

January 2026 (FINAL)

# Dunnigan Water District Groundwater Recharge Basis of Design and Recharge Operations Manual

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PREPARED BY:

DUNNIGAN WATER DISTRICT IN PARTNERSHIP WITH RECLAMATION DISTRICT NO. 108 AND  
COLUSA COUNTY WATER DISTRICT

## Professional Certification

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This document titled “Dunnigan Water District Groundwater Recharge Basis of Design and Recharge Operations Manual” dated January 2026, was prepared for Dunnigan Water District (DWD) in partnership with Reclamation District No. 108 (RD108) and Colusa County Water District (CCWD) under the supervision of Ryan Fulton, Larry Walker Associates. Ryan Fulton is a registered engineer in California and experienced in the field water resources management.

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Attachment B – South Colusa – North Yolo (SCNY) Regional Cooperation Agreement

Attachment C – DWD Rootzone Water Balance (from C2VSimFG v1.5)

Attachment D – SCNY Groundwater Elevation Maps

Attachment E – State Water Resources Control Board – Groundwater Quality Considerations for High and Medium Priority Basins

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Attachment H – Recharge Photos

# 1 INTRODUCTION

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## 1.1 Background

In the Dunnigan area, historically low groundwater levels are threatening the water supply for both agricultural and domestic users and is suspected of causing land subsidence. The subsidence is damaging nearby infrastructure, including the Tehama-Colusa Canal (TCC) and Interstate 5, both provide critical support for the agricultural industry and residents. Groundwater levels between Fall 2010 and Fall 2020 declined by over 30 feet in areas. DWR reports total subsidence between June 2015 and January 2023 up to -1.05 feet. Approximately 207 domestic wells are in the Dunnigan area, of which 19 (or 9%) were susceptible to going dry in the recent drought. Domestic and public supply well depths range from approximately 100 feet to over 700 feet. Wells susceptible of going dry generally range from approximately 100 feet deep to 200 feet deep.

Dunnigan Water District (DWD or District) receives Sacramento River water through the TCC. Soon after TCC became operational in the 1980s, groundwater levels rebounded from the historical lows observed at that time and remained relatively stable. Groundwater levels started to decline again starting in the early-2000s due to increased pumping. Groundwater levels dropped during the 2021/22 drought in many areas where surface water was limited and growers relied heavily on groundwater near groundwater level prior to the TCC being operable. In response, DWD performed a pilot project in February 2022 when the TCC was emptied to complete repairs. Approximately 275 AF of surface water was discharged into Buckeye Creek. Groundwater levels at nearby monitoring wells increased by approximately five (5) inches immediately following the recharge (Attachment A).

In response to the successful pilot test, the District in collaboration with the California Department of Water Resources (DWR), Westside Sacramento Integrated Regional Water Management (IRWM) Program, Yolo Subbasin Groundwater Agency (YSGA), California American Water, The Nature Conservancy (TNC), and local stakeholders partnered to form the Dunnigan Area Recharge Program (DARP or Program). The Program sought to immediately address the unprecedented drought conditions impacting the disadvantaged community of Dunnigan and provide a strategic roadmap to implement groundwater recharge projects at large scale across the region.

In 2022 the DARP received funding through DWR's Urban and Multibenefit Drought Relief Program to implement the program. The funding allowed the District to expand their groundwater level monitoring network, perform benefit assessments, plan and design infrastructure upgrades, and purchase surface water for recharge. The Program utilized high flow from the Sacramento River (e.g., 3F water), excess Central Valley Project (CVP) contract water from DWD, and purchased surface water from senior water right holders as needed. Surface water was diverted from the Sacramento River through the TCC into Buckeye and Bird Creeks (i.e., ephemeral streams) and on to fallow farmland enrolled in TNC's multi-benefit recharge program. The Program improved water supply reliability for the disadvantaged community of Dunnigan; provided habitat for migratory waterfowl; minimized depletions from interconnected surface waters (ISW); and reduced the risk of subsidence.

This District is leading a substantial outreach effort to show the success of the DARP. This includes collaborating with neighboring water districts and growers solely reliant on groundwater for irrigation, presenting at professional organizations such as United States Committee on Irrigation

& Drainage and California Groundwater Resources Association. The Program received regional and statewide recognition for advancing groundwater recharge through the Northern California Water Association and the Los Angeles Times. In 2025, landowners across the South Colusa – North Yolo (SCNY) region formed a Regional Cooperation Agreement (Attachment B). The goal of this grass-roots effort within the SCNY region is to self-fund the planning, design, and implementation of groundwater recharge projects to achieve groundwater sustainability goals and to prevent undesirable results (e.g., subsidence and lowering of groundwater levels)..

The SCNY Working Group consists of landowners from the following subareas (Figure 1-1):

- Colusa Subbasin White Area Landowners
- Yolo Subbasin White Area Landowners
- Colusa County Water District
- Dunnigan Water District
- Colusa Drain Mutual Water Company
- Reclamation District No. 108

As of January 2026, approximately 80,000 acres of farmed lands are enrolled in the SCNY program and landowners have contributed over \$600,000 in the first year to advance recharge. This regional effort advances projects and management actions (PMAs) across the Yolo and Colusa Subbasins in accordance with local Groundwater Sustainability Plans (GSPs). Local stakeholders have participated in regular meetings with DWR, in partnership with the Northern California Water Association, to ensure the stakeholders are meeting all State regulatory requirements and are staying informed on other State funding opportunities and technical assistance resources. Subsidence is a significant concern for the area with observed subsidence up to 2.7 feet from June 2015 through June 2024 with the worst occurring near Arbuckle (Figure 1-2). The SCNY Working Group is committed to immediately prevent subsidence caused by the lowering of groundwater levels.

Dunnigan Water District, Reclamation District No. 108, and Colusa County Water District have been awarded other state and federal funding through DWR’s Flood Diversion Recharge Enhancement (FDRE) Initiative, the Northern Sacramento Valley IRWM, DWR’s Sustainable Groundwater Management Program, and the U.S. Bureau of Reclamation to continue to advance recharge.

The remainder of this Basis of Design and Recharge Operations Manual will discuss each applicable sustainability indicator under the Sustainable Groundwater Management Act (SGMA), current and potential recharge projects, proposed method to rank and select projects to implement, infrastructure designs for highest ranked projects, observed benefits from recharge, and recommendations to further advance recharge in the area. Preliminary designs are provided for recharge projects that received the highest benefit score.

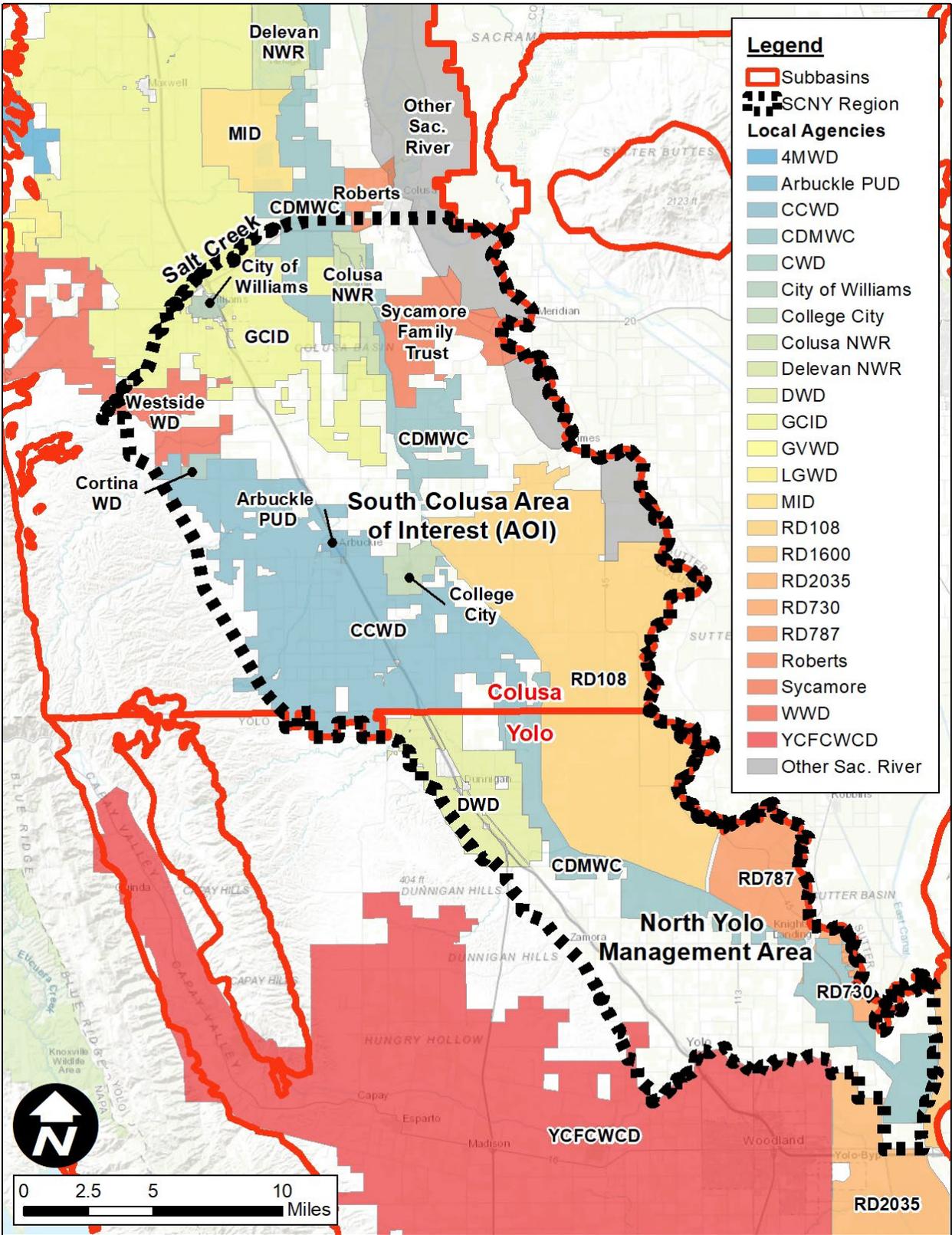


Figure 1-1. Overview of SCNY Participants.

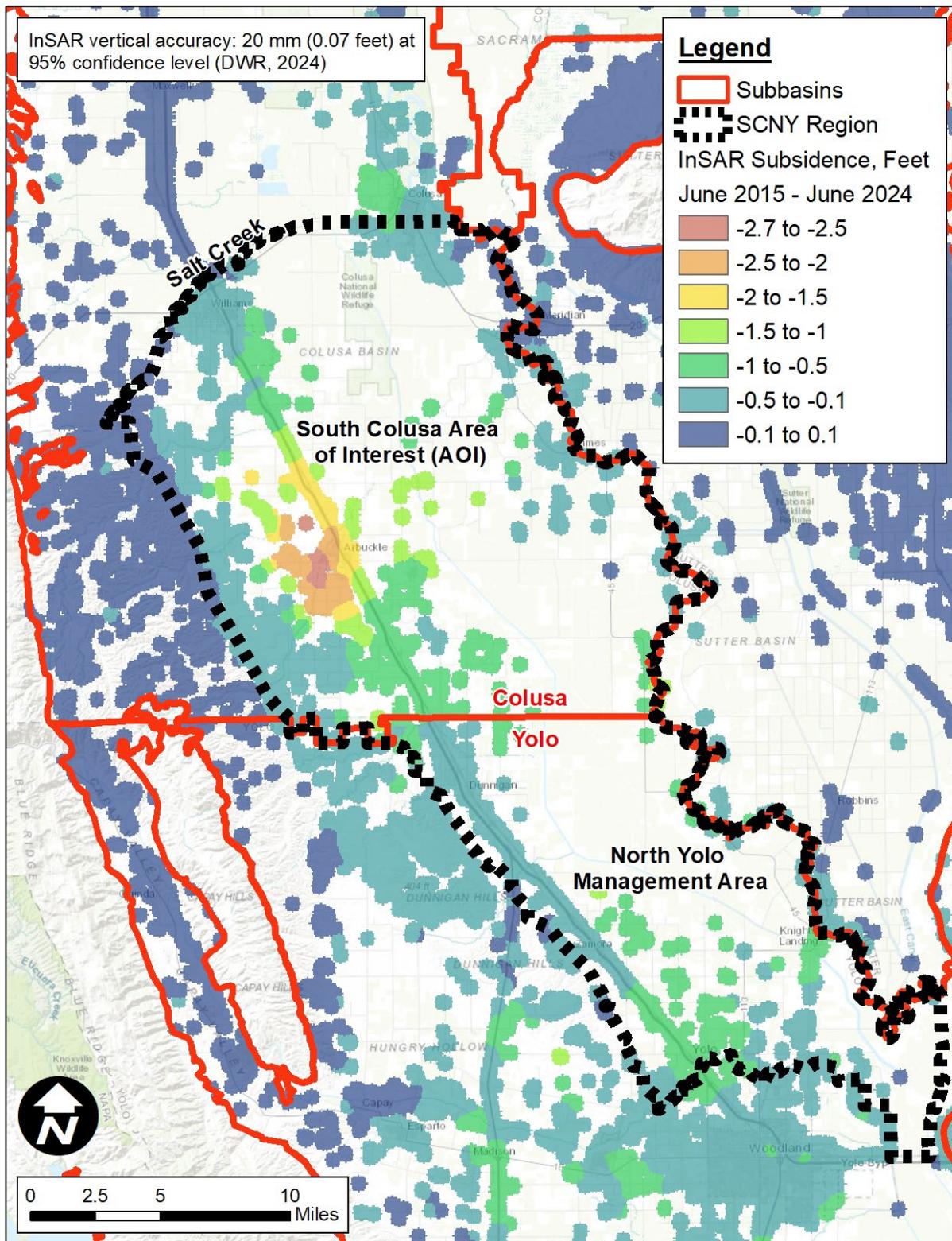


Figure 1-2. SCNY Region Subsidence.

## **2 HISTORICAL & CURRENT WATER BUDGET AND GROUNDWATER CONDITIONS**

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This section describes historical water conditions for Dunnigan Water District and more broadly across the SCNY region, and groundwater conditions relative to the six defined SGMA sustainability indicators. It's important to evaluate groundwater conditions on a regional level as neighboring areas can influence groundwater behavior in adjacent areas.

### **2.1 Overview**

Water budgets and groundwater conditions were explored and analyzed using two different approaches: (1) modeling using DWR's California Central Valley Groundwater – Surface Water Simulation Model (C2VSimFG, or Model) released June 2025, and (2) actual well observations (measured data). Both approaches provide valuable insights into groundwater pumping, water levels, storage changes, interconnected surface waters (ISW), and groundwater dependent ecosystems (GDEs). Each approach is further described below.

#### **2.1.1 C2VSimFG Integrated Hydrologic Model**

The Integrated Water Flow Model (IWFm) was developed by DWR beginning in 2001, with the fine-grid Central Valley application (C2VSimFG) first released in 2012. The model simulates groundwater-surface water interactions on a monthly time step, incorporating precipitation data, evapotranspiration data, stream inflow data, surface water diversions, and annual land use inputs. Over successive updates, refinements have included expanded crop categories to better represent ponded crops such as rice and wetlands, recalibrated soil and root zone parameters, and improved land use datasets from county surveys, crop mapping, NDVI, and CDL sources. The most recent version, C2VSimFG v1.5<sup>1</sup>, extended the historical simulation period starting October 1973 through Water Year 2021, improved consistency in evapotranspiration, precipitation, and water supply datasets, and incorporated local GSP data to enhance calibration of water budgets and groundwater elevations. Local data from Dunnigan Water District and more broadly across Yolo and Colusa Subbasins were not incorporated into the C2VSimFG release in June 2025. C2VSimFG v1.5 rootzone water budget results for Dunnigan Water District are provided in Attachment C.

#### **2.1.2 Actual Well Observations**

Wells of various uses and depths were assembled from multiple sources to build a Region-wide view of groundwater elevations. These wells were selected (1) by available well measurement data from the Water Data Library (WDL) and (2) by local water districts' by working with stakeholders to expand individual district monitoring networks. Wells on the WDL were only utilized if the well had at least ten good quality measurements within the period of record, and measurements marked with quality assurance exception notes were removed from the dataset. Stakeholder wells were equipped with continuous groundwater measurement equipment, such as well sounders or pressure transducers, outfitted with telemetry, and submit data to a stakeholder portal that districts can view in real time.

