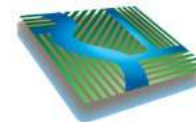




Remote Sensing Estimates of Groundwater Extraction Using the GEEEO Process

October 2, 2024



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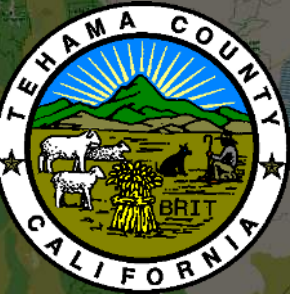
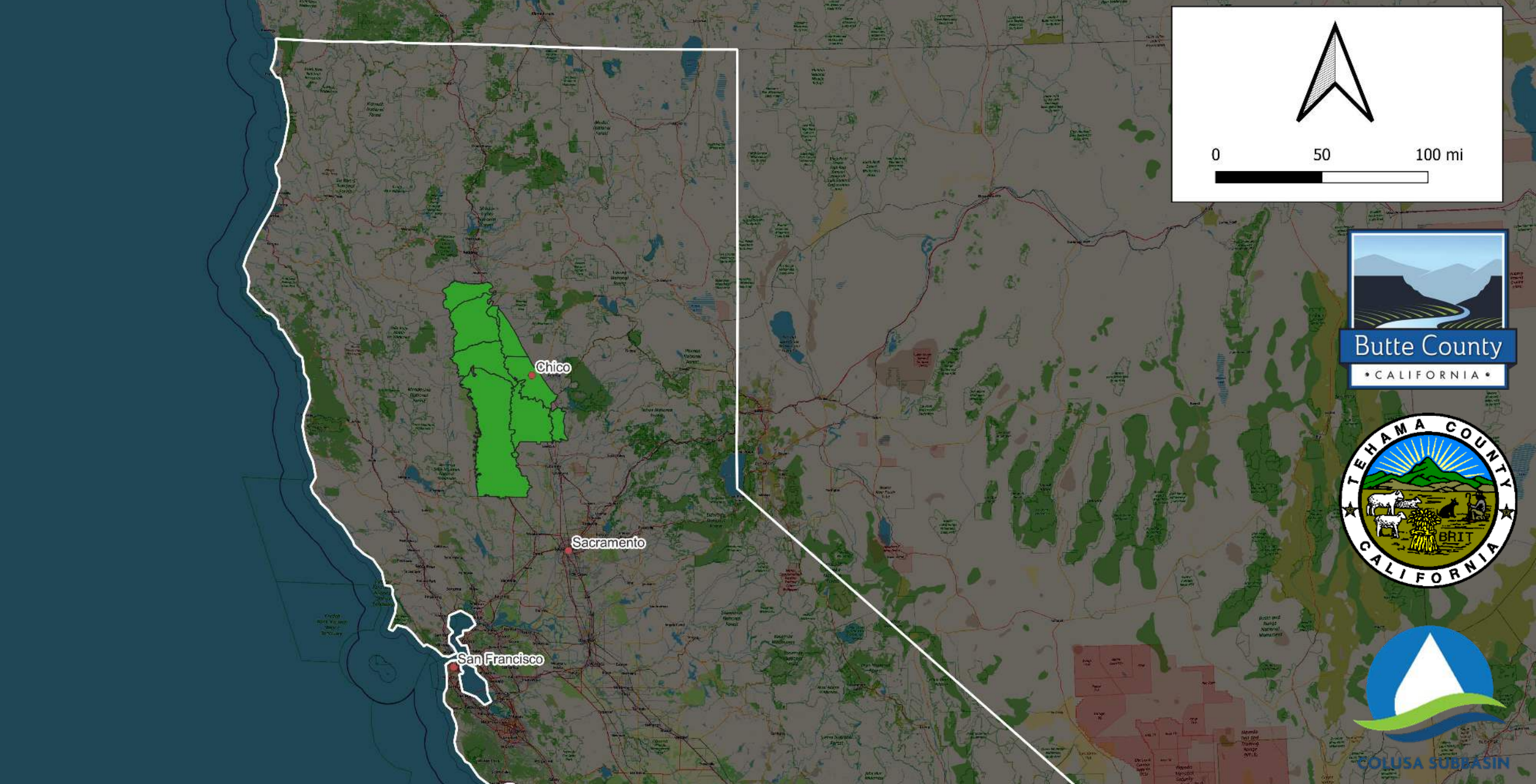
Agenda

