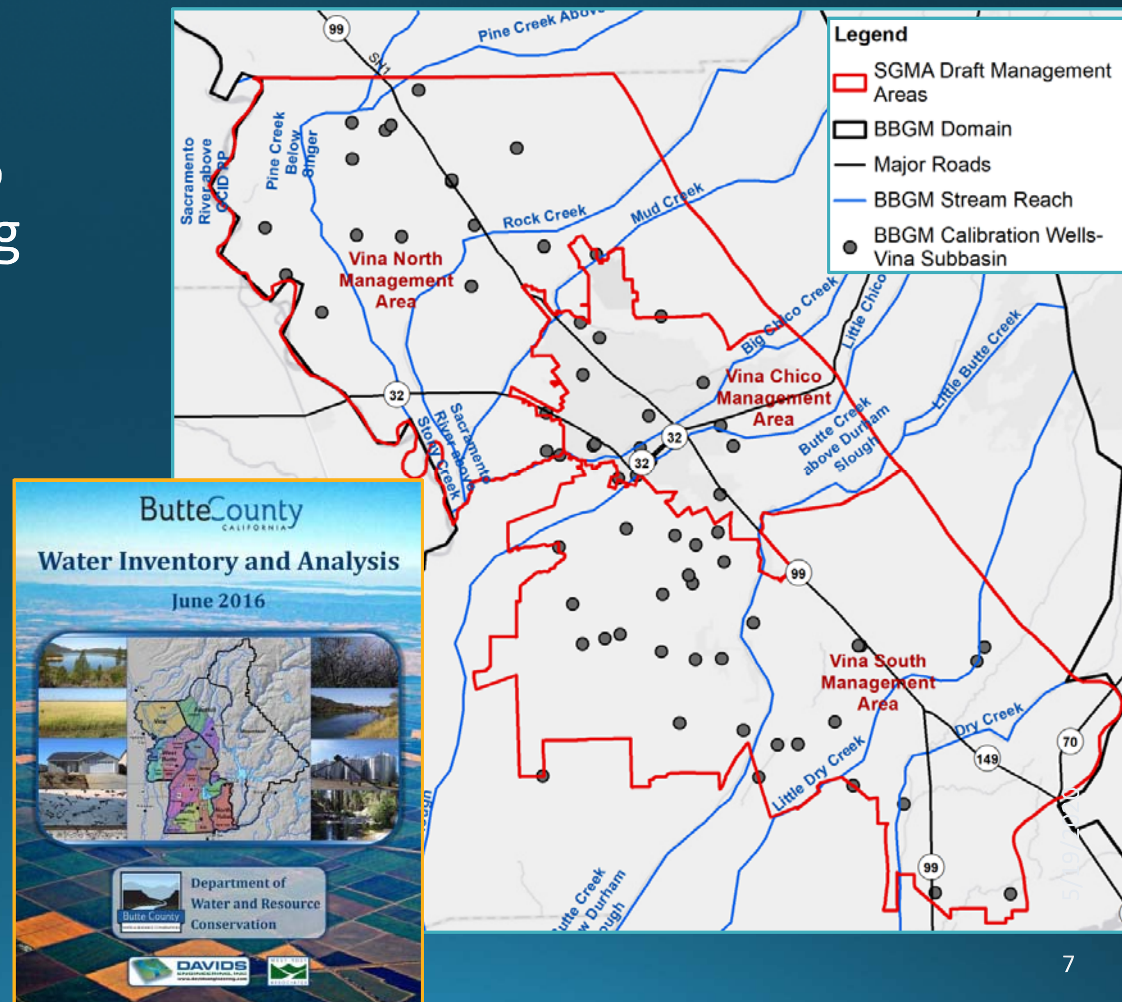
"Model Calibration" Process



- Process of "turning knobs" so "observed" data better matches model "simulated" results
- Can involve
  - Refining data inputs (ex. Diversion data)
  - Adjusting physical properties (ex. Hydraulic Conductivity = parameter reflecting how well water moves through the material)

BBGM Calibration

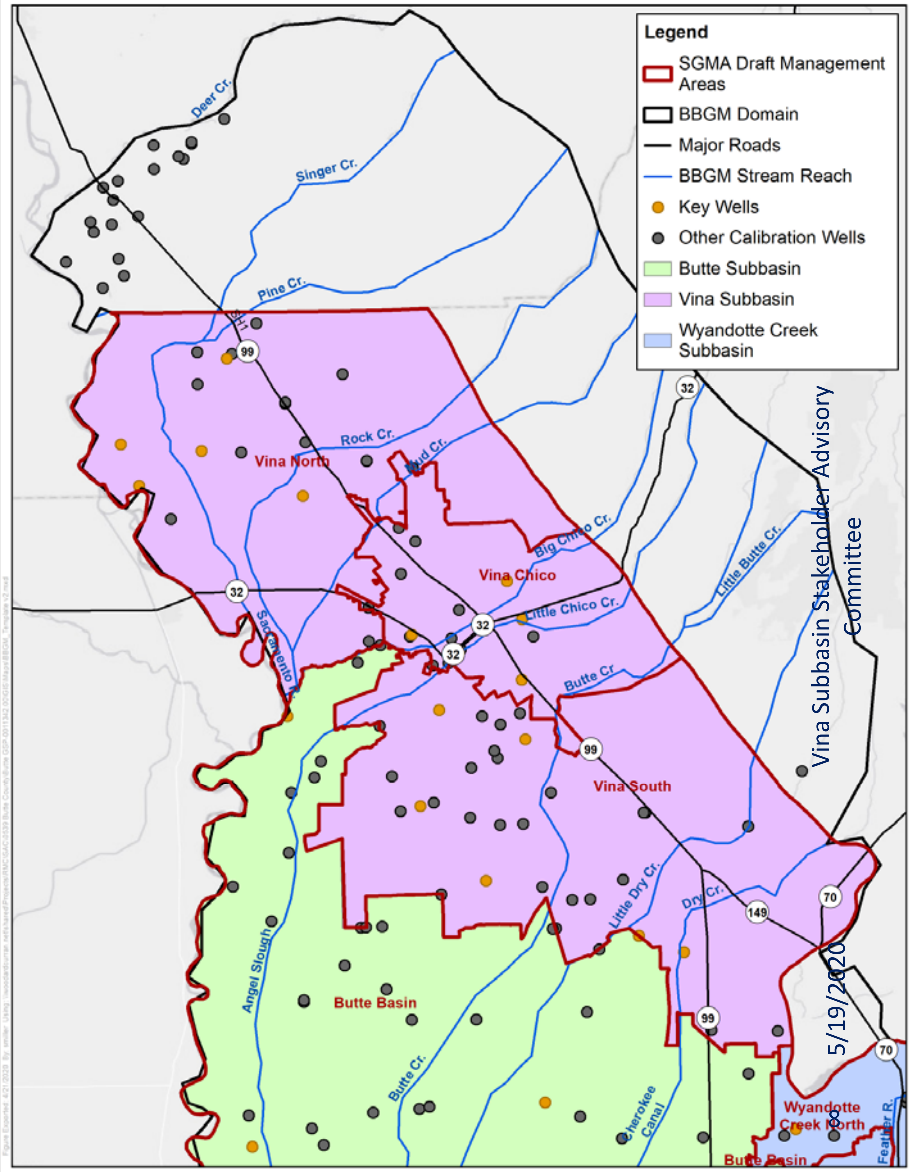
- Builds upon historical land and water use information from 2016 Water Inventory & Analysis, along with updated data
- Goal: Reasonably estimate historical observations
  - groundwater levels
  - stream flows
- 88 calibration wells in Vina Subbasin
- 27 multi-completion intervals



Vina Subbasin Calibration

- 86 Calibration Wells
- Including:
  - 8 nested well locations
  - 8 Cal Water wells
  - 27 Key Wells
    - 5 nested well locations

Area	Calibration Wells	Key Wells
North of Vina Subbasin	28	0
Vina Subbasin	86	27
Butte Subbasin	97	19
Wyandotte Creek Subbasin	18	7
South of Butte and Wyandotte Creek Subbasins	86	0



Calibration Statistics

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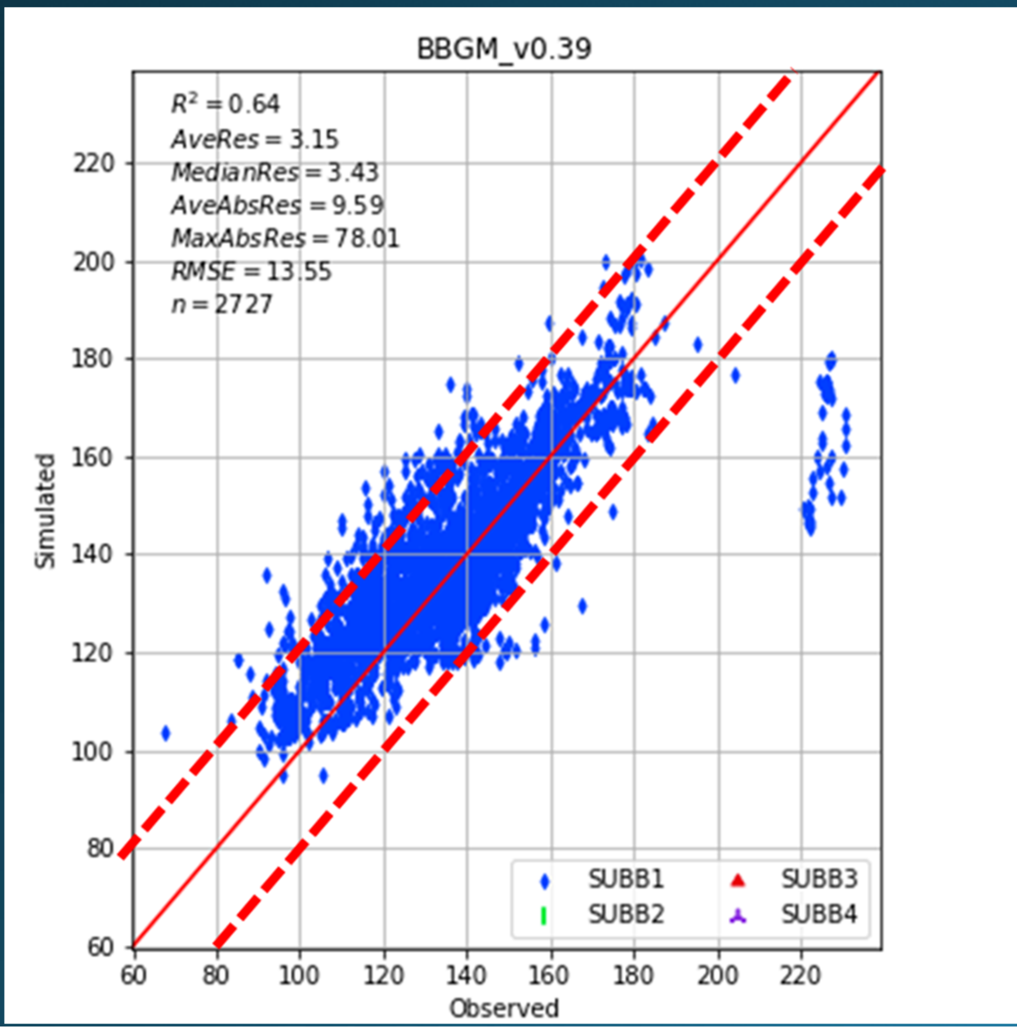
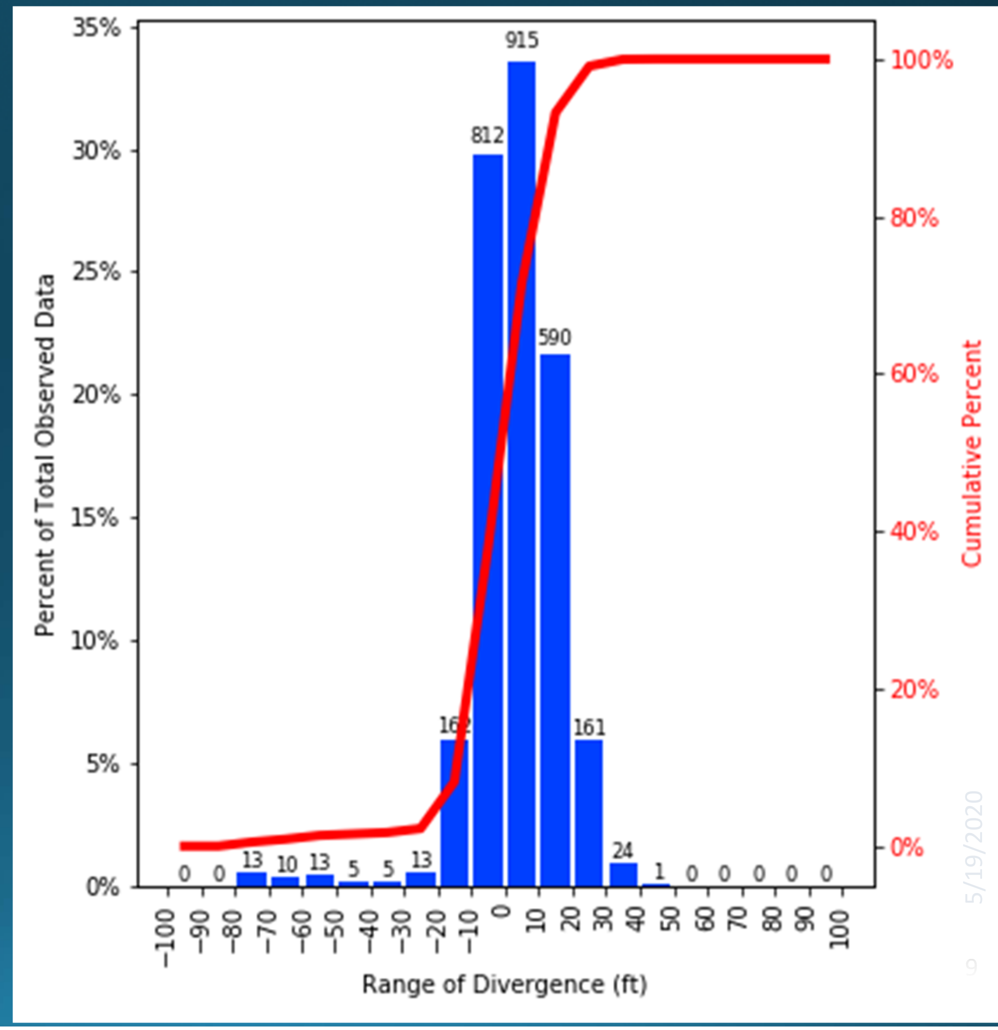
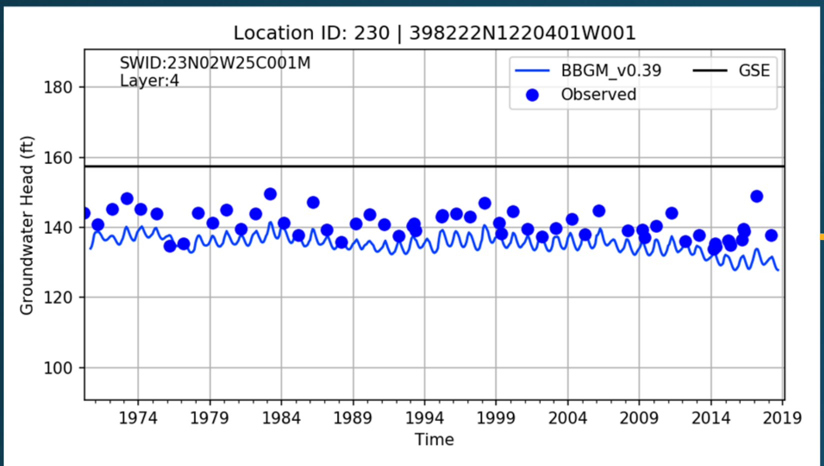
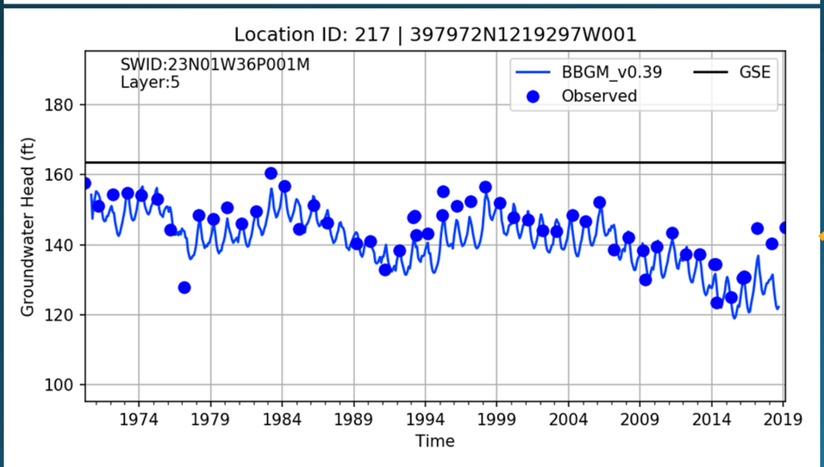
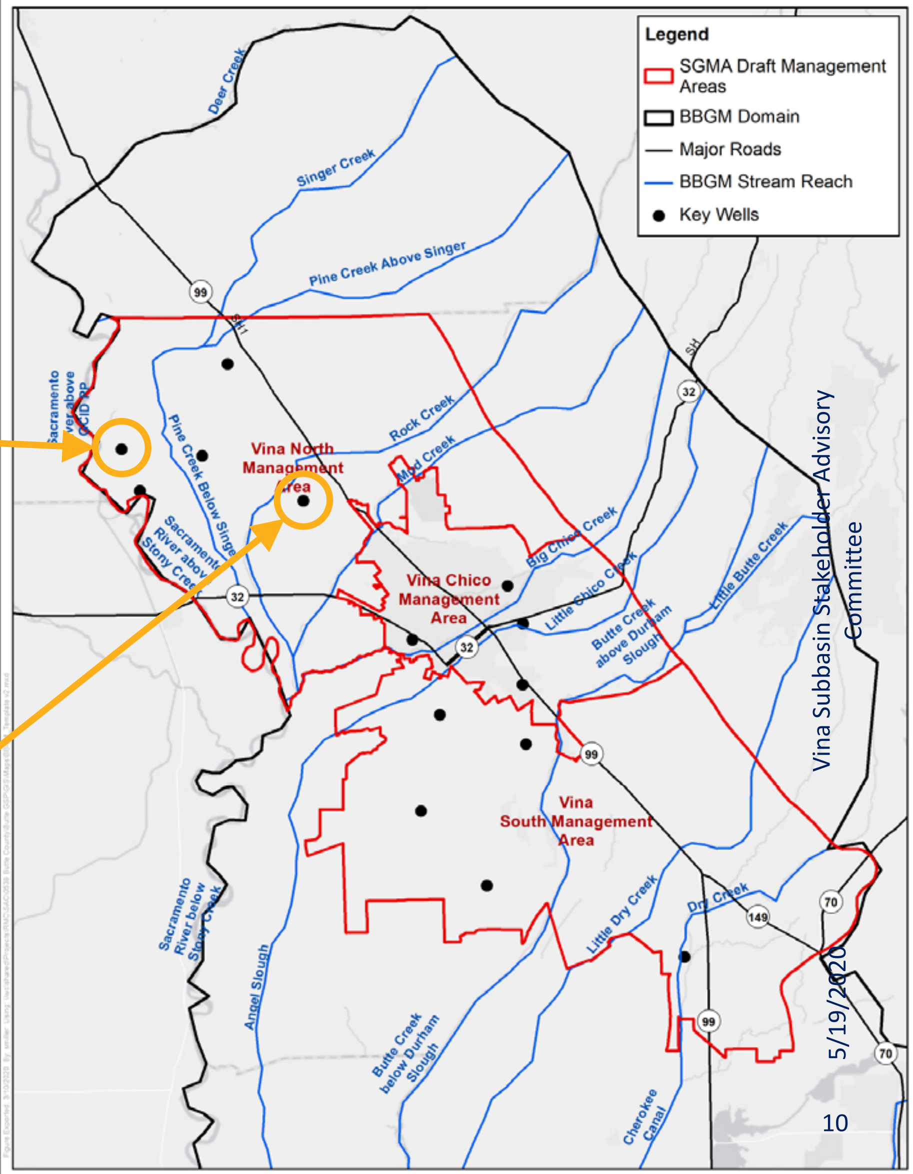