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<sup>1</sup> California Central Valley Groundwater-Surface Water Simulation Model – Fine Grid version 1.5 Model Documentation (DWR, June 2025); download here: <https://data.cnra.ca.gov/dataset/c2vsimfg>

To extend these point-based observations into a regional view, linear 2D interpolations of the measured data were developed to visualize Regional groundwater levels. These interpolations were created for fall and spring, each year, from 2000 to 2025. Spring measurements had to take place between February 15<sup>th</sup> and May 31<sup>st</sup>, representing high groundwater levels in the Region pre-irrigation season. Fall measurements had to take place between August 1<sup>st</sup> and November 15<sup>th</sup>, representing low groundwater levels post-irrigation season. If a well had multiple good-quality measurements during a season, the median measurement was selected for the interpolation. This process generated raster imagery and contour maps of groundwater elevations and depths to water, with each 200-foot pixel calculated from the nearest well measurements. Only wells that are less than 1,000 feet deep were used in the interpolation. For multi-completion wells, multiple measurement points in the same physical location could not be used simultaneously in the interpolation, so only observations of the shallowest completion were used. Groundwater elevation maps are provided in Attachment D.

### 2.1.3 Modeled vs. Measured Data

The Model, as discussed, is built on hydrologic principles, boundary conditions, and various input datasets. Careful construction and calibration of the Model allow it to generate spatially continuous, gridded estimates across the basin, including areas of the Region where no monitoring wells exist. Modeled results are inherently dependent on assumptions, parameterization, and the quality of the input and calibration datasets. Ultimately, the Model is predictive, and serves more as a decision-making tool for water managers through thoughtful interpretation.

Measured data, by contrast, reflects actual field conditions at specific locations and times. Well observations, over a period of time, capture local variability, seasonal fluctuations, and can indicate long-term trends. A network of wells that are consistently measured informs flow direction across a region and groundwater level trends on a regional scale. These observations can also be used, as mentioned above, to interpolate groundwater surface elevation contours, and to make quick, simple estimations of groundwater storage in an underlying aquifer.

Although modeled and measured datasets are not strictly interchangeable, they are highly complementary. Measured data anchors the model to reality through calibration and validation, while modeled data extends the reach of measured data by filling gaps and projecting future scenarios. Both the Model results and measured data will be referenced in the following sections when discussing baseline groundwater conditions.

## 2.2 Water Budget

The historical water budget was developed using C2VSimFG v1.5 and the analysis period spans from 1984 to 2021. The Model incorporates the following data as inputs to the water budget calculation:

- **Stream Flows:** Data from C2VSimFG were used as best estimates for inflows and outflows from major rivers, streams, and drains within and along basin boundaries.
- **Land Use:** Agricultural, native, and urban land uses were estimated annually based on county agricultural commissioner cropping reports and DWR land use surveys conducted in 2014, 2016, 2018, 2019, 2020, 2021 and various county-specific surveys conducted prior to 2014.

- **Agricultural Water Demand:** Crop demands are estimated using C2VSimFG and are based on crop type, actual evapotranspiration, precipitation, root depth, soil characteristics, and irrigation practices.
- **Urban and Industrial Water Demand:** Population estimates were based on data from the Department of Finance. Water use estimates came from Small Supplier Conservation Reports and Urban Water Management Plans.
- **Surface Water Diversions:** In the model, surface water deliveries were constructed to simulate actual historical surface water transfers and were derived from a combination of reported diversions from surface water suppliers and Bureau of Reclamation records.
- **Groundwater Pumping:** To the extent available, historical pumping records were integrated into the water budget, although estimates of pumping for private wells often had to be calculated in the model by subtracting surface water diversions from the total simulated crop demand.

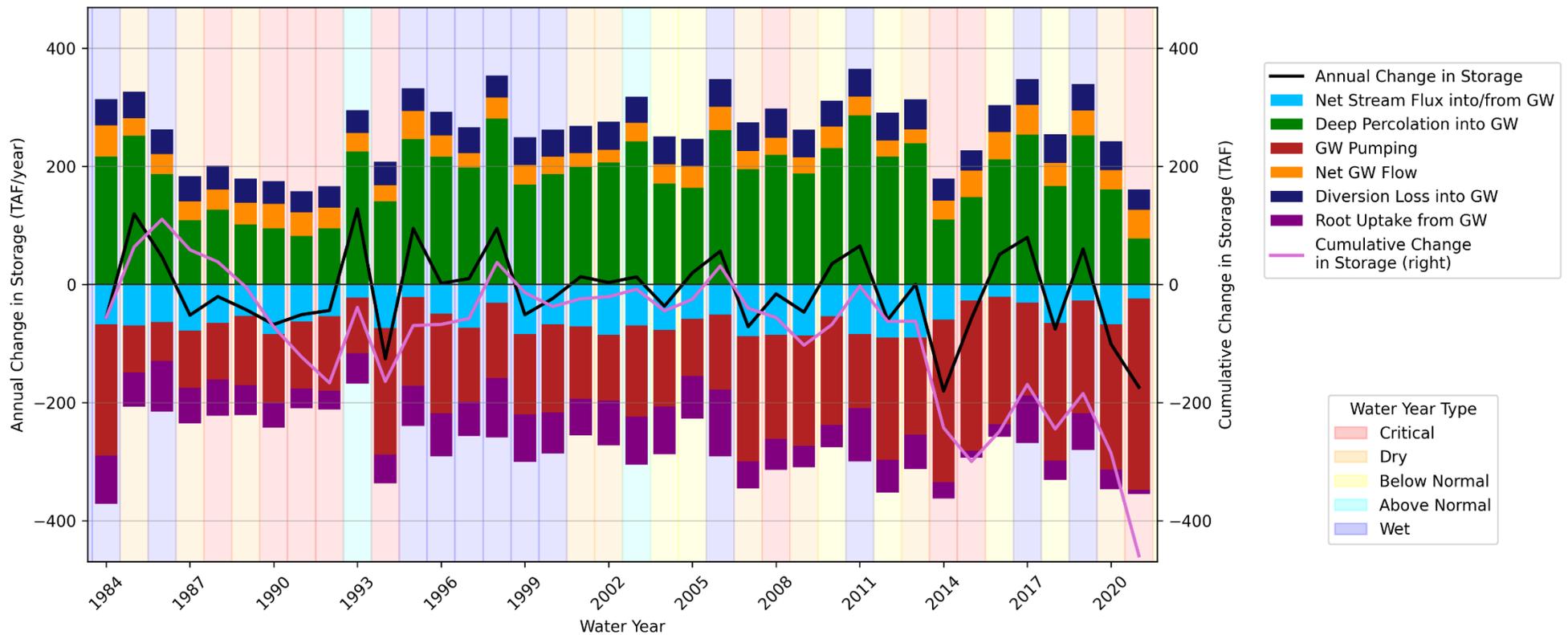
Figure 2-1 shows the groundwater budget of the Region annually from 1984 to 2021. The stacked bars represent individual components of the water budget, with deep percolation, diversion losses, and net groundwater flow representing inflows into the groundwater system and groundwater pumping, stream-aquifer exchange, and root uptake being outflows from the groundwater system. Both the annual change in storage (black line) and cumulative change in storage (pink line) are also displayed. The cumulative trend shows a long-term decline in groundwater storage, with sharper losses during dry and critical water years, especially during the 2012-2015 and 2020-2021 droughts.

### 2.3 Groundwater Conditions

The Colusa and Yolo Groundwater Sustainability Plans (GSPs) indicate that groundwater levels in both the Colusa and Yolo Subbasins were generally stable throughout the late 20th century, with short term decreases occurring during droughts and short-term increases occurring during wet periods. Seasonal fluctuations in groundwater elevations are both evident and significant in both subbasins, which is expected due to the Mediterranean-type climate of the region producing wet winters and dry summers. Depth to groundwater typically increases during the dry season due to higher pumping demands and decreases during the wet season as the aquifer naturally recharges. Hydrographs from long-term monitoring wells illustrate these seasonal highs and lows, with the seasonal differences regularly reaching as much as 40 feet in certain areas and periods.

Regionally, groundwater flows from west-to-east toward the Sacramento River and north-to-south toward the Sacramento-San Joaquin Delta. Localized cones of depression usually form in the fall near municipal and agricultural centers, which causes groundwater flow to temporarily reverse towards the geographic center of the region.

The six sustainability indicators identified by the California Sustainable Groundwater Management Act (SGMA), groundwater levels, groundwater storage, seawater intrusion, water quality, land subsidence, and depletion of interconnected surface water, are further discussed in the following section in detail to provide context for the baseline groundwater conditions of the Region.



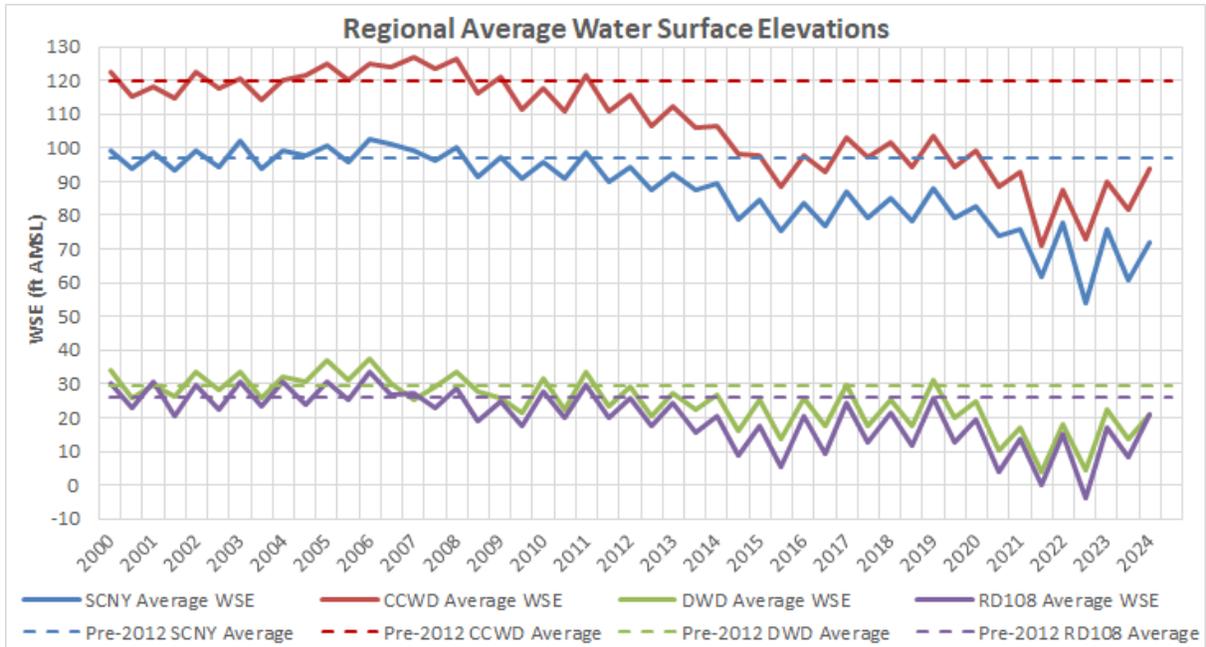
**Figure 2-1. Annual water budget results from the C2VSimFG model for the entire SCNY region. Change in storage was calculated using the model by subtracting the outflows (Net stream flux, groundwater pumping, root uptake) from the inflows (deep percolation, net groundwater flow, and diversion loss to groundwater).**

### **2.3.1 Lowering of Groundwater Levels**

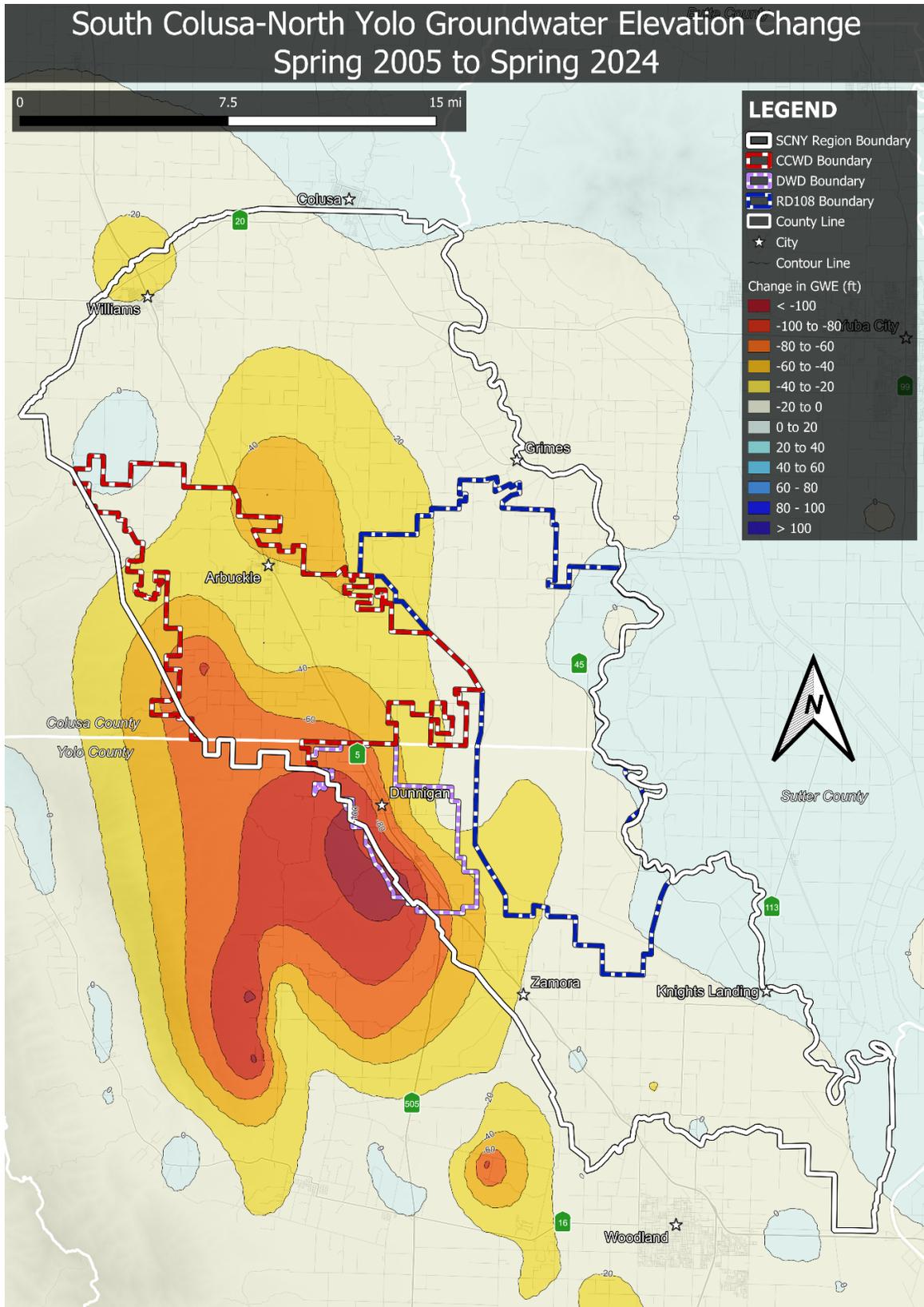
Since approximately 2007, declining groundwater levels have been observed in both the Yolo and Colusa Subbasins. Declines were most pronounced during the 2012-2016 drought and 2020-2022 drought. Figure 2-2 illustrates these trends with groundwater level hydrographs for the SCNY Region along with three of its key entities: Colusa County Water District (CCWD), Dunnigan Water District (DWD), and Reclamation District 108 (RD108). The groundwater levels for these hydrographs were retrieved by averaging the pixel values of the interpolated groundwater elevation dataset.

Between 2000 and 2012, the average groundwater level in the SCNY region was roughly 97 feet. As the Region was trying to recover from drought between 2016 and 2020, average water levels stabilized around 80 feet, roughly 17 feet drop averaged over the entire subbasin. The 2020 to 2022 drought caused another dramatic drop in groundwater levels. This pattern is echoed by CCWD. For DWD and RD108, the groundwater level drops are less dramatic, with only a slight regression from average during the 2012 drought. The Region has seen groundwater levels rebound in 2023 and 2024.