- Introduction
- Data Sources
- Process/Approach
- Example: 2023 Vina Subbasin Annual Report
- Future Refinements

What is the GEEEO?

- Groundwater Extraction Estimates from Earth Observations
- Developed to support GSP¹ Annual Reports
- Not a full water budget
- Spatial water use analysis
 - 30m X 30m pixel-scale resolution
 - Monthly time step

¹Groundwater Sustainability Plan



Data Sources

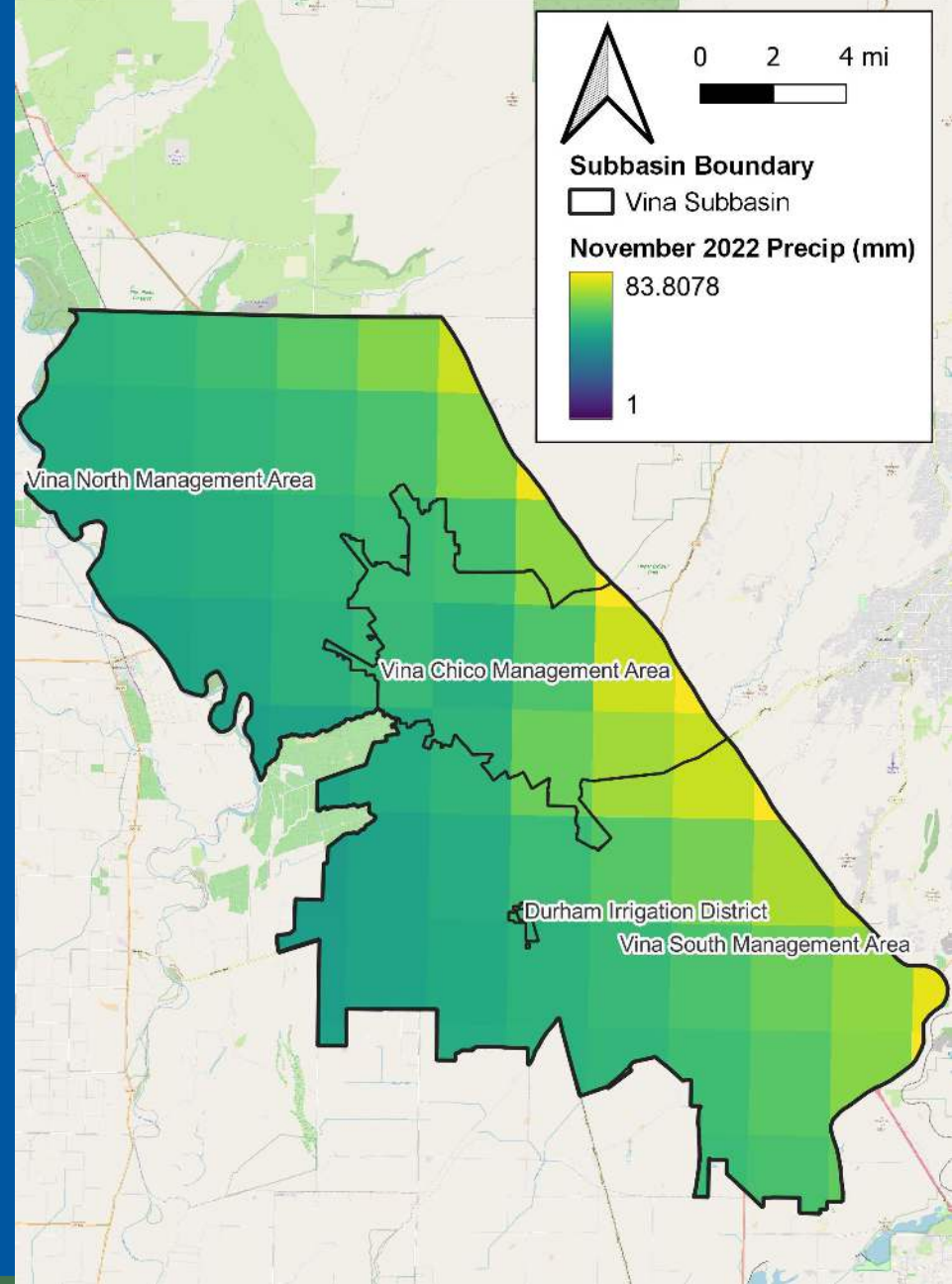
- Evapotranspiration (ET)
 - OpenET
- Land Use
 - DWR² Statewide Crop Mapping
 - USDA³ CropScape
- Precipitation
 - PRISM⁴
- Local Water Supplies
 - USBR⁵
 - State Water Project
 - Local Data Requests

