Sustainable Groundwater Management Act
GSP Preparation

Chowchilla Subbasin

First Technical Meeting

2:00 p.m. to 4:00 p.m., March 7, 2018
Chowchilla Water District
Chowchilla, CA

Project Objectives

- Develop a set of projects and management actions that when fully implemented result in a cost effective sustainable groundwater condition for the Chowchilla subbasin
- Develop a Groundwater Sustainability Plan (GSP) that is approved by
  - California Department of Water Resources (DWR)
  - California State Water Resources Control Board (SWRCB)

Groundwater Sustainability Plan

- Requires sustainable groundwater (GW) management over a period of years during which water supply conditions approximate average conditions:
  1. No undesirable results in sustainability indicators
     - GW levels/storage, subsidence
     - Surface water (SW) depletion
     - Impacts on GW-dependent ecosystems (GDEs)
     - Impacts on GW quality
  2. No overdraft
     - No change in GW storage
     - Groundwater system inflows equal outflows

Today—Preliminary Estimates

- Overdraft based on a historical basin boundary water budget over a period of years during which water supply conditions approximate average conditions
  - Surface water system
  - Groundwater system
  - Combined
- Projects and management actions
  - Costs
  - Water to increase inflows and/or
  - Decreases in outflows

Surface Water Budget–Punchline

- Average Net Recharge from SWS: -93,600 AF/yr (-78,000 to -117,000 AF/yr)
- Orchard crop area increased from about 20,000 acres in 1989 to just over 60,000 acres in 2015
- Corresponding decreases in:
  - Miscellaneous field crop area from about 25,000 acres in 1989 to about 1,000 acres in 2015
  - Pasture and alfalfa crop area from about 35,000 acres in 1989 to about 20,000 acres in 2015
- Corresponding increase in evapotranspiration (ET) from about 30 to 36 inches per year

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What is a Water Budget?

- A complete accounting of all water flowing into and out of a defined area (the Chowchilla Subbasin) over a specified period (1989 through 2014)
- Basic Accounting Principle:
  Inflow – Outflow ± Change in Storage = 0
- Just like your checking account:
  Deposits – Withdrawals ± Change in Balance = 0

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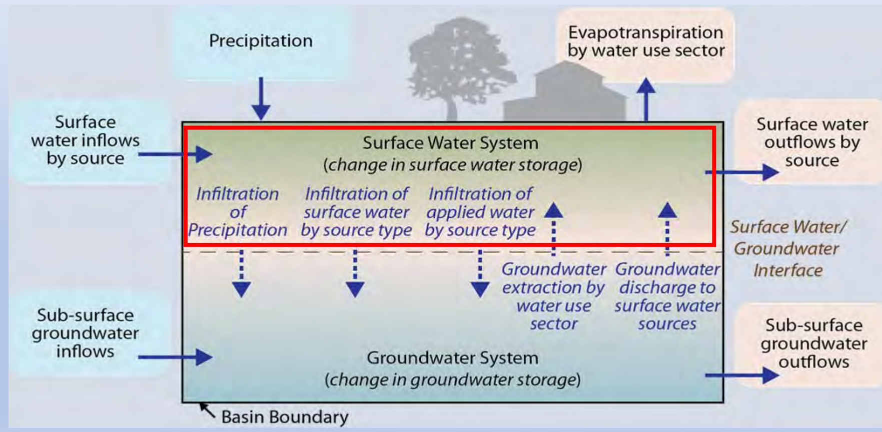
Water Budget Schematic