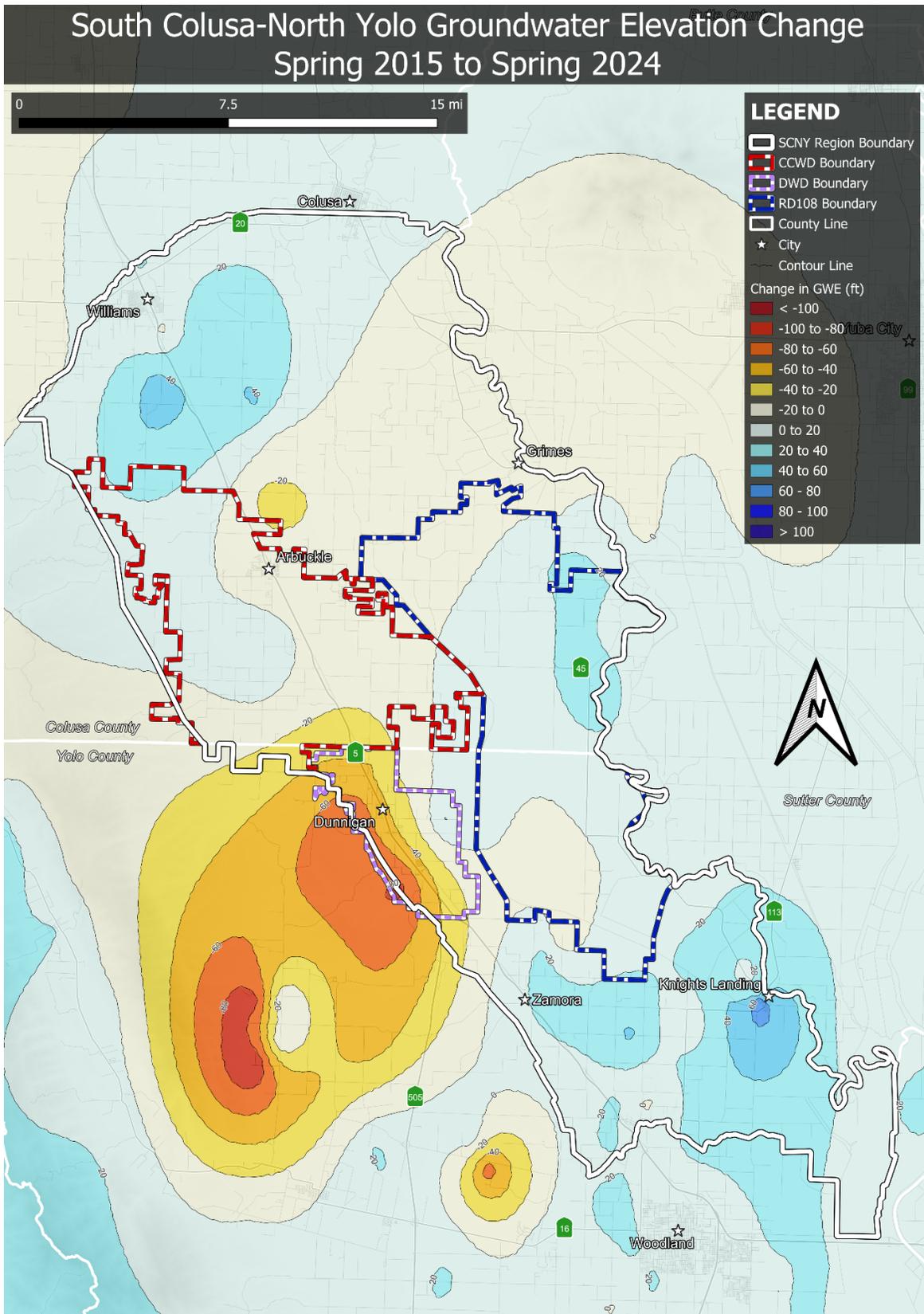
Attachment D contains maps of the Region that show groundwater elevation contours for spring and fall, 2000 through 2025. These maps and contours were made using the 2D interpolations of actual well measurements described in Section 2.1.3. Pixel-level subtraction was performed between the interpolated datasets to create groundwater elevation change contours and maps for 2005 and 2024 and 2015 and 2024 shown in Figures 2-3 and 2-4; respectively. Substantial drops in groundwater elevation are detected when comparing 2005 and 2024, especially in DWD and CCWD, with drops in groundwater elevation totaling over 50 feet. From 2015 to 2024, on the other hand, shows visible recovery in the northern, eastern, and southern parts of the Region.



**Figure 2-2. Average regional water surface elevations for all of SCNY, as well as Colusa County Water District (CCWD), Dunnigan Water District (DWD), and Reclamation District 108 (RD108).**



**Figure 2-3. 2005 to 2015 groundwater elevation change map.**



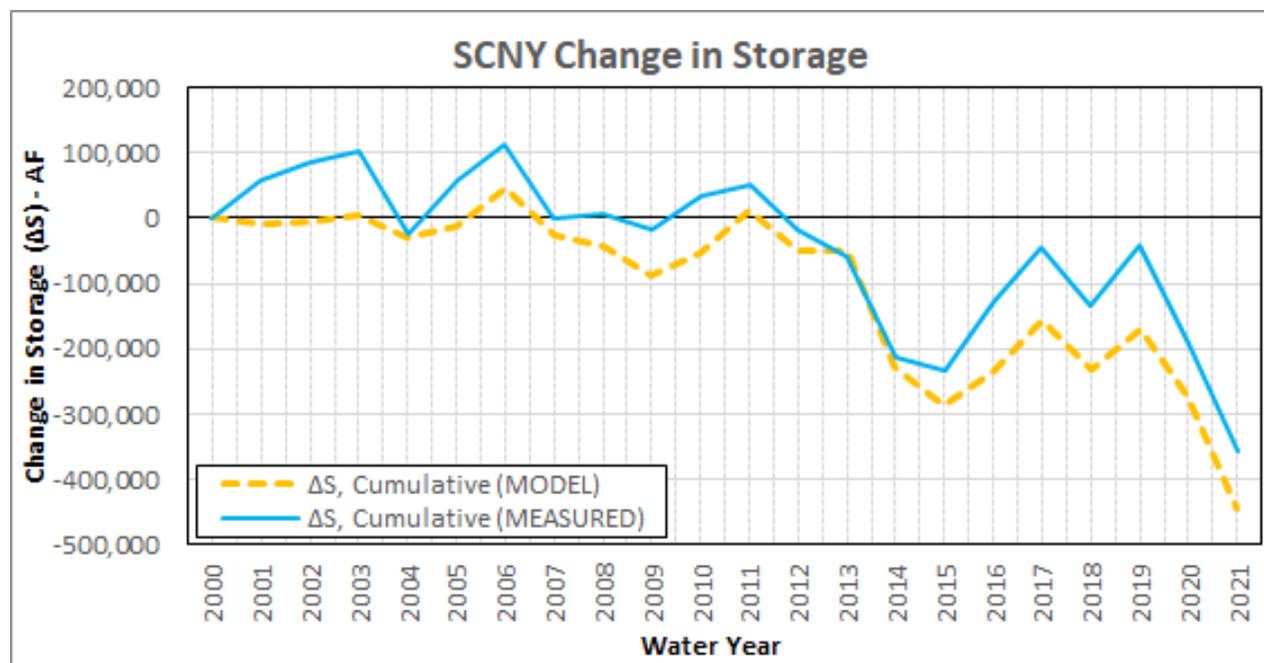
**Figure 2-4. 2015 to 2024 groundwater elevation change map.**

Overall, the Region has experienced long-term average groundwater level decline since about 2005. Current groundwater levels are similar to levels prior to the construction of the Tehama-Colusa Canal in the early 1980s. Generally, the aquifer rebounds during wet years, and declines in dry years as surface water is limited forcing more landowners to rely on groundwater.

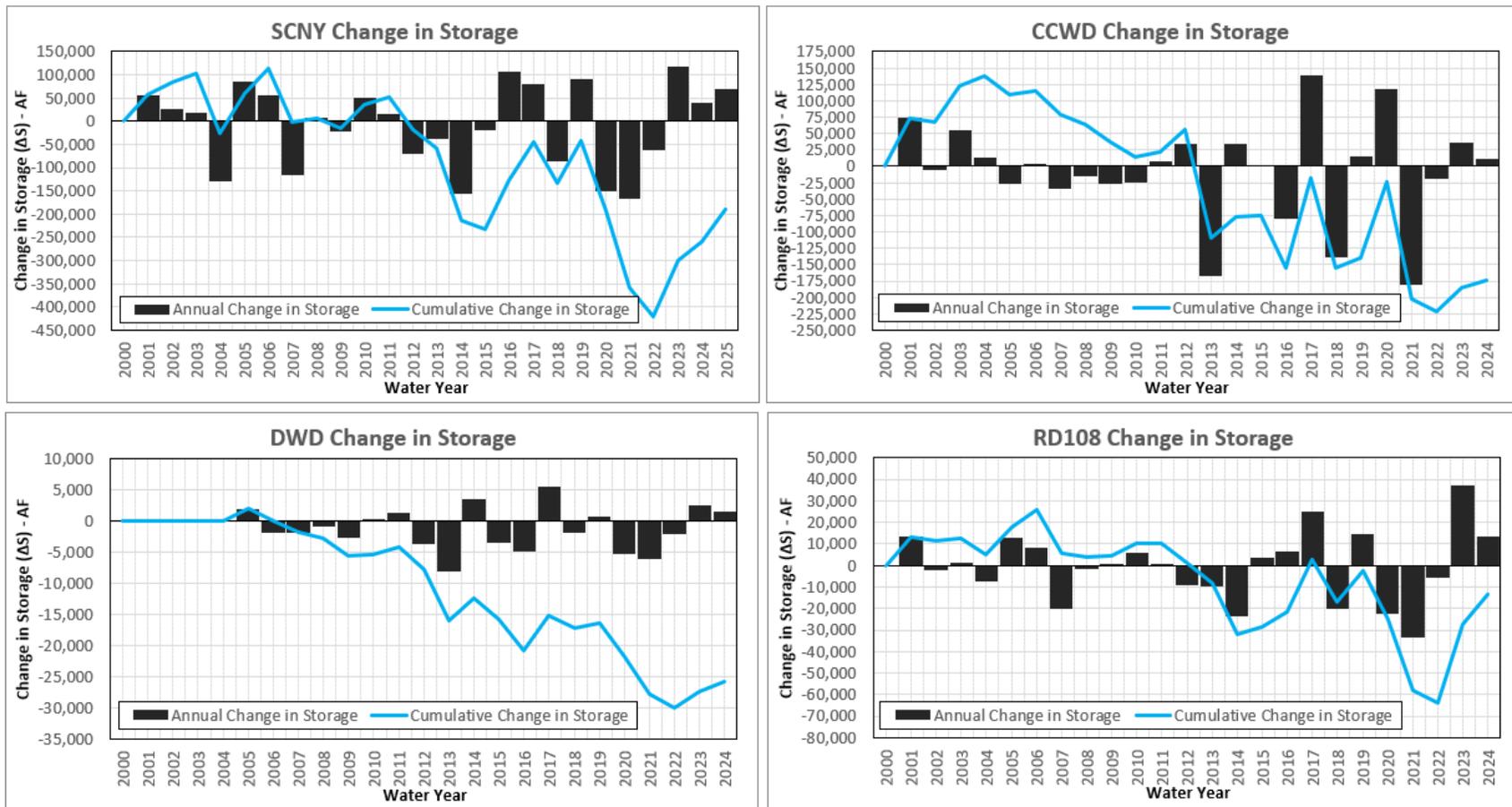
### 2.3.2 Reduction of Groundwater Storage

Storage in the aquifer underlying the Colusa and Yolo Subbasins was relatively stable until 2012. The drought that lasted from 2012 through 2015 reduced storage available in the aquifer. Both the Model and observed well data was used to estimate annual change in storage. The Model shows a downward trend in cumulative change in storage. This downward trend is also indicated by the measured data, as seen in Figure 2-5, which compares cumulative change estimated by the Model to calculations from observed data. Both methods indicate a downward trend and have good agreement in regards to periods of decline, periods of recharge, and overall trend of the line.

The average annual change in storage from the Model and measured data across SCNY from 2005 through 2021 is approximately -15 TAF per year. Cumulative change in storage is also shown for DWD, CCWD, and RD108 in Figure 2-6. Average annual change in storage for these districts from 2005 through 2024 is approximately -2 TAF, -7.5 TAF, and -1 TAF, respectively.



**Figure 2-5. Cumulative change in storage from 2000 to 2021 based on annual changes in storage calculated from (1) the Model and (2) the average water surface elevations as measured from all wells in the Region.**



**Figure 2-6. Annual and cumulative change in storage all of SCNY, as well as Colusa County Water District (CCWD), Dunnigan Water District (DWD), and Reclamation District 108 (RD108). Storage is summed for two periods: 2000 through 2025 (from baseline, pre-SGMA conditions) and 2015 through 2025 (from post-SGMA conditions).**

### 2.3.3 Seawater Intrusion

Seawater intrusion is not applicable to the Region.

### 2.3.4 Degraded Water Quality

Pumping and groundwater recharge influence the flow direction, spread, and concentration of contaminants in the groundwater. Heavy pumping can degrade water quality by drawing in contaminants, mobilizing naturally occurring elements like arsenic, or increasing salinity through upwelling of deeper brackish water. In contrast, recharge can act as a restorative process, not only replenishing aquifers but by diluting existing pollutants. However, the quality of recharge water is vital. Nutrients, pesticides, or pathogens in the recharge water or soil profile of the recharge site can be hazardous to the groundwater quality of the aquifer.

The State Water Resources Control Board (SWRCB) recommended constituents to monitor specific to each groundwater basin in a letter addressed to DWR on November 22, 2022 (see Attachment E). The constituents for the Yolo and Colusa Subbasins per State Board recommendation were Arsenic, Hexavalent Chromium (Cr<sup>6+</sup>), Nitrate, Nitrite, and Total Dissolved Solids (TDS, or salinity). These constituents, along with corresponding Maximum Contaminant Levels (MCLs) and Agricultural Water Quality Goals, are listed in Table 2-1 and discussed individually in the following sections. While other constituents were discussed in the Colusa and Yolo GSPs, they either had low historical concentrations or were being monitored by another program operating in the region and were thusly not prioritized.

**Table 2-1. Constituents that the SWRCB recommended that the Colusa and Yolo Subbasins monitor, associated water quality standards, and historical levels in the Region.**

Contaminate	Units	Drinking Water Standard	Agricultural Water Quality Goal	Maximum Historical Levels
Arsenic	ppb	10	100	28
Hexavalent Chromium	ppb	10	100	40
Nitrite (as N)	ppm	1	N/A	N/A
Nitrate + Nitrite (as N)	ppm	10	N/A	45
Total Dissolved Solids	ppm	500	450	500+

#### 2.3.4.1 Arsenic<sup>2</sup>

Arsenic is a naturally occurring metal and known carcinogen that is commonly found in drinking water sources across California. All observed arsenic concentrations are below the listed MCL (10 ppb). Of the ten sites, only the Stucker Field recharge site was found to have a concentration of arsenic greater than 2 ppb. That site still measured below the MCL for arsenic at 7 ppm.

<sup>2</sup> SWRCB: [https://www.waterboards.ca.gov/drinking\\_water/certlic/drinkingwater/Arsenic.html](https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Arsenic.html)

#### **2.3.4.2 Hexavalent Chromium<sup>3</sup>**

Hexavalent chromium (Cr<sup>6+</sup>) is a heavy metal with industrial applications that occurs naturally in the environment. This form of chromium is known to be carcinogenic and toxic to the liver. Two Cr<sup>6+</sup> exceedances were observed within Dunnigan Water District. All other sites were below the listed MCL (10 ppb). These exceedances, in addition to historical exceedances described in the Colusa and Yolo GSPs throughout the Region, make it clear that additional sampling is needed near the recharge sites especially near the Colusa Basin Drain where these exceedances occurred.