²Department of Water Resources

³United States Department of Agriculture

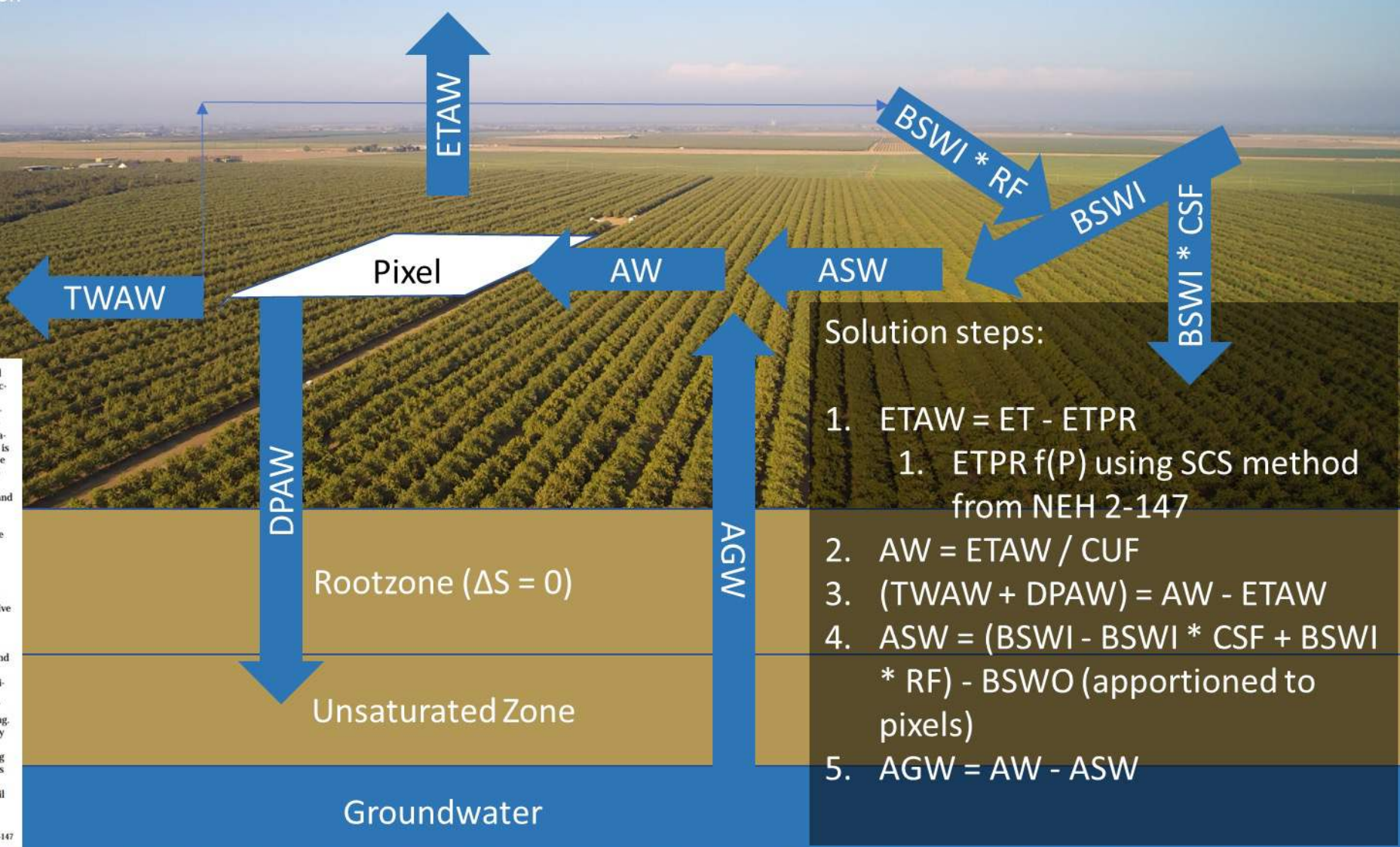
⁴Parameter-elevation Regressions on Independent Slopes Model