Groundwater Level Calibration: Vina North Management Area

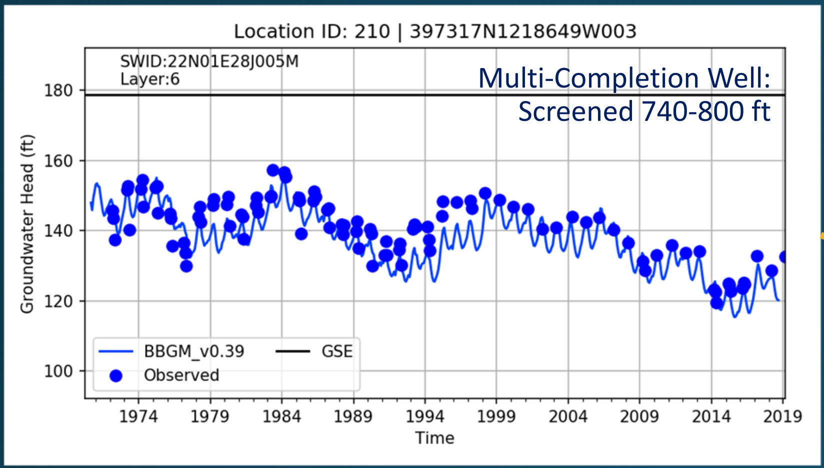


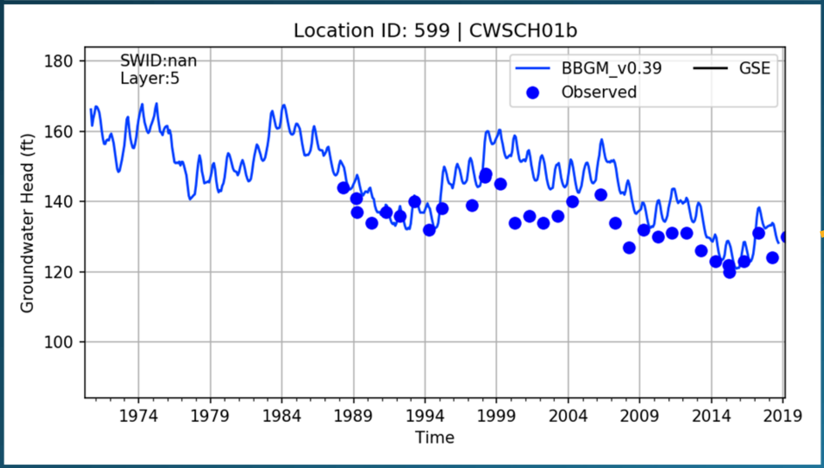


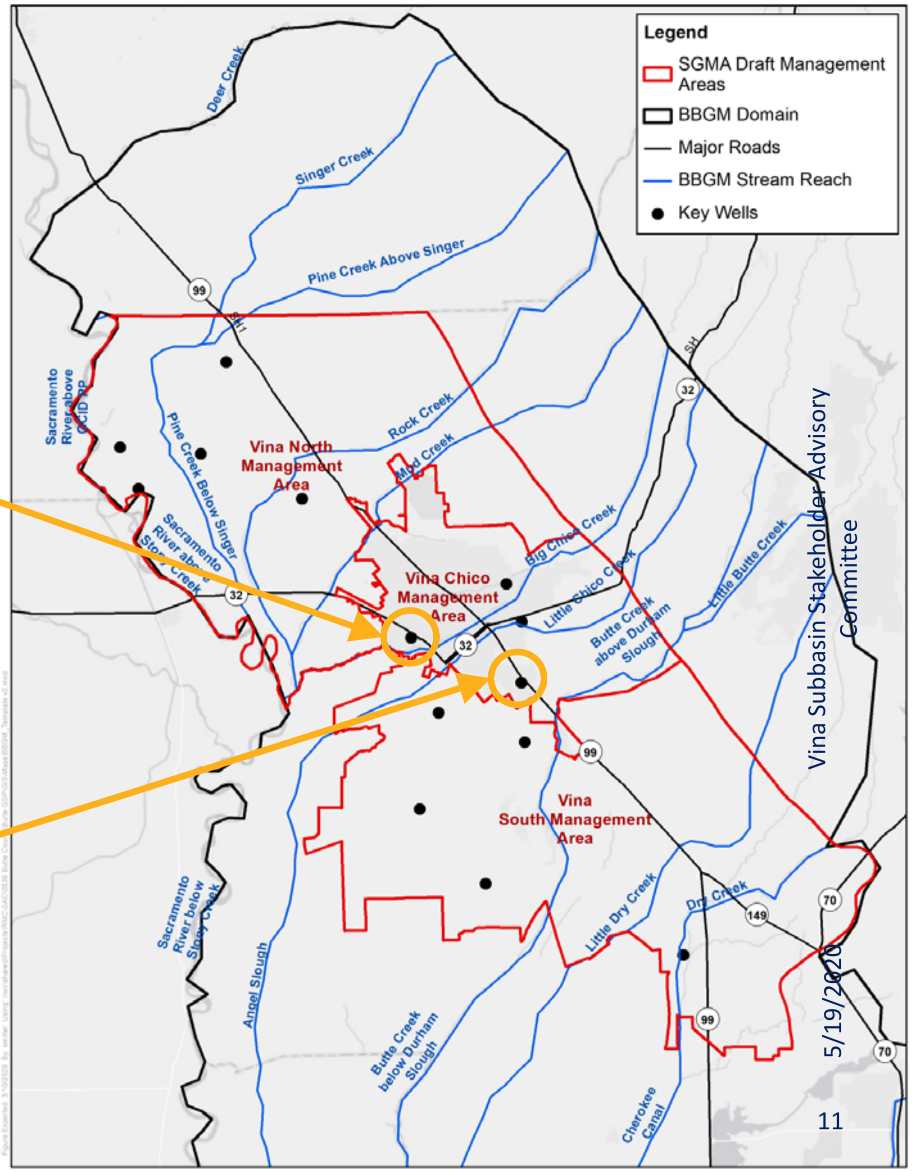


Note: Only Spring (March-May) observed water levels are shown

Groundwater Level Calibration: Vina Chico Management Area

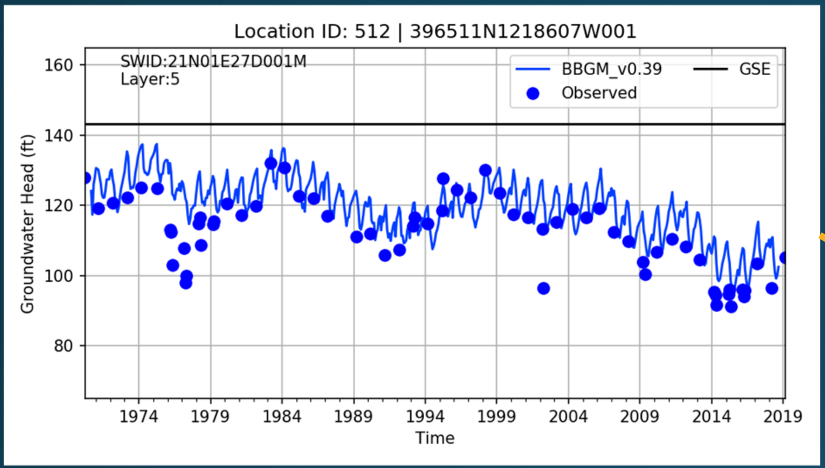


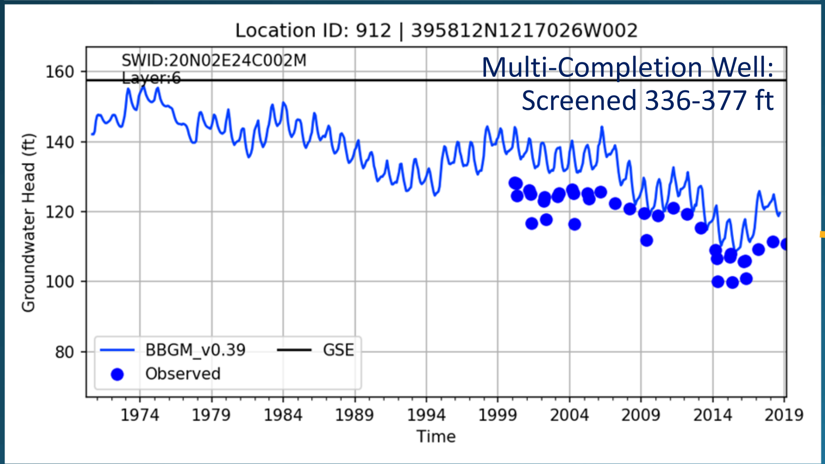




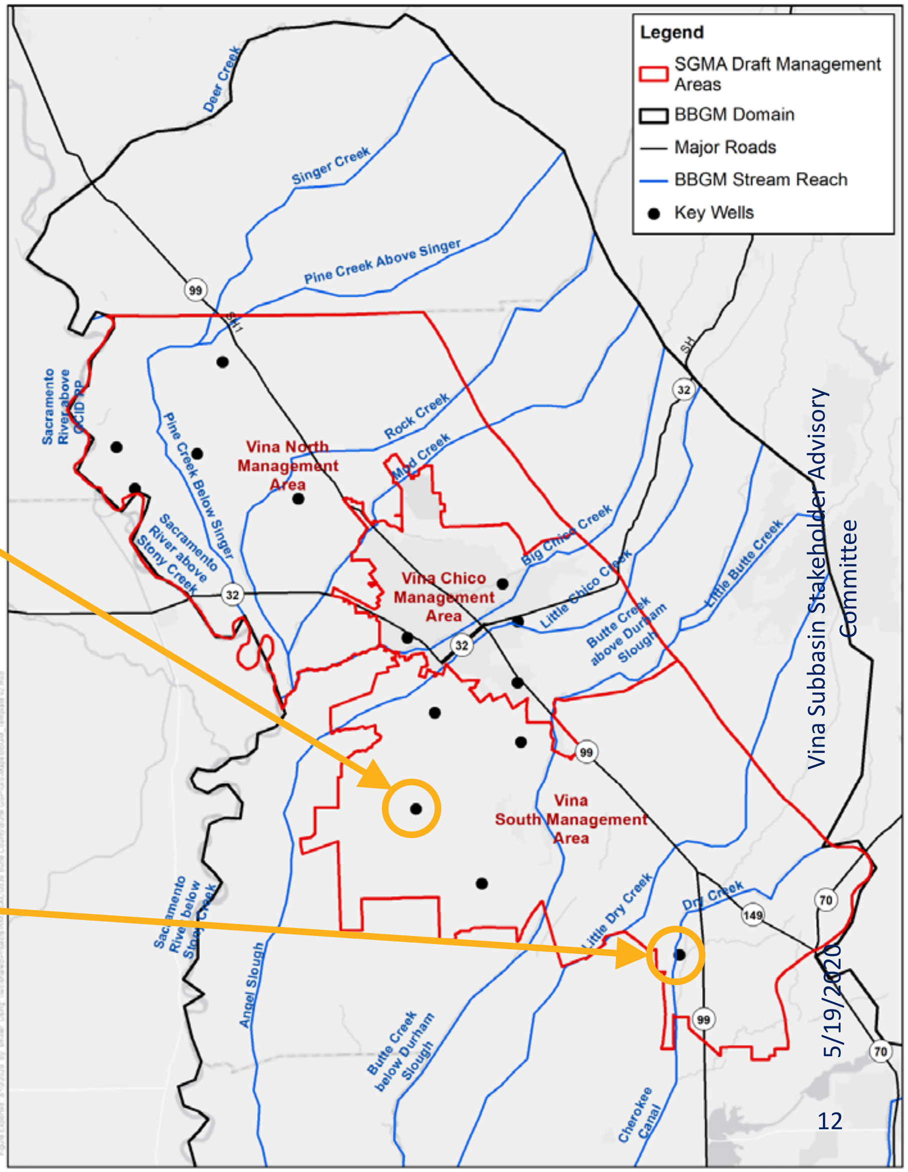
Note: Only Spring (March-May) observed water levels are shown

Groundwater Level Calibration: Vina South Management Area



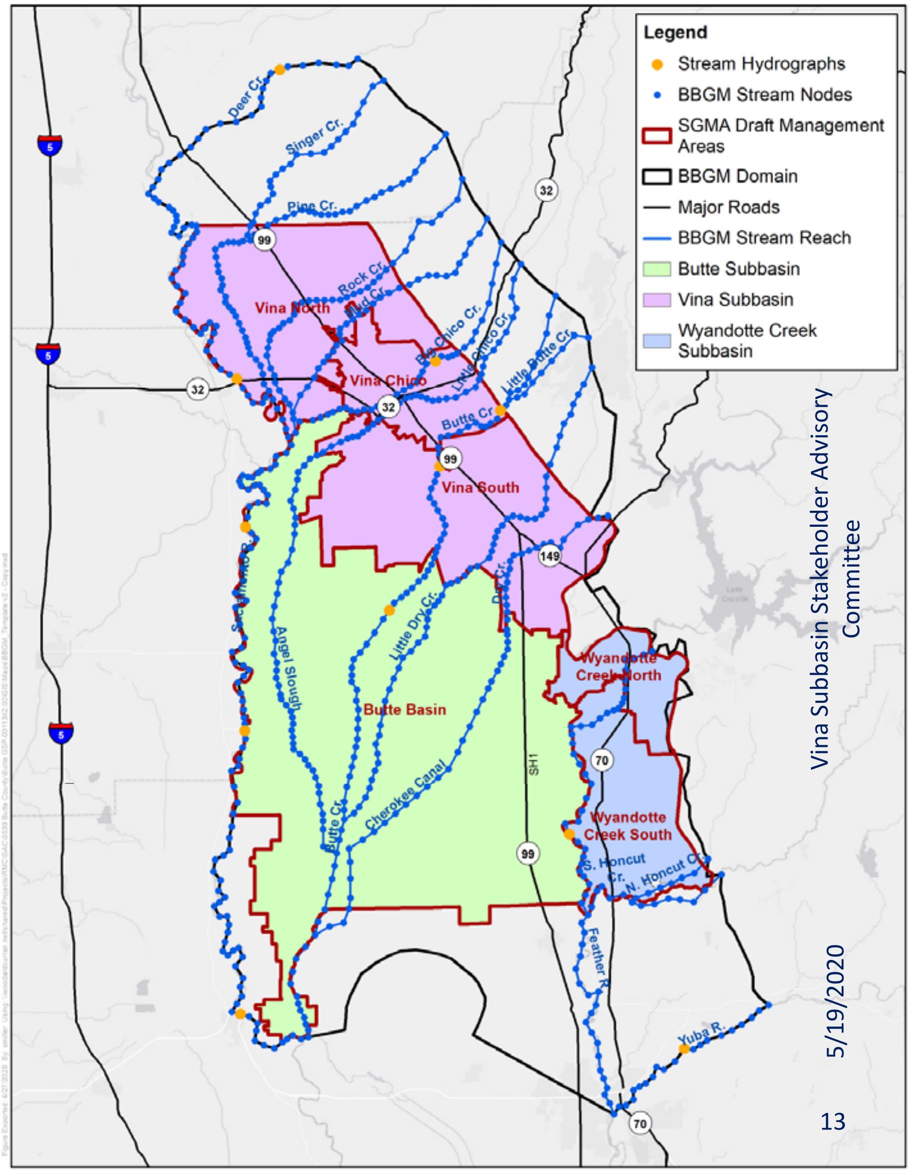


Note: Only Spring (March-May) observed water levels are shown

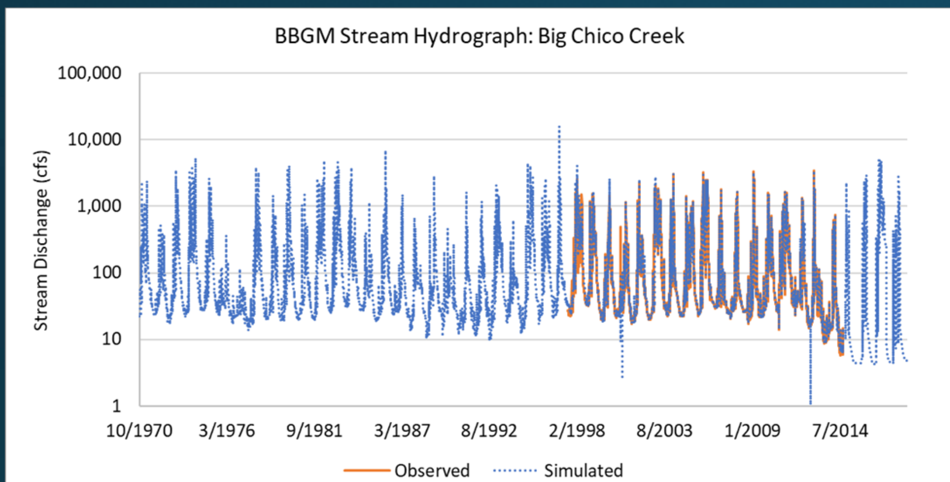


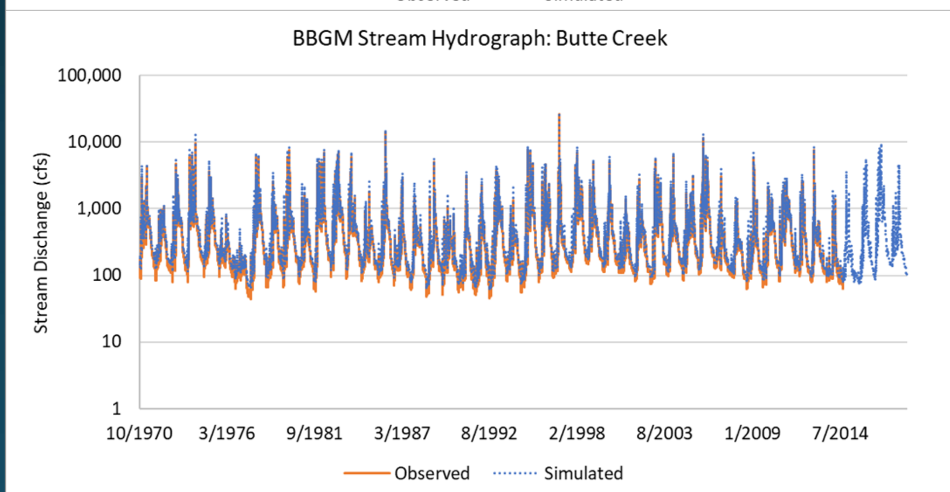
BBGM Stream Calibration

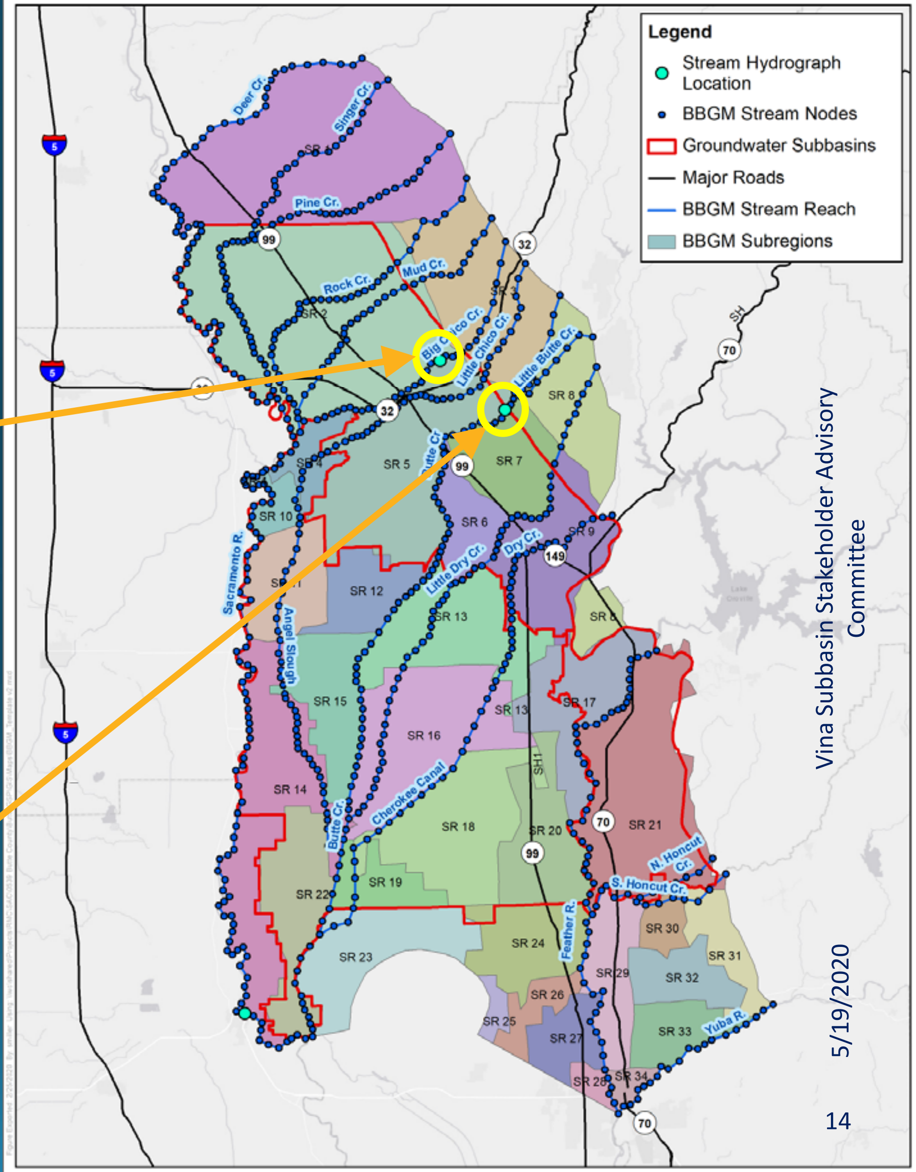
- 11 stream hydrograph locations with observed stream flows for comparison



Stream Calibration: Big Chico Creek and Butte Creek







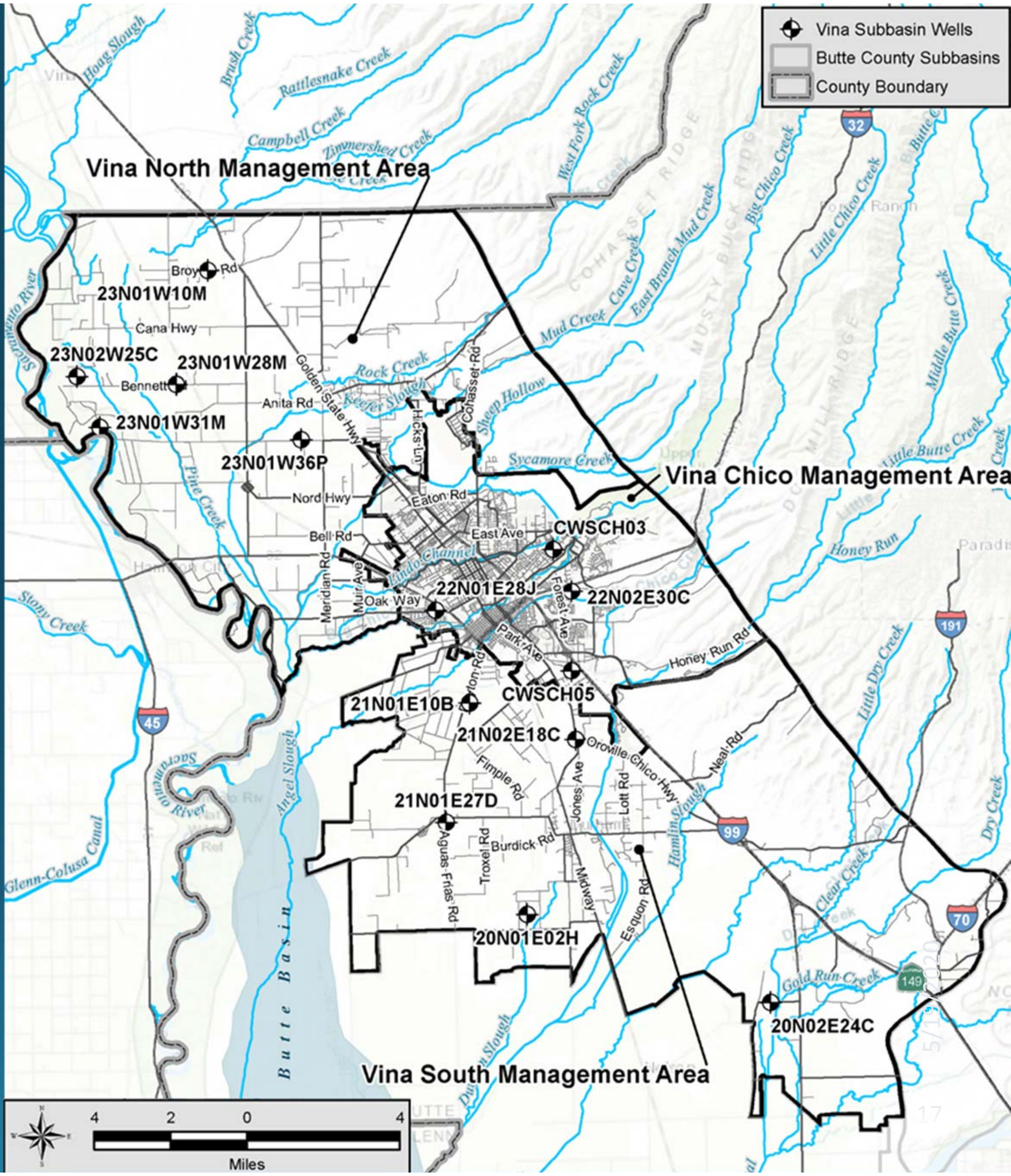
Modeling Conclusions and Path Forward

- Current Status
  - High confidence in land surface information
  - Calibration statistics very good for regional model
  - Sufficient for initial GSP development
  - Used to develop draft water budgets
- Next Steps
  - Support development of Sustainable Management Criteria
  - Consider using for evaluation of Projects and Management Actions
- Future Work
  - Refine characterization of Western Boundary through Interbasin Evaluation project
  - Incorporate understanding from AEM project to refine hydrogeologic characterization
  - Consider updates to support annual GSP reporting during implementation