#### **2.3.4.3 Nitrate and Nitrite<sup>4</sup>**

Nitrates are naturally occurring compounds that form when nitrogen and oxygen combine in soil. Small concentrations (~2 ppm) of nitrate in soil are expected, but larger concentrations occur in areas with a high density of septic systems, confined animal feeding operations (CAFO), or agriculture. Many agricultural regions in California, including the SCNY Region, make use of nitrogen-based fertilizers. Normally, nitrogen in the root zone is gradually consumed by plants. In the late fall and winter months, when seasonal crops have been harvested and perennial crops are dormant, excess nitrogen will stay in the root zone. When water infiltrates into bare soil that was previously planted and fertilized, the excess nitrogen is carried with the water out of the root zone and into the aquifer; a process that can be accelerated by deliberate groundwater recharge.

Consistent exposure to nitrite can impact the oxygen-carrying ability of blood. Nitrite and nitrate can cause methemoglobinemia, or blue baby syndrome, in infants. As such, nitrogen contamination of the groundwater supply is a significant concern in ag-dominated areas in California. In the Region, all observed nitrate concentrations at recharge sites were below the listed MCL (10 ppm). Nitrite was not detected at any of the sites.

#### **2.3.4.4 Total Dissolved Solids<sup>5</sup>**

Total Dissolved Solids, or TDS, is a measure of salinity. Salinity can be measured either by TDS concentrations (mg/L or ppm) or by electrical conductivity (µS/cm). Unlike the rest of the contaminants identified by the SWRCB in the Region, high salinity poses a greater threat to crop production than it does to people. MCLs for drinking water are implemented mainly for aesthetic purposes. Certain crops grown in the Region, however, will have their yields impacted if irrigated with water that has high salinity. One TDS exceedance of the MCL was observed at the Stucker House site, but all other locations were below the listed 500 ppm MCL. There were three other sites, however, that were close to the agricultural water quality goal (Stucker Field, Reddington Well, Jenson Domestic). Given salinity's agronomic implications, additional monitoring of TDS at the recharge sites will likely be required to assess the impacts of recharge activities on salinity in the Region.

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<sup>3</sup> SWRCB: [https://www.waterboards.ca.gov/drinking\\_water/certlic/drinkingwater/SWRCBDDW-21-003\\_hexavalent\\_chromium.html](https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/SWRCBDDW-21-003_hexavalent_chromium.html)

<sup>4</sup> SWRCB: [https://www.waterboards.ca.gov/drinking\\_water/certlic/drinkingwater/Nitrate.html](https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Nitrate.html)

<sup>5</sup> SWRCB: [https://www.waterboards.ca.gov/drinking\\_water/certlic/drinkingwater/documents/ddw\\_secondary\\_standards.pdf](https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/ddw_secondary_standards.pdf)

**Table 2-2. Initial water quality measurements sampled near recharge sites on November 11, 2025, for constituents of concern for the Colusa and Yolo Subbasins.**

District / Site	Water Type	Arsenic	Cr <sup>6+</sup>	Nitrate (N)	Nitrite (N)	TDS	Perchlorate
Recharge Site 1	Sac. River	1	0.2	ND	ND	190	ND
DWD Landowner Well 1 <sup>b</sup>	GW	1	<b>10.9</b>	5.2	ND	320	0.8
Bird Creek	Sac. River	1	0.1	ND	ND	190	ND
DWD Landowner Well 2	GW	2	<b>15.9</b>	3.9	ND	<b>510</b>	0.1
Recharge Site 2	Comingled	7	0.4	ND	ND	430	ND
CCWD Landowner Well 1	GW	ND	3.1	3.2	ND	360	0.5
CCWD Landowner Well 2	GW	ND	3	7.4	ND	440	1.3
Salt Creek	Sac. River	1	0.2	ND	ND	170	ND
Elk Creek	Sac. River	1	0.1	ND	ND	180	ND
CCWD Landowner Well 3	GW	ND	1.8	8	ND	440	1.1
	<b>MCL</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>1</b>	<b>500</b>	<b>N/A</b>
	<b>Units</b>	<b>ppb</b>	<b>ppb</b>	<b>ppm</b>	<b>ppm</b>	<b>ppm</b>	<b>ppb</b>

- a. ND = non-detect (concentration was too low to be detected)
- b. Sample collected on November 21, 2025.

### 2.3.5 Land Subsidence

There are two types of land subsidence: elastic subsidence and inelastic subsidence. Elastic subsidence refers to temporary, reversible changes in land surface elevation. When groundwater is pumped from a confined aquifer, pore pressure decreases, increasing effective stress on the soil layer. If the effective stress remains below the preconsolidation stress<sup>6</sup>, the aquifer responds elastically. The soil layer will compress slightly during pumping and rebound when recharge occurs. These fluctuations are relatively small (about ±0.2 feet) and occur seasonally, with compression during dry months with lots of pumping and rebound during wet months with less pumping. Elastic subsidence occurs in small amounts of displacement, is reversible, and does not damage infrastructure or reduce groundwater storage, so it is not a sustainability concern.

Inelastic subsidence, however, is a key sustainability concern, and occurs when effective stress exceeds the preconsolidation stress. Inelastic subsidence can compact soil layers irreversibly, reducing aquifer storage capacity. This compaction can continue even after pumping stops, due to slow pore pressure equilibration in thick clay layers. Historical subsidence in the Sacramento Valley has been linked to groundwater withdrawals from the Tehama Formation, with the

<sup>6</sup>Estimation of preconsolidation stress of clays from piezocone by means of high-quality calibration data (D'Ignazio, M. et al. May 8, 2019): <https://www.aimspress.com/aimspress-data/aimsgeo/2019/2/PDF/geosci-05-02-104.pdf#:~:text=The%20preconsolidation%20stress%20represents%20the%20maximum%20vertical,%CF%83%20is%20the%20present%20vertical%20effective%20stress>.

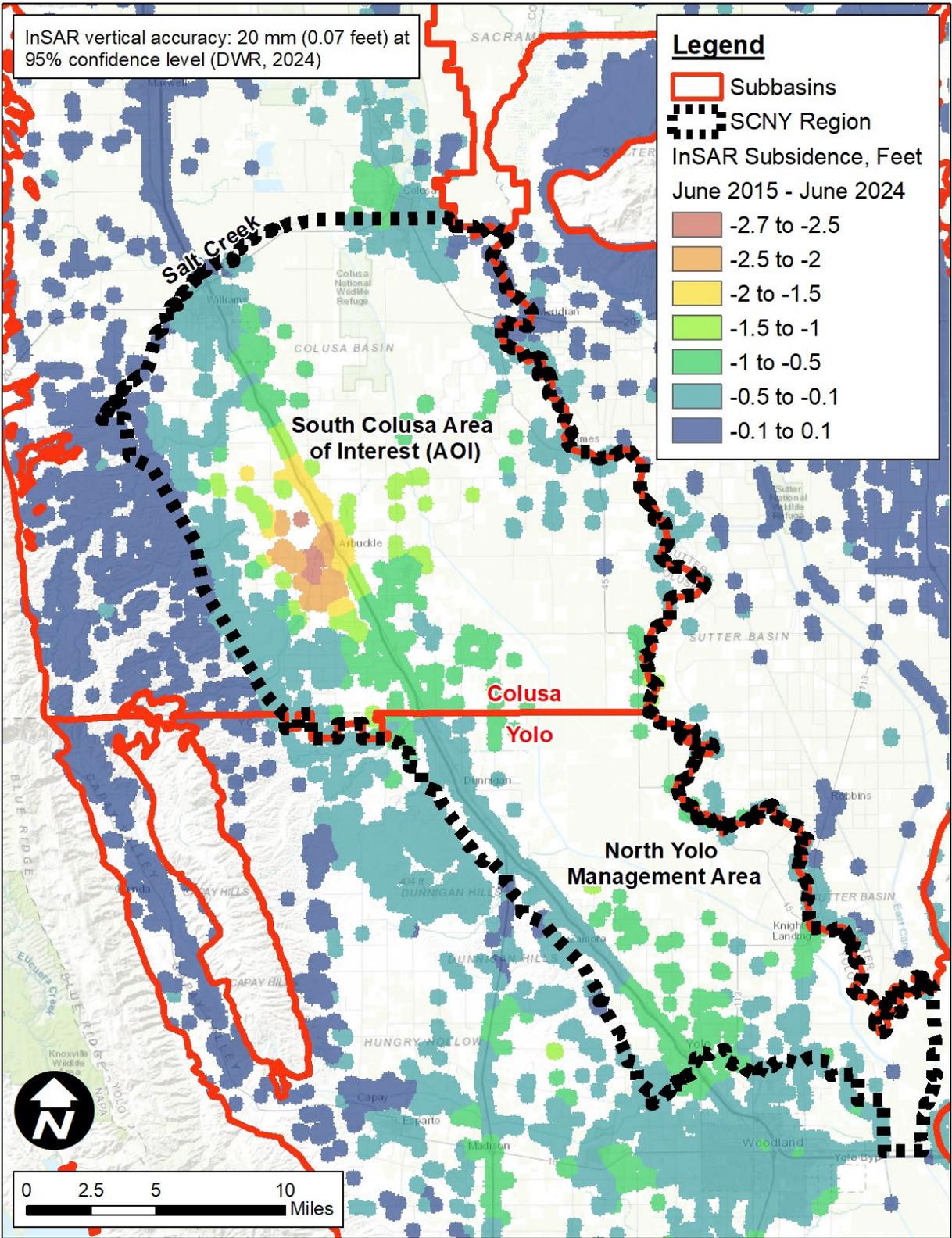
maximum historical subsidence 5.4 feet south of the Tehama-Colusa Canal terminus.<sup>7</sup> The extreme dewatering scenario would not take place in the Region under managed groundwater use, but even a fraction of theoretical maximum subsidence has been shown in other areas to cause millions of dollars in damage to infrastructure.

Monitoring of subsidence in the Region relies on multiple techniques. Benchmark surveys conducted under the Sacramento Valley Height-Modernization Project provide a snapshot of land displacement from pre-SGMA to post-SGMA (2008 to 2017). Interferometric Synthetic Aperture Radar (InSAR) imagery has been used since 2015 to calculate annual subsidence rates across the region. Additionally, extensometers installed throughout Yolo and Colusa counties measure ground surface displacement directly, offering localized insights into subsidence processes. Together, these methods allow the Region to track both elastic fluctuations and cumulative inelastic subsidence and can inform water managers what areas need local recharge projects.

In the Colusa Subbasin, the benchmark survey recorded total subsidence to be greater than 2 feet near Arbuckle across 10 years (2008 to 2017). In the Yolo Subbasin, the same survey recorded total subsidence greater than 1 foot near Zamora and north of Woodland. Figure 2-7 shows cumulative subsidence from 2015 and 2024 recorded by InSAR, where over 2.5 feet of subsidence was recorded west of Arbuckle.

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<sup>7</sup> Land Subsidence from Groundwater Use in California (Borchers, J.W., 1998): [https://cawaterlibrary.net/wp-content/uploads/2017/04/1397858208-SUBSIDENCEFULLREPORT\\_FINAL.pdf](https://cawaterlibrary.net/wp-content/uploads/2017/04/1397858208-SUBSIDENCEFULLREPORT_FINAL.pdf)



**Figure 2-7. Subsidence recorded via InSAR between 2015 and 2024 throughout the SCNY Region.**

### 2.3.6 Depletion of Interconnected Surface Water and Groundwater Dependent Ecosystems

Interconnected surface water (ISW) refers to surface water bodies, such as rivers, streams, and wetlands, that are hydrologically connected to the underlying shallow aquifer through a continuous saturated zone. When surface water is connected to groundwater, groundwater extraction can directly influence surface flows. Under SGMA, managing the depletion of interconnected surface water is essential to avoid undesirable results.

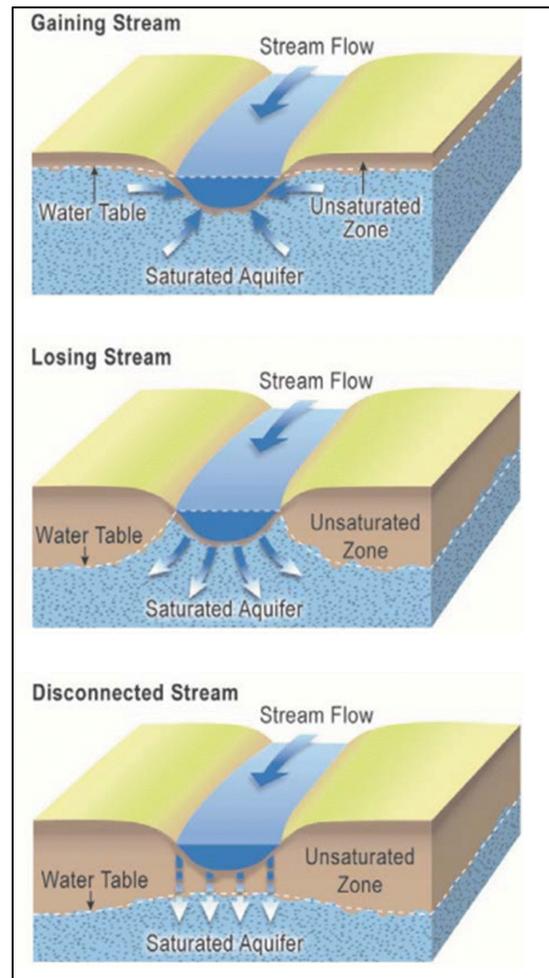
#### 2.3.6.1 Interconnected Surface Water (ISW)

Two major challenges in identifying and managing ISW regard timing and location. The Sacramento River, for instance, is verifiably interconnected with groundwater, but may be gaining or losing depending on the specific reach and time of year. Groundwater pumping during the irrigation season may cause the flow groundwater to slope inward towards the agricultural heart of the Region, causing the stream to be losing. During the wet season, when the shallow aquifer gets a chance to recharge due to the infiltration of precipitation, groundwater levels will rebound and possibly cause the river to be gaining again. Ephemeral streams, or waterways that only temporarily flow during the wet season, are disconnected from the aquifer, and cannot be classified as ISW. Gaining streams, losing streams, and disconnected streams are illustrated in Figure 2-8.

Using the Model, the percentage of time that a modeled reach of a stream can be estimated. Figure 2-9 is a map of the SCNY Region that displays the percentage of time a modeled reach is gaining for Sacramento River, Colusa Basin Drain, and Cache Creek. As anticipated, the Sacramento River is gaining most of the time in most reaches, although the river is curiously only gaining 25% of the time in southern RD108.

Two approaches were used to verify the potential ISW identified by the model:

1. The ICONS<sup>8</sup> dataset, and



**Figure 2-8. Illustration of gaining streams (top), losing streams (middle), and disconnected stream (bottom).**

<sup>8</sup> ICONS: Interconnected Surface Water in the Central Valley (Stanley, C., et al):

<https://www.scienceforconservation.org/products/icons>

## 2. Actual well observations in and around the Region.

ICONS aims to categorize waterways in the Central Valley using average, minimum, and maximum groundwater elevation data from 2011 and 2018. The dataset was developed in partnership with The Nature Conservancy and is designed to support GSAs in identifying ISW and Sustainable Management Criteria for surface water depletion. A screenshot of the Region as seen in the ICONS mapping interface is shown in Figure 2-10, and indicates that the Sacramento River, Colusa Basin Drain, and all minor waterways in between them are connected with the aquifer. The ICONS dataset suggests that the Sacramento River is losing north of Grimes, while the Model suggests that the river is gaining. Both datasets agree that the Sacramento River south of Wilkins Slough could be losing. ICONS shows that most of the unmodeled ephemeral streams that flow into the Colusa Basin Drain are connected or uncertain a few miles upstream of their confluence with the drain.