⁵United States Bureau of Recreation



Abbreviations
 AGW – Applied Groundwater
 ASW – Applied Surface Water
 AW – Total Applied Water
 BSWI – Boundary Surface Water Inflow
 BSWO – Boundary Surface Water Outflow
 CSF – Conveyance System Fraction
 CUF - Consumptive Use Fraction
 DPAW – Deep Percolation of Applied Water

ET – Evapotranspiration
 ETAW – Evapotranspiration from Applied Water
 ETPR – Evapotranspiration from Precipitation
 P – Precipitation
 RF - Reuse Fraction
 TAW – Tail Water of Applied Water



- Solution steps:**
- ETAW = ET - ETPR
 1. ETPR f(P) using SCS method from NEH 2-147
 - AW = ETAW / CUF
 - (TAW + DPAW) = AW - ETAW
 - ASW = (BSWI - BSWI * CSF + BSWI * RF) - BSWO (apportioned to pixels)
 - AGW = AW - ASW

(2) Monthly effective precipitation
 SCS scientists analyzed 50 years of rainfall records at 22 locations throughout the United States to develop a technique to predict effective precipitation (USDA 1970). A daily soil moisture balance incorporating crop evapotranspiration, rainfall, and irrigation was used to determine the evapotranspiration effectiveness. The resulting equation for estimating effective precipitation is: [2-84]

$$P_e = SF \left(0.70917P_i^{0.82416} - 0.11556 \right) \times 10^{0.02426 ET_c}$$

where:
 P_e = average monthly effective monthly precipitation (in)
 P_i = monthly mean precipitation (in)
 ET_c = average monthly crop evapotranspiration (in)
 SF = soil water storage factor

The soil water storage factor was defined by: [2-85]

$$SF = (0.531747 + 0.295164 D - 0.057697 D^2 + 0.003804 D^3)$$

where:
 D = the usable soil water storage (in)

The term D was generally calculated as 40 to 60 percent of the available soil water capacity in the crop root zone, depending on the irrigation management practices used.

The solution to equation 2-84 for $D = 3$ inches is given in table 2-43 and figure 2-38. For other values of D, the effective precipitation values must be multiplied by the corresponding soil water storage factor given in

The procedures used to develop equations 2-84 and 2-85 did not include two factors that affect the effectiveness of rainfall. The soil infiltration rate and rainfall intensity were not considered because sufficient data were not available or they were too complex to be readily considered. If in a specific application the infiltration rate is low and rainfall intensity is high, large amounts of rainfall may be lost to surface runoff. A sloping land surface would further reduce infiltration amounts. In these cases the effective precipitation values obtained from equations 2-84 and 2-85 need to be reduced.