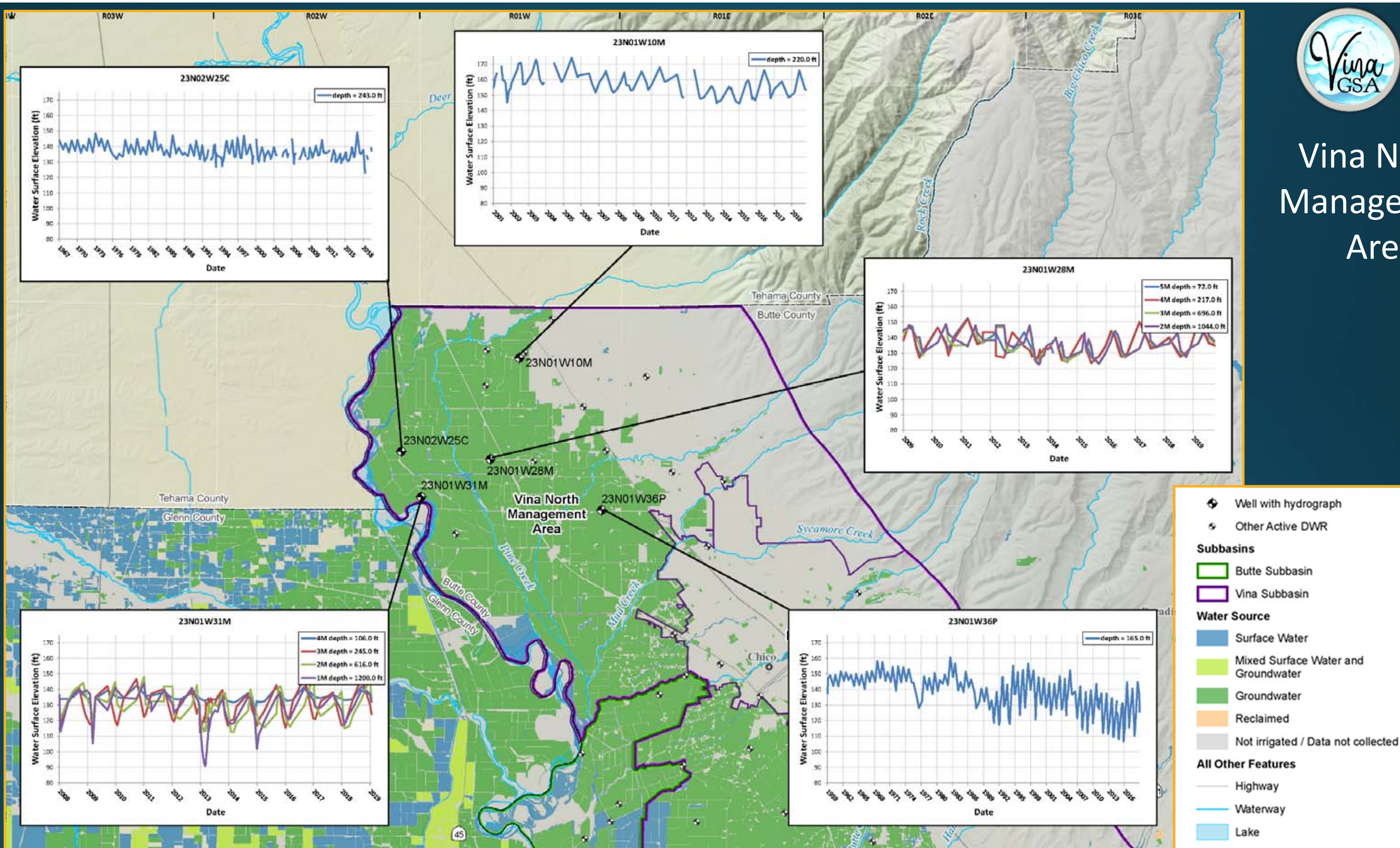
Historical Groundwater Conditions

Historical Conditions: Groundwater Levels

- Hydrographs (historical groundwater levels) compiled for key wells
- Separate maps developed for each management area
- Trends for individual wells provide insight into aquifer conditions over time



Vina North Management Area



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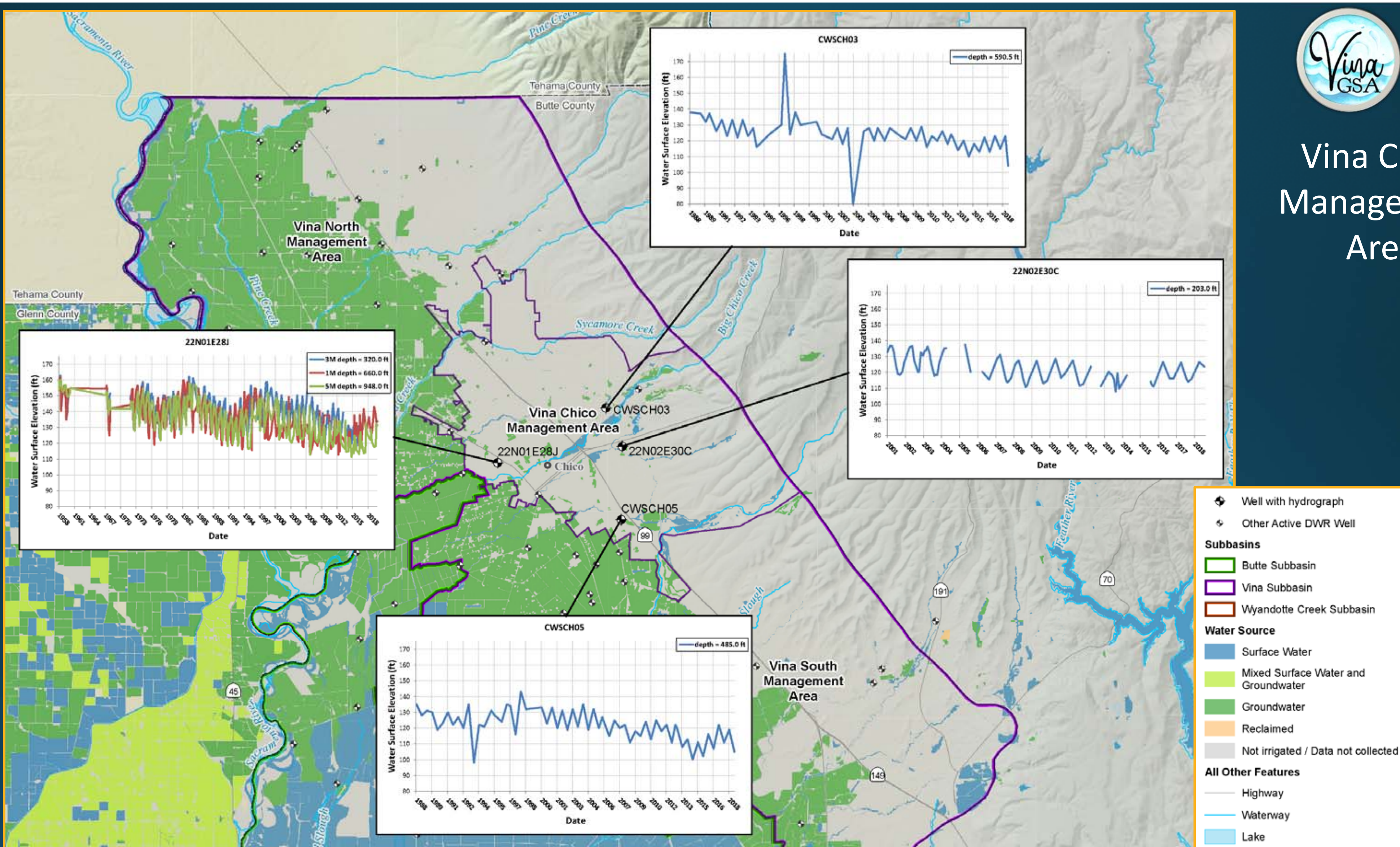

Vina Chico Management Area

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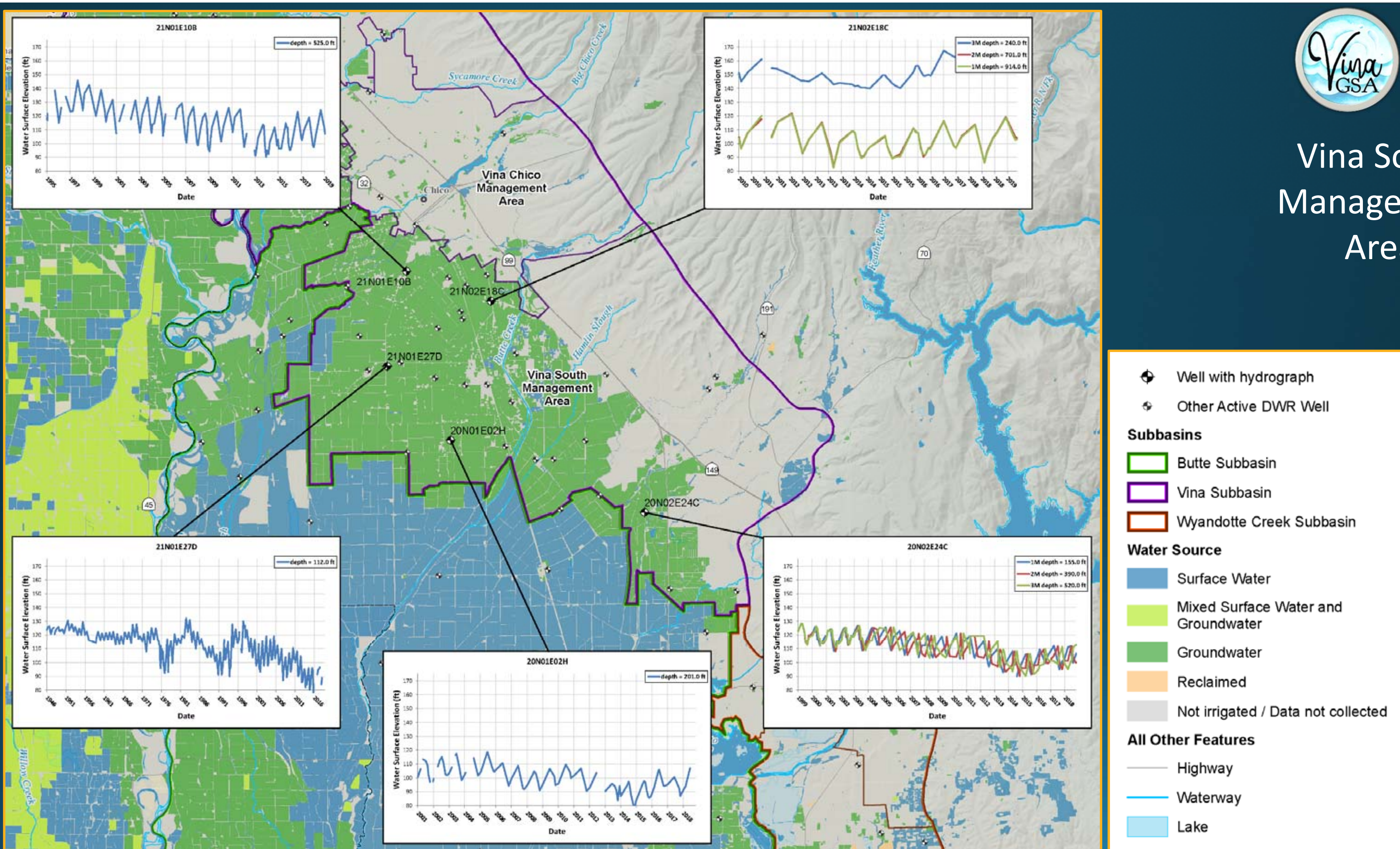
Vina South Management Area



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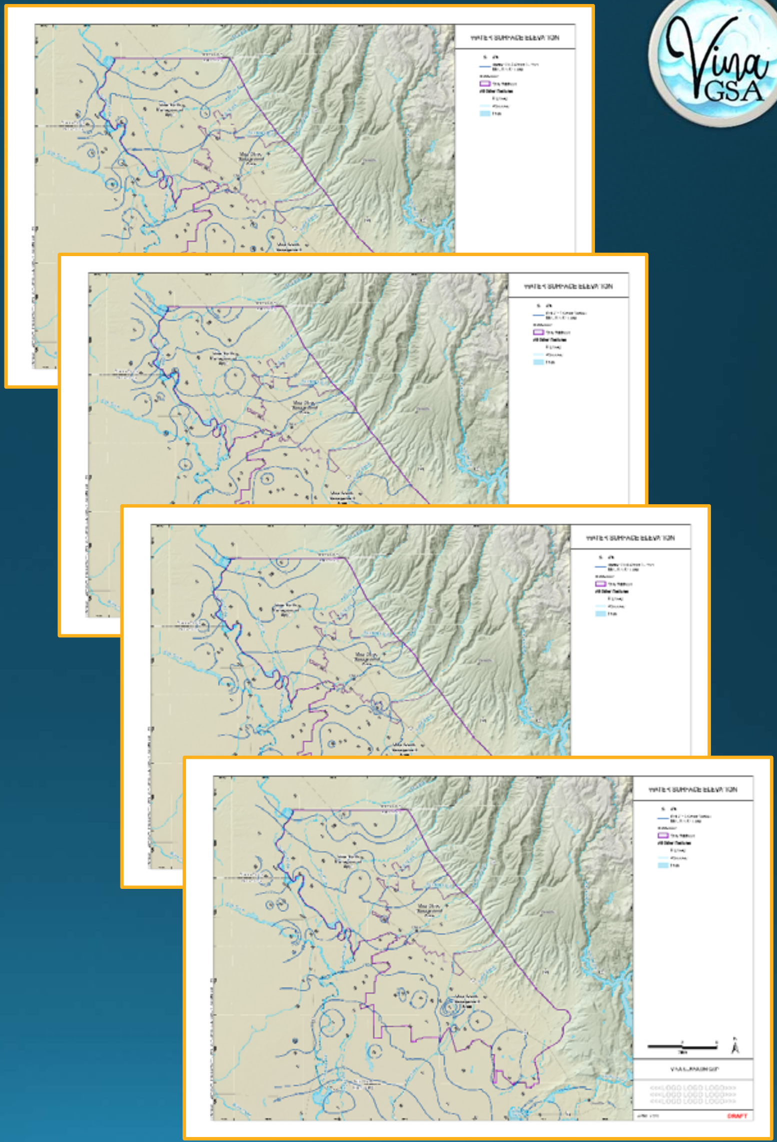
Historical Conditions: Groundwater Level Contours and Flow Directions

- Lines of Equal Groundwater Surface Elevation
- Groundwater Flow is Perpendicular to Contours and from Greater to Lesser Elevation
- Provide Insight into Flow within Basin and Interbasin Flow



2015 Groundwater Level Contours

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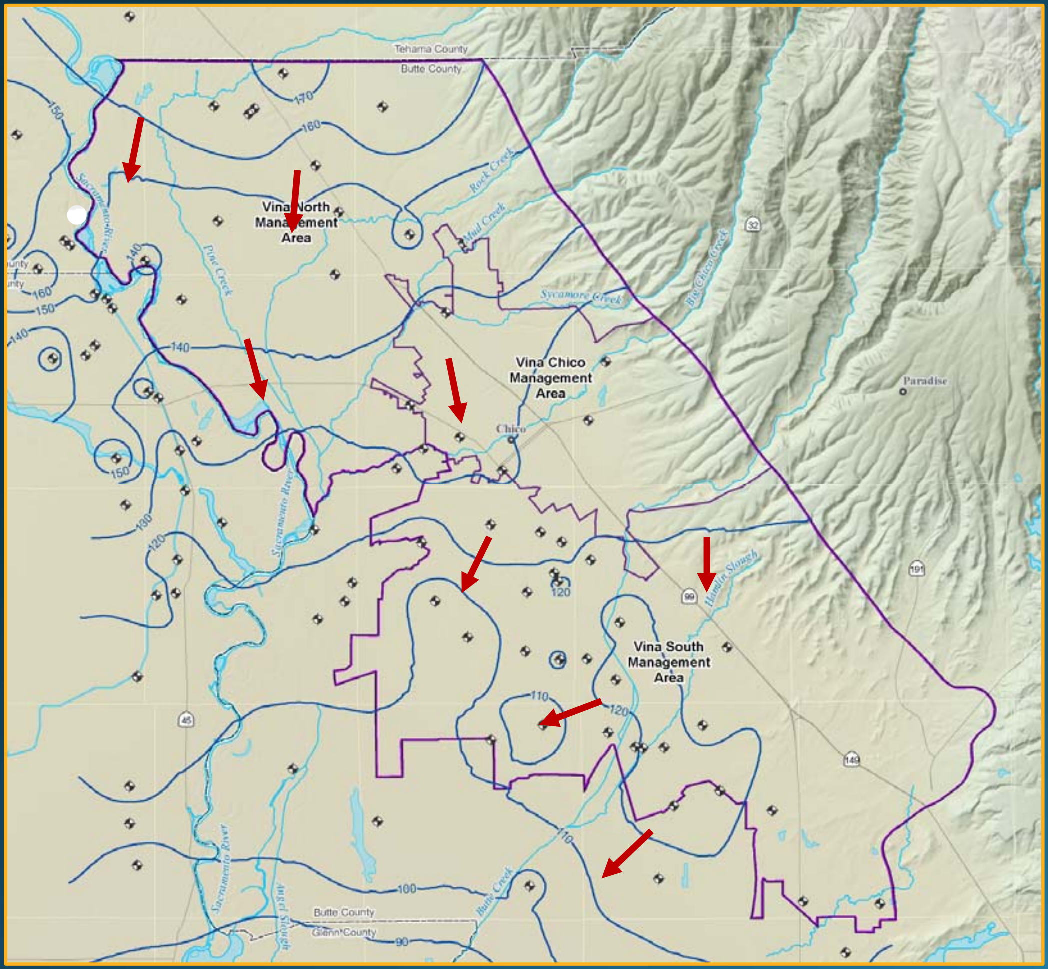
Vina GSA

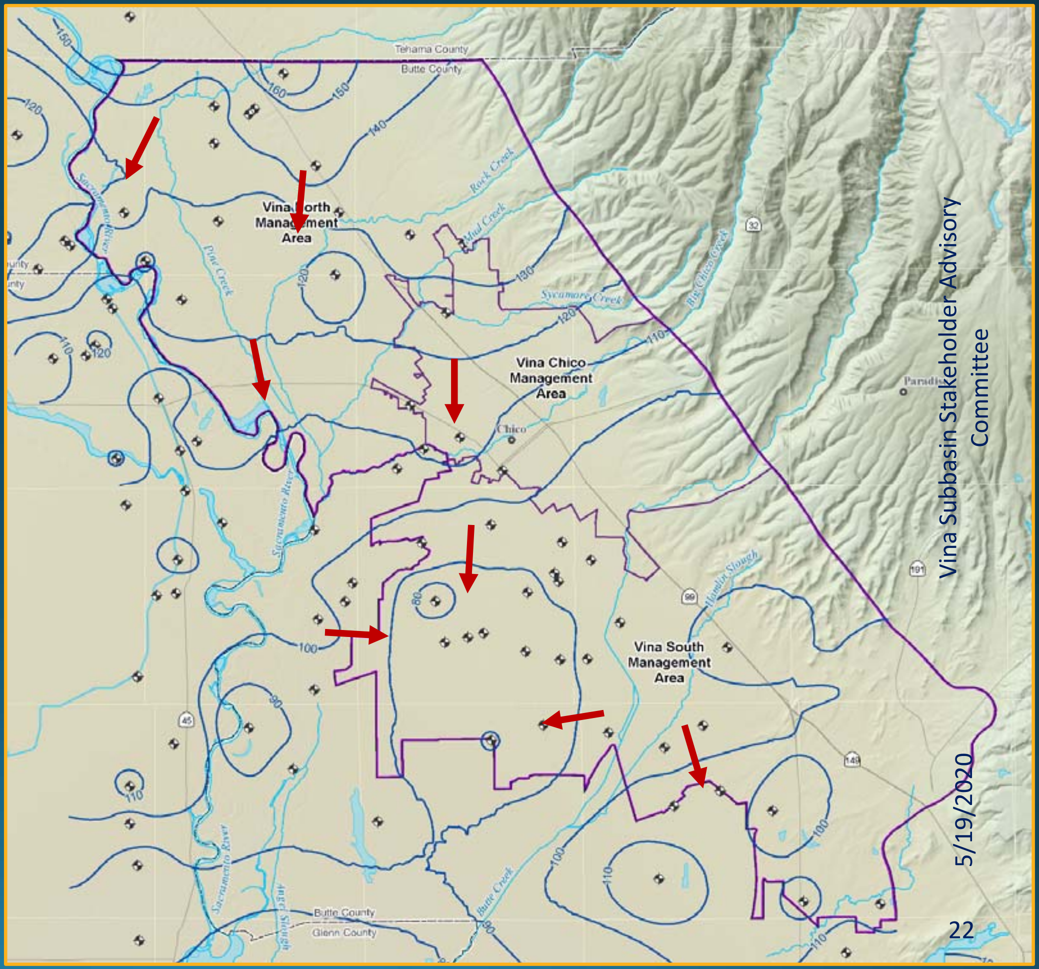
Butte County

WATER & RESOURCE CONSERVATION

Spring 2015 Groundwater Elevation Contours



Fall 2015 Groundwater Elevation Contours



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2019 Groundwater Level Contours