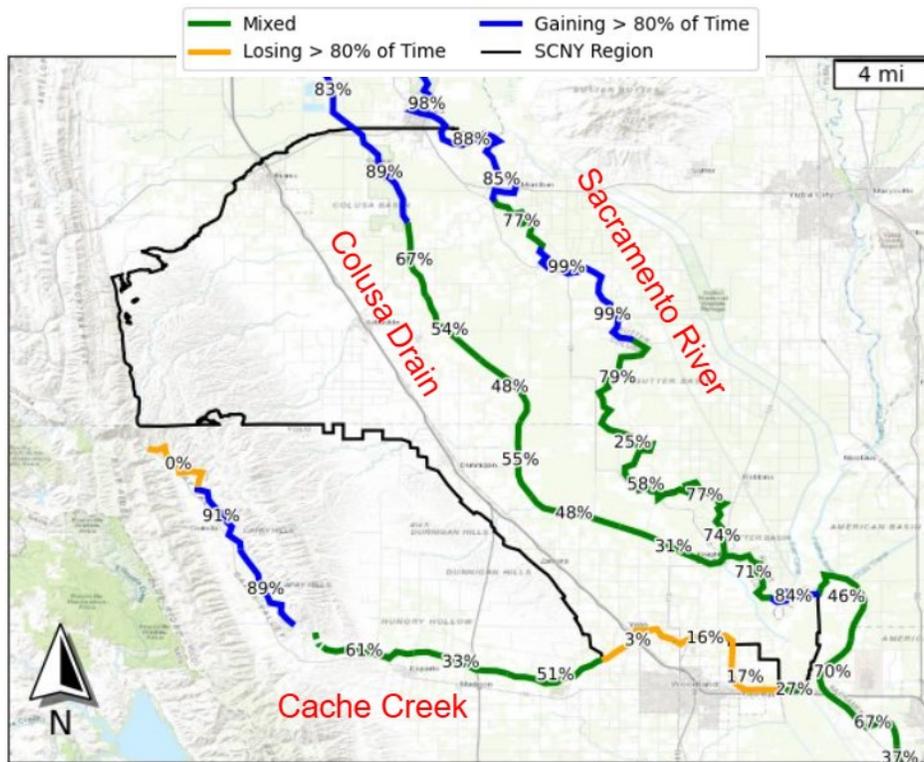
Actual well observations have been used to create an interpolated, regional depth-to-water dataset that was used as a comparison to results from ICONS and the Model. Streams were simplified into a series of points, 1,000 feet apart, and the depth to groundwater was sampled from the interpolated dataset for the following years: 2005 (Figure 2-11), 2015 (Figure 2-12), 2021 (Figure 2-13), and 2022 (Figure 2-14). 2005 was used to establish a pre-drought baseline snapshot of potential ISW in the Region. 2015 was used to establish baseline potential ISW at the passing of SGMA. 2021 and 2022 were investigated as they are considered to be ‘low points’ in terms of groundwater conditions in the Region. This analysis did not attempt to determine if a stream was gaining or losing, merely if it was connected or disconnected. A depth-to-water cutoff of 30 feet was used to distinguish connected stream points (i.e., potential ISW) and disconnected stream points (i.e., not likely ISW).

In 2005, measurements of local wells reveal similar surface water connections as ICONS, with the Sacramento River, Colusa Basin Drain, and ephemeral stream reaches near the drain having a potential connection. In 2015, however, the map changes drastically. Starting just north of RD108, the Colusa Basin Drain and nearby ephemeral streams no longer appears to be connected. There are also a portion of the Sacramento River that appears to be disconnected at roughly the same location that ICONS shows as losing and the Model shows 25-58% gaining. 2021 appears to be the years with least amount of ISW, with the entirety of the Colusa Basin Drain and additional reaches of the Sacramento River within the Region shown as not likely ISW. A slight recovery occurs in 2022, but there is still less ISW than there was in 2015.

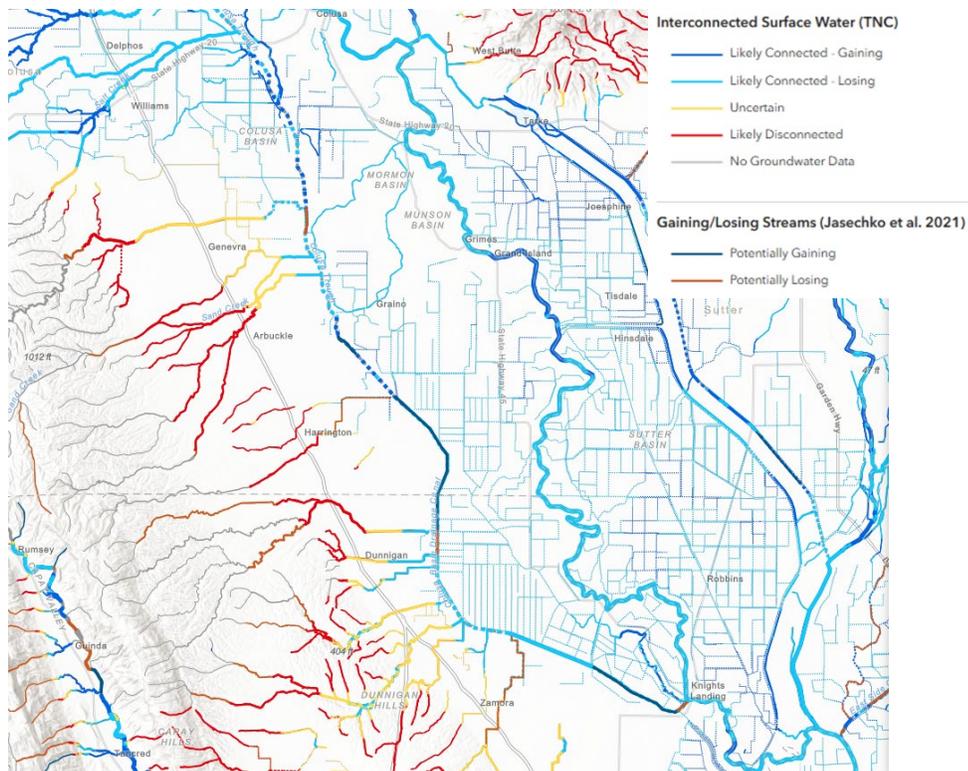
Common threads can be drawn when examining the Model, ICONS, and observed data for ISW:

1. Before the 2007-2010 and 2012-2015 droughts, most if not all, of the Colusa Basin Drain and Sacramento River reaches in the Region could be considered ISW.
2. The Colusa Basin Drain is interconnected, possibly even gaining, when entering the Region from the north, but transitions into a losing or possibly even disconnected stream depending on the time and type of year.
3. The Sacramento River is likely gaining when entering and in the northern half of the Region, but transitions into a losing stream or possibly even disconnected stream around the Wilkins Slough outlet depending on the time and type of year. South of RD108, all sources point to the river transitioning back into confidently being ISW, although it is difficult to tell if it is primarily gaining or losing.

4. While the ephemeral streams that flow from the western foothills may be ISW near their confluence with the Colusa Basin Drain, all datasets suggest that are disconnected near the Tehama-Colusa Canal and western boundary of the Region.



**Figure 2-9. Map of major waterways in the Region. Stream reach colors indicate the percentage of time the reach is gaining according to the Model between 2005 to 2021.**



**Figure 2-10. Screenshot of ICONS ISW web map.**

### **2.3.6.2 Groundwater Dependent Ecosystems**

Groundwater dependent ecosystems (GDEs), according to GSP regulations, are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. In order to start managing GDEs, however, patches of vegetation throughout the Region must first be classified as either possibly being groundwater dependent or not. The Natural Communities Commonly Associated with Groundwater (NCCAG) dataset, developed by a working group comprised of DWR, the California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC), and has been described by DWR as a useful starting point to help GSAs and other agencies identify GDEs<sup>9</sup>.

The NCAAG dataset consists of polygonal patches of vegetation across California that have been assigned a dominant, possibly groundwater dependent species of plant. The centroids of these polygons were used to sample from the interpolated depth-to-water dataset discussed previously. The depth-to-water was then compared to an assumed rooting depth to determine if the dominant species at the polygon have access to surface water. Sources for rooting depths were compiled using The Nature Conservancy's Plant Rooting Depth Database<sup>10</sup>. Figure 2-15 shows the vegetation type of each NCCAG polygon centroid and includes a table that shows the rooting depth used for each vegetation type. The types of native vegetation that characterize the Region will be discussed in more detail in Section 3.2.3.

Depth-to-water for each NCCAG polygon centroid was determined for 2005 (Figure 2-16), 2015 (Figure 2-17), and 2022 (Figure 2-18). In 2005, potential GDEs were found along the Sacramento River, along the Colusa Basin Drain, and just south of DWD. In 2015, the only potential GDEs that could be flagged were mainly along the Sacramento River, with 2022 only further reducing the number of potential GDEs. Note that vegetation found along stream banks likely depends on the steady flow of surface water and not groundwater. If 2015 conditions were to be treated as the regulatory baseline, then only select stands of Valley Oak in the eastern half of the region would qualify as GDEs. Recharge activities are expected to have limited benefit for GDEs as most the GDEs in NCCAG dataset likely rely on stored soil moisture and / or surface water.

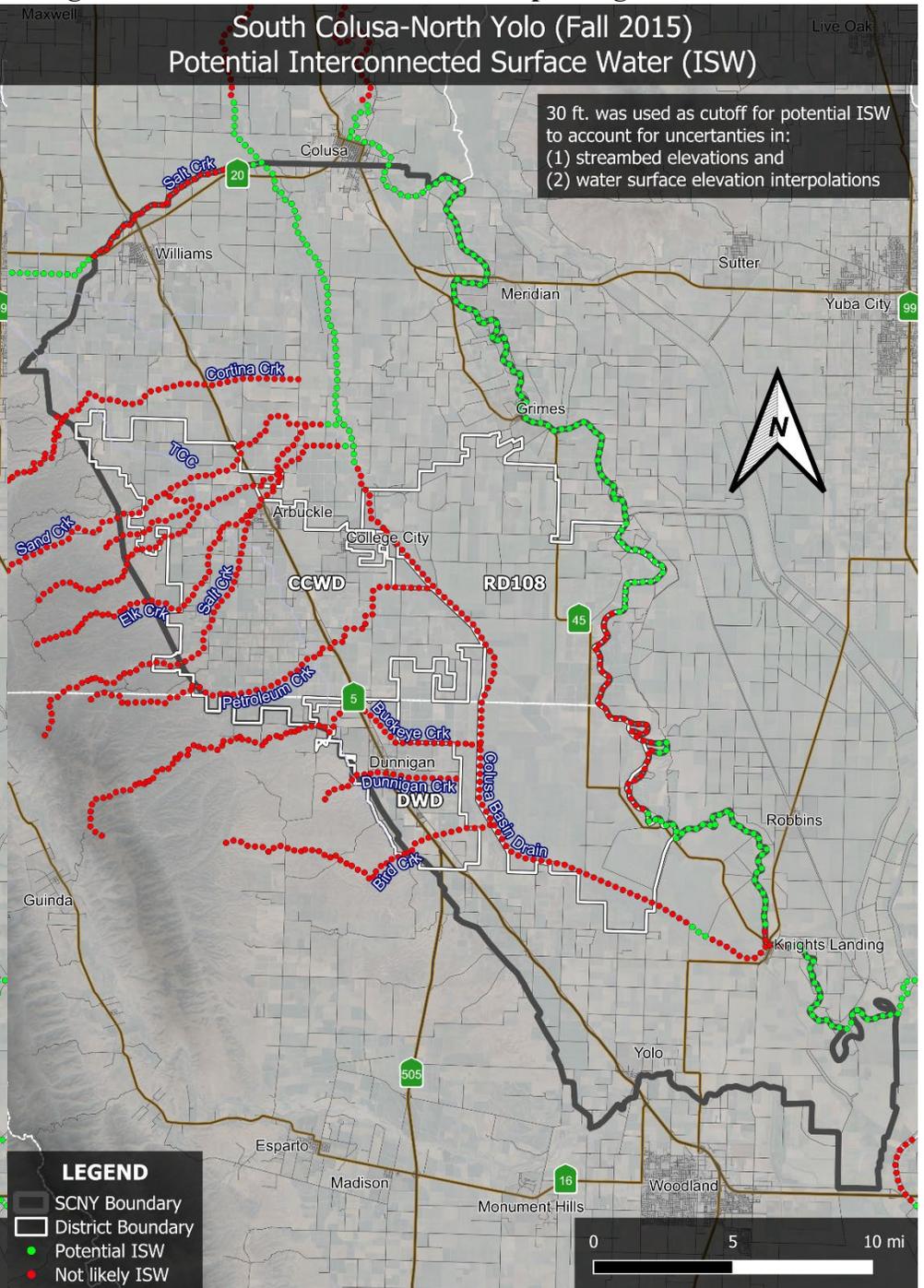
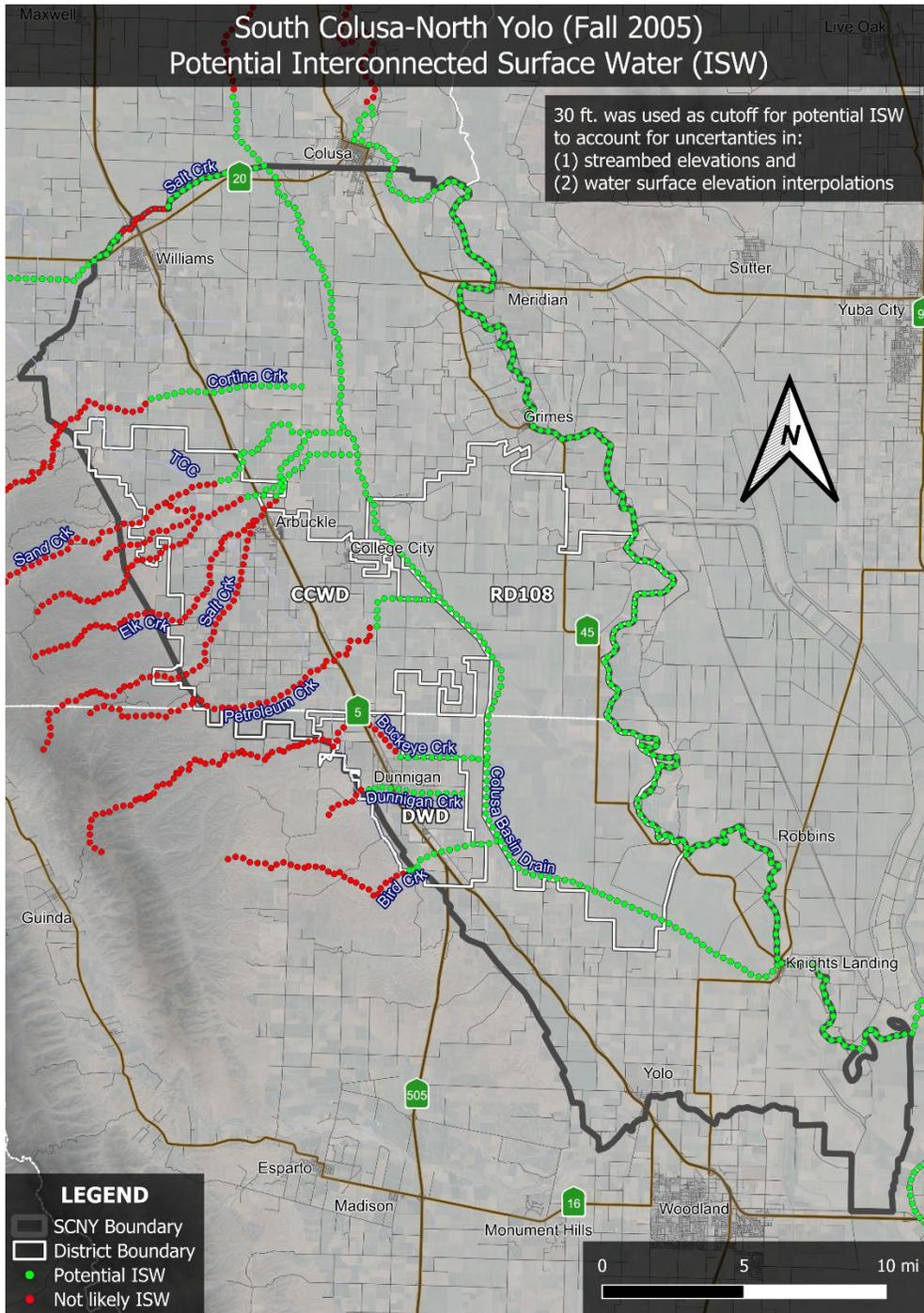
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<sup>9</sup> Natural Communities Commonly Associated with Groundwater (DWR): <https://data.ca.gov/dataset/natural-communities-commonly-associated-with-groundwater>

<sup>10</sup> Plant Rooting Depth Database (TNC): <https://www.groundwaterresourcehub.org/where-we-work/california/plant-rooting-depth-database/>

Figure 2-11. Potential ISW based on depth to groundwater in 2005.