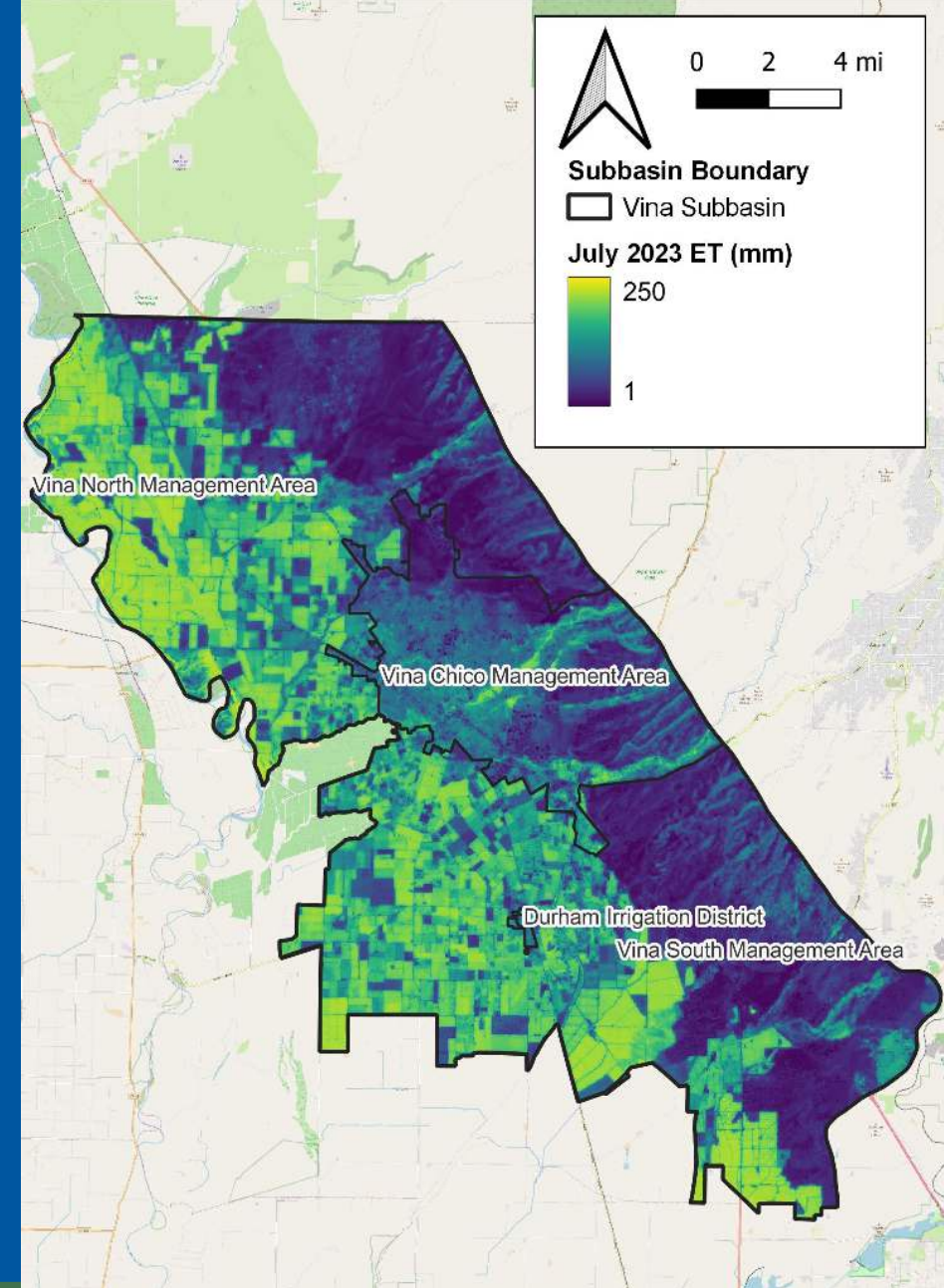
A recent comparison (Patwardhan, et al. 1990) of the USDA-SCS method (USDA 1970) with a daily soil moisture balance incorporating surface runoff highlighted the need for this modification. The authors concluded that the USDA SCS method was in fairly good agreement with the daily water balance procedure for well drained soils, but overpredicted effective precipitation for poorly drained soils.