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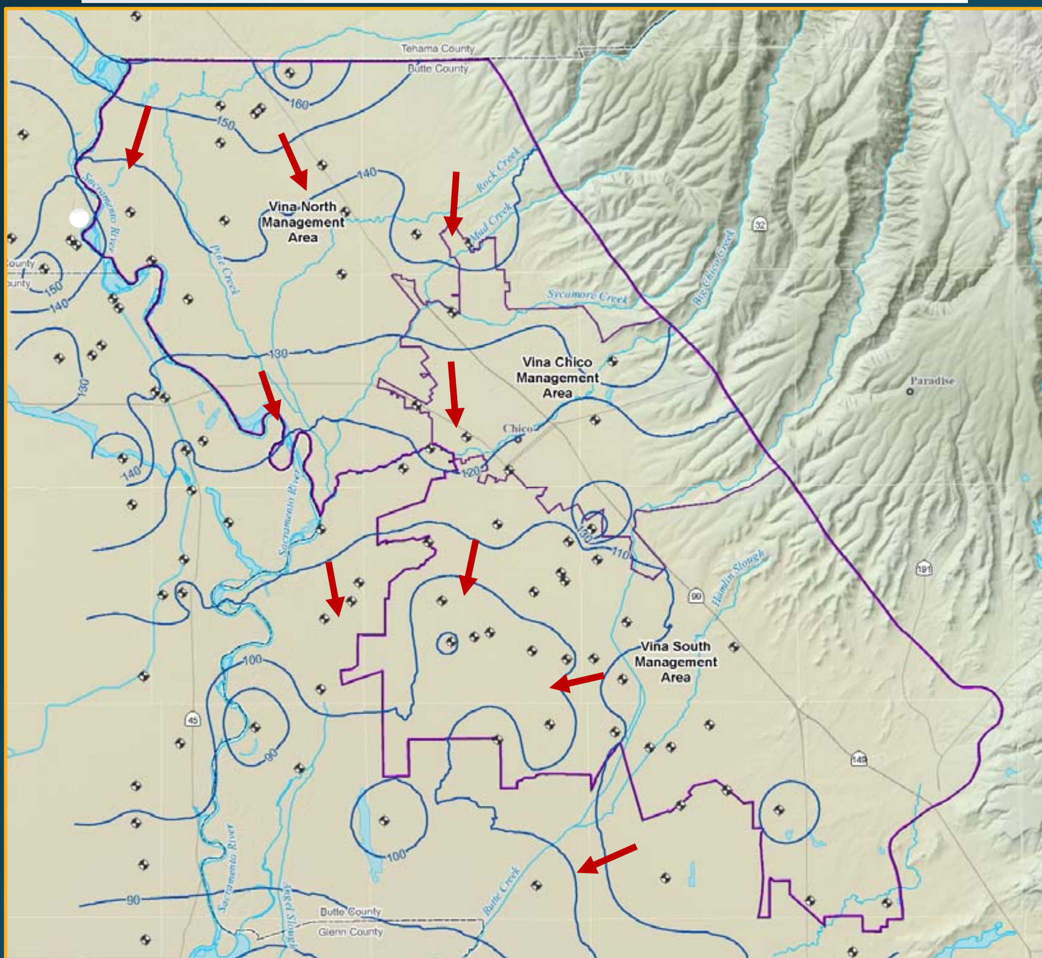
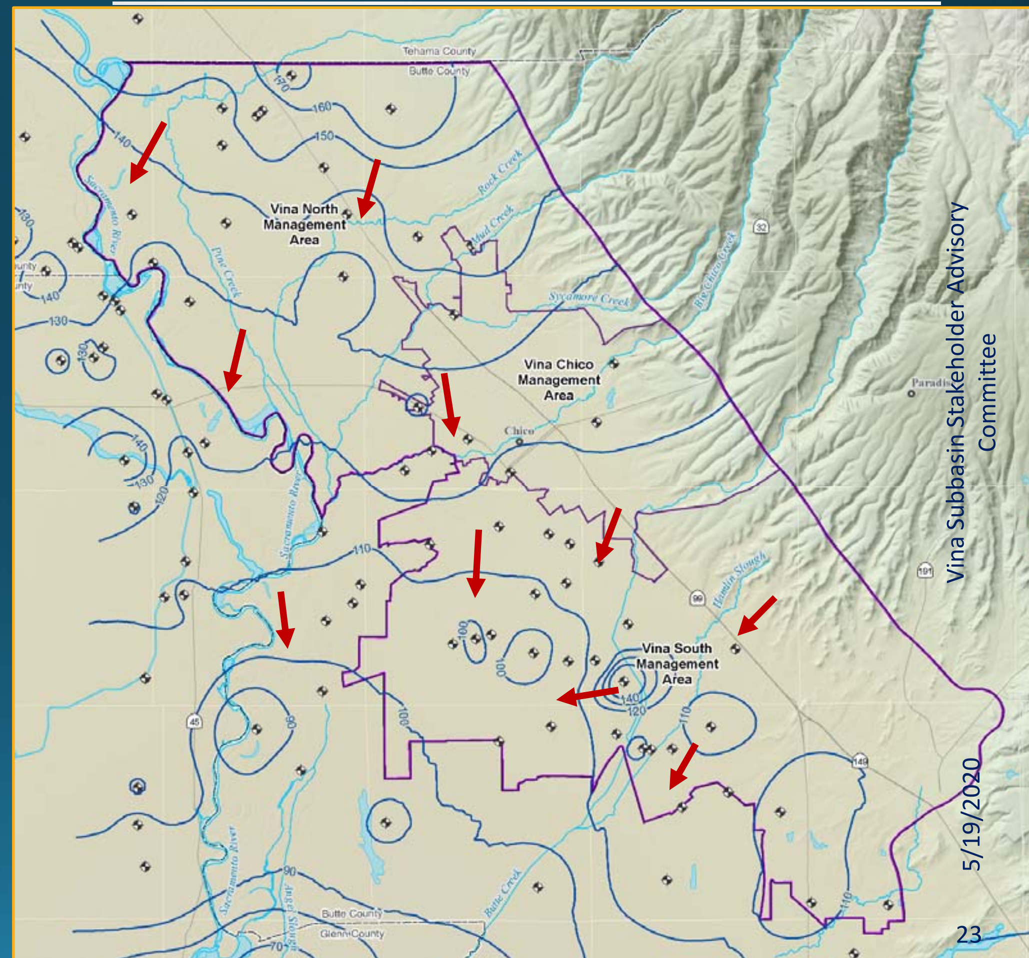
Spring 2019 Groundwater Elevation Contours



Fall 2019 Groundwater Elevation Contours



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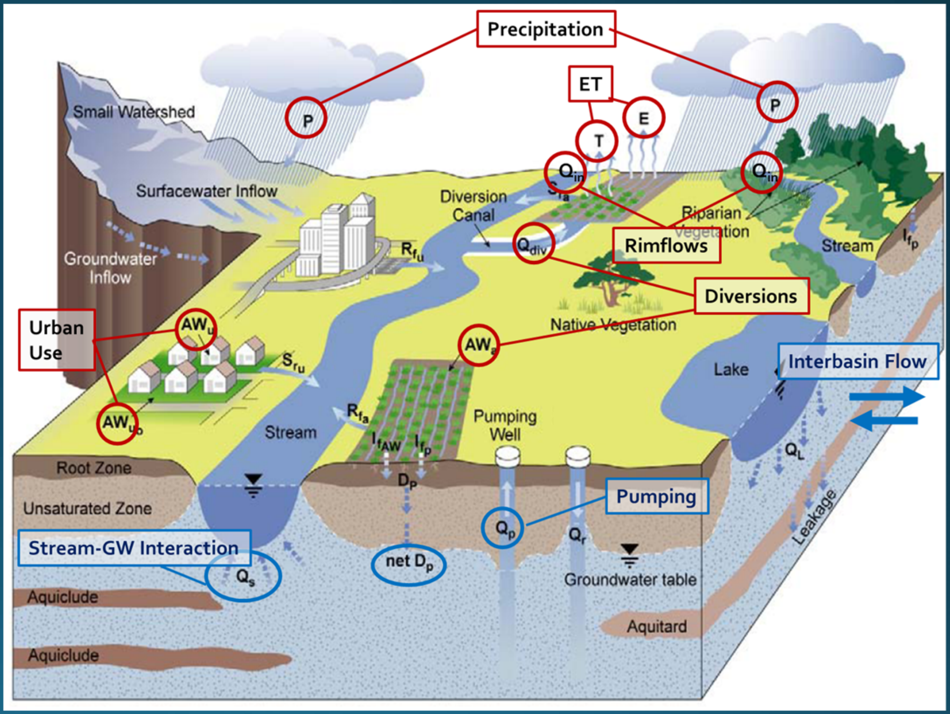
Draft Historical Water Budget

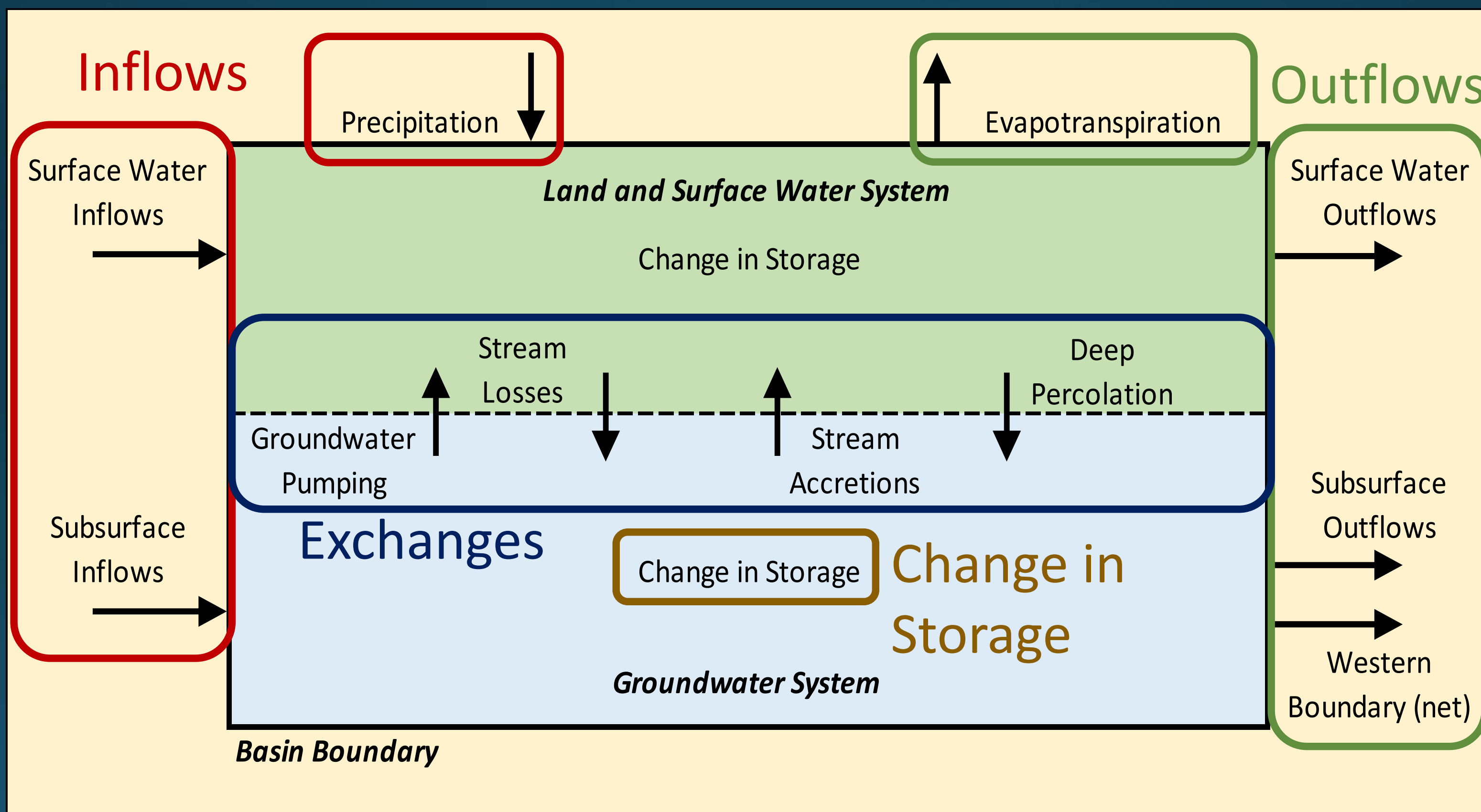
Historical Water Budget

- Complete accounting of inflows, outflows, and change in storage
- Just like a bank account
  - Deposits – Withdrawals = Change in Savings
  - Inflows – Outflows = Change in Storage
- Represents land surface, surface water, and groundwater systems
- Insight into how the system has worked in the recent past (2000-2018)
- Estimated using Butte Basin Groundwater Model



What Are the Main Components of the Water Budget?

(Reporting of Water Budgets in GSP Includes Additional Detail)



Primary Water Budget Drivers

- Land Use
- Precipitation
- Evapotranspiration
- Surface Water Supplies
- Groundwater Pumping
- Percolation
- Surface Water – Groundwater Interaction
- Interbasin Flows

Land Use

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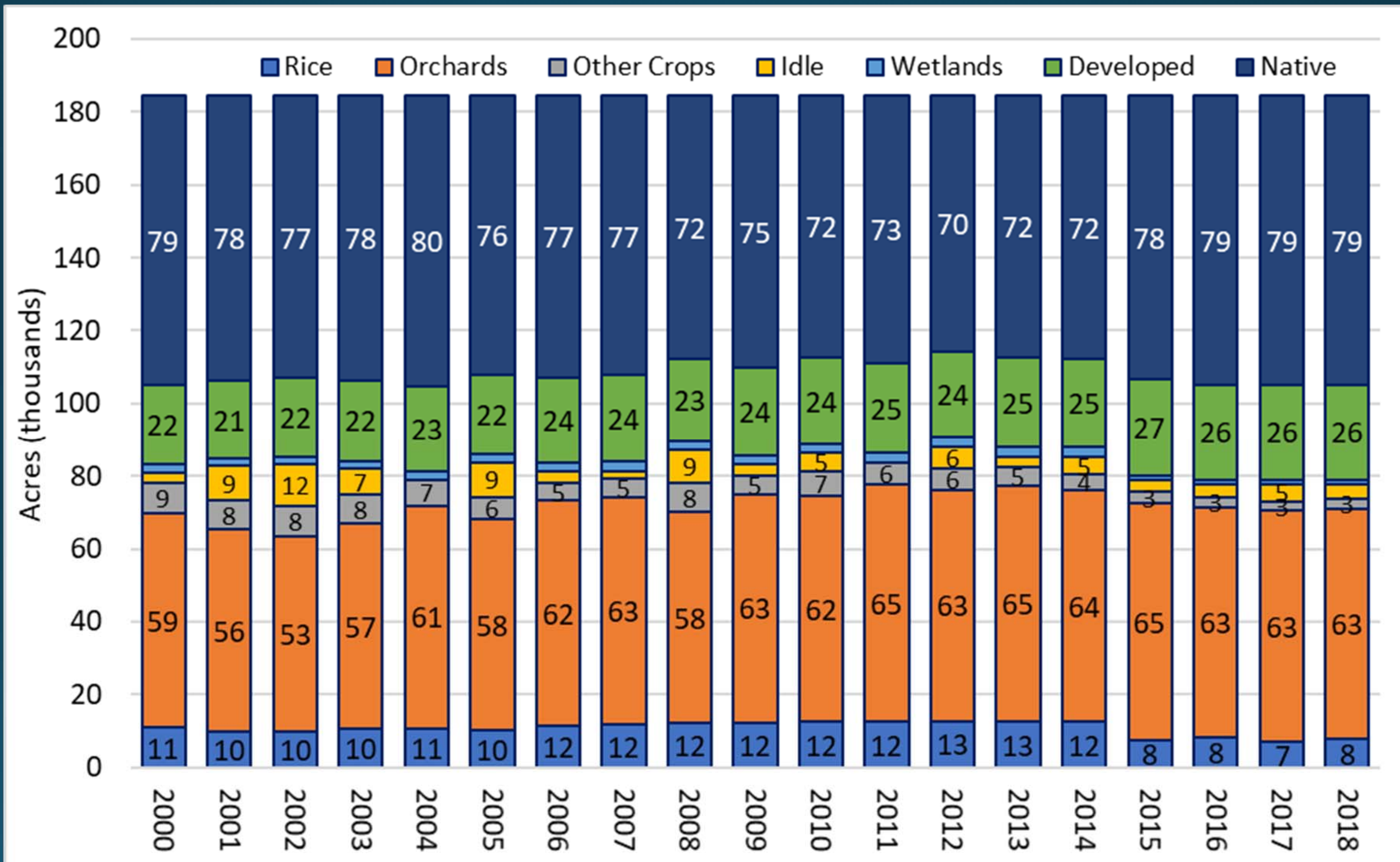
- Agriculture: 45%
- Developed: 13%
- Native: 42%

Native vegetation includes grasslands, riparian, and wetlands.



Year	Rice	Orchards	Other Crops	Idle	Developed	Native
2000	11	59	9		22	79
2001	10	56	8	9	21	78
2002	10	53	8	12	22	77
2003	10	57	8	7	22	78
2004	11	61	7		23	80
2005	10	58	6	9	22	76
2006	12	62	5		24	77
2007	12	63	5		24	77
2008	12	58	8	9	23	72
2009	12	63	5		24	75
2010	12	62	7	5	24	72
2011	12	65	6		25	73
2012	13	63	6	6	24	70
2013	13	65	5		25	72
2014	12	64	4	5	25	72
2015	8	65	3		27	78
2016	8	63	3		26	79
2017	7	63	3	5	26	79
2018	8	63	3		26	79

Precipitation

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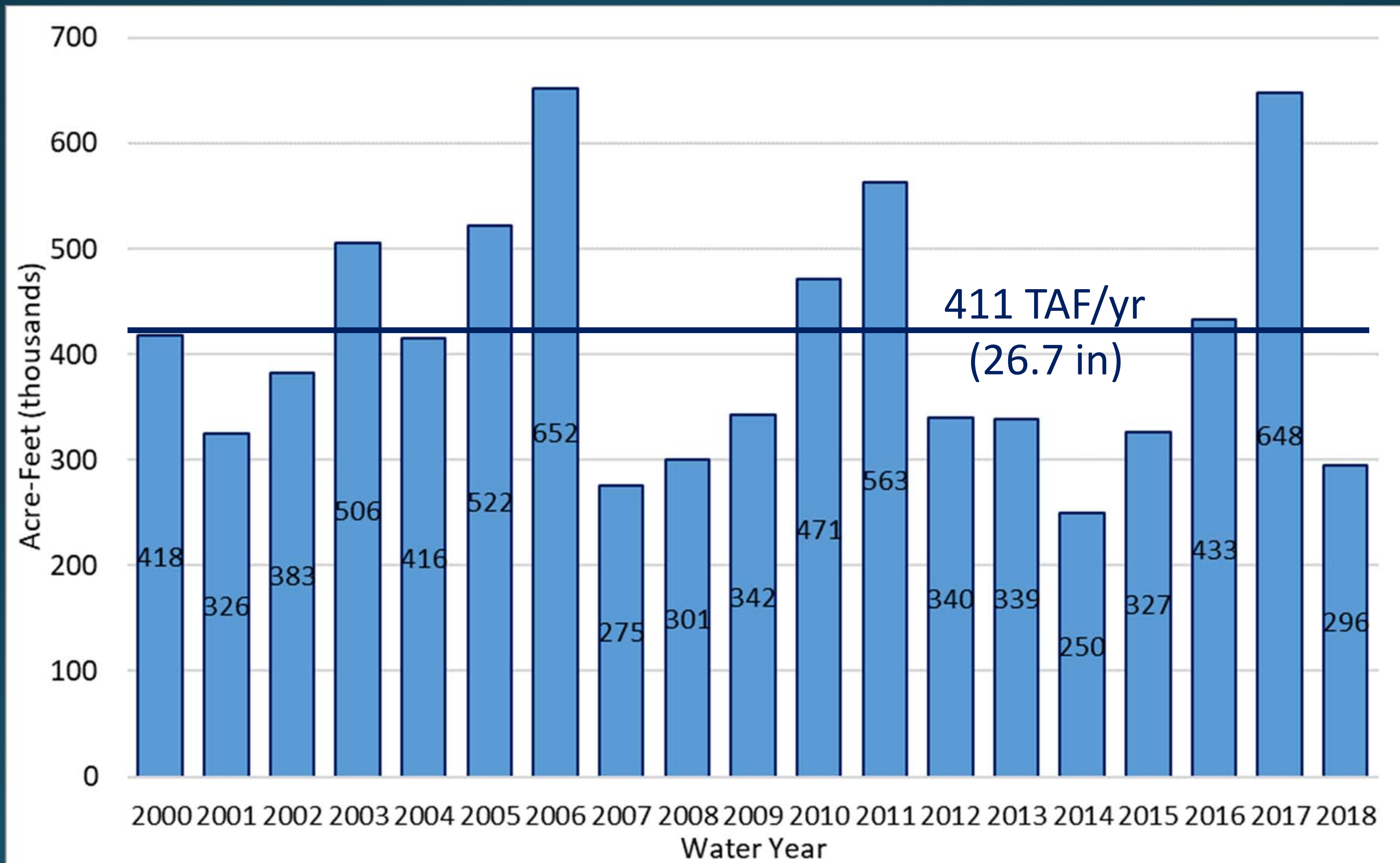

Evapotranspiration

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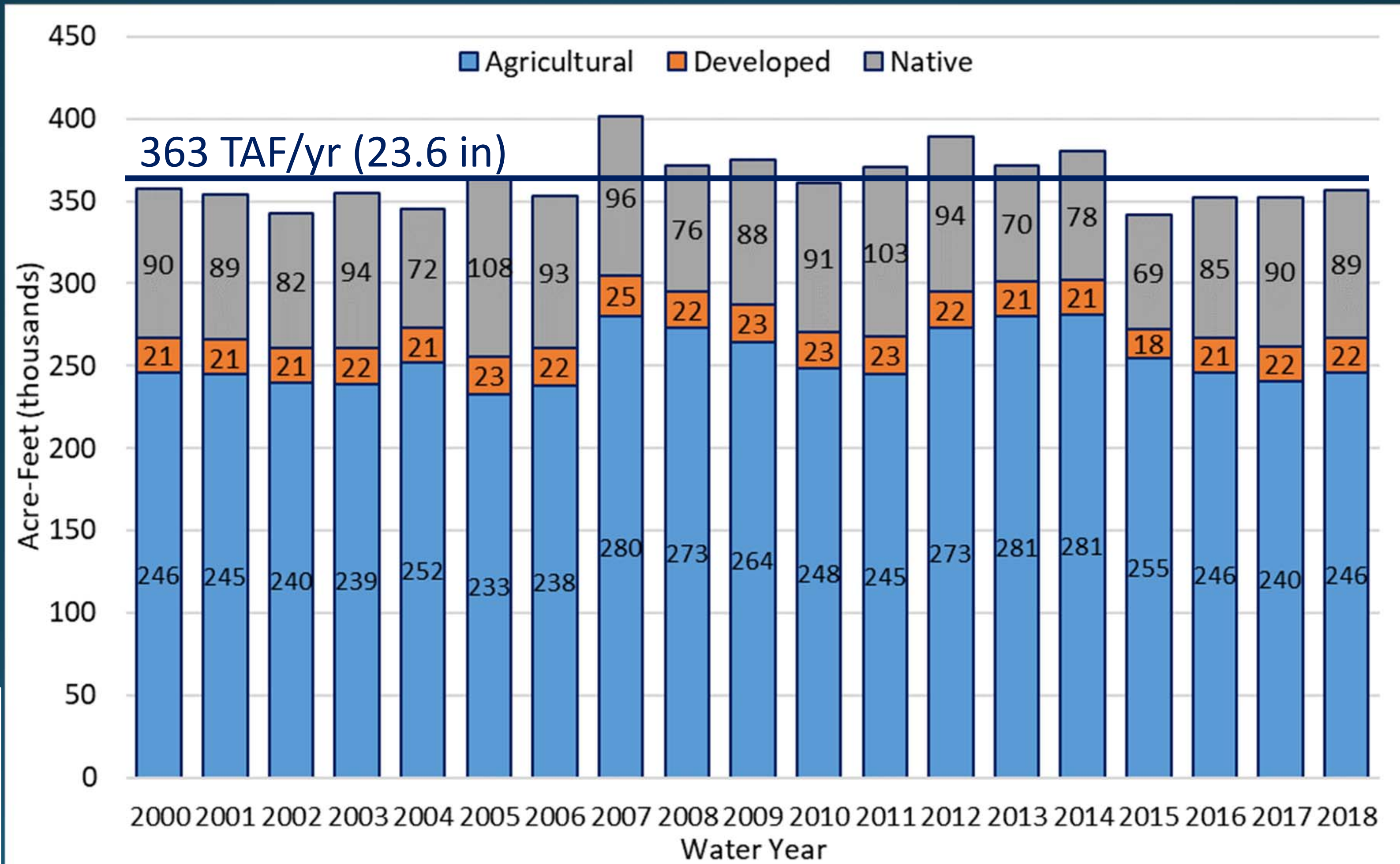
- Agriculture: 70%
- Developed: 6%
- Native: 24%



Native vegetation includes grasslands, riparian, and wetlands.