Figure 2-12. Potential ISW based on depth to groundwater in 2015.



**Figure 2-13. Potential ISW based on depth to groundwater in 2021.**

**Figure 2-14. Potential ISW based on depth to groundwater in 2022.**

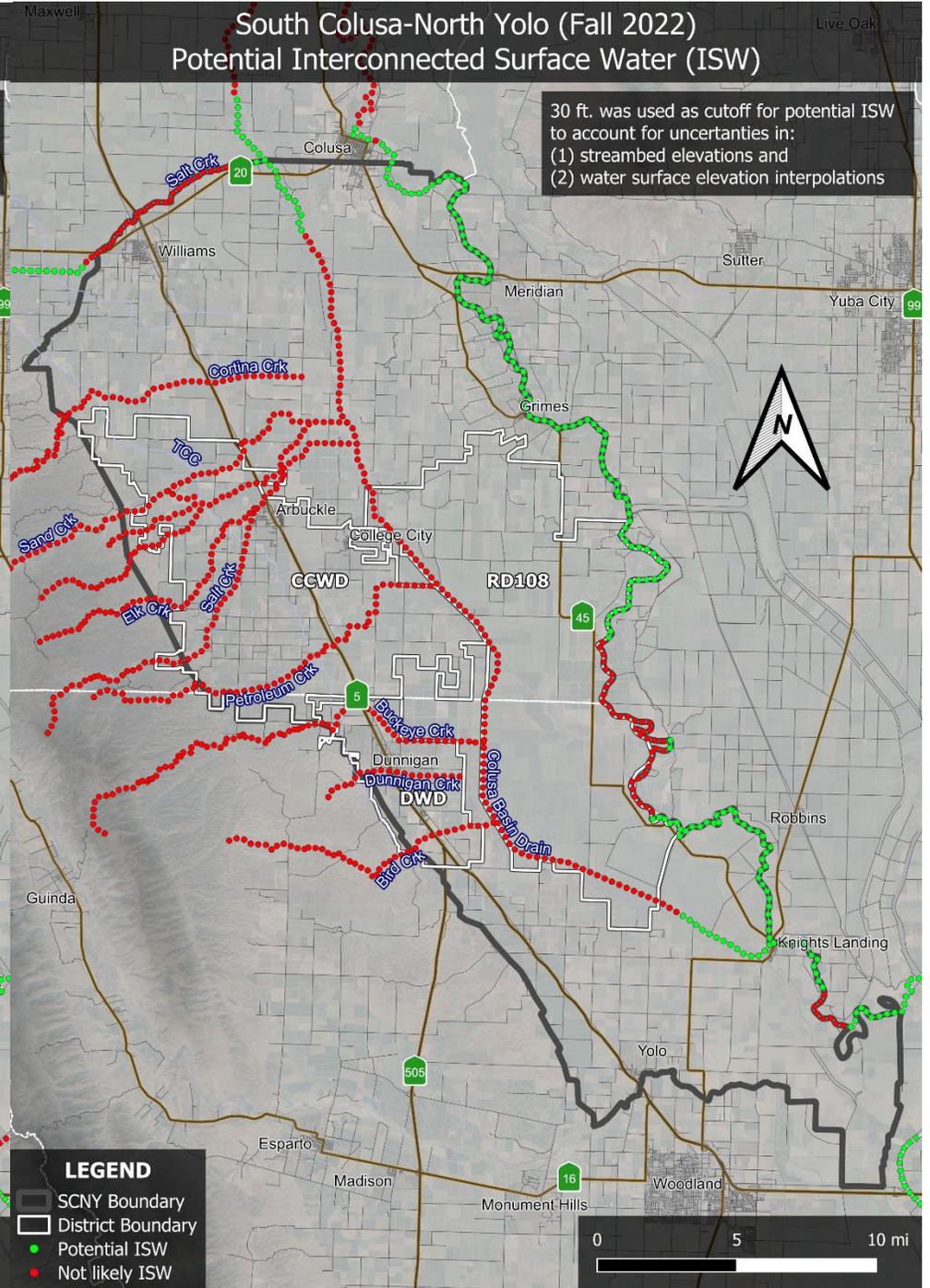
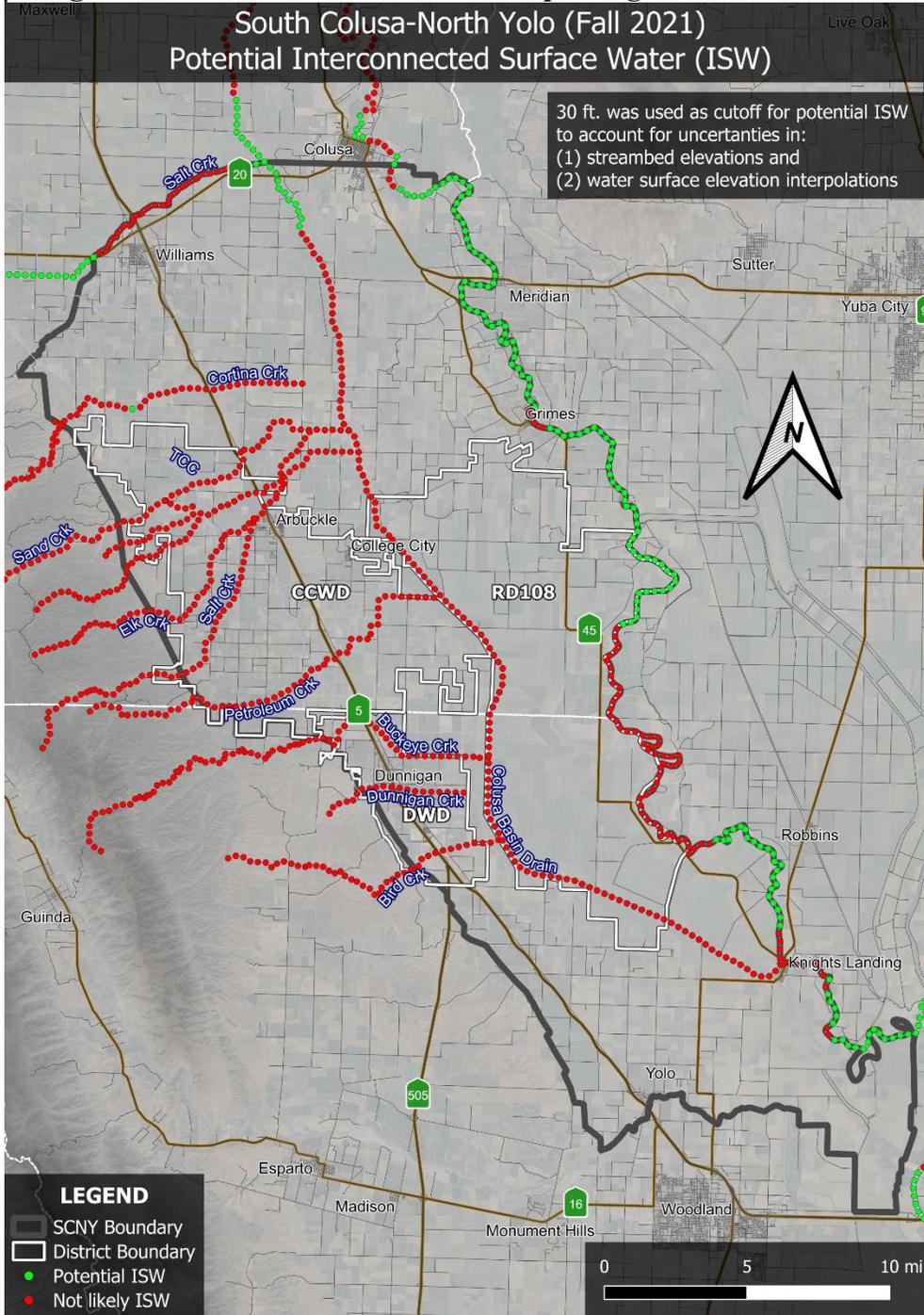


Figure 2-13. Map of vegetation types for potential GDEs.

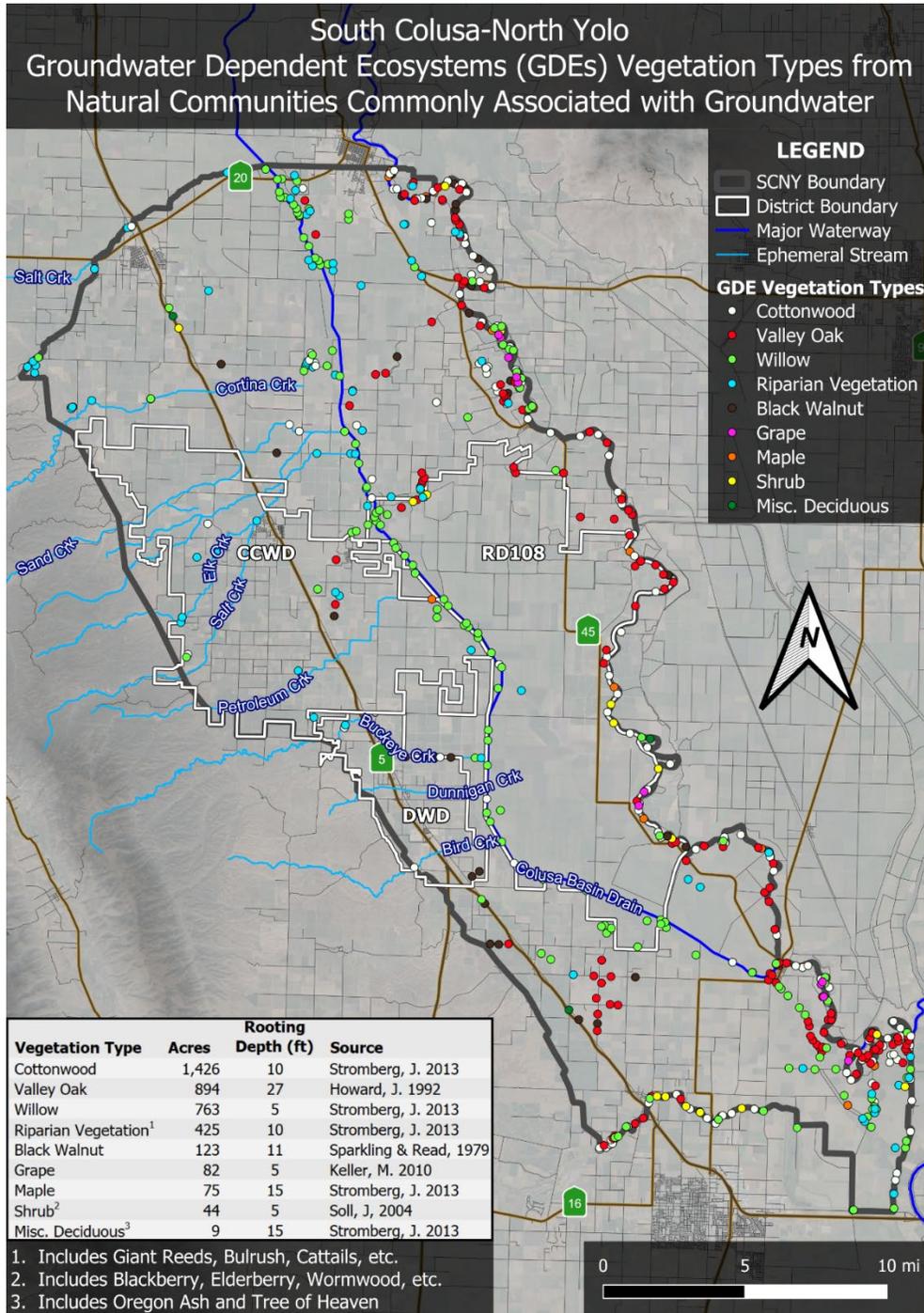


Figure 2-14. Potential GDEs based on depth to groundwater in 2005.