The USDA-SCS method is generally recognized as applicable to areas receiving low intensity rainfall and to soils that have a high infiltration rate (Dastane 1974). The method averages soil type, climatic conditions, and soil-water storage to estimate effective precipitation. This provides reasonable estimates of effective precipitation, especially for project planning. Further, the procedures were designed for a monthly time step. If additional detail is needed for a more thorough project analysis or for irrigation scheduling purposes, a daily time step would be required. In this case more sophisticated techniques can be used to estimate effective precipitation. Computer-based soil

(210-v1-NEH, September 1993) 2-147

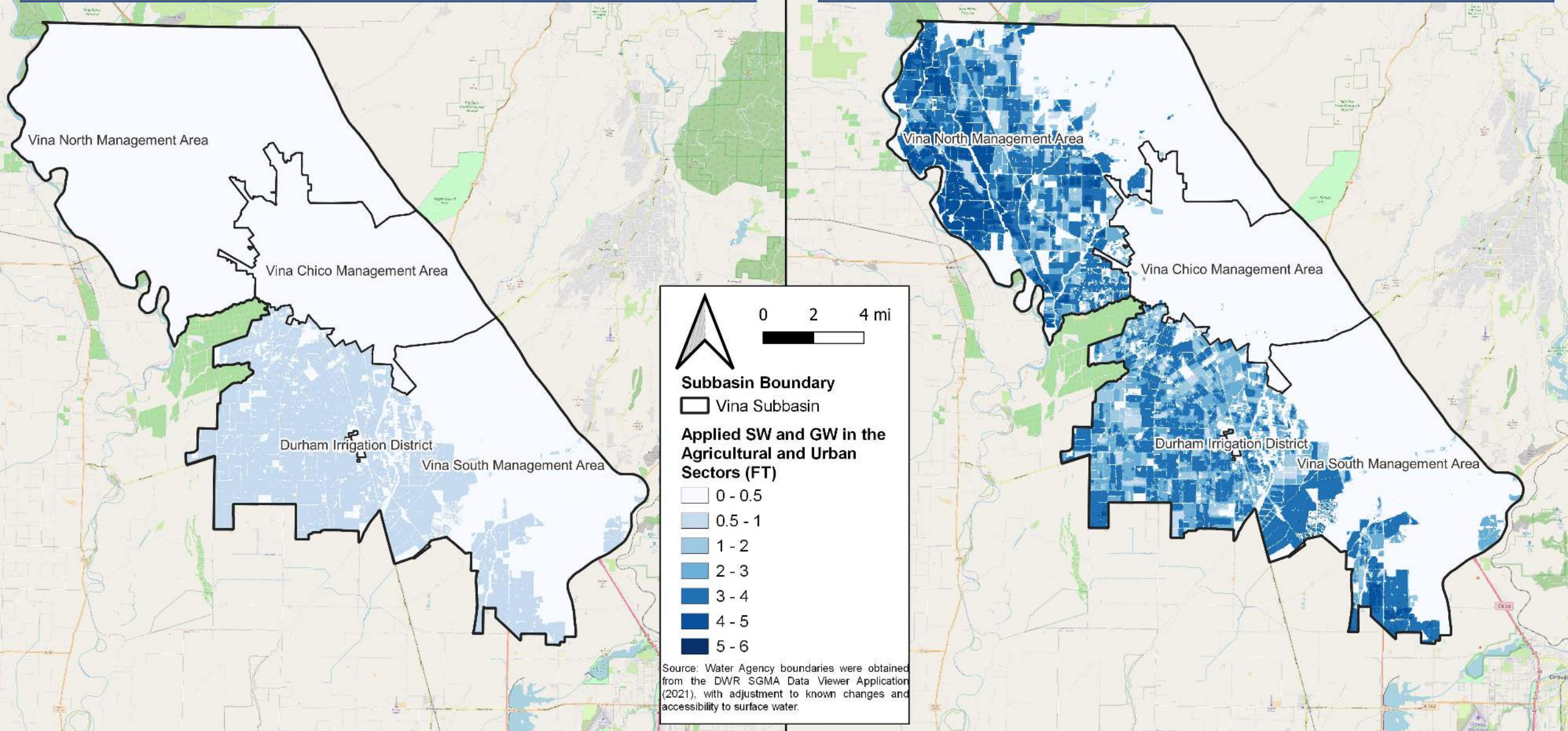
Process/Approach

- Area is separated into Subregions
- ET is used to quantify total water requirements
- Effective Precipitation is calculated from precipitation and estimated mean crop rooting depth
- Available surface water is assumed to be evenly distributed across all irrigated lands
- Applied groundwater demand is calculated as the difference between total water demand and available water



Estimated Applied Surface Water (AF/AC) (WY 2023)

Estimated Applied Groundwater (AF/AC) (WY 2023)



Slide 8 - Remote Sensing Estimates of Groundwater Extraction Using the GEEEO Process

10/9/24



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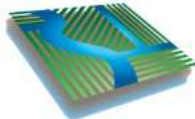
Subbasin	LULC Name	LULC Area (AC)	Water Year	Precip (AF)	ETa (AF)	ETpr (AF)	ETaw (AF)	App. Water (AF)	App. SW (AF)	App. GW (AF)
