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COLUSA SUBBASIN

Remote Sensing Estimates of Groundwater Extraction Using the GEEEO Process

September 25, 2024

DAVIDS ENGINEERING, INC

Serving Stewards of Western Water Since 1993

Agenda

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

What is the GEEEO?

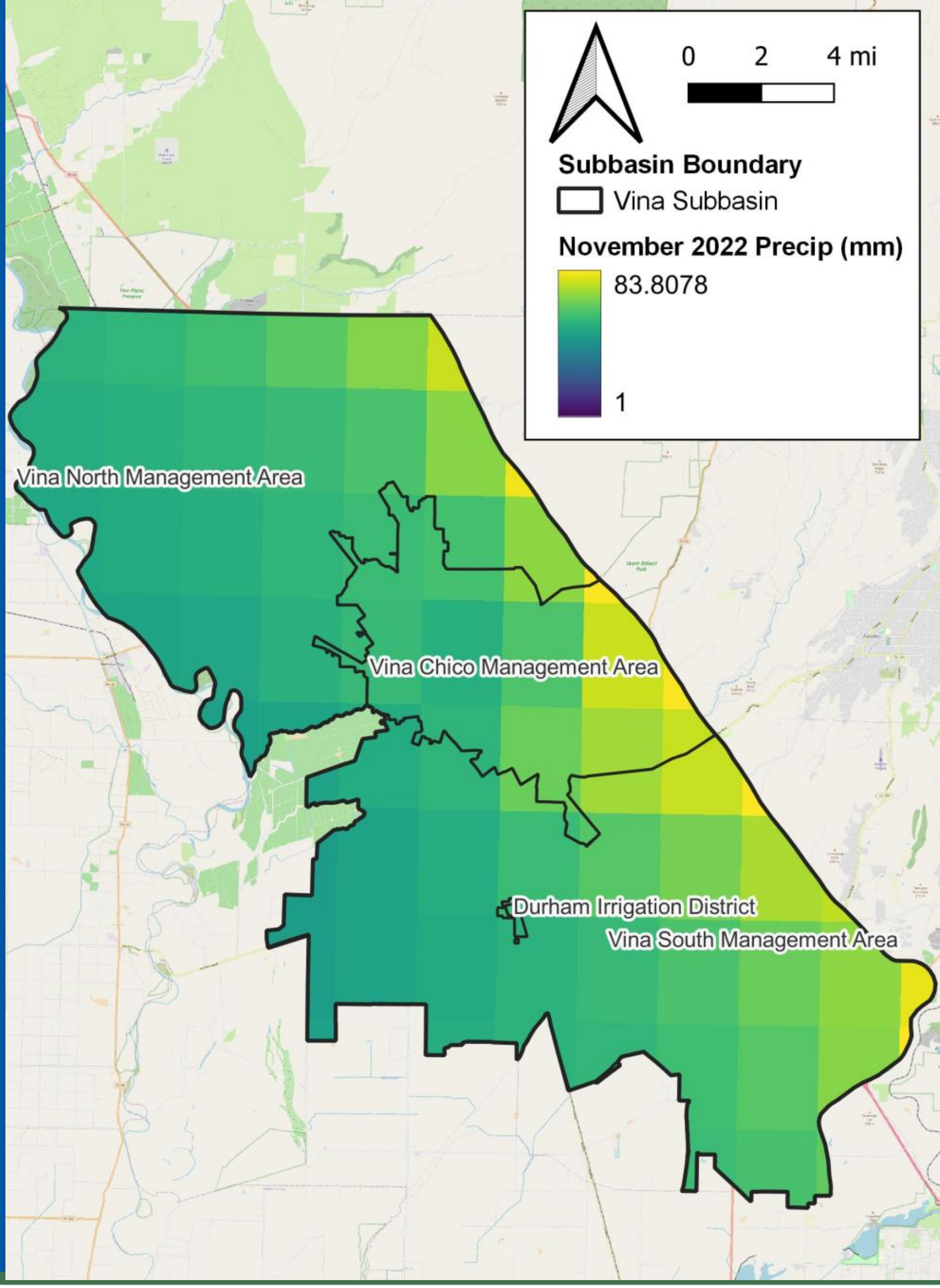
- Groundwater Extraction Estimates from Earth Observations
- Developed to support GSP[1] Annual Reports
- Not a full water budget
- Spatial water use analysis
  - 30m X 30m pixel-scale resolution
  - Monthly time step