Complexity of water budget varies depending on setting

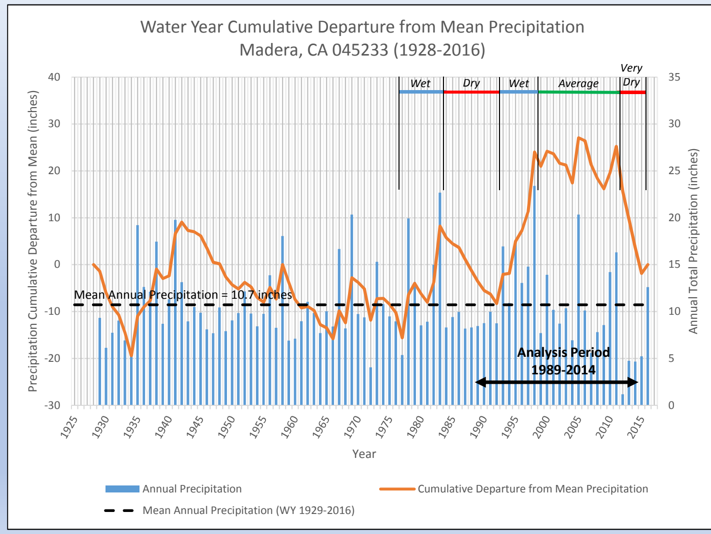


Source: Water Budget BMP, December 2016

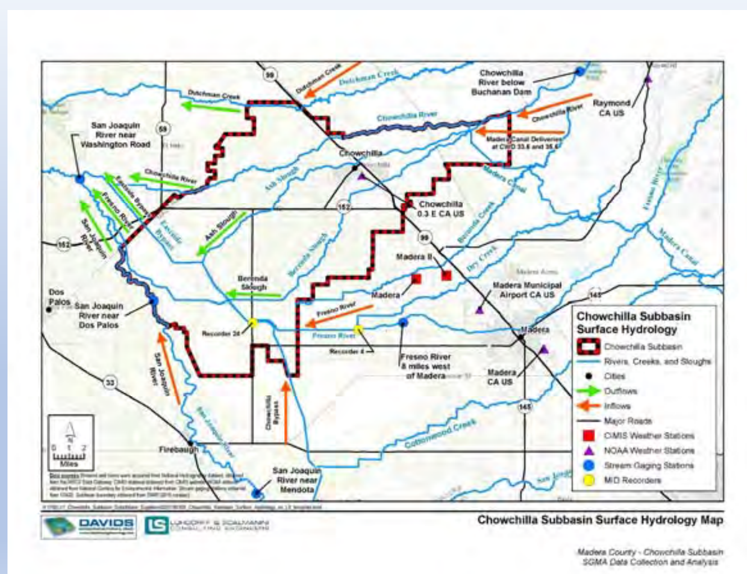
Data Time Period and Time Step

- Data time periods per SGMA
  - Current: Recent one year period (2016)
  - Historical: 1989-2014 (26 years)
  - Projected: minimum of 50 years historical precipitation, evapotranspiration and stream flow
- Time step
  - Minimum of annual required
  - Recommend monthly for water budgets
  - Compile daily data when available to support analysis of projects and management actions

Historical Conditions



Chowchilla Subbasin Flow Paths



Historical Conditions (1989 -2014)

Select Inflows	Historical Record Period	Average Annual Volume		Difference (acre-feet)	Percent Difference
		Historical Record	1989-2014		
Buchanan Dam	1912-2017	70,520 AF	63,340 AF	-7,180 AF	-10.2%
Madera Canal (deliveries and flood)	1978-2016	109,920 AF	103,440 AF	-6,480 AF	-5.9%
Millerton Reservoir	1922-2014	1,718,700 AF	1,689,380 AF	-29,320 AF	-1.7%
Precipitation	1929-2016	10.72 in	10.91 in	0.19 in	1.8%

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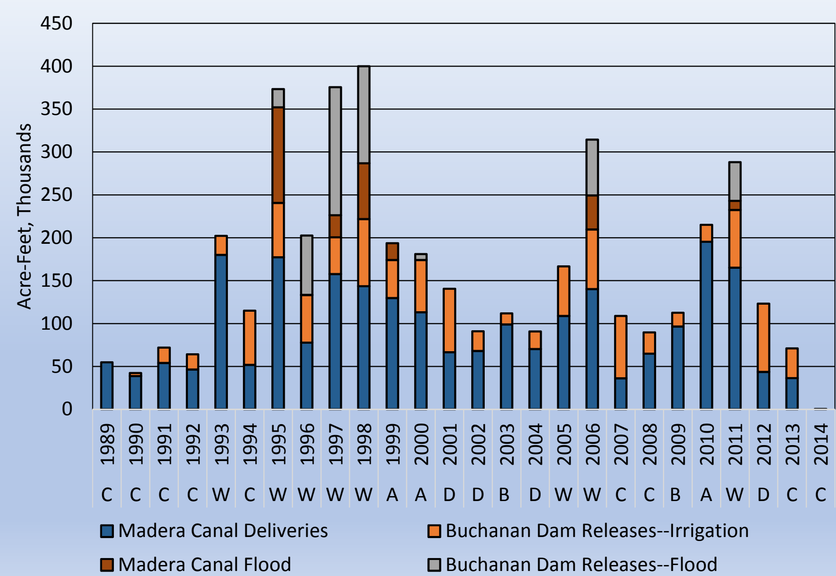
Surface Water Inflows