Water Supplies

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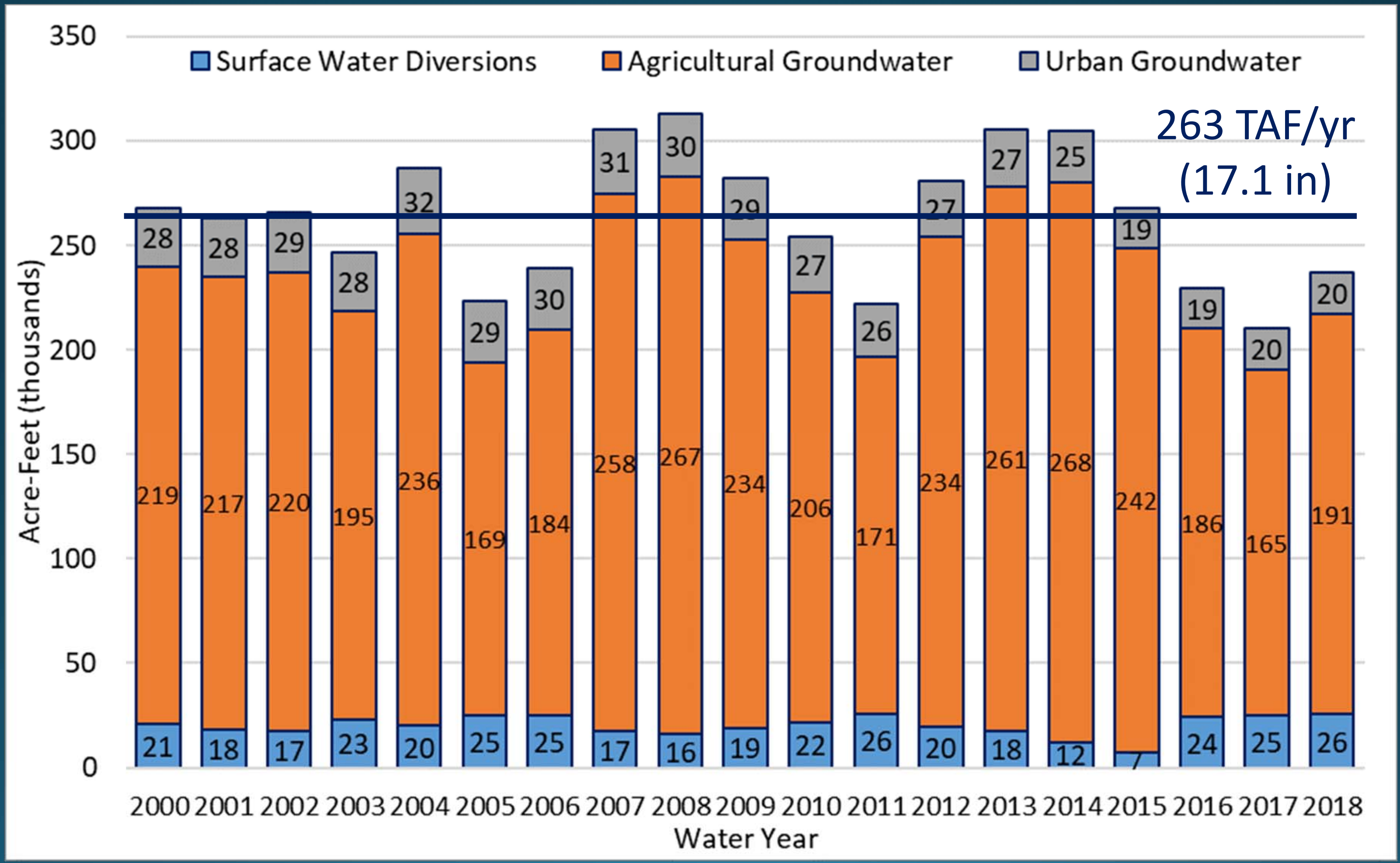
- Surface Water:
  8%
- Ag Pumping:
  82%
- Urban Pumping:
  10%



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Percolation

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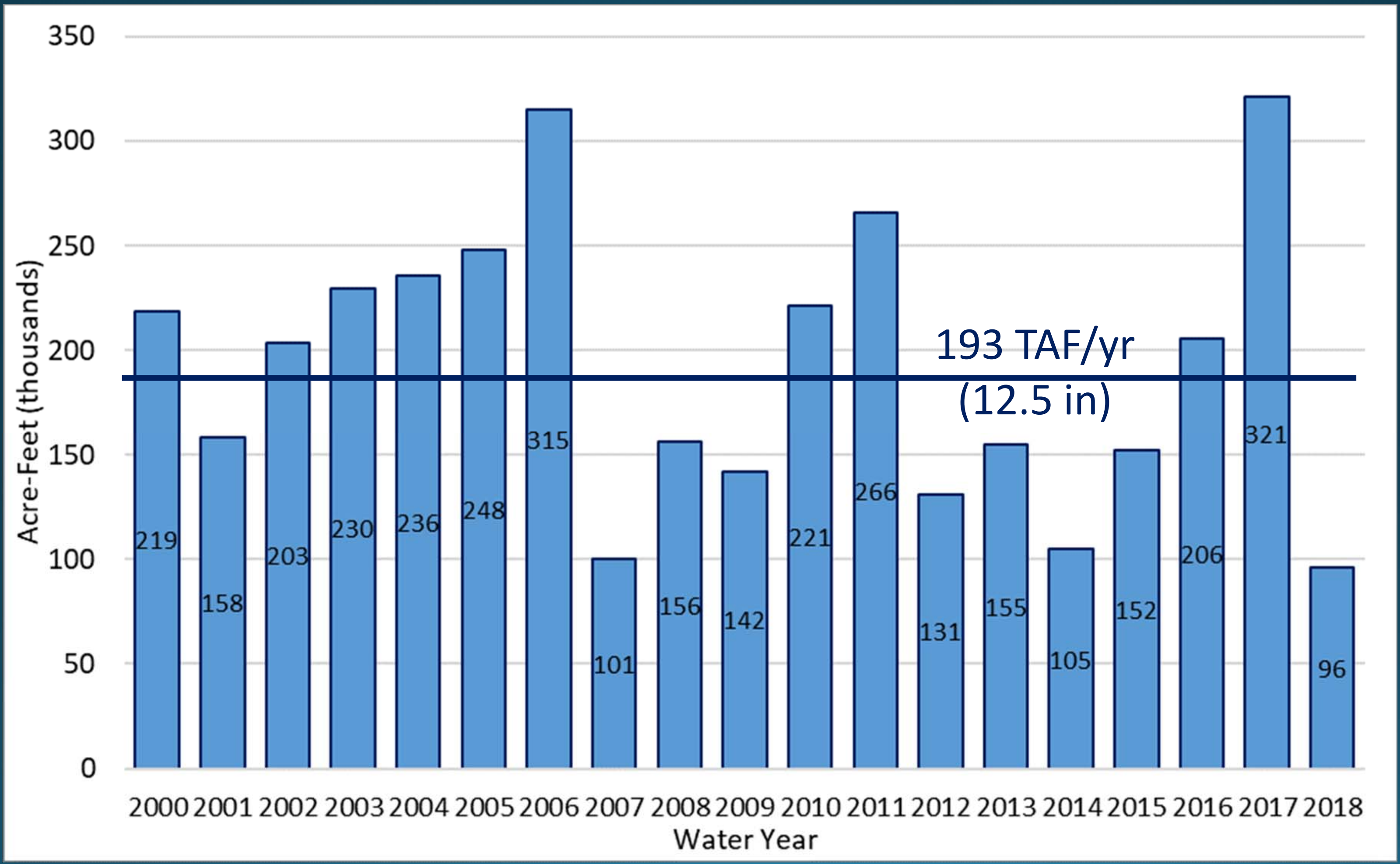

Surface Water – Groundwater Interaction

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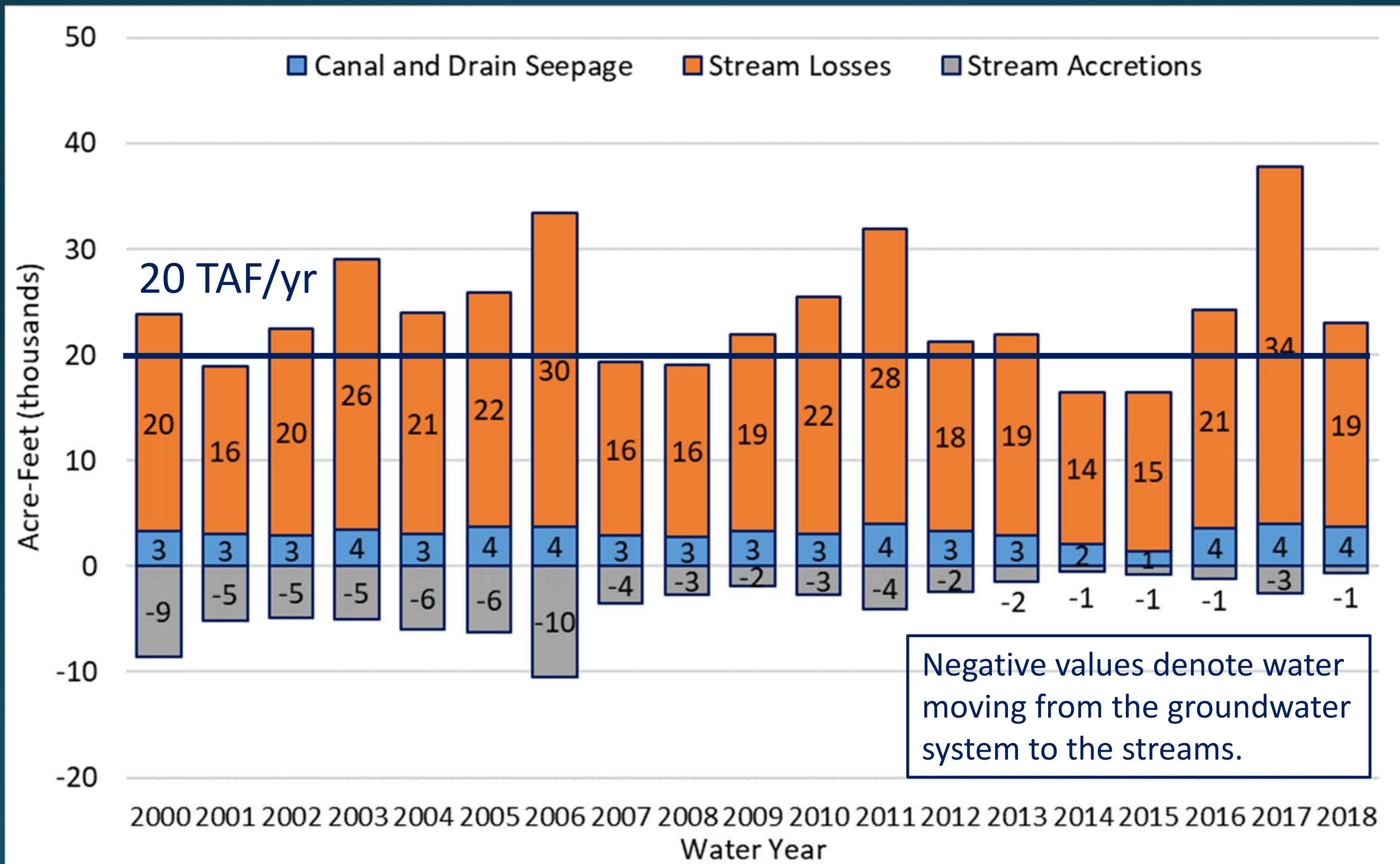

Surface Water – Groundwater Interaction

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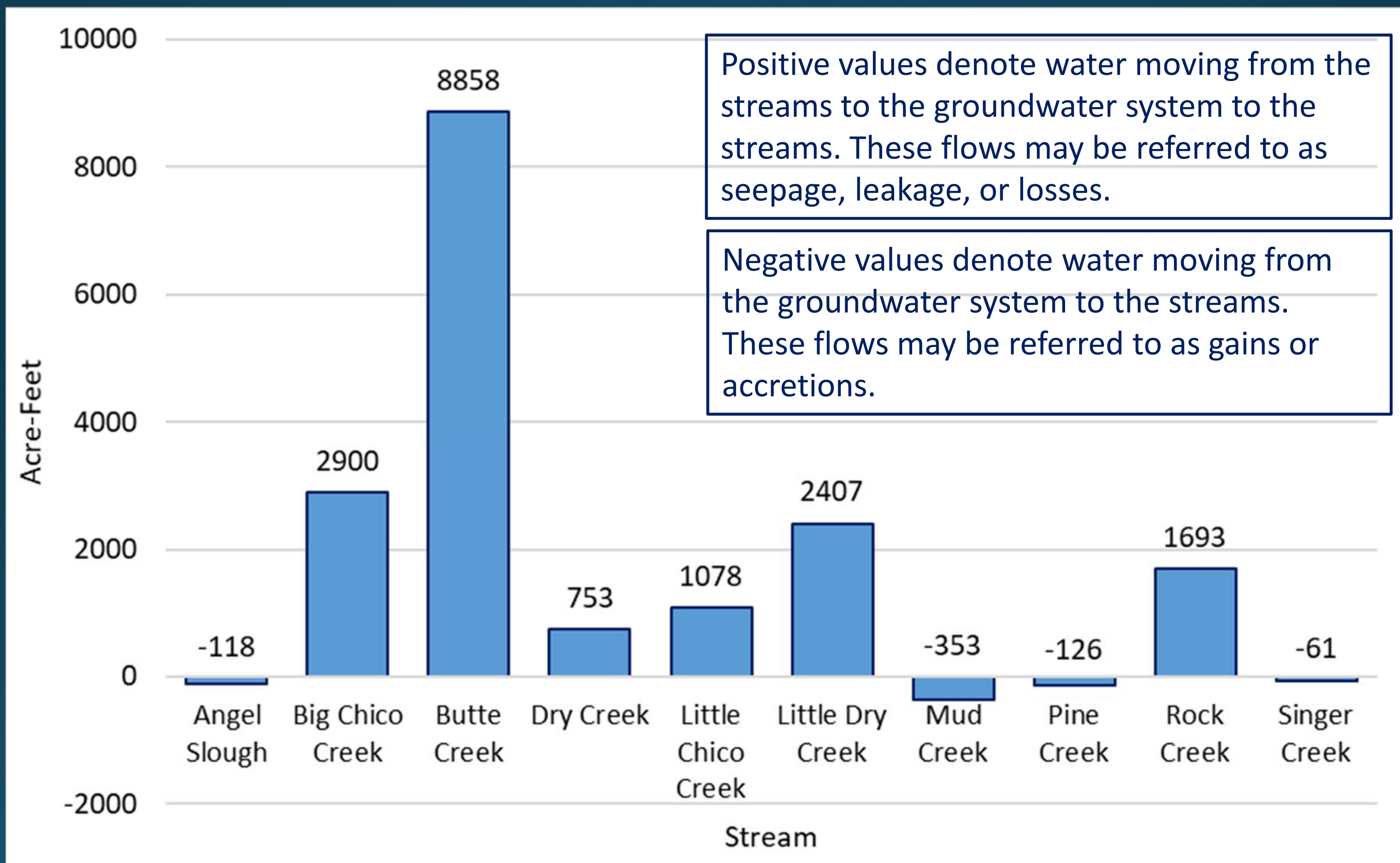

Interbasin Flows

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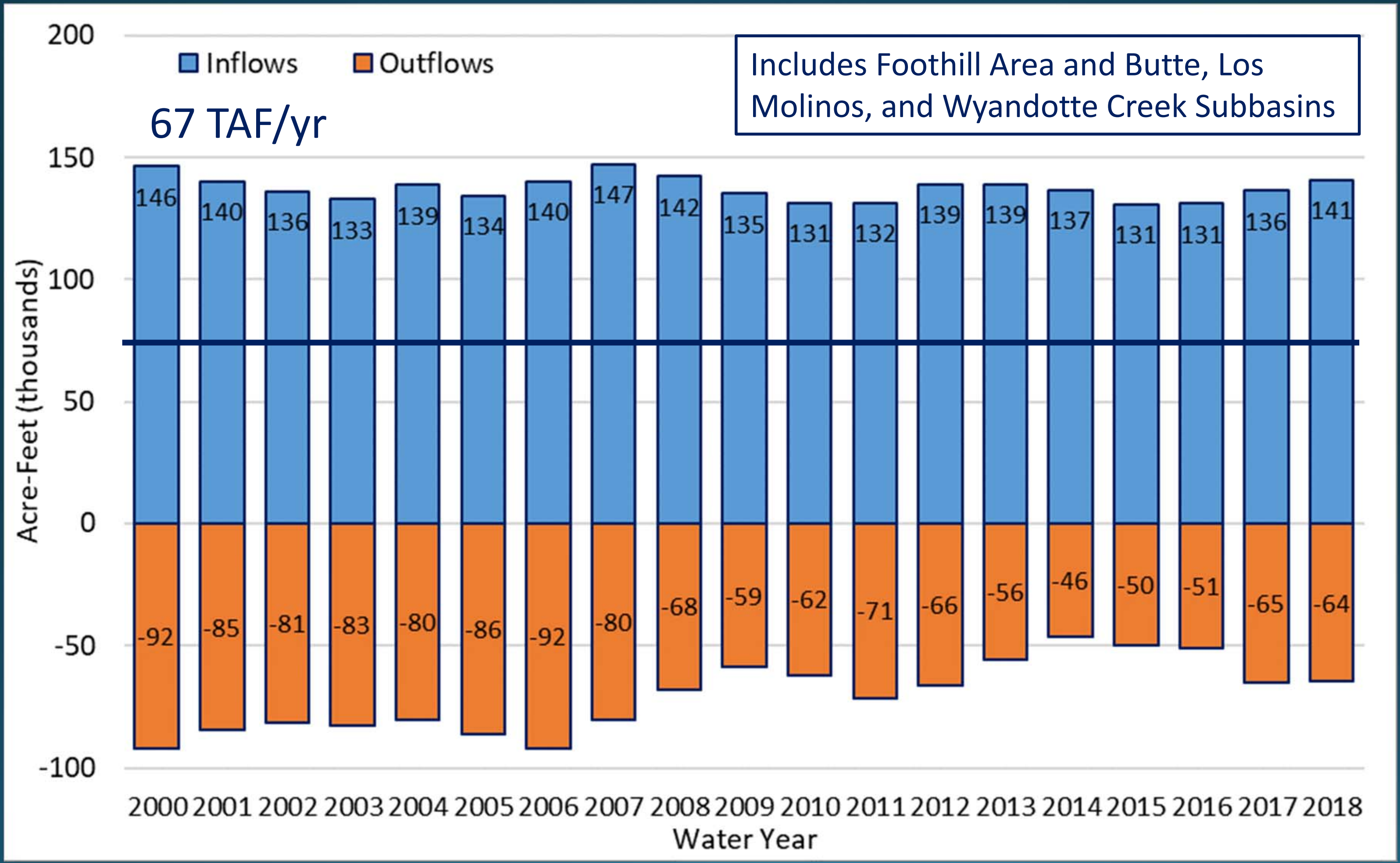

Interbasin Flows

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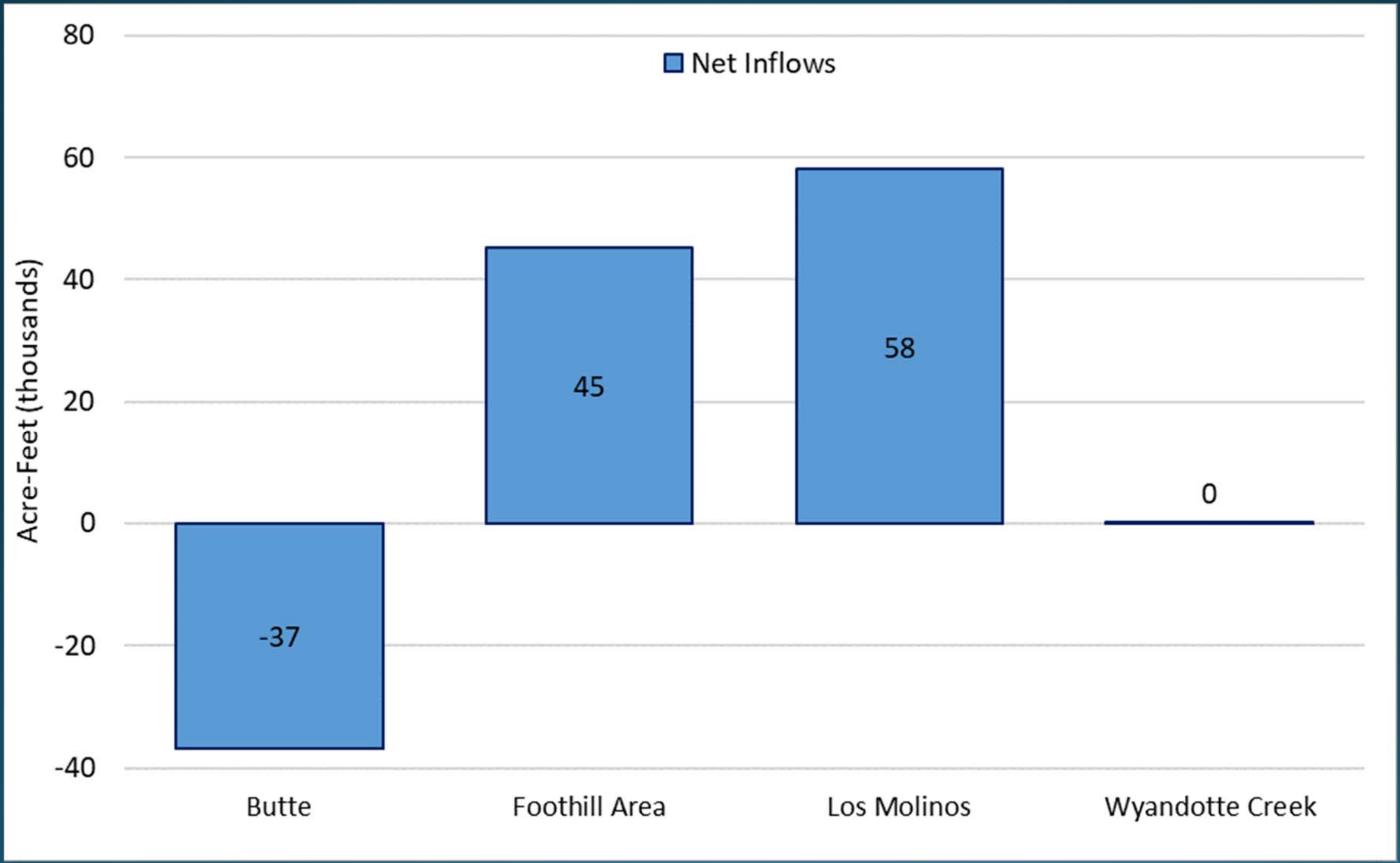

Western Boundary (Sacramento River)