[1]Groundwater Sustainability Plan

Data Sources

- Evapotranspiration (ET)
  - OpenET
- Land Use
  - DWR[2] Statewide Crop Mapping
  - USDA[3] CropScape
- Precipitation
  - PRISM[4]
- Local Water Supplies
  - USBR[5]
  - State Water Project
  - Local Data Requests

[2]Department of Water Resources
[3]United States Department of Agriculture
[4]Parameter-elevation Regressions on Independent Slopes Model
[5]United States Bureau of Recreation



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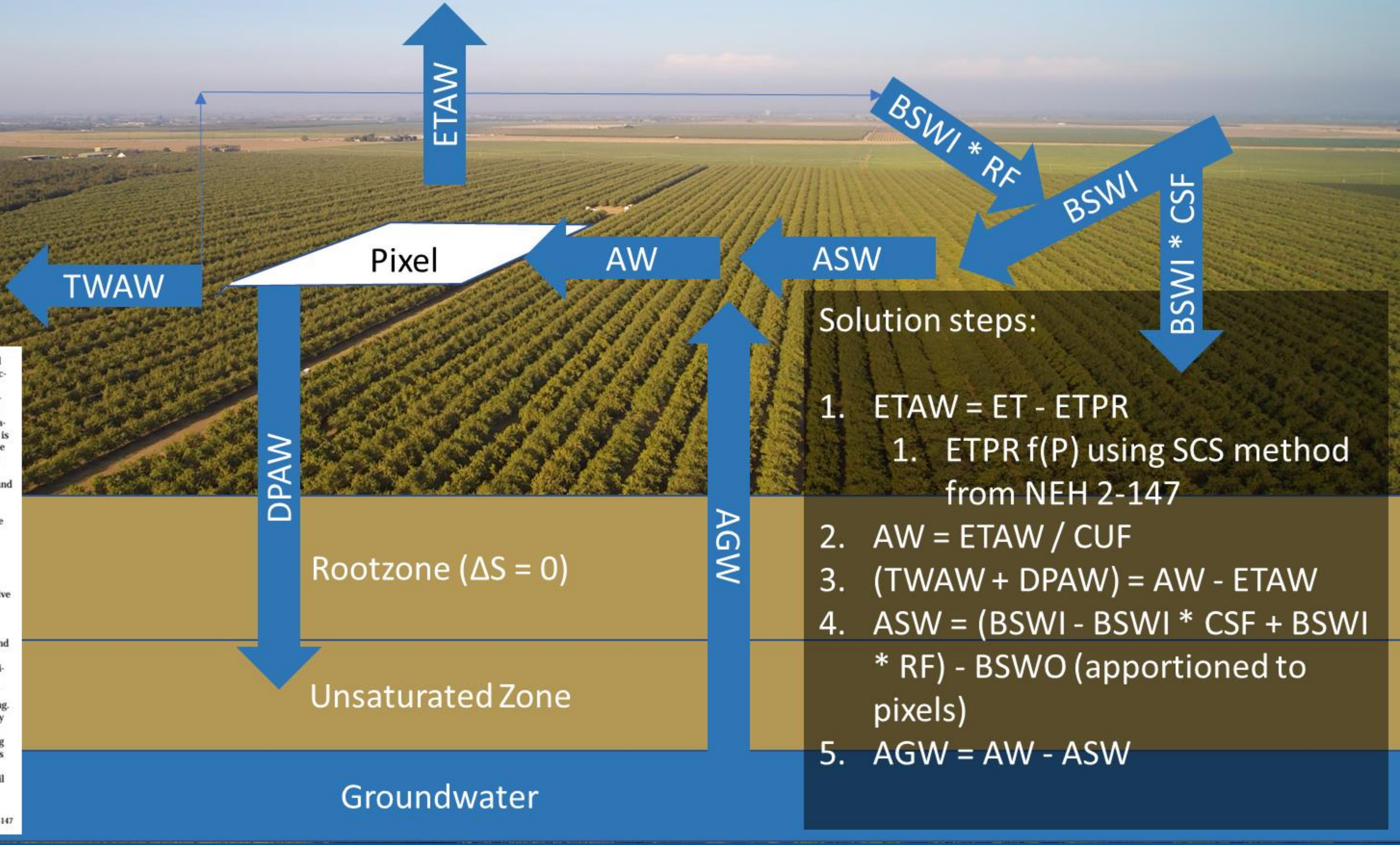
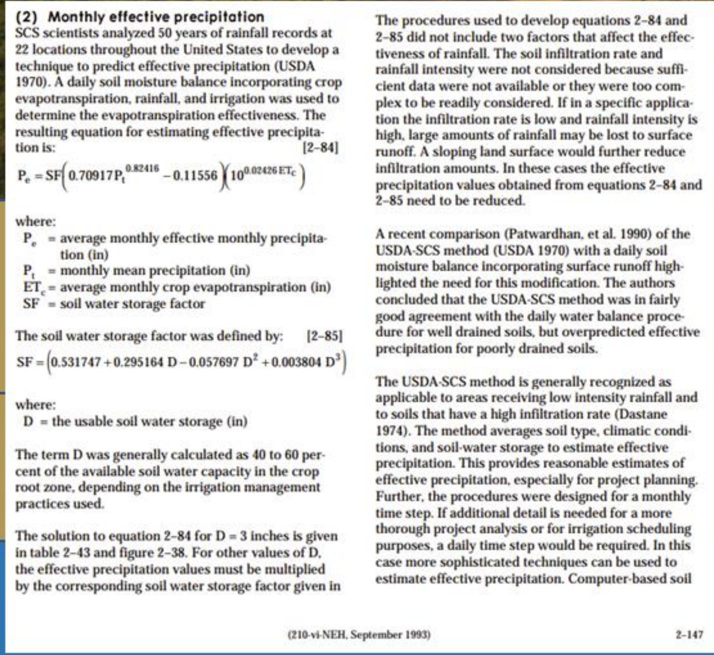
Abbreviations