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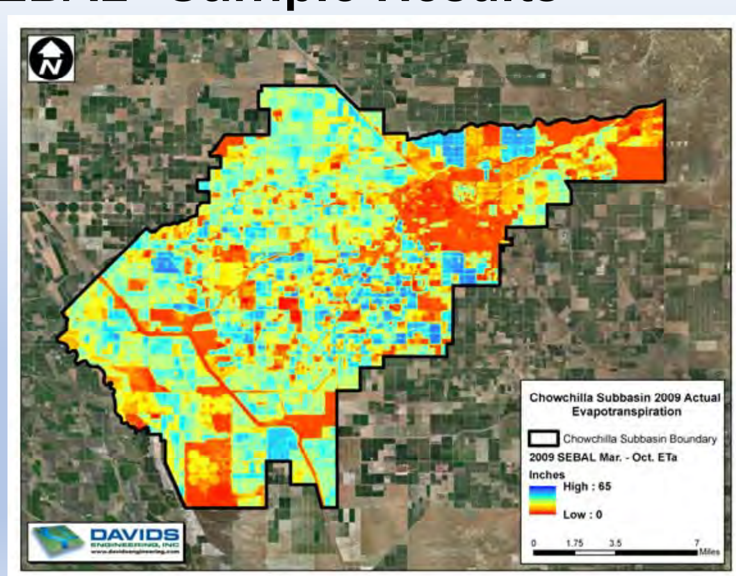
Evapotranspiration and Precipitation

- CIMIS ET_o and precipitation Fresno/Madera/Madera II
  - 1989-2015 average ET_o = 55.3 inches
  - 1989-2015 average precipitation = 10.1 inches
- Crop Coefficients Derived from Remotely Sensed SEBAL Analysis in 2009
- Integrated Water Flow Model Demand Calculator (IDC)
- Land Use
  - DWR Land Use Surveys Madera County (1995, 2001, 2011) Merced County (1995, 2002, 2012)
  - Land IQ (DWR) Remotely Sensed Land Use 2014
  - County Agriculture Commission Data

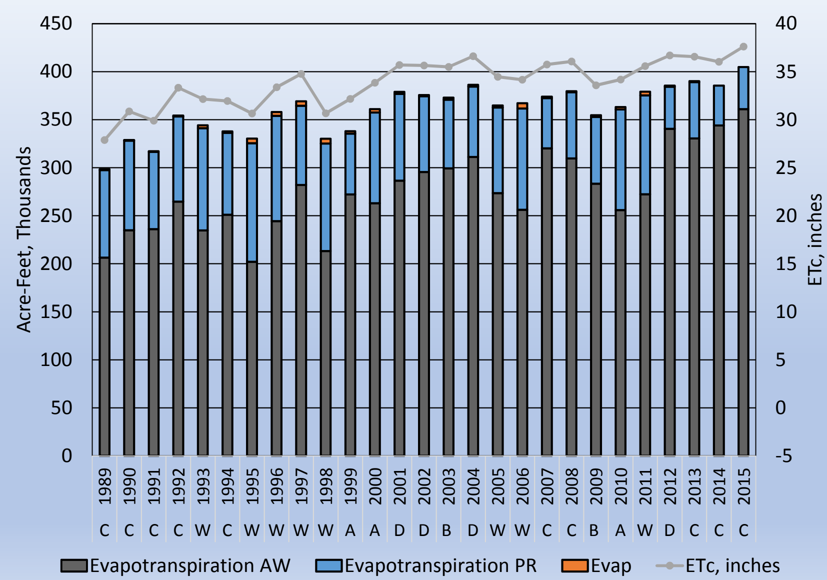
SEBAL—Sample Results



Land Use and ET

Land Use	Area (acres)		Average ET, 1989-2014 (inches)		
	1989	2014	ET_c	ET_pr	ET_aw
Almonds	12,268	49,560	41.6	7.1	34.5
Alfalfa	19,428	18,550	38.6	7.2	31.3
Corn	10,447	17,686	35.1	5.1	30.0
Grapes	8,015	10,620	26.7	6.7	20.0
Pistachios	1,944	9,971	37.1	6.6	30.4
Native	21,405	8,749	7.8	7.8	0.0
Urban	2,633	7,141	14.2	6.7	7.5
Idle	19,881	2,253	6.9	6.9	0.0
Mixed Pasture	15,503	451	28.8	7.0	21.8
Misc. Field Crops	22,854	4,527	31.0	6.5	24.4