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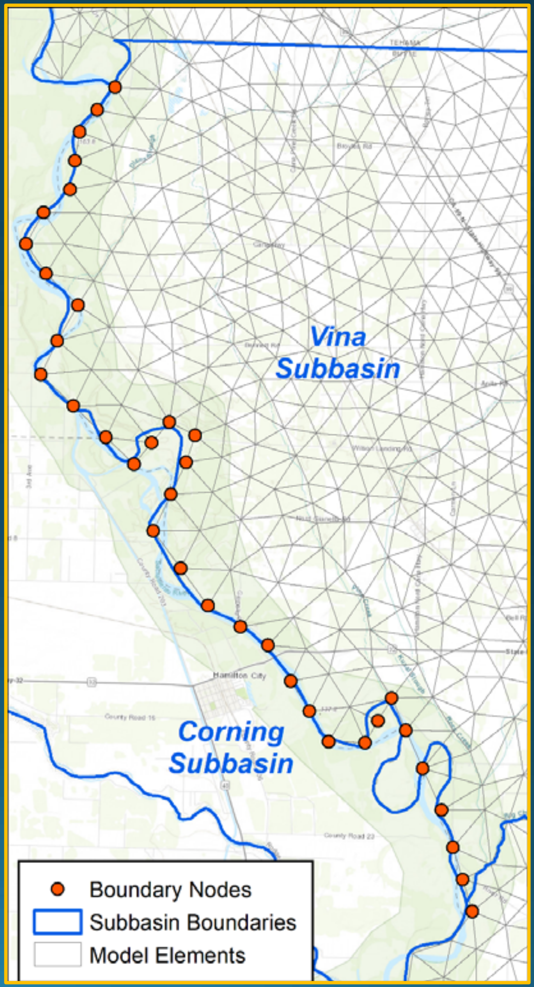
- Edge of Model Domain
- Groundwater Levels at 39 Boundary Nodes Based on Earlier DWR C2VSim Model
- Combination of
  - Sacramento River Interaction
  - Corning Subbasin Interbasin Flows
- Split Between River Interaction and Interbasin Flows Highly Uncertain
- Groundwater level contours provide insight into interbasin flow
- Identified as a Data Gap
- Opportunity to Evaluate Based on Neighboring Models (future)
- Explore through Interbasin Evaluation and Future GSP Updates



Western Boundary Net Inflows

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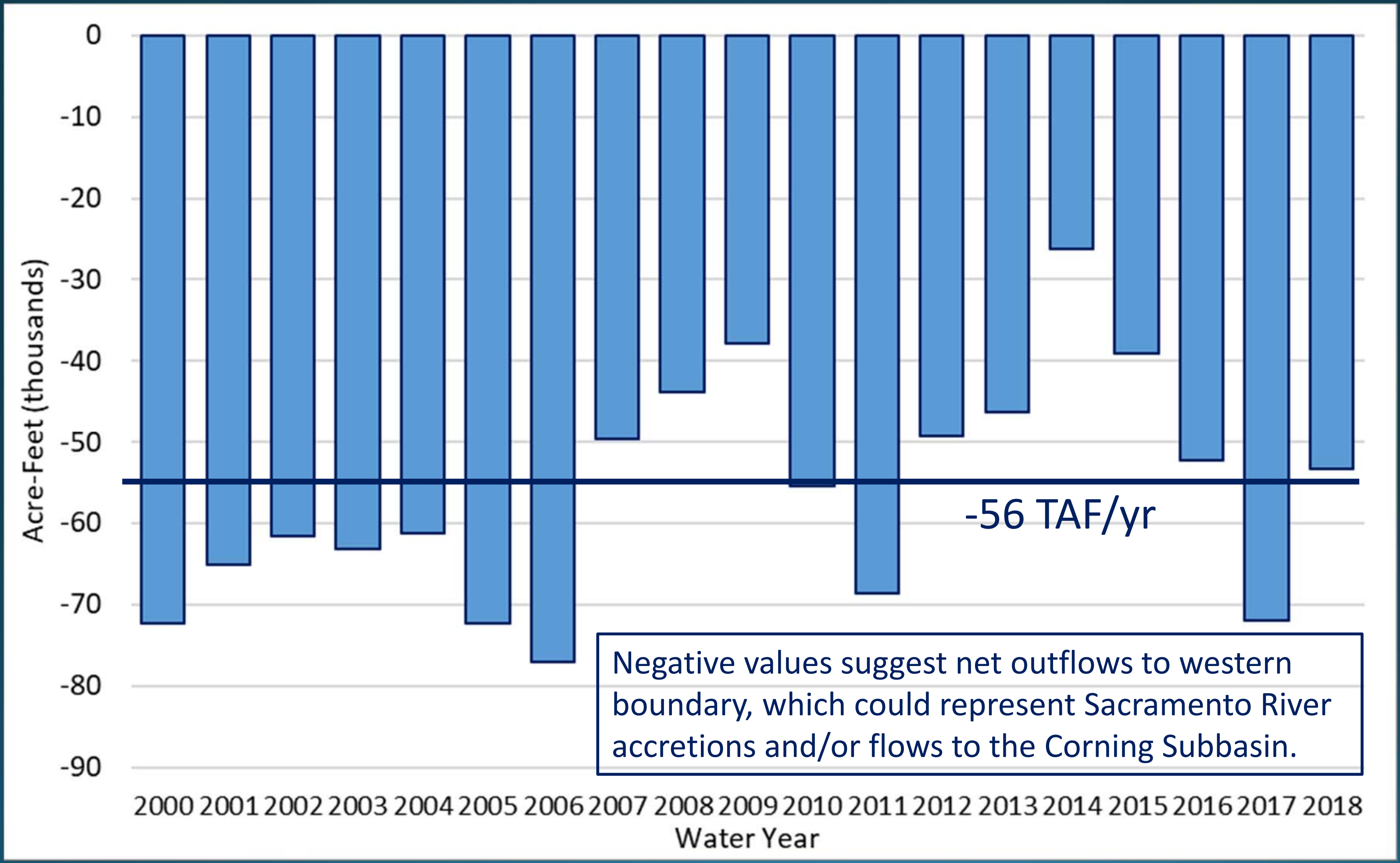

Historical Water Budget Summary

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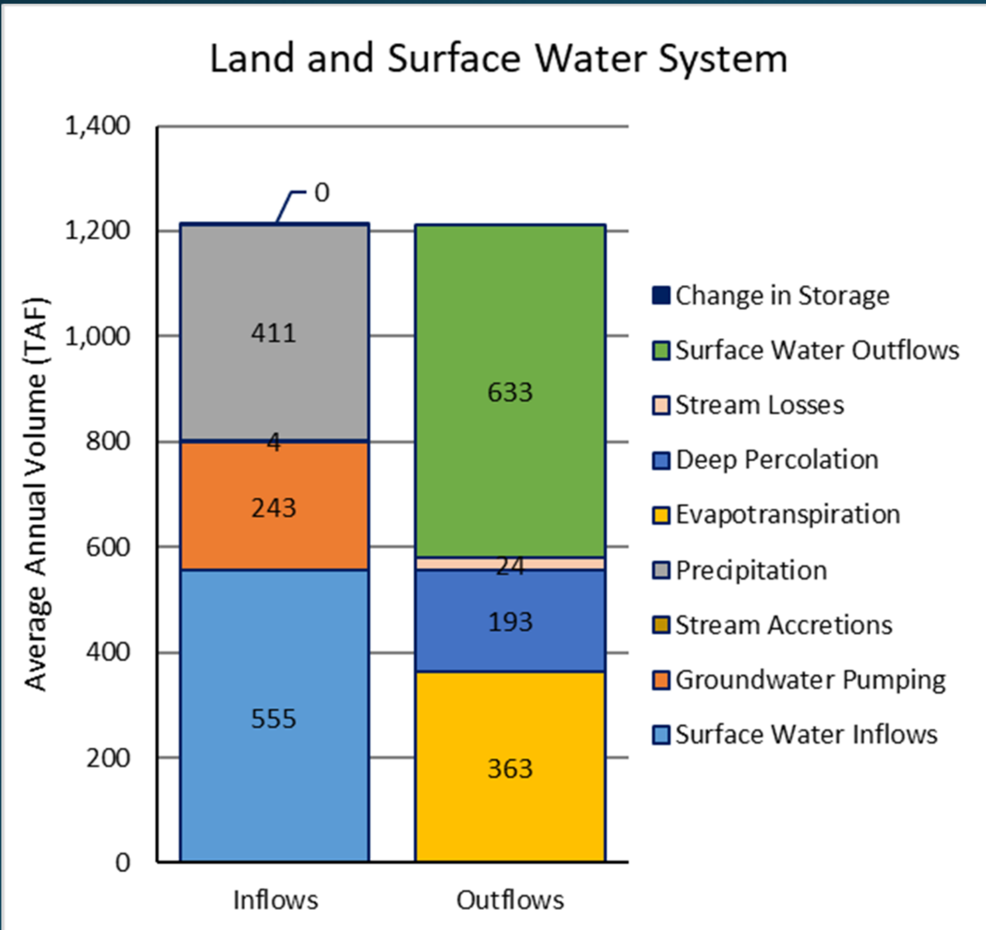

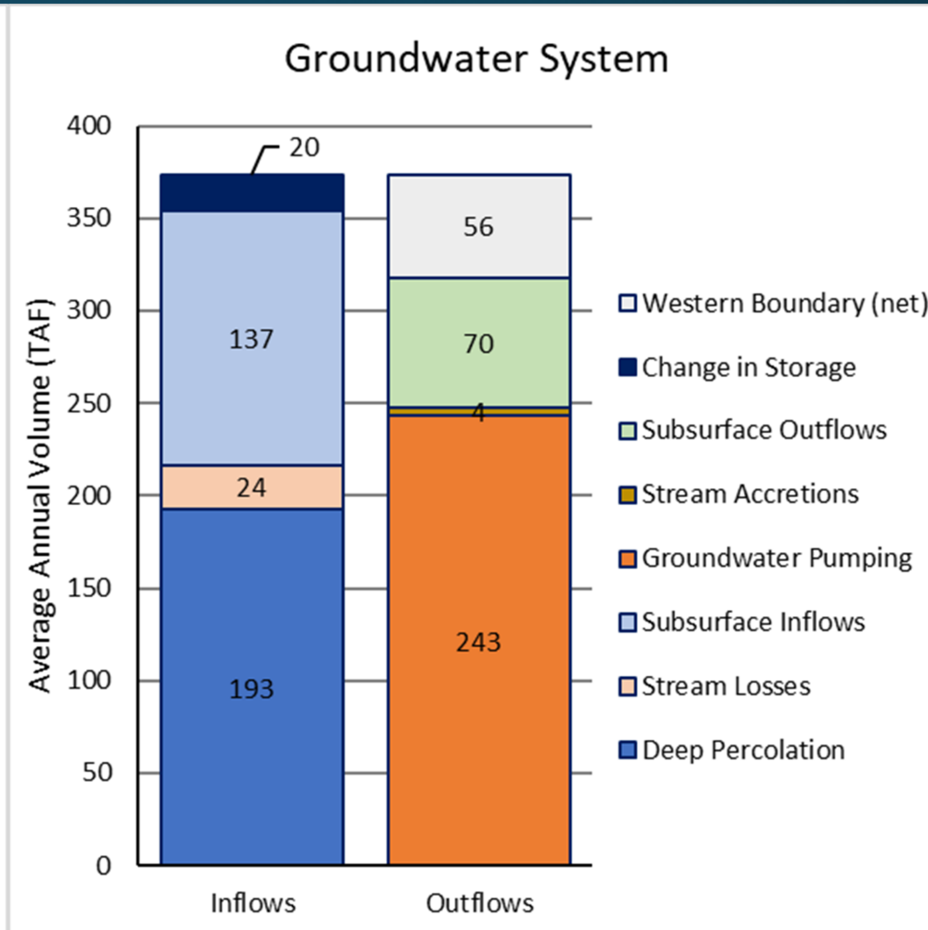

Historical Water Budget Summary

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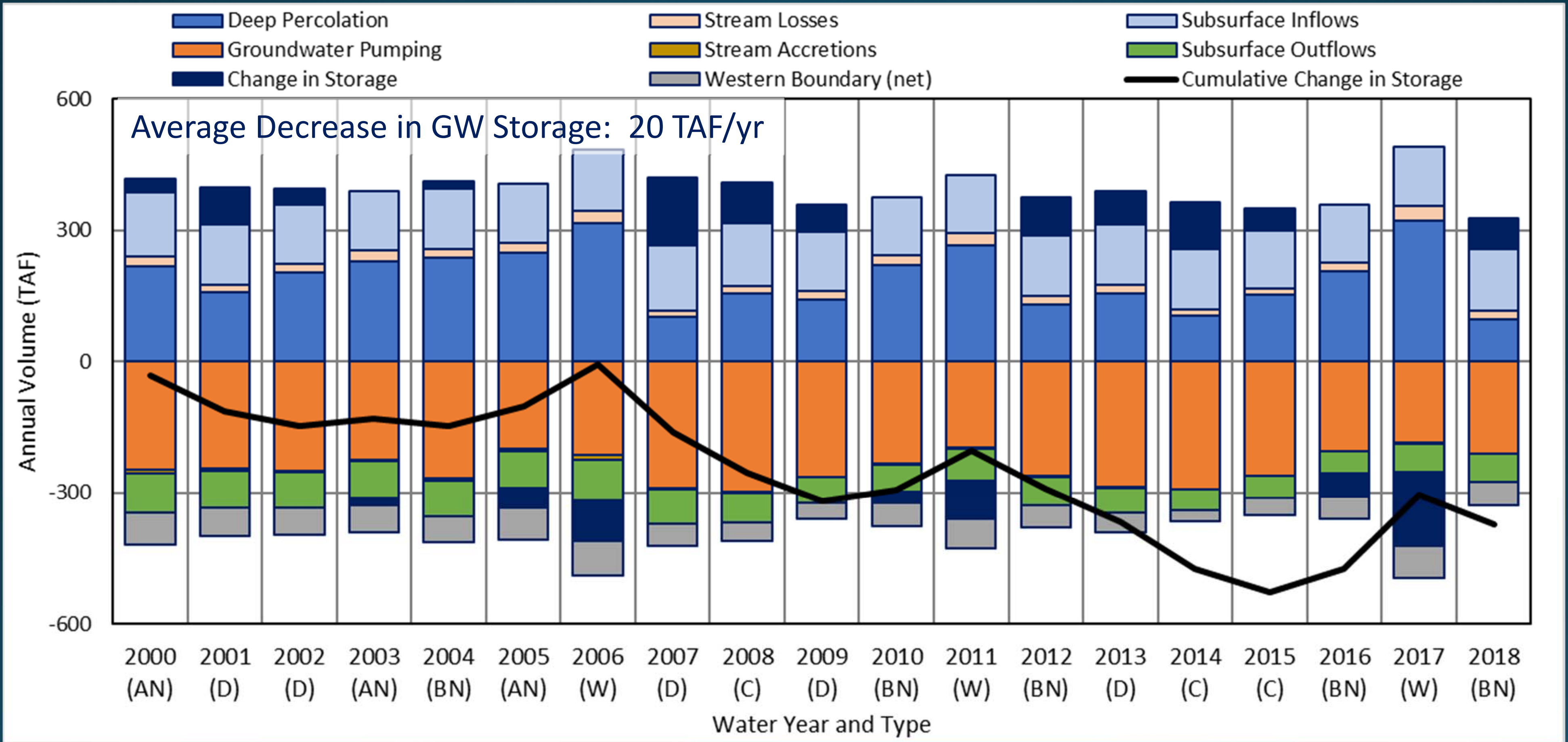
Annual Groundwater Budget and Cumulative Change in Storage



Year Types: Critical (C), Dry (D), Below Normal (BN), Above Normal (AN), Wet (W)

Historical Water Budget Summary

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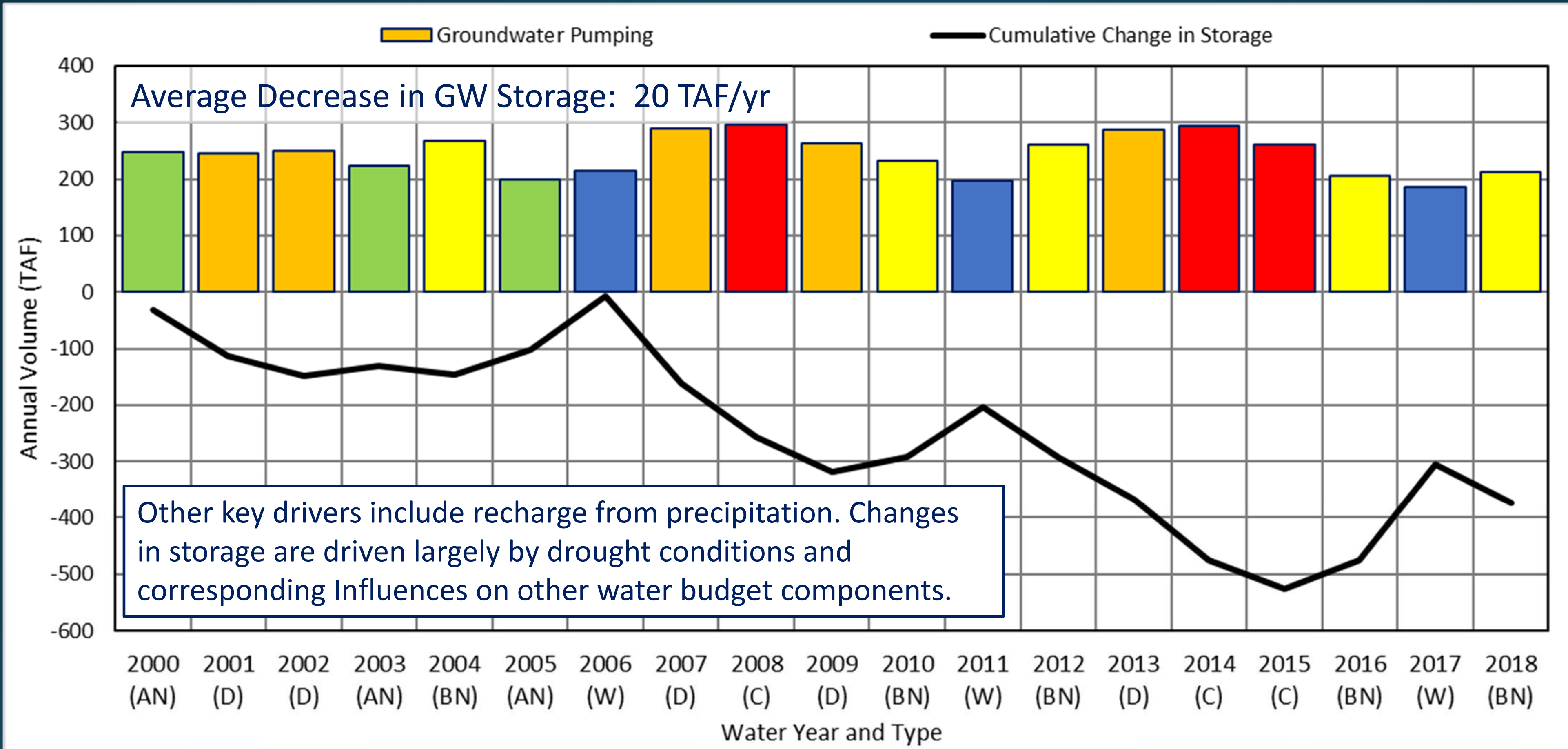
Annual Groundwater Pumping and Cumulative Change in Storage



Year Types: Critical (C), Dry (D), Below Normal (BN), Above Normal (AN), Wet (W)

Historical Water Budget Takeaways

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- Land Use Relatively Constant
- Strong Reliance on Groundwater for Beneficial Uses
- Precipitation and Resulting Recharge Highly Variable
- Indications of Decreased Stream Accretions and Increased Interbasin Inflows over Time
- Need to Better Understand Western Boundary
- Reductions in Groundwater Storage Appear to be More Related to Recent Historic Drought than Increased Groundwater Pumping

Water Budget Scenario Assumptions

Current and Projected Water Budget Assumptions

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- Current Conditions
  - 1971 – 2018 hydrology (precipitation, ET, streamflows)
  - 2015 and 2016 land use and diversions, mapped to historical hydrology
    - Normal (2016) vs. Dry (2015) Years Based on Lake Oroville Inflows
- Future Conditions
  - Builds on current conditions scenario
  - Three additional scenarios
    - Future development without climate change
    - 2030 and 2070 DWR central tendency climate change scenarios

Historical Hydrology (1971 – 2018)

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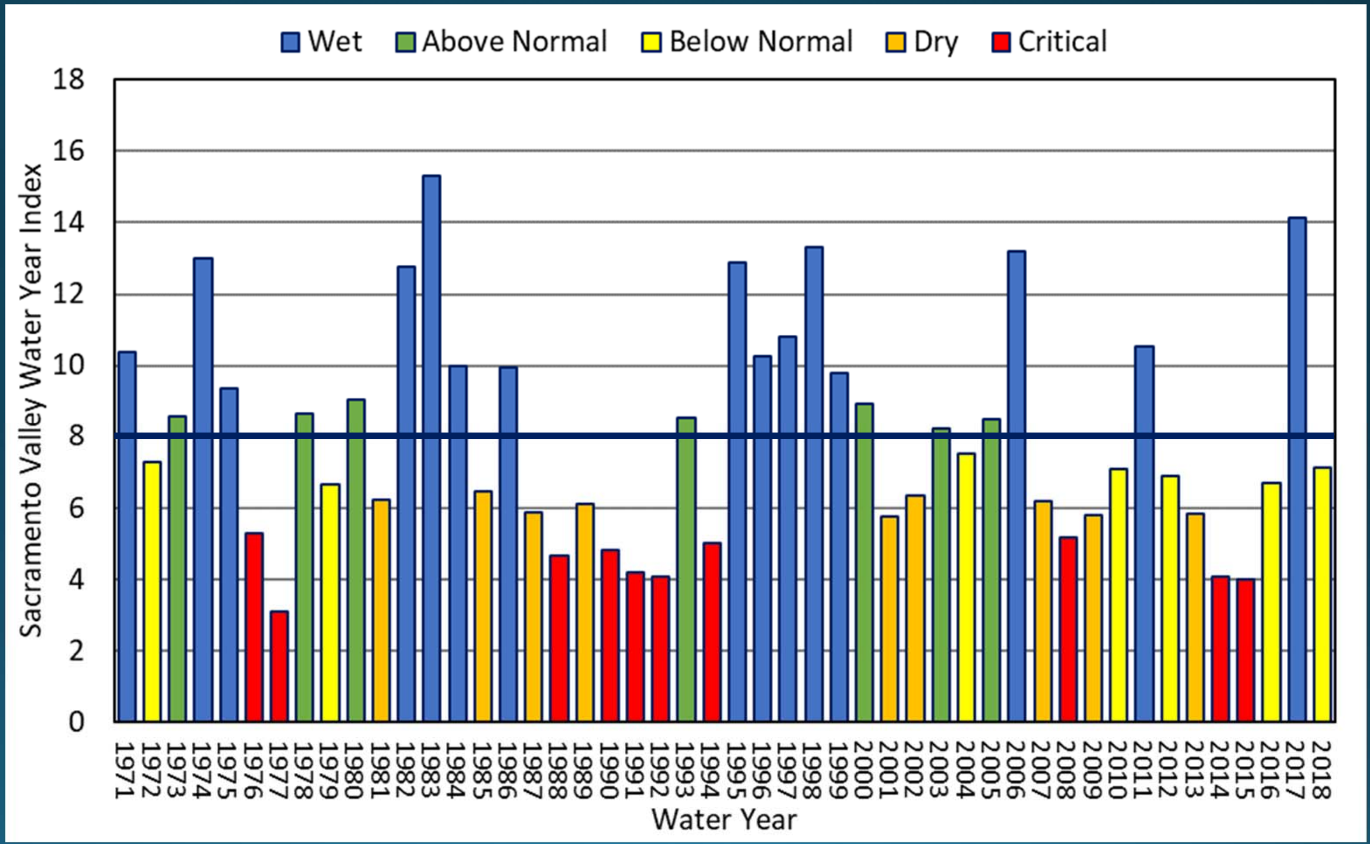
- Sacramento Valley Index
  - 1906 to 2018 avg. = 8.1
  - 1971 to 2018 avg. = 8.0
- Precipitation
  - 1906 to 2018 avg. = 24.8 in
  - 1971 to 2018 avg. = 26.3 in