- 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
- TWAW –Tail Water of Applied Water



Solution steps:

1. ETAW = ET - ETPR
   1. ETPR f(P) using SCS method from NEH 2-147
2. AW = ETAW / CUF
3. (TWAW + DPAW) = AW - ETAW
4. ASW = (BSWI - BSWI * CSF + BSWI * RF) - BSWO (apportioned to pixels)
5. 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]

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

where:

P_e = average monthly effective monthly precipitation (in)
P_t = 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]

$$SF = \left(0.531747 + 0.295164\,D - 0.057697\,D^2 + 0.003804\,D^3\right)$$

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.

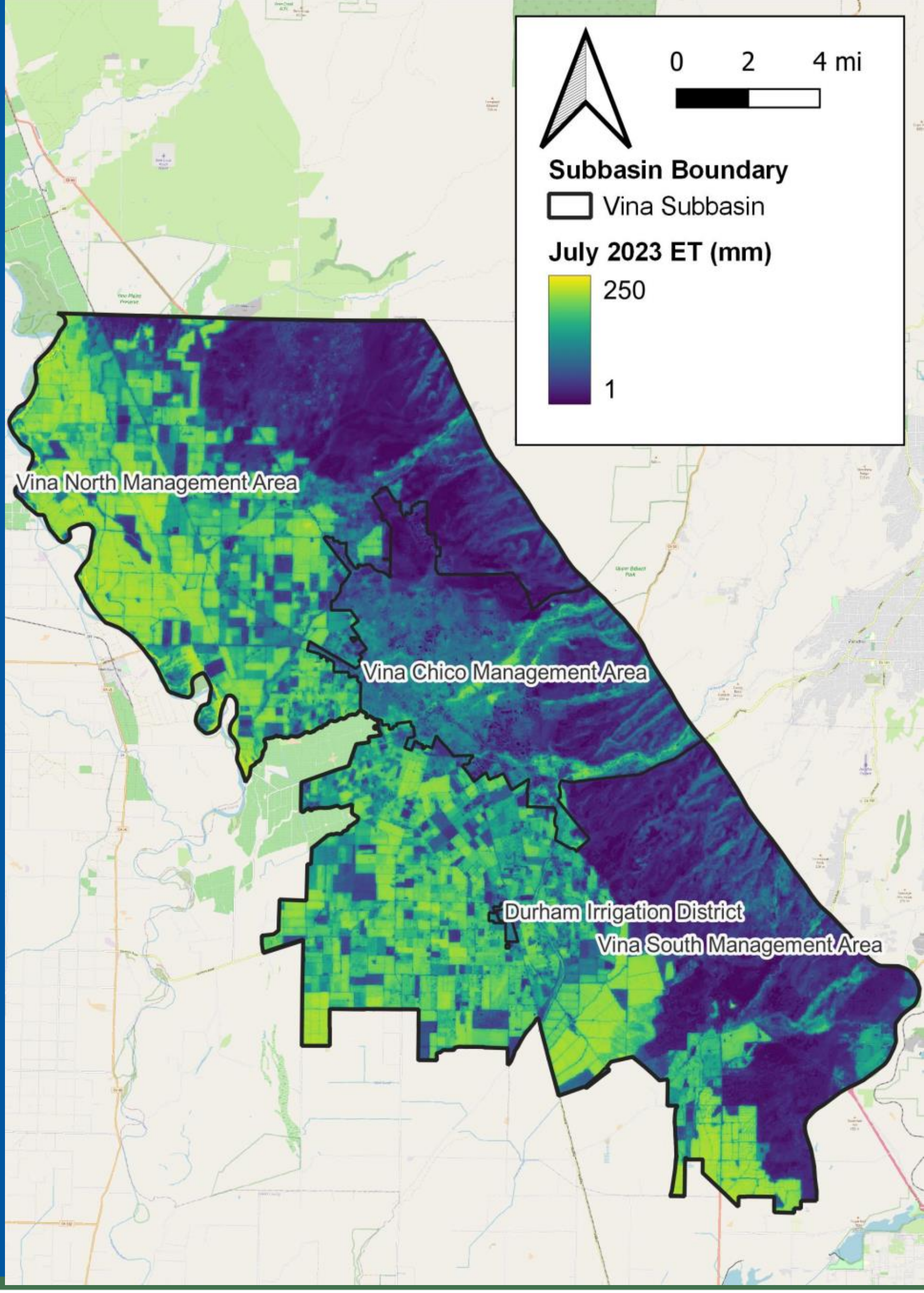
A recent comparison (Patwardhan, et al. 1990) of the USDA-SCS method (USDA 1970) with a daily soil moisture balance incorporating surface runoff highlighted the need for this modification. The authors concluded that the USDA-SCS method was in fairly good agreement with the daily water balance procedure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