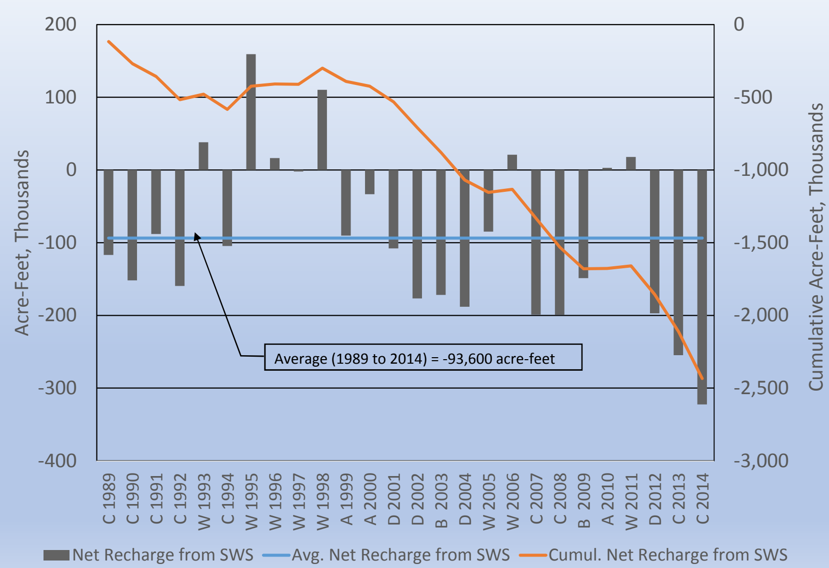
Evapotranspiration



Net Recharge from SWS

- Net Recharge from SWS = Recharge - Extraction
- Recharge:
  - Seepage from Canals (including rivers and sloughs when used as part of the distribution system)
  - Seepage from Rivers and Streams
  - Deep Percolation from Precipitation
  - Deep Percolation from Applied Water
- Extraction
  - Groundwater Extraction (Urban and Agriculture)
  - Groundwater Discharge

Net GW Recharge from SWS



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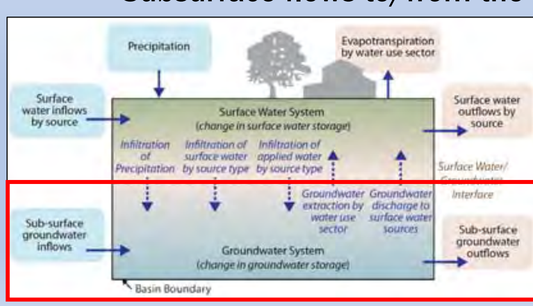
Groundwater System Balance

- Unconfined and Confined Groundwater Zones
- Changes in Groundwater Storage
  - Changes in groundwater levels
- Subsurface Groundwater Inflows and Outflows
  - Subsurface flows to/from the Chowchilla Subbasin



Some GW Components Estimated from Surface System Analysis

- Groundwater Extractions
- Groundwater Recharge/Discharge

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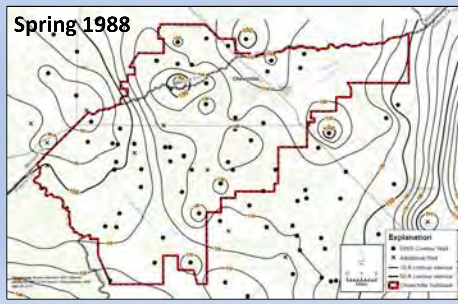
GW Storage and Subsurface Flow Estimation Approach