Land Use

Future Development Based on 2030 General Plan and Parcel Zoning

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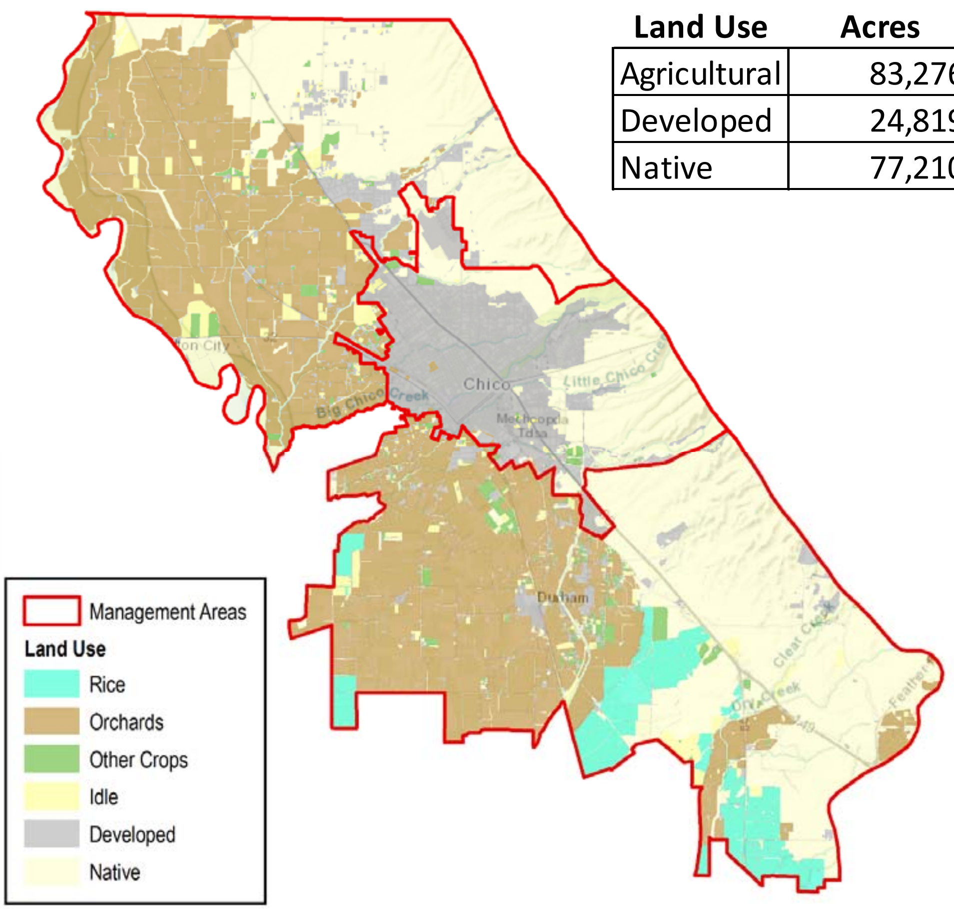
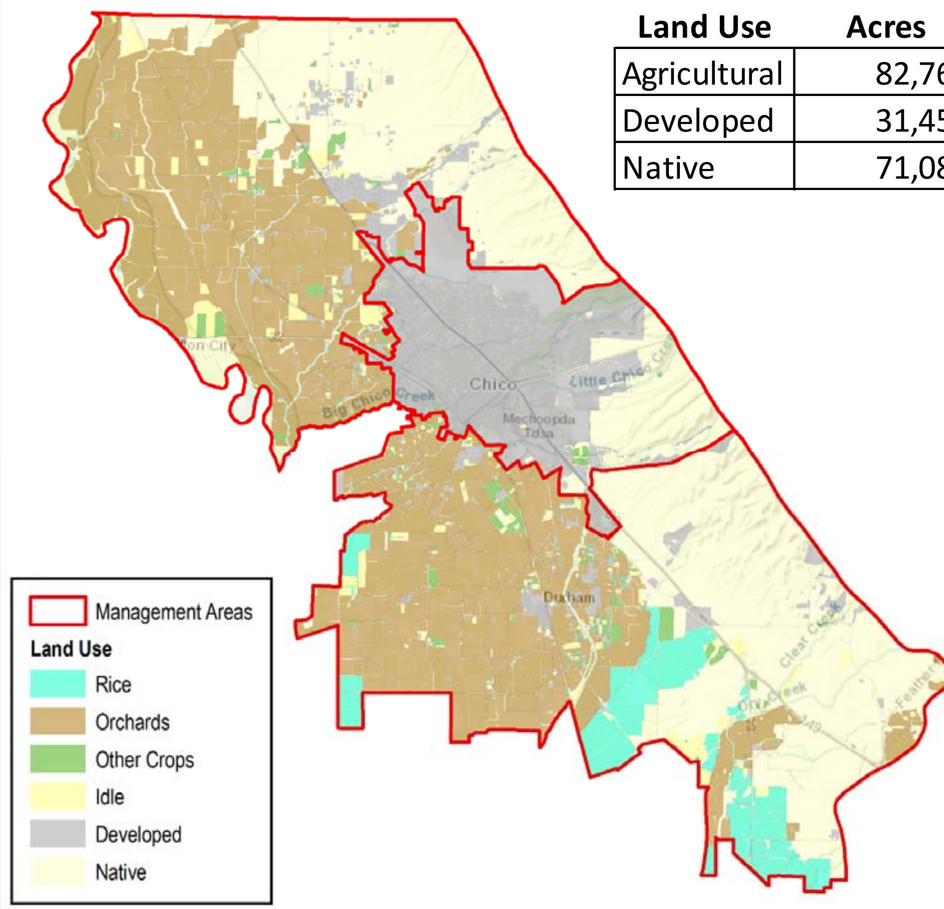
Current Conditions

Land Use	Acres
Agricultural	83,276
Developed	24,819
Native	77,210



Future Conditions

Land Use	Acres
Agricultural	82,766
Developed	31,459
Native	71,081



Available Climate Change Scenarios

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- Four Scenarios from DWR
  - 2030 Central Tendency
  - 2070 Central Tendency
  - 2070 Drier with Extreme Warming
  - 2070 Wetter with Moderate Warming
- Used to Modify Historical Hydrology and Surface Water Supplies
- Currently Utilizing 2030 and 2070 Central Tendency Scenarios

Climate Scenarios in Other GSPs

Basin	Climate Change Scenario(s)
Butte	2030CT, 2070CT
Chowchilla	2030CT
Delta-Mendota	2030CT, 2070CT
East Kaweah	2030CT, 2070CT
Eastern San Joaquin	2070CT
Kings	2030CT, 2070CT
Madera	2030CT
Merced	2070CT
North Yuba	2030CT
South Yuba	2030CT
Westside	2030CT
Yolo	2030CT, 2070CT, 2070DW, 2070WW

2030CT – 2030 Central Tendency
2070CT – 2070 Central Tendency
2070DW – 2070 Drier with Extreme Warming
2070WW – 2070 Wetter with Moderate Warming

Valley Floor Climate Change Effects

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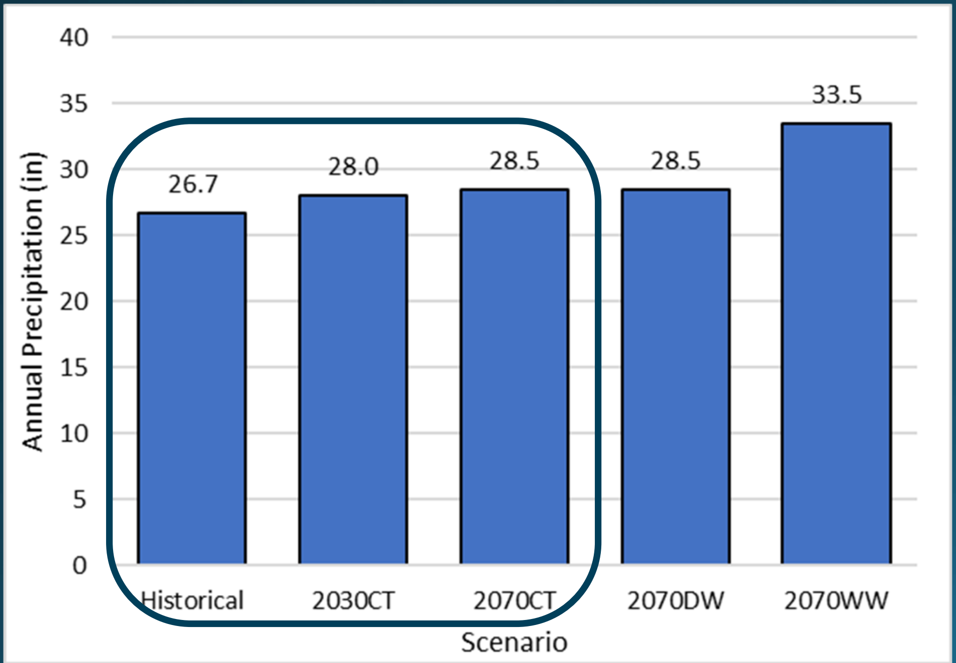
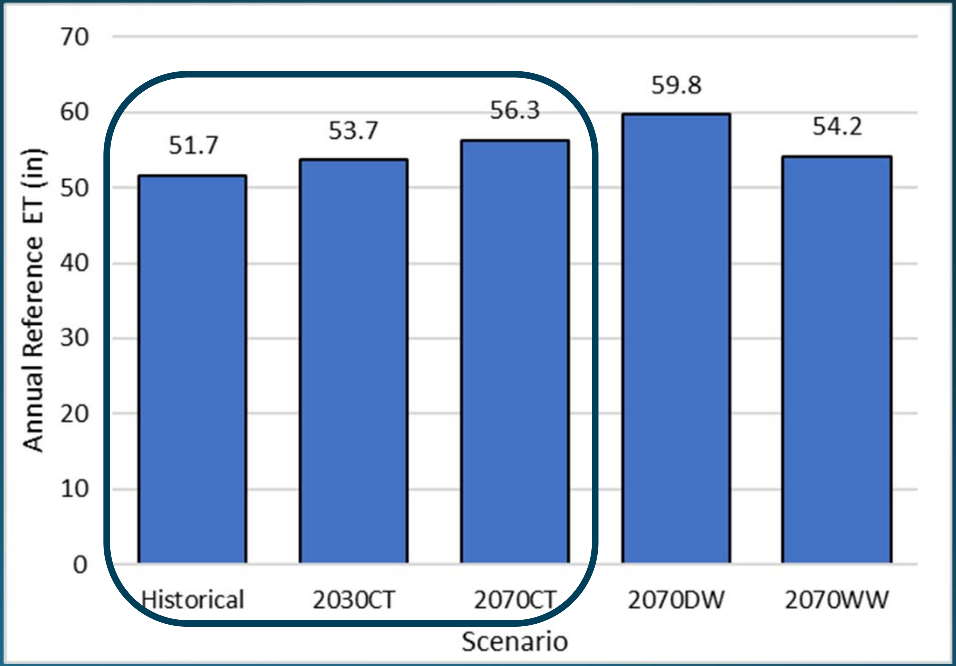
Butte County
WATER & RESOURCE CONSERVATION

- Annual Average Precipitation and Reference Evapotranspiration

Precipitation



Reference Evapotranspiration



2030CT – 2030 Central Tendency
2070CT – 2070 Central Tendency
2070DW – 2070 Drier with Extreme Warming
2070WW – 2070 Wetter with Moderate Warming

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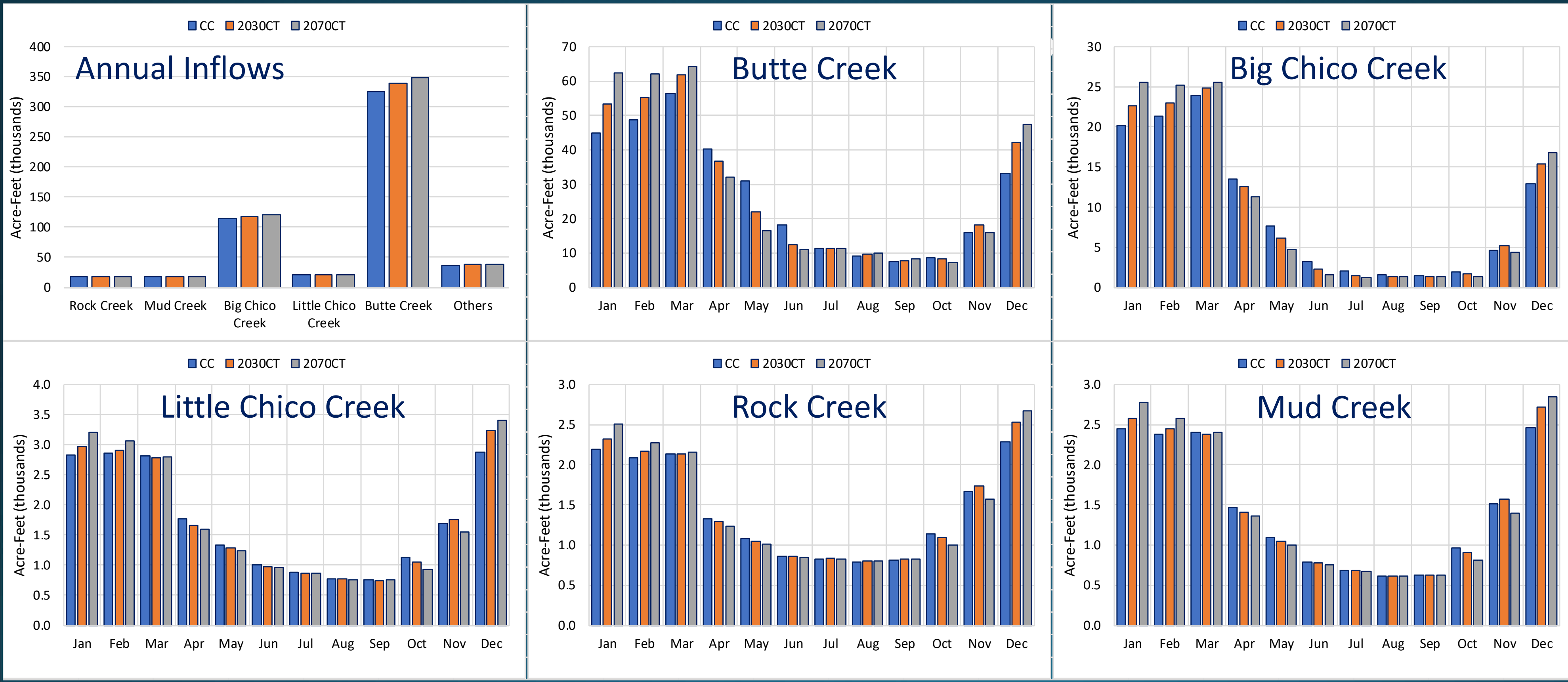
Stream Inflow Climate Change Effects



2030CT – 2030 Central Tendency
2070DW – 2070 Drier with Extreme Warming
2070CT – 2070 Central Tendency
2070WW – 2070 Wetter with Moderate Warming

Water Budget Scenario Results

Water Budget Scenarios Consider Possible Changes in Land Use, Demands, and Climate

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Water Budget Scenario	Assumptions			
	Land Use	**Urban Demands**	**Diversions**	**Hydrology**
Historical	2000-2018	2000-2018	2000-2018	2000-2018
Current Conditions	2015-2016	2016-2018	2015-2016	1971-2018[1]
Future, No Climate Change	2015-2016[2]	2050[3]	2015-2016	1971-2018[1]
Future, 2030 Climate Change	2015-2016[2]	2050[3]	2015-2016	1971-2018[4]
Future, 2070 Climate Change	2015-2016[2]	2050[3]	2015-2016	1971-2018[5]

1. WY2004 and WY2005 added at end of simulation to provide 50 years of hydrology.
2. Land use modified to reflect planned urban development based primarily on Butte County 2030 General Plan.
3. Primarily based on CalWater 2050 preliminary draft projections for 2020 UWMP.
4. Historical hydrology modified based on DWR Central Tendency climate projections for 2030.
5. Historical hydrology modified based on DWR Central Tendency climate projections for 2070.

Primary land use changes are increased urban development, which will offset native lands and, to a lesser extent, irrigated agriculture

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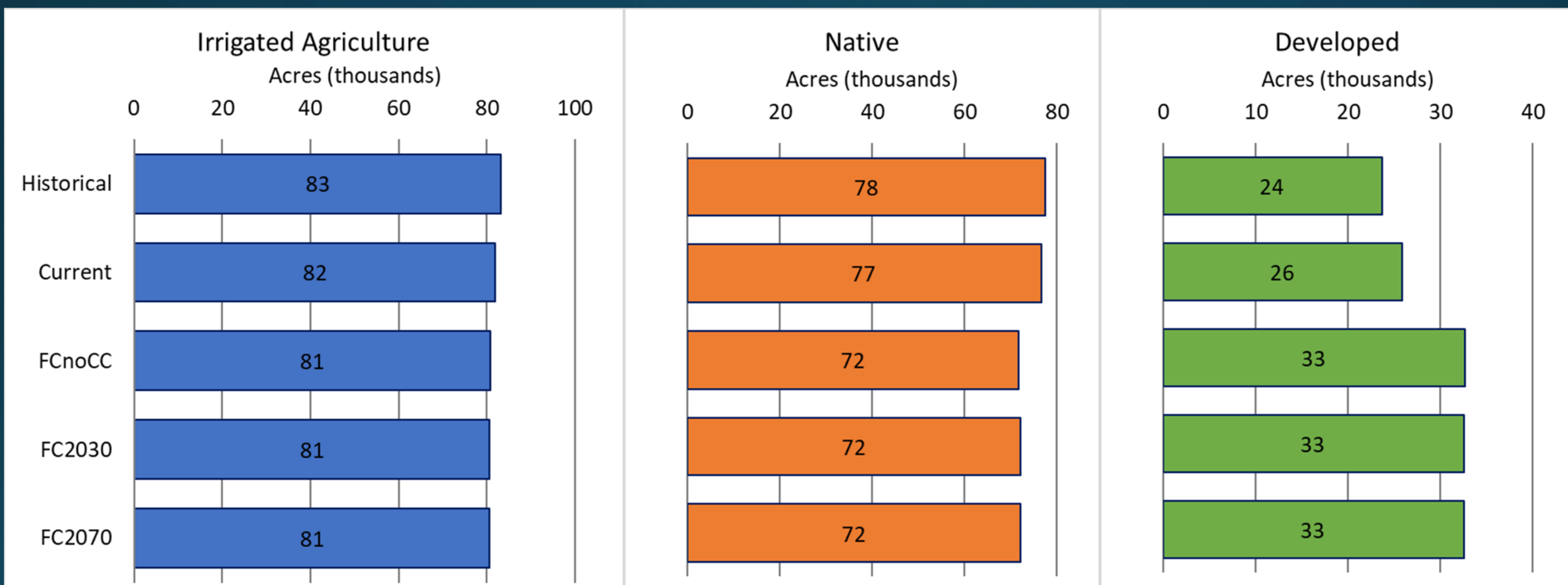

Historical = 2000-2018 Average **Current** = Current Conditions **FCnoCC** = Future Development, No Climate Change
FC2030 = Future Development, 2030 Climate Change **FC2070** = Future Development, 2070 Climate Change

Changes in hydrology and demands are driven by a combination of factors

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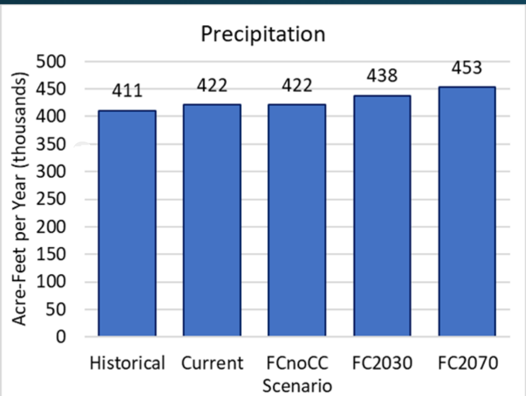

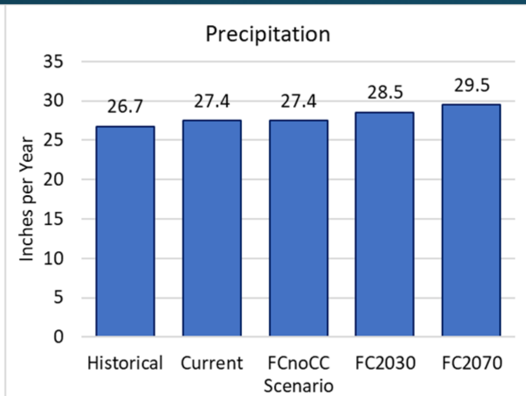

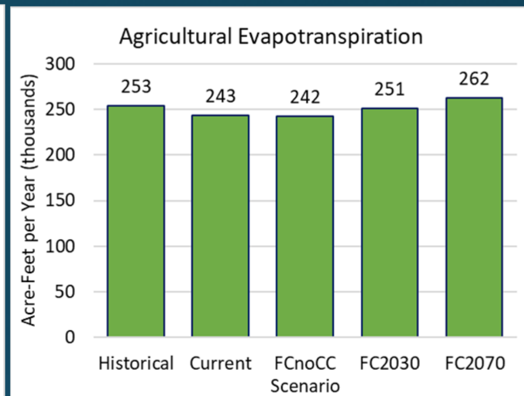

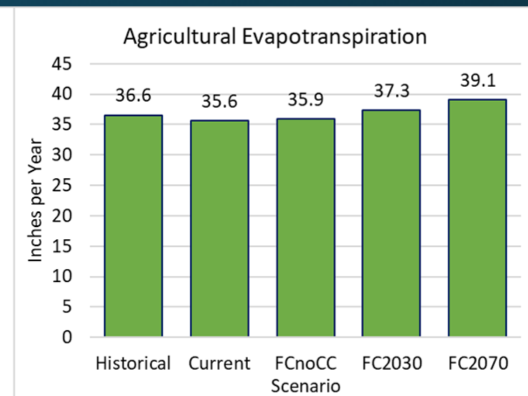

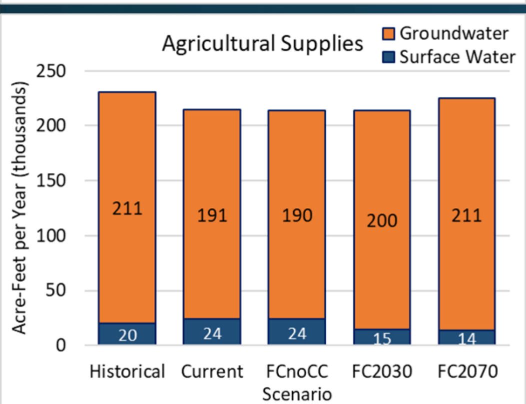

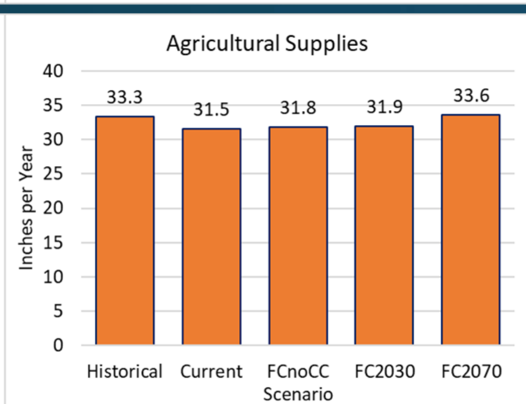

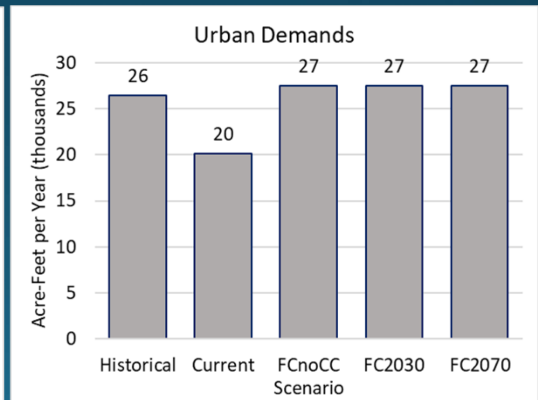

- Increasing precipitation and evapotranspiration with climate change
- Increased urban demands resulting from planned development