Vina	Alfalfa	53	2023	130	120	40	80	130	20	100
Vina	Almonds	29,743	2023	73,300	94,010	21,120	72,890	91,110	18,140	72,970
Vina	Citrus and Subtropical	821	2023	2,450	2,430	580	1,850	2,310	680	1,630
Vina	Dry Beans	38	2023	90	70	20	50	80	0	80
Vina	Wheat	725	2023	1,890	1,210	450	770	1,180	110	1,070
Vina	Grain and Hay	715	2023	1,820	1,280	410	870	1,340	480	850
Vina	Grapes	58	2023	150	120	40	80	100	20	90
Vina	Idle	7,869	2023	20,180	15,050	3,360	0	0	0	0
Vina	Miscellaneous Deciduous	5,412	2023	13,270	13,940	3,160	10,770	13,470	1,840	11,630
Vina	Miscellaneous Field Crop	302	2023	740	610	170	440	680	260	420
Vina	Miscellaneous Pasture	537	2023	1,370	1,370	320	1,050	1,610	340	1,280
Vina	Miscellaneous Truck Crop	155	2023	390	340	100	240	300	80	220
Vina	Native Vegetation	64,367	2023	187,470	84,370	36,520	0	0	0	0
Vina	Onions and Garlic	85	2023	210	170	60	120	150	80	70
Vina	Pistachios	855	2023	2,120	2,430	520	1,910	2,390	220	2,170
Vina	Rice	8,536	2023	21,700	28,520	6,110	22,410	34,480	7,350	27,130
Vina	Riparian Vegetation	11,114	2023	27,690	31,230	7,290	0	0	0	0
Vina	Sunflower	88	2023	210	240	60	180	270	50	230
Vina	Urban	25,226	2023	67,520	49,540	9,990	0	0	0	0
Vina	Open Urban	321	2023	880	920	140	0	0	0	0
Vina	Walnuts	26,818	2023	65,690	90,280	16,740	73,540	91,920	6,290	85,630
Vina	Water	699	2023	1,720	2,600	330	0	0	0	0
Vina	Barren	480	2023	1,230	870	200	0	0	0	0

Future Refinements

- Refined Distribution of Surface Water
- Calibrated Calculation of Effective Precipitation



Questions?



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