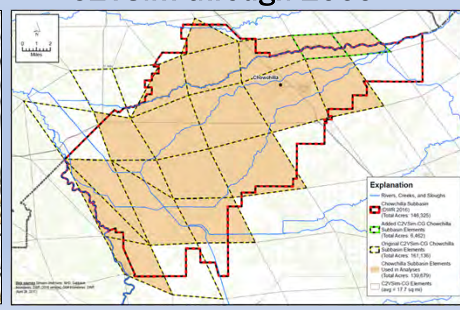
Calculated:
GW Level Contours

- Unconfined GW only
- Varying timing/quality

Modeled:
Based on C2VSim-CG

- Smaller element area
- Upper and Lower Aquifer
- C2VSim through 2009

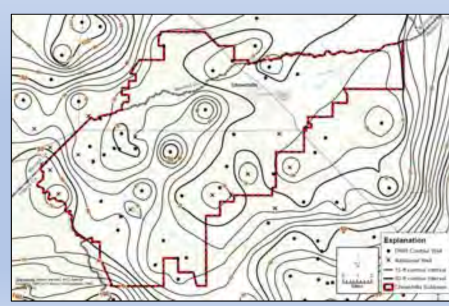




Change in Groundwater Storage

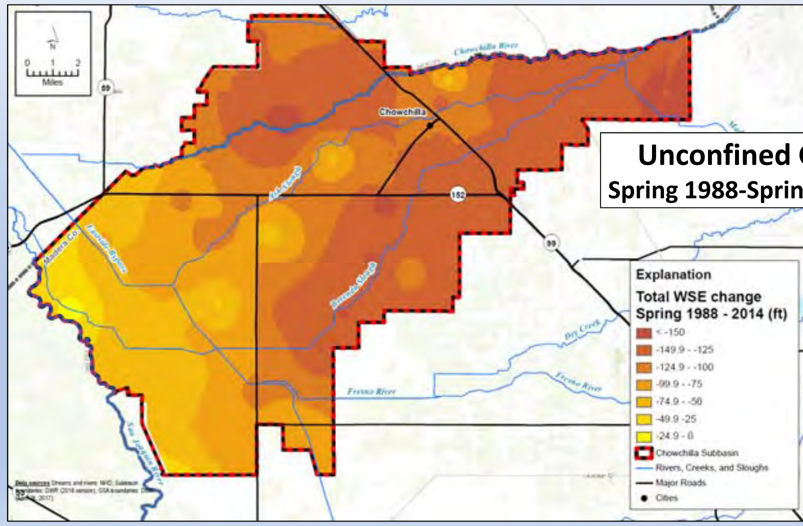
- Calculated from Groundwater Level Contours
  - Only for unconfined groundwater in Chowchilla Subbasin
  - Difference over discrete time period(s)
  - Uses Specific Yield: *volume of water that can be extracted per unit volume of saturated aquifer material*

Spring 1988



Spring 2014

Change in Groundwater Levels



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Calculated Change in GW Storage

Unconfined GW: WY 1989-2014 because of data quality

- Average unconfined groundwater storage change: -91,000 AF/yr
- Estimated range (excluding high value): -52,000 to -86,000 AF/yr

Unconfined Zone Specific Yield Scenario	Calculated Storage Change: 1989-2014 (AF/yr)
C2VSim *(variable)*	-147,000
CVHM *(variable)*	-86,000
DWR *(8.6%)*	-52,000
GMP *(13%)*	-79,000

- Limited confined groundwater data; however, much smaller
  - Confined = low storativity

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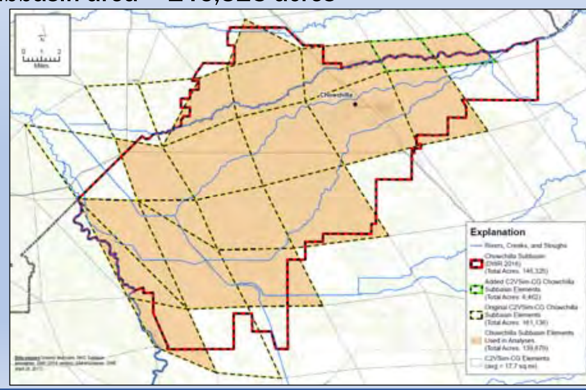
Modeled Change in GW Storage

Limitations associated with current C2VSim-CG

- Coarse grid element configuration
  - Model element area used = 139,679 acres
  - DWR-designated subbasin area = 146,325 acres
- Results scaled up
- Simulation period through 2009 (substitute years for 2010-2014)



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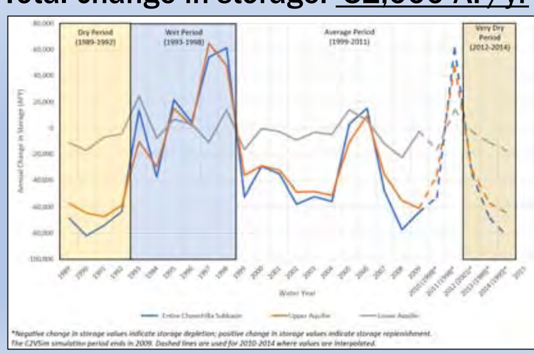
Modeled Change in GW Storage

Modeled: WY 1989-2014 (scaled up, substitute years 2010-14)

- Unconfined zone (model layer 1): -28,000 AF/yr
- Confined zone (model layers 2&3): -4,000 AF/yr
- Total change in storage: <u>-32,000 AF/yr</u>



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GW Storage Change Estimates

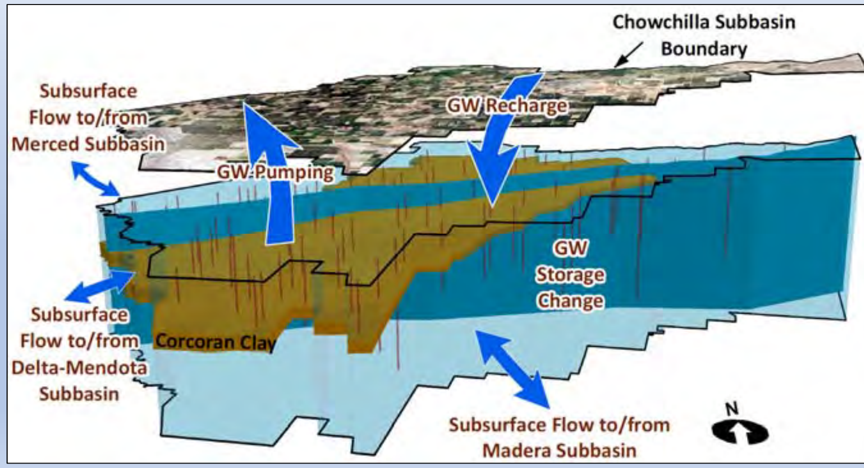
- Analysis Period 1989–2014
- Calculated:
  - -52,000 to –86,000 AFY
- Modeled:
  - -32,000 AFY
- Combined:
  - -32,000 to – 86,000 AFY