Historical = 2000-2018 Average **Current** = Current Conditions **FCnoCC** = Future Development, No Climate Change
FC2030 = Future Development, 2030 Climate Change **FC2070** = Future Development, 2070 Climate Change

Changes in deep percolation are driven by changing land use and precipitation

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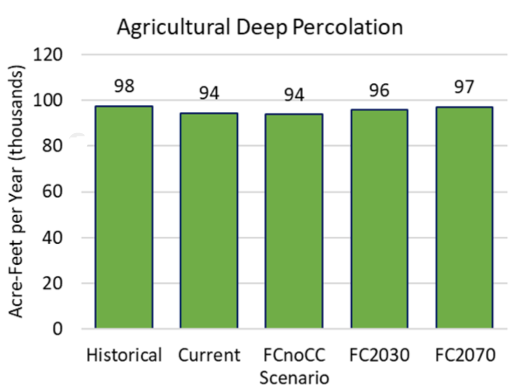

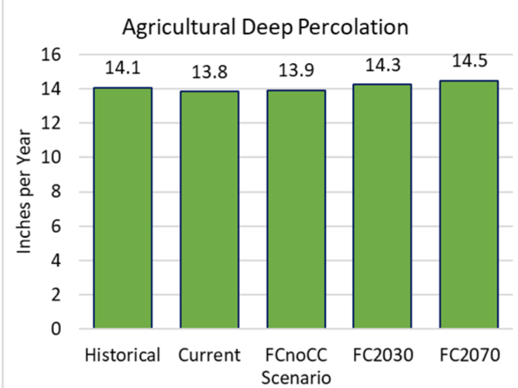

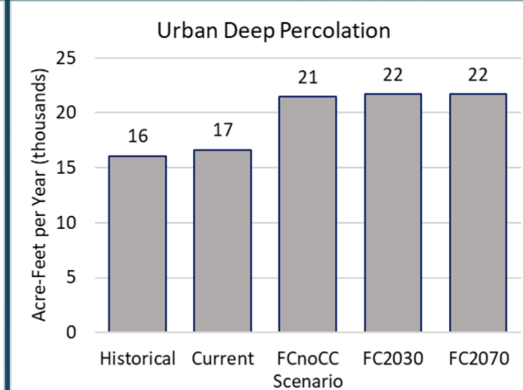

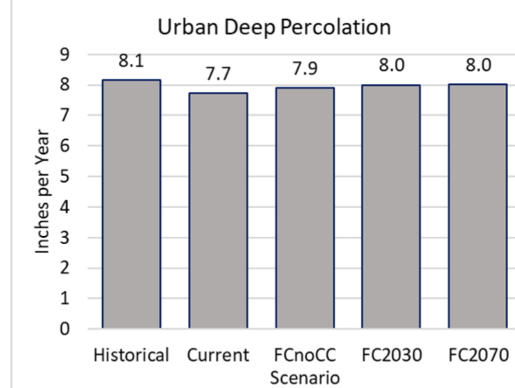

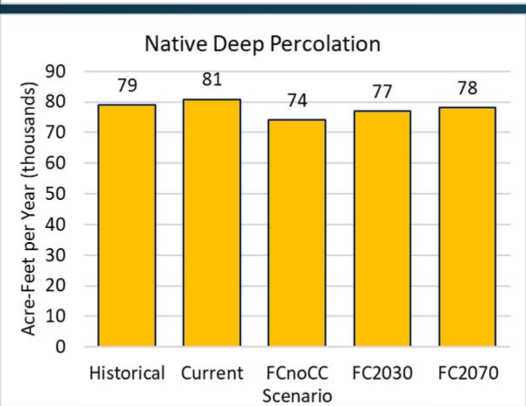

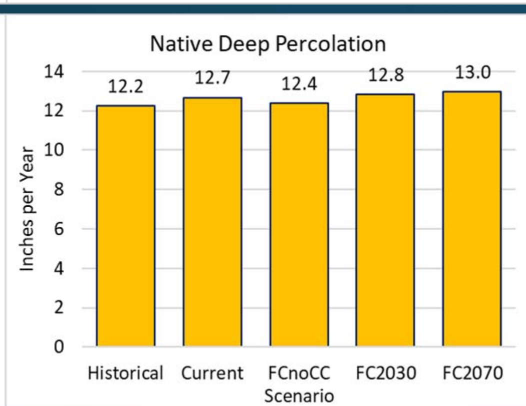

- Increasing precipitation provides increased recharge from deep percolation
- Urban areas estimated to have greater runoff and less recharge from deep percolation compared to native vegetation

Historical = 2000-2018 Average **Current** = Current Conditions **FCnoCC** = Future Development, No Climate Change
FC2030 = Future Development, 2030 Climate Change **FC2070** = Future Development, 2070 Climate Change

Potential changes in interbasin flows vary.

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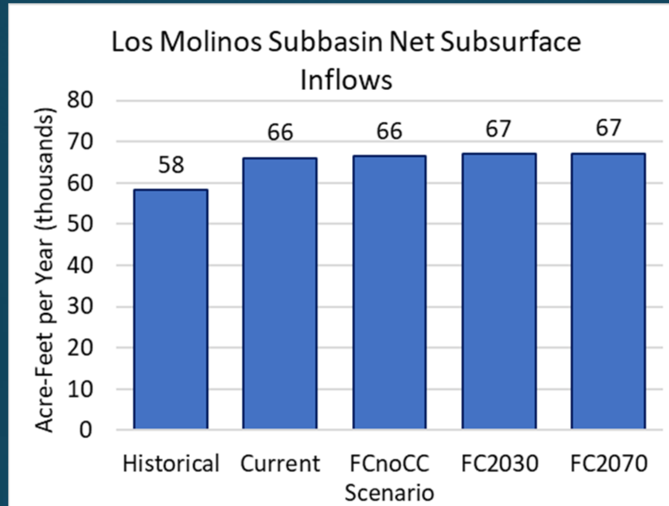
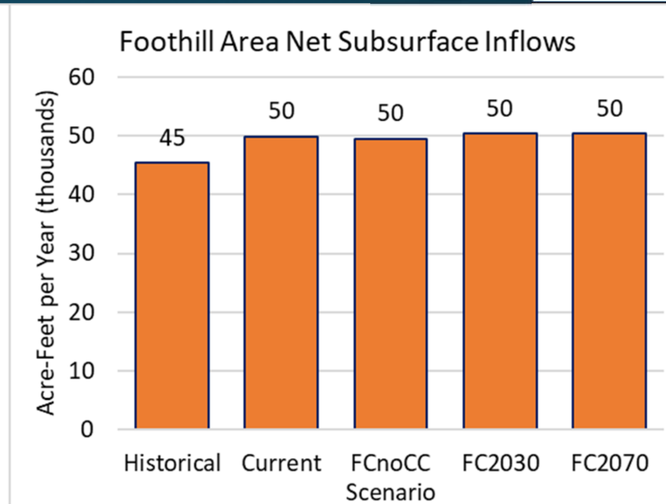
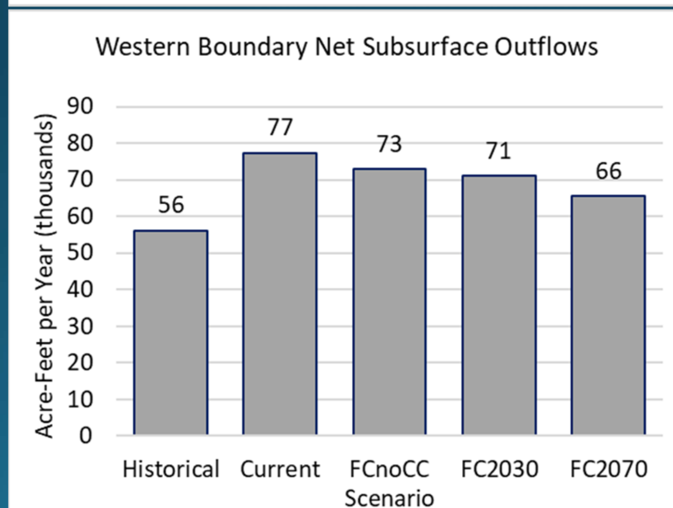
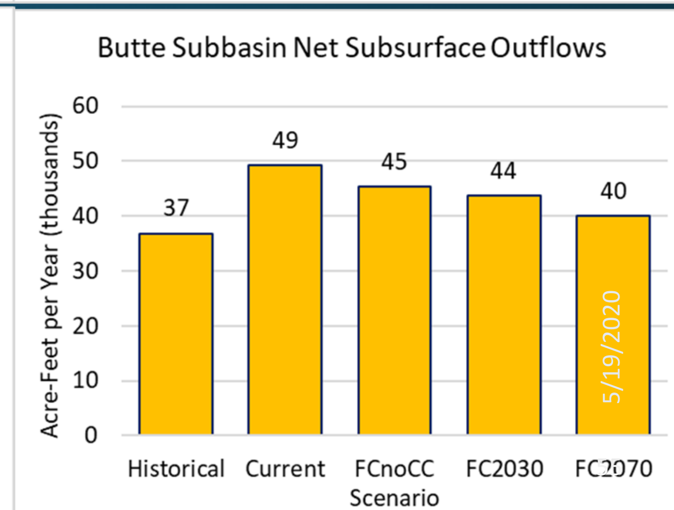
- Increase in net subsurface inflows from Los Molinos Subbasin and Foothill Area
- Increase in western boundary outflows (Sacramento River and/or Corning Subbasin)
- Increase in net subsurface outflows to Butte Subbasin
- Potential changes in interbasin groundwater flows uncertain at this time and require coordination









5/19/2020

Future conditions scenarios result in limited increase in stream losses compared to current conditions baseline, greater increases when compared to historical conditions.

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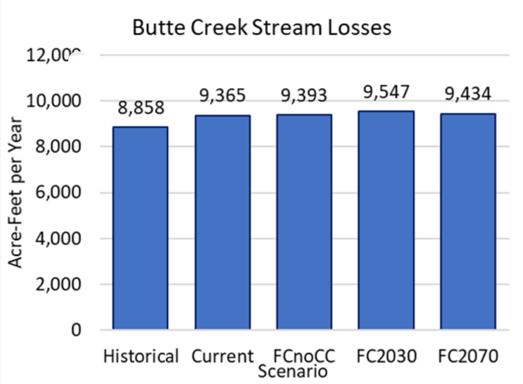

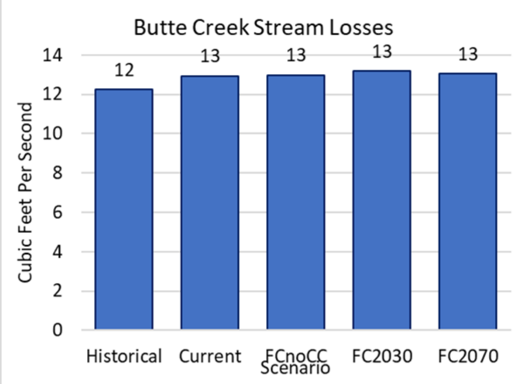

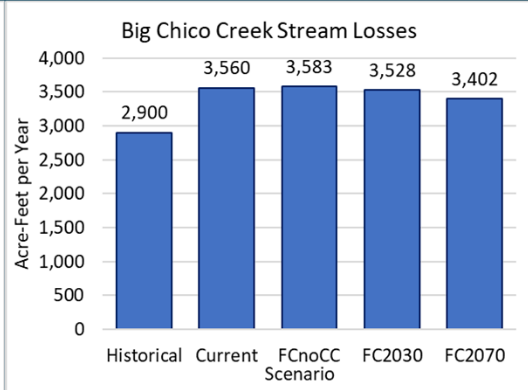

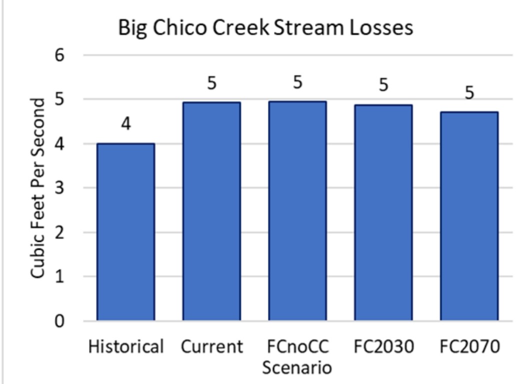

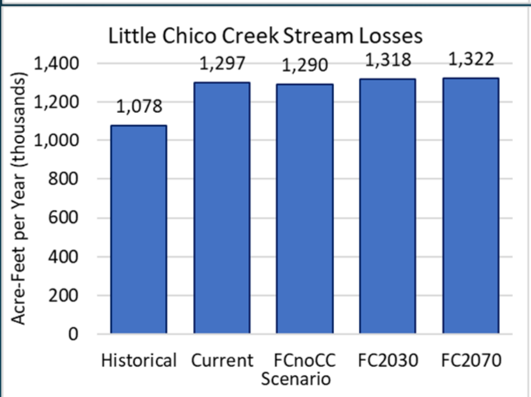

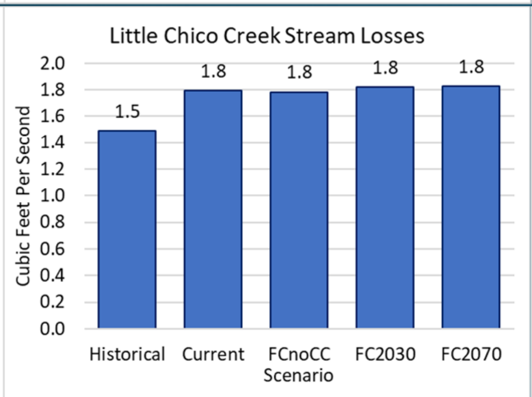

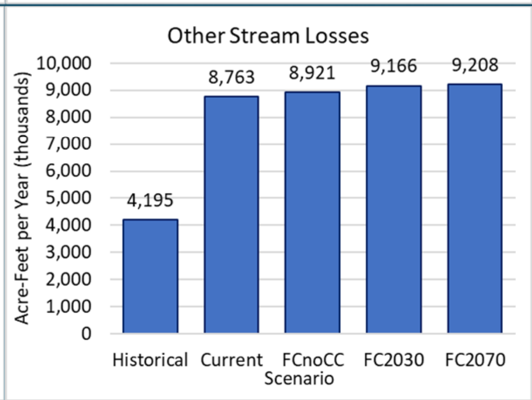

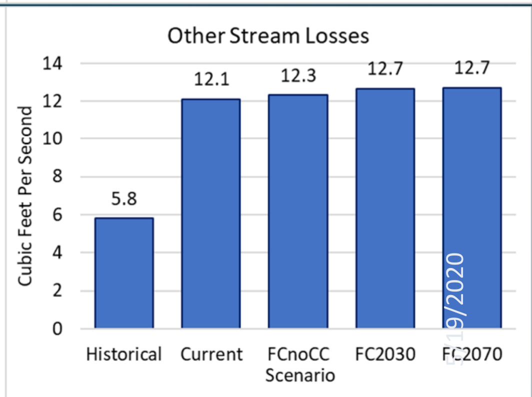

Draft water budget results suggest relatively stable basin conditions in the future.

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DRAFT Land and Surface Water System Water Budgets

Water Budget Scenario	Inflows (TAF/yr)				Outflows (TAF/yr)				Change in Storage (TAF/yr)
	Surface Water In	Groundwater Pumping	Stream Accretions	Precipi-tation	Evapotrans-piration	Deep Percolation	Stream Losses	Surface Water Out	
Current	602	209	1	422	348	192	28	666	0
Future, No Climate Change	598	216	1	422	347	189	28	672	0
Future, 2030 Central Tendency	631	226	1	438	358	194	28	715	0
Future, 2070 Central Tendency	652	238	1	453	371	197	27	749	0

DRAFT Groundwater System Water Budgets

Water Budget Scenario	Inflows (TAF/yr)			Outflows (TAF/yr)				Change in Storage (TAF/yr)
	Deep Percolation	Stream Losses	Subsurface In	Groundwater Pumping	Stream Accretions	Subsurface Out	Western Boundary (net)	
Current	192	28	143	209	1	76	77	-1
Future, No Climate Change	189	28	143	216	1	72	73	-2
Future, 2030 Central Tendency	194	28	145	226	1	71	71	-2
Future, 2070 Central Tendency	197	27	145	238	1	68	66	-3

(**TAF/yr** = thousands of acre-feet per year)

Water Budget Scenario Cumulative Change in Storage

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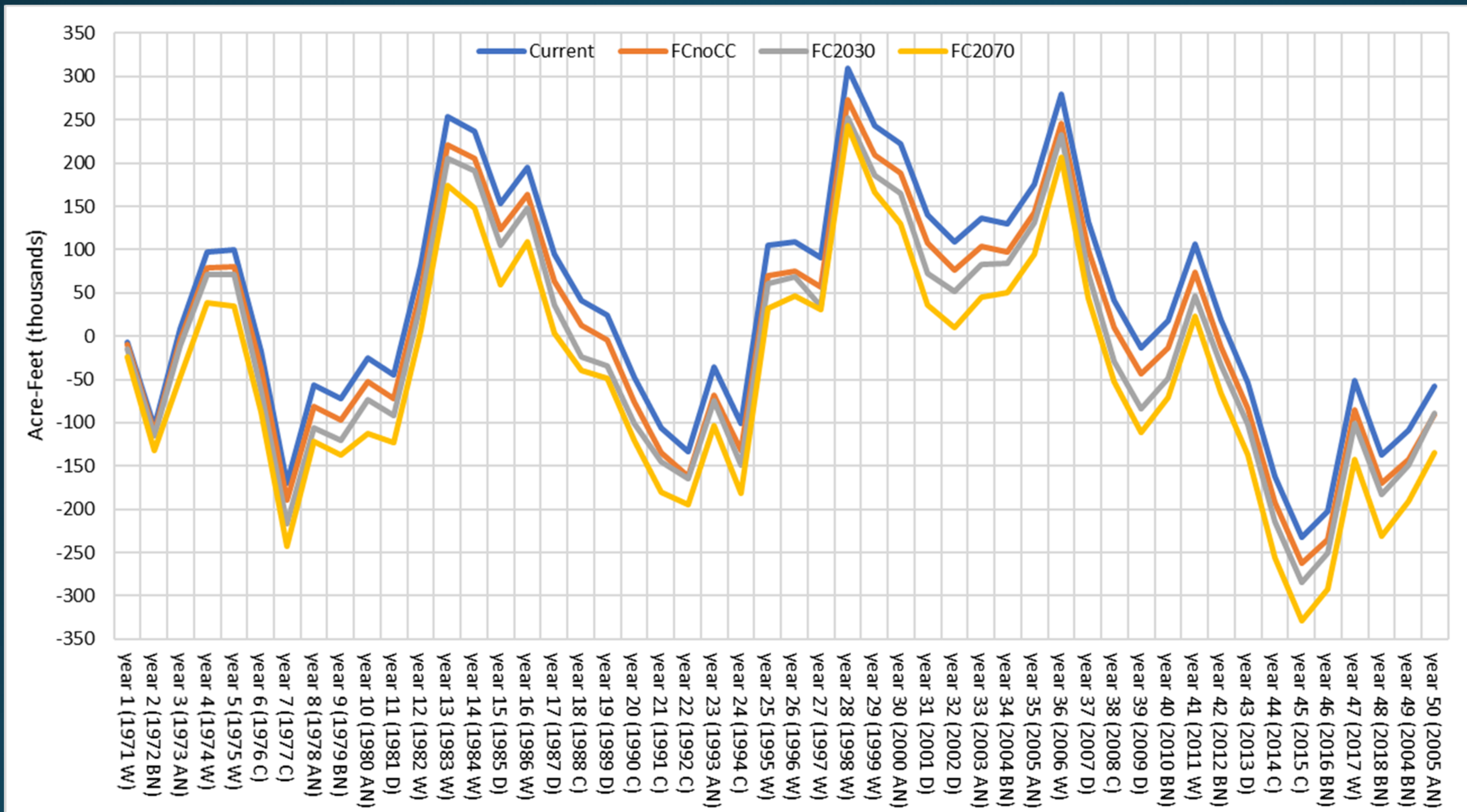

Year Types:
Critical (C)
Dry (D)
Below Normal (BN)
Above Normal (AN)
Wet (W)

Current = Current Conditions **FCnoCC** = Future Development, No Climate Change
FC2030 = Future Development, 2030 Climate Change **FC2070** = Future Development, 2070 Climate Change

Water Budget Scenario Takeaways

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- Increased Urbanization in Vina Chico MA will Replace Undeveloped Lands; Limited Reduction in Agriculture
- Climate Change May Result in
  - Overall Increase in Precipitation and ET Demands
  - Increased Surface Water Inflows, with Shift from Spring to Winter
- Modest Increase in Net Stream Losses Compared to Historical Period
  - Important to Understand Timing within and across Years

Water Budget Scenario Takeaways (continued)

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Butte County
WATER & RESOURCE CONSERVATION

- Increase in Subsurface Inflows from Los Molinos Subbasin and Foothill Area
- Increase in Outflows to Butte Subbasin and along Western Boundary to Sacramento River and/or Corning Subbasin
- Variability in Groundwater Storage of Approximately 600-700 TAF over 50-year Planning Horizon, with Similar Conditions Across Scenarios
- Modest Reduction in Average Annual Groundwater Storage of 1 to 3 TAF per year, depending on scenario

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What Does This All Mean?

- Groundwater storage is largely driven by drought cycles. Drought planning will be important to prevent undesirable results.
- Climate change may affect stream flows more than groundwater pumping, particularly during critical periods for environmental uses.
- Reductions in storage add up over time. Projects and Management Actions targeting recharge in wet years need to consider how often they are likely to occur.
- Monitoring will be important to better understand how changes in water budgets translate to groundwater conditions over time.

Additional Discussion