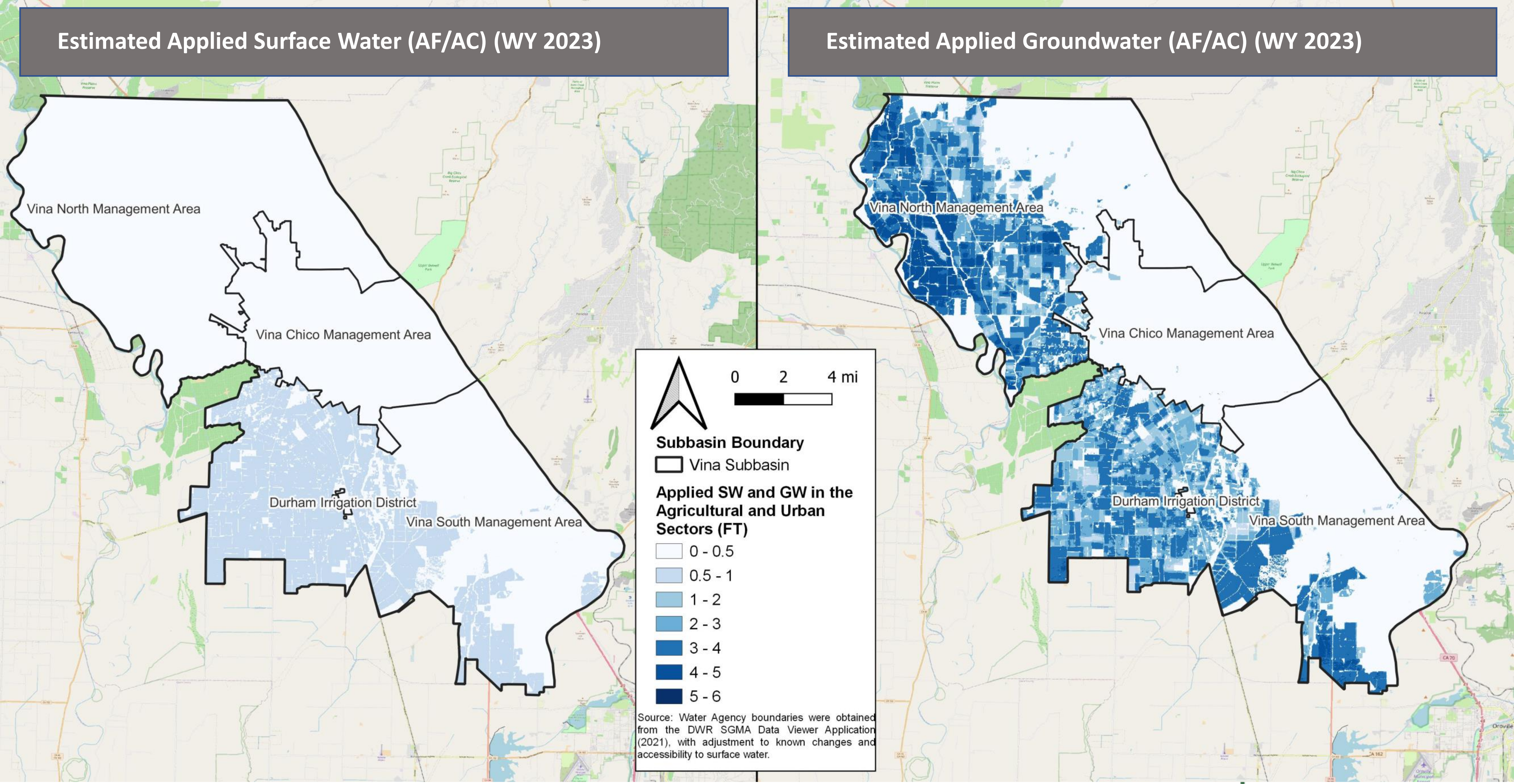
The USDA-SCS method is generally recognized as applicable to areas receiving low intensity rainfall and to soils that have a high infiltration rate (Dastane 1974). The method averages soil type, climatic conditions, and soil-water storage to estimate effective precipitation. This provides reasonable 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-vi-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)
Vina North Management Area
Vina Chico Management Area
Durham Irrigation District
Vina South Management Area
0 2 4 mi
Subbasin Boundary
Vina Subbasin
Applied SW and GW in the Agricultural and Urban Sectors (FT)
0 - 0.5
0.5 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
Source: Water Agency boundaries were obtained from the DWR SGMA Data Viewer Application (2021), with adjustment to known changes and accessibility to surface water.

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?