Estimated Subsurface Groundwater Inflows/Outflows

- Analysis Period WY 1989-2014
- High uncertainty for contour-based calculations
  - Variable quality and timing of GW level contours
  - Potential bias from timing of contours
  - Differences in aquifer properties (C2VSim vs. CVHM)
- Average C2VSim simulated subsurface flow = 25,000 to 30,000 AF/yr net inflow

Combined Water Balance

Inflows – Outflows = Change in Storage



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Combined Water Budget

- Inflows – Outflows = Change in Storage
- Net Recharge from SWS: -93,600 AF/yr (-78,000 to -117,000 AF/yr)
- Inflows to Groundwater System
  - Infiltration of precipitation: 34,800 AF/yr (26,100 to 43,500 AF/yr)
  - Infiltration of surface water: 38,800 AF/yr (29,100 to 123,000 AF/yr)
  - Infiltration of applied water: 94,600 AF/yr (66,200 to 123,000 AF/yr)
- Outflows from Groundwater System
  - Pumping: 261,800 AF/yr (196,000 to 327,000 AF/yr)

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Historical Overdraft

- Inflows – Outflows = Change in Storage (*Overdraft*)
- Different Overdraft Estimates for WY 1989-2014
  - Estimate from Surface System Water Budget

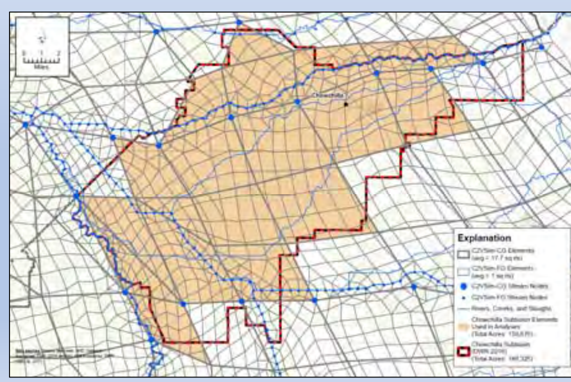
    Net recharge from SWS: -93,600 AF/yr (-78,000 to -117,000 AF/yr)
    +
    Subsurface inflow: 27,500 AF/yr (25,000 to 30,000 AF/yr)
    =
    Overdraft: -66,100 AF/yr (-49,000 to -83,000 AF/yr)

  - Estimate from Change in Groundwater Storage

    Overdraft: -59,000 AF/yr (-32,000 to -86,000 AF/yr)

Refined Analyses for GSP

- Utilize foundational structure of C2VSim-FG, when released (expected March-April 2018)
- Compare preliminary water balance
- Refine C2VSim-FG considering water balance comparison
- Utilize refined C2VSim-FG for GSP sustainability analyses



Projects and Management Actions

- Supply augmentation
  - 7 projects identified in existing studies
  - Additional projects are still being reviewed
- Demand management
  - Incentives to facilitate trading
  - Cropland idling
- Identify least-cost and combination of projects and management actions
  - Establish financial and economic feasibility

Supply Augmentation Projects

Project Description	Capital Cost ($M)	$/AF	Gross TAF/yr	Key uncertainties
Merced-Chowchilla Intertie	$13	$300	6	Land acquisition, permitting
Increase capacity of Buchanan Dam by 50,000 AF	$45	$310	10	Project cost

Supply Augmentation Projects Being Evaluated

- Recharge basins
- Winter flooding of crop lands
- Madera Canal increase in capacity
- Madera Canal off stream storage
- White area distribution systems
- Improve CWD distribution systems
- Temperance Flat Reservoir