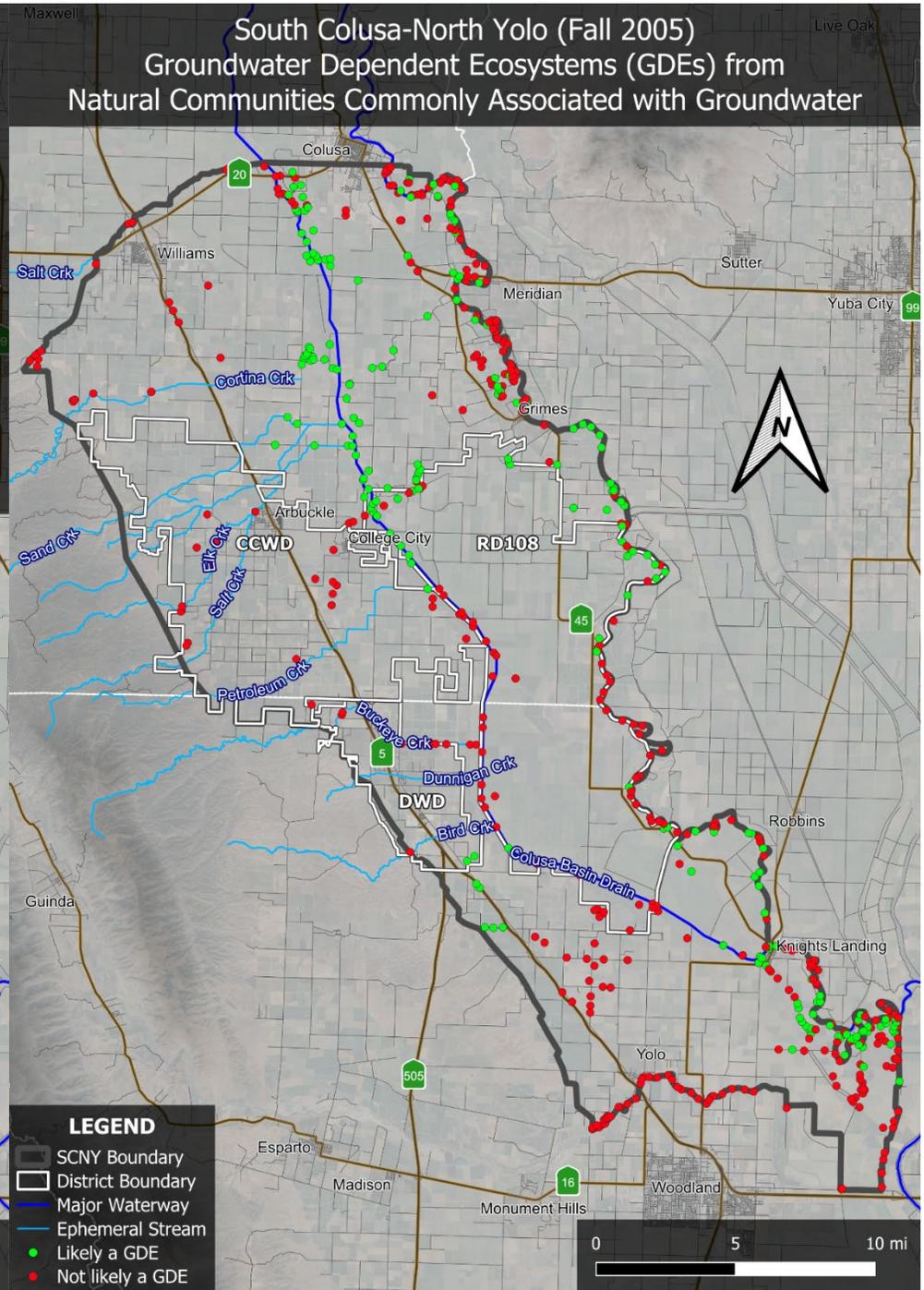
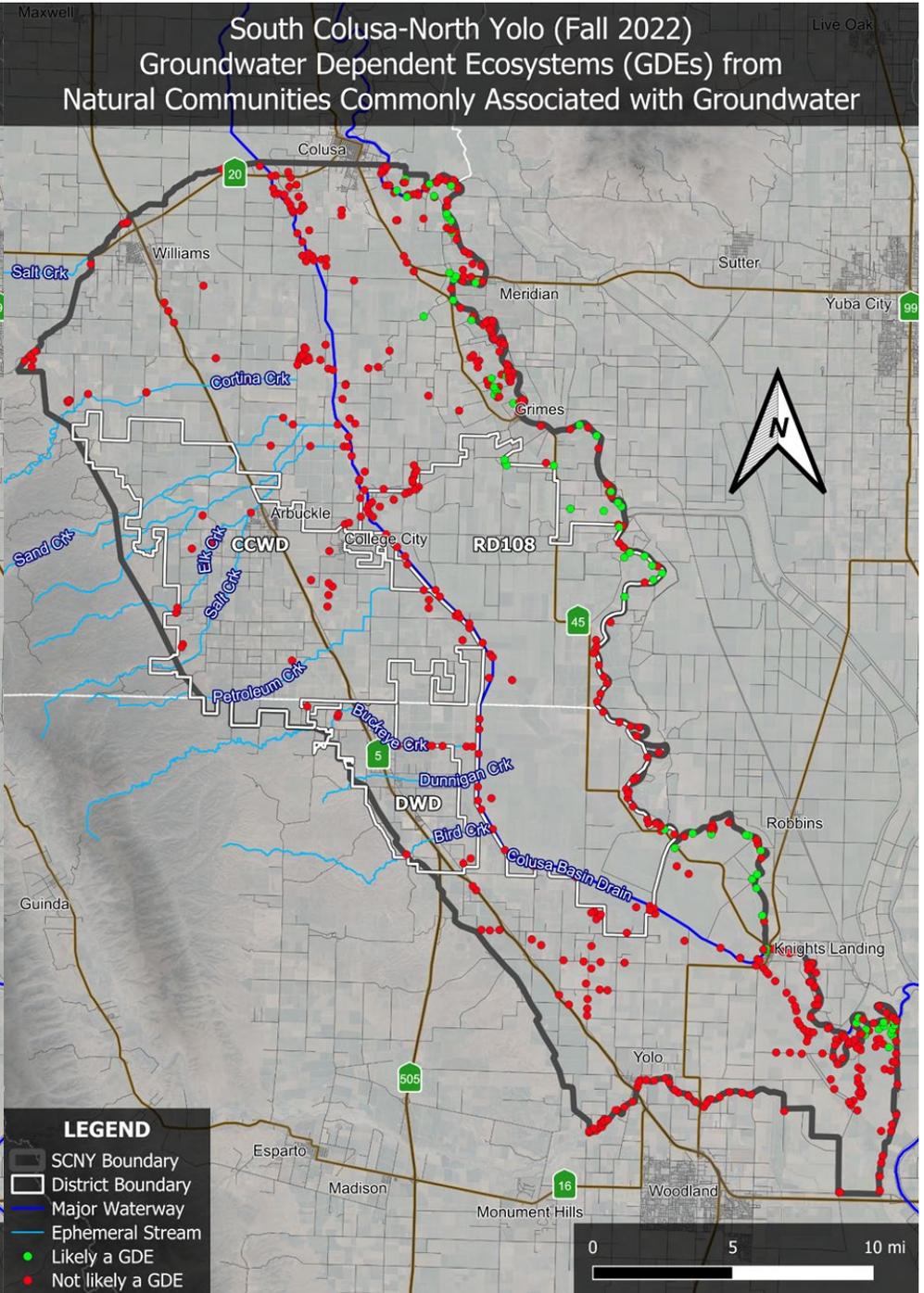
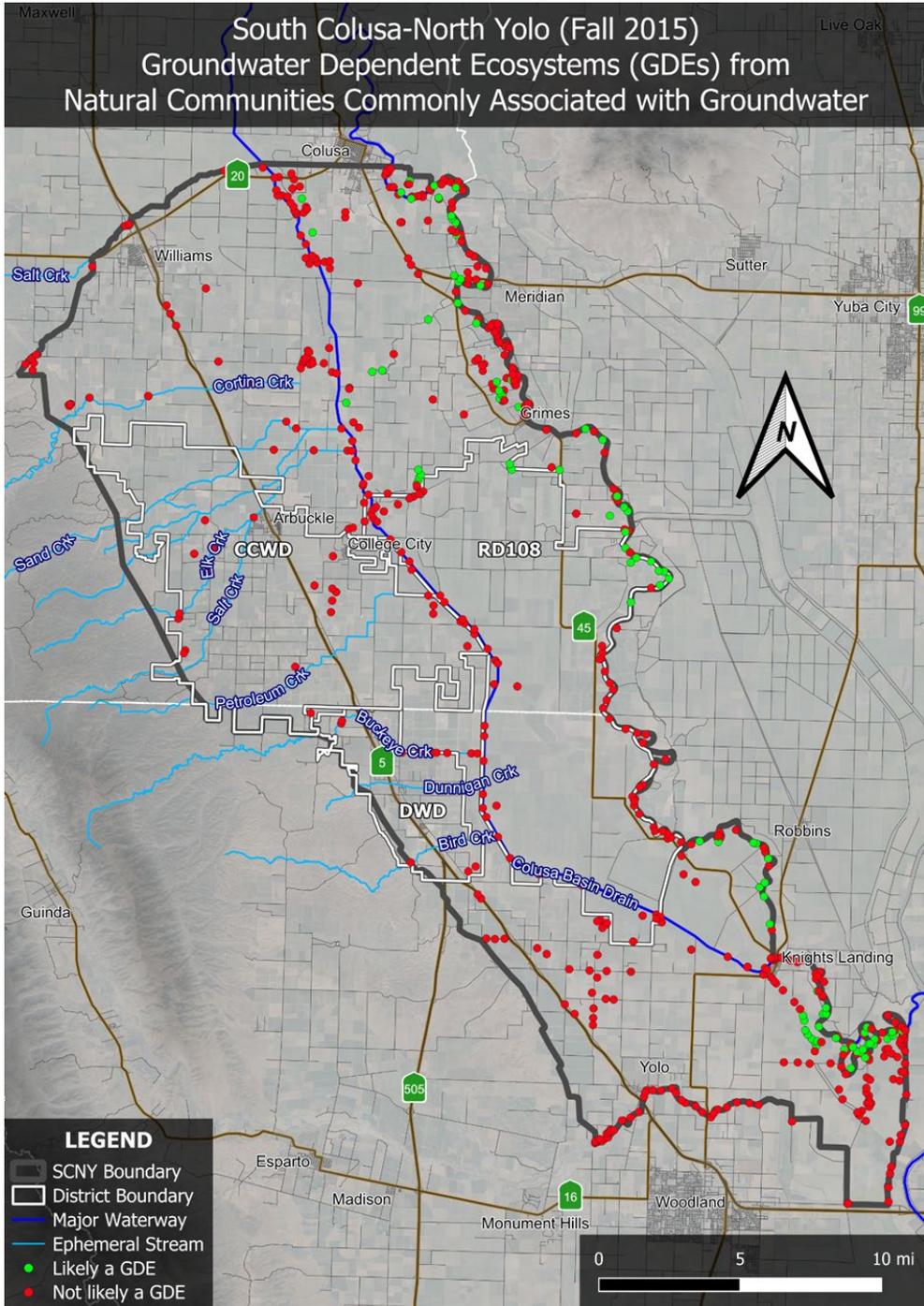


Figure 2-15. Potential GDEs based on depth to groundwater in 2015.

Figure 2-16. Potential GDEs based on depth to groundwater in 2022.



## 3 LAND AND WATER USE

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This section describes existing land and water use in the Region.

### 3.1 Overview

The primary use of both land and water in the Region is for agriculture. Of the 340,000 acres of land in the Region, nearly 240,000 acres (or ~70%) are covered by cultivated land. Three major waterways route water into and throughout the Region. On the west side of the Region, the Tehama-Colusa Canal conveys Sacramento River water from the diversion in Red Bluff to CCWD and DWD, terminating near the bottom of DWD. The Sacramento River forms the eastern boundary of the Region, providing irrigation water to RD108. The Colusa Basin Drain flows through the center of the Region, which CDMWC also reclaims water from. Ephemeral streams flow out of the foothills into the west side of the Region, feeding into the Colusa Basin Drain and ultimately the Sacramento River. The Sacramento River and Colusa Basin Drain serve as the major surface water outlets for the Region.

### 3.2 Existing Land Use

The California Department of Water Resources conducts an annual survey of agricultural land use across the state, the most recently published land use dataset was released for 2023.<sup>11</sup> Land use classified by delineated fields, and this land use coverage by field for the Region can be seen in Figure 3-1.

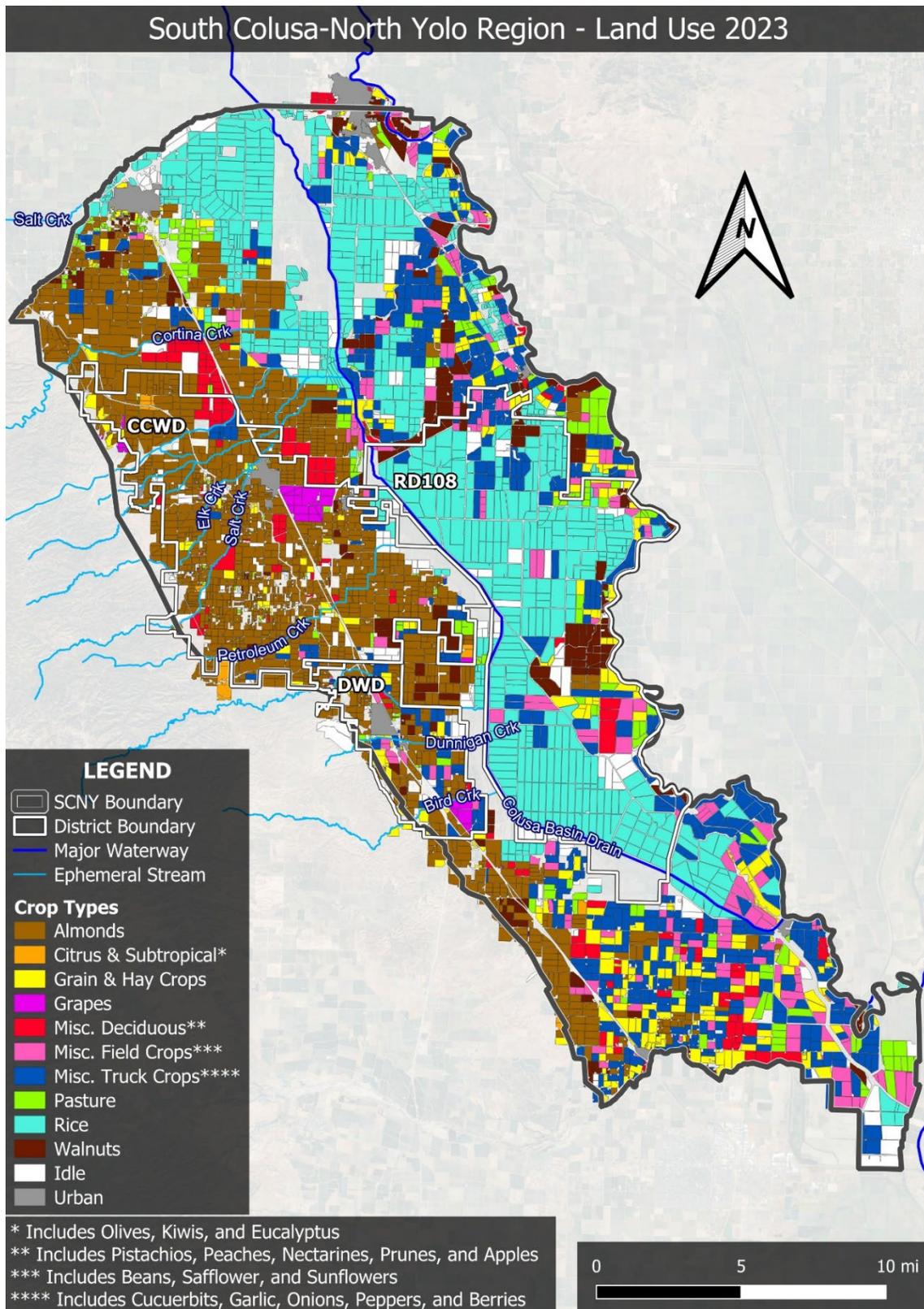
#### 3.2.1 Agriculture

Table 3-1 summarizes the land use of the Region, including subareas CCWD, DWD, and RD108, by acreage using DWR's 2023 statewide crop coverage. Almonds and rice are the dominant crops of the Region, equating to over half of the cropped acreage. Other crops include (from highest to lowest in total acreage) grains, hays, walnuts, pastureland, pistachios, cucurbits, sunflowers, grapes, beans, safflower, olives, and peppers.

Most rice can be found in the eastern half of the Region where clay soils are more suitable for growing rice, and most of the almonds are in the western half. Almonds account for over 30,000 acres within CCWD and DWD, two water districts in the west. RD108, bordered by the Colusa Basin Drain and Sacramento River, has senior water rights providing more reliable access to surface water. RD108 has over 30,000 acres of rice within its 45,000-acre service area, with less than 500 acres of almonds. The southern-most portion of the Region with heavy reliance on groundwater is the most diverse. This area has various miscellaneous hay, grain, deciduous, field, and truck crops occupying the landscape. The differences in land and water use necessitate a precise approach in executing a recharge program. Areas most suitable for recharge is on the west side of the Region.

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<sup>11</sup> DWR land use surveys: <https://water.ca.gov/programs/water-use-and-efficiency/land-and-water-use/land-use-surveys> (accessed October 2025)



**Figure 3-1. Land use map of the SCNY Region.**

**Table 3-1. Acreages of crop types across the entire Region, also broken down by water district service areas.**

Crop Type	SCNY Region		Colusa County W.D.		Dunnigan W.D.		R.D. 108	
	Field Count	Cropped Acreage	Field Count	Cropped Acreage	Field Count	Cropped Acreage	Field Count	Cropped Acreage
Almonds	1,869	63,829	1,035	28,038	163	5,067	4	297
Citrus & Subtropical	35	980	20	390	3	3	0	0
Grain & Hay Crops	373	15,038	51	1,179	32	900	41	2,018
Grapes	37	1,699	22	1,182	6	417	0	0
Misc. Deciduous	183	8,840	52	1,588	7	148	4	759
Misc. Field Crops	205	12,554	6	251	10	479	33	2,530
Misc. Truck Crops	697	37,579	45	1,590	51	1,763	86	5,889
Pasture	259	9,368	35	450	11	202	24	1,178
Rice	760	61,372	3	200	0	0	266	30,766
Walnuts	290	12,111	30	796	12	298	65	3,561
Idle	460	14,476	155	2,510	30	678	42	2,956
<b>Totals</b>	<b>5,168</b>	<b>237,844</b>	<b>1,454</b>	<b>38,176</b>	<b>325</b>	<b>9,954</b>	<b>565</b>	<b>49,954</b>

### 3.2.2 Urban and Residential Areas

Across the entirety of the Region, only 4,090 acres are occupied by urban landscapes. The largest urban areas in the Region are Arbuckle, College City, Dunnigan, Grimes, Knights Landing, and Williams. The City of Colusa also straddles the northern boundary of the Region.

### 3.2.3 Native Vegetation and Sensitive Species

Outside of agricultural and the small amount of urban and residential land, the remaining ~30% of land consists of wetlands, waterways, and various native vegetation. With the many waterways routed through the region, much of the native vegetation is riparian, consisting of bulrush, cattail, reeds, and shallow-rooted shrubs and trees.

As discussed in section 2.3.6., the NCCAG dataset identifies vegetation types in the Region that may be groundwater-dependent, and thus, sensitive to groundwater level decline. While many of the species of vegetation present require additional verification and context-specific information to properly identify as a GDE, there is one type of deep-rooted tree present in the Region that has widely been identified to be sensitive to groundwater decline: *Quercus Lobata*, or the Valley Oak.