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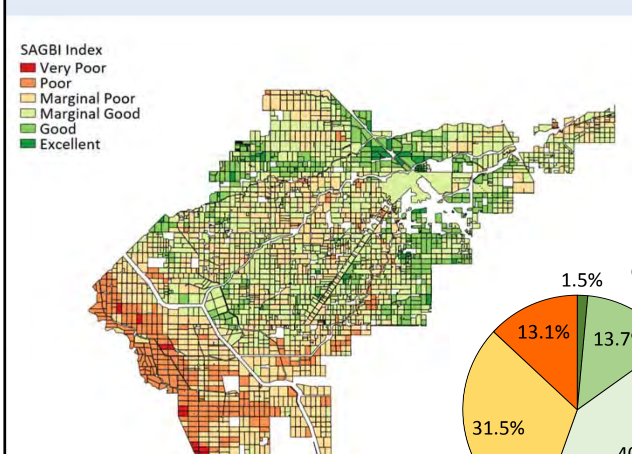
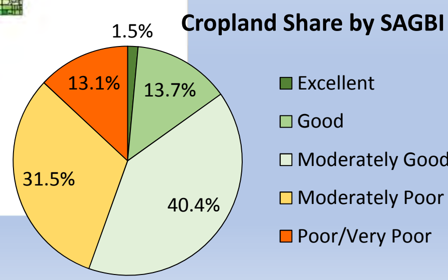
SAGBI Recharge Potential



Soil Agricultural Groundwater Banking Index (SAGBI)

Cropland Share by SAGBI



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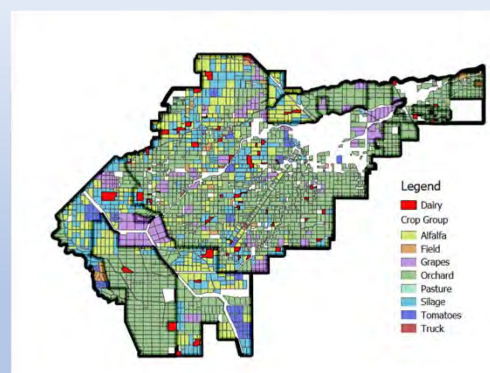
SAGBI Recharge Acreage

- Groundwater recharge potential varies across GSA's
  - Preliminary evaluation includes cropland only
  - Approximately 18,500 acres classified as "good" or "excellent"
- Uncertainties
  - Existing infrastructure
  - Flood flow magnitude and frequency

GSA	Excellent	Good	Moderately Good	Moderately Poor	Poor	Very Poor
CWD	1,100	11,845	39,745	19,400	1,695	0
Madera Co.	615	3,495	9,235	14,155	7,990	230
Merced Co.	65	1,390	150	0	0	0
Triangle T	0	0	245	4,915	5,550	495
Total	**1,780**	**16,730**	**49,370**	**38,470**	**15,240**	**725**

Subbasin Overview

- Farming generates over $610 million of gross output per year
- Supports local jobs and businesses
  - 2-6 full time equivalent jobs per million in farm revenue
  - Farming generates
    - Over 25% of output
    - Over 23% of employment
- High-value production
  - Permanent crops, dairy



Demand Management Options

- Cropland idling program
  - Pay growers per AF of ETAW to temporarily idle land
- Ground and/or surface water markets
  - Develop water trading system and allow growers to buy and sell over short/long term
- Groundwater extraction fees
  - Levy fee for groundwater extraction to reduce pumping

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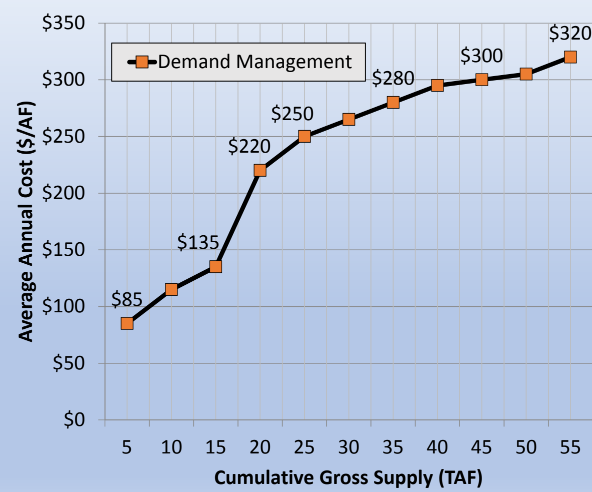
Demand Management Costs

- Preliminary idling analysis
  - Average cost $260/AF
  - Does not include admin costs
  - Does not include stranded capital costs
- Uncertainties
  - Crop market conditions
  - Water conditions
  - 3rd party impacts



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Delineation of Potential Management Areas

- Physical/Hydrogeology Considerations
  - Hydrogeologic features (e.g., Corcoran Clay extent)
  - Basin conditions (e.g., groundwater level trends, subsidence, SW/GW interaction)
- Jurisdictional Considerations
  - GSA boundaries
- Potential Additional Considerations
  - Water supply source
  - Other

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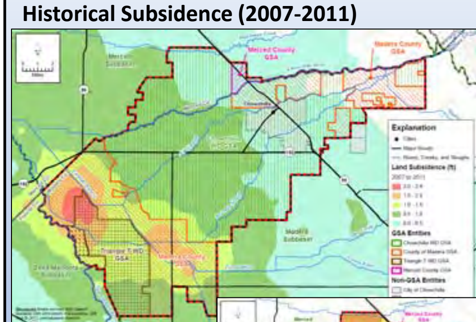
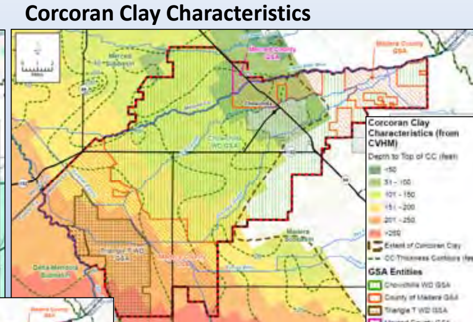
Hydrogeologic Considerations

Historical Subsidence (2007-2011)



Corcoran Clay Characteristics



Soil Hydraulic Conductivity

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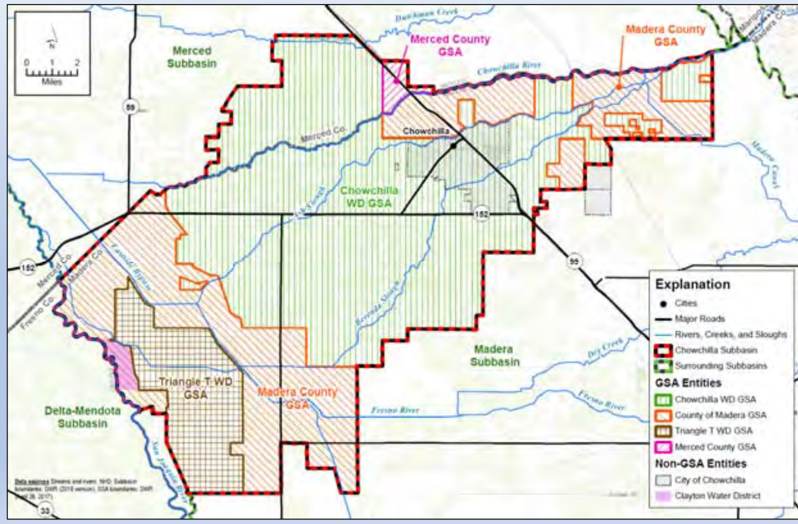
Jurisdictional Considerations

GSA Boundaries



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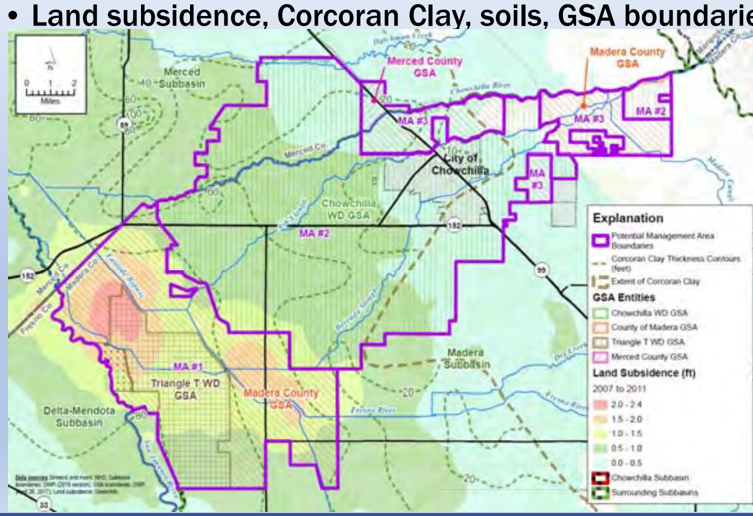
Discussion of Potential Management Areas

- Land subsidence, Corcoran Clay, soils, GSA boundaries



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Potential Implications of Defining Management Areas for GSP

- Pros
  - Establish management actions and monitoring tailored to unique issues/conditions of specific areas
- Cons
  - Potential to artificially restrict flexibility of groundwater management between management areas
  - Each management area must be described in detail in GSP
- Possibly delineate fewer management areas based on hydrogeology and estimate water budgets for management areas and also GSA areas

Next Technical Workshop

- June 2018
  - GSA surface water budget results
  - Projects and management actions
  - Groundwater model selection and refinement
  - Groundwater dependent ecosystems


Discussion
DAVIDS
ERA Economics
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