Nearly 900 acres of Valley Oak-dominated native landscape can be found in the Region according to the NCAAG dataset. Valley Oaks are endemic to California, ubiquitous in valleys and foothills across the state, deciduous, and long-lived, with the oldest known specimens having lived up to 600 years. As mentioned previously, Valley Oaks are deep rooted trees, typically having a rooting depth around 27 feet. In some cases, the taproot of the Valley Oak can grow more than 50 feet deep. Groundwater decline poses a significant ecological threat to native areas dominated by Valley Oak.

### **3.3 Existing Water Use**

The Region uses a combination of groundwater pumping and surface water diversions for agriculture.

#### **3.3.1 Surface Water Use**

The two major surface water suppliers of the Region are the Sacramento River Settlement Contractors (SRSC) and the Tehama-Colusa Canal Authority (TCCA).

##### **3.3.1.1 Sacramento River Settlement Contractors**

The SRSC is a non-profit partnership of over 100 water purveyors, both agricultural and municipal, that hold senior water rights along the Sacramento River that predate the Central Valley Project (CVP).<sup>12</sup> The group was established with US Bureau of Reclamation to properly budget how much water these senior rights holders can divert from the Sacramento River, and the SRSC continues to protect members' water rights to this day.

RD108, one of the largest SRSC accounting for approximately 25% of the SCNY Region, diverts over 160 TAF of surface water every year from the Sacramento River. According to the Sacramento Valley Regional Water Management Plan, RD108 has deployed water conservation methods including reuse of approximately 60 TAF per year of tailwater to minimize diversions from the Sacramento River. This leaves excess surface water available to meet other demands. In-basin transfers can allow for excess SRSC supplies to be transferred within the Region.

##### **3.3.1.2 Tehama-Colusa Canal Authority**

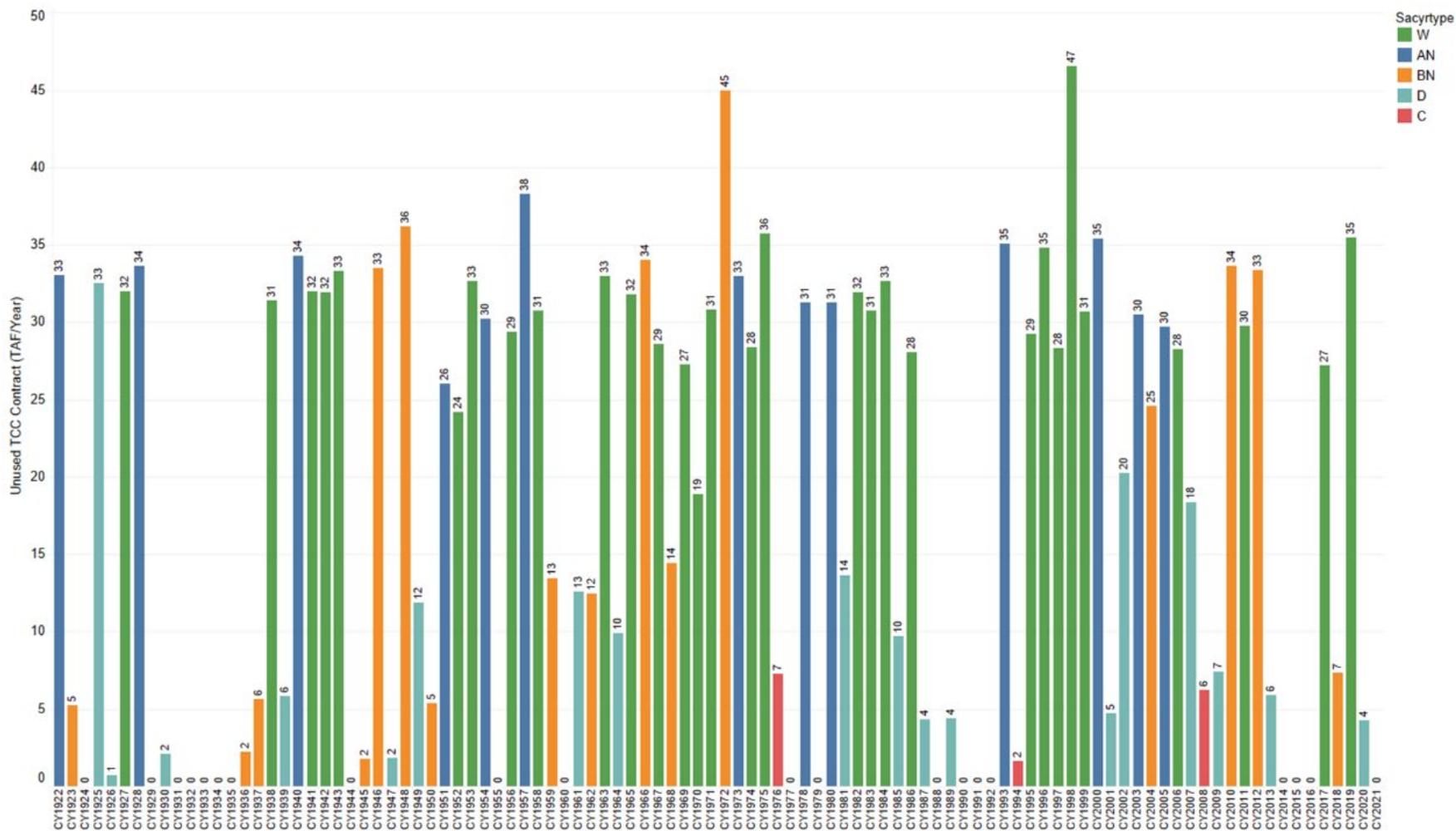
The Tehama-Colusa Canal (TCC) was authorized for construction under the Sacramento Canals Unit of the CVP in 1950. Upon its completion in 1980, the TCC was built to divert over 2,500 CFS of water from the Sacramento River just south of Red Bluff and convey it 111 miles through Tehama, Glenn, Colusa, and Yolo counties. The TCCA is a Joint Powers Authority that is comprised of and provides water services to 17 water districts.<sup>13</sup> The second and third-largest water districts fully contained within the boundaries of the SCNY Region, CCWD and DWD, are both members of the TCCA. CCWD and DWD deliver over 50 TAF and 10 TAF of agricultural surface water supplies to growers in most years, respectively.

The TCCA, unlike the SRSC, frequently receives reduced surface water allocation during dry and critically dry years in the Sacramento Valley, meaning that CCWD, DWD, and all other water districts in the TCCA receive partial or no surface water. Figure 3-2 shows that TCCA water districts leave between 19 and 47 TAF of allocated surface water supplies unused in wet and above normal years.

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<sup>12</sup> Sacramento River Settlement Contractors: <https://sacvalleywater.org/>

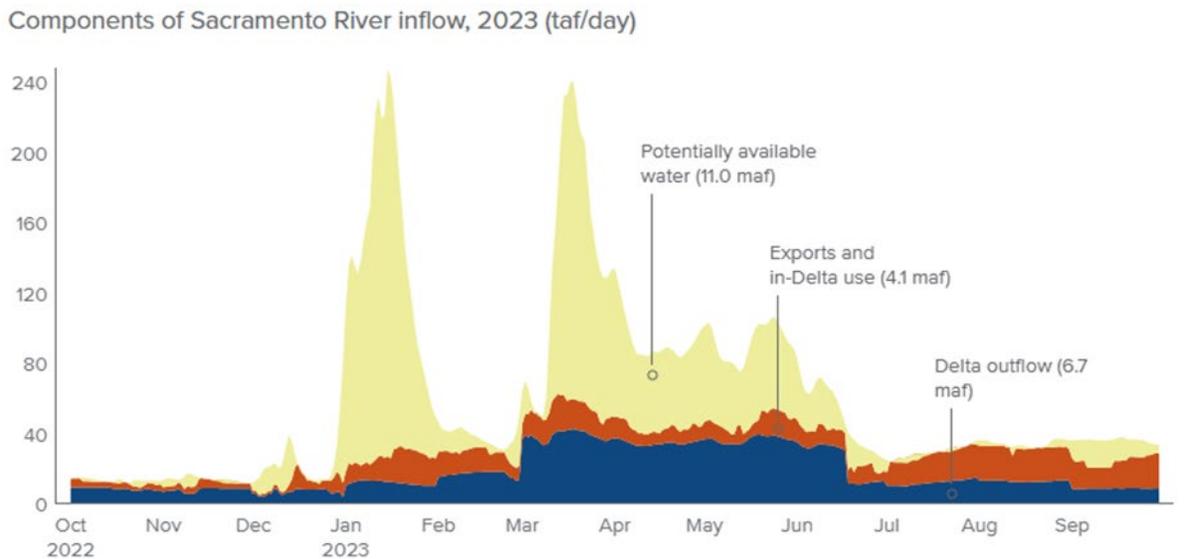
<sup>13</sup> Tehama Colusa Canal Authority: <https://www.tccanal.com/>



**Figure 3-2. Sum of unused TCC contract water (TAF/year) for each CY. Color of bars indicates the Sacramento Valley water year type (obtained from MBK Engineers).**

### 3.3.2 PPIC Sacramento Valley Recharge Potential

The Sacramento River Basin shows great potential for implementing recharge. In 2025, the Public Policy Institute of California (PPIC) published a study that found that roughly 11 MAF of water from the Sacramento River Basin could have been available for recharge in 2023.<sup>14</sup> Figure 3-3 shows the daily flow volume of the Sacramento River in 2023 and highlights delta outflow requirements (blue), combined exports and in-Delta use (orange), and excess water in the Delta (yellow). The plot illustrates just how much water is available during California’s wet winters and springs. Both the PPIC study and data released by the SRSC and TCCA indicate that there is sufficient surface water to address overdraft in the Region estimated to be approximately 20 TAF per year.



**Figure 3-3. Water potentially available for recharge from the Sacramento River surged during winter and spring storms in 2023. This figure was created by authors of “How Much Water Is Available for Groundwater Recharge in the Central Valley?” and was developed using data from the DWR Dayflow Program.**

### 3.3.3 Groundwater

Groundwater use consists of agricultural, municipal, and domestic pumping, and varies widely from year to year depending on surface water availability. Unlike surface water diversions off major waterways, total groundwater extraction is not consistently monitored or measured across all entities in the Region.

#### 3.3.3.1 Agricultural Pumping

Pumping that occurs within the service areas of the Region’s water districts is typically dependent on how wet the water year was. For example, RD108 will pump groundwater to meet demands for

<sup>14</sup> How Much Water Is Available for Groundwater Recharge in the Central Valley? (Hanak, E. et al, 2025): [https://www.ppic.org/publication/how-much-water-is-available-for-groundwater-recharge-in-the-central-valley/?utm\\_source=ppic&utm\\_medium=email&utm\\_campaign=epub](https://www.ppic.org/publication/how-much-water-is-available-for-groundwater-recharge-in-the-central-valley/?utm_source=ppic&utm_medium=email&utm_campaign=epub)

their growers under surface water curtailments but may not pump any groundwater in wet years. Landowners in TCCA districts, in critical years when the district's allocation is reduced, are forced to either pump groundwater, transfer water from another district, or fallow their land. Some districts own water supply wells where they directly monitor pumping volumes, but pumping by individual landowners in the district is more difficult to track.

Much of the groundwater pumping, however, occurs in “white areas”, or swathes of agricultural land that are not inside the sphere of influence of any agricultural water purveyor. Since landowners in white areas do not have access to surface water, they are forced to rely on groundwater. The amount of pumping that occurs in white areas is more consistent than inside of water districts, and is only reduced in wetter years with high amounts of effective rainfall during the irrigation season.

### **3.3.3.2 Municipal and Domestic Pumping**

Residents in the Dunnigan area (and other rural communities within SCNY) rely on groundwater for their water supply. A public supply system operated and maintained by California American Water supplies some residents within Dunnigan. Additionally, there are approximately 207 domestic wells in the Dunnigan area, of which 19 (or 9%) were susceptible to going dry in the 2021/22 drought. Domestic and public supply well depths range from approximately 100 feet to over 700 feet. Domestic wells susceptible of going dry generally range from approximately 100 feet deep to 200 feet deep. Figure 3-4 shows domestic wells across the SCNY region.

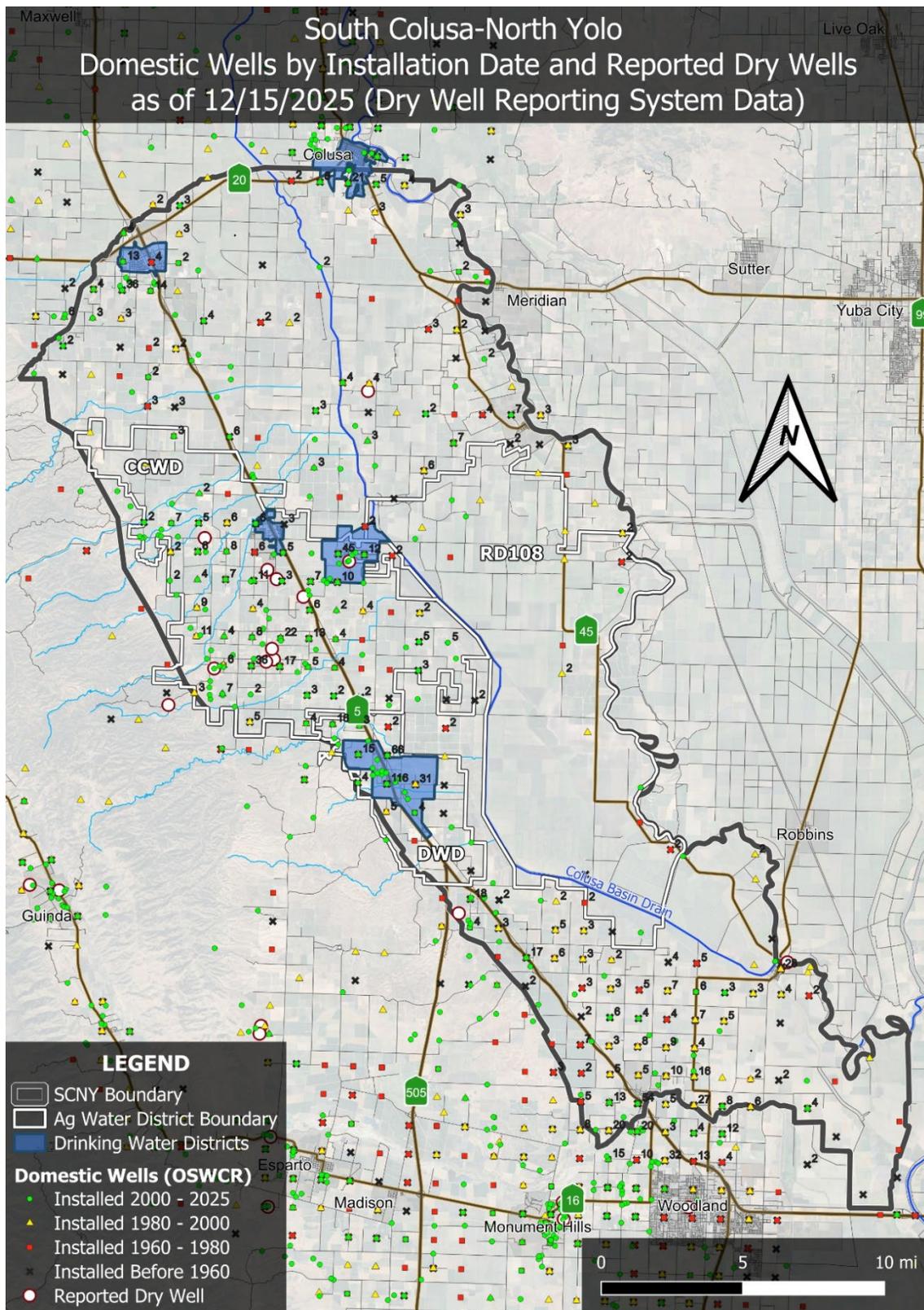


Figure 3-4. Domestic wells by installation date. Numbers indicate number of wells in cluster.

## **4 RECHARGE METHODS**

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This section summarizes the recharge methods that were considered for implementation in Dunnigan Water District.

### **4.1 Overview**

Direct recharge is the application of water onto land with the goal of allowing the water to infiltrate into the ground. Direct recharge is a part of the water cycle and occurs naturally when rain falls onto barren soil. Land can be prepared and/or engineered in a way to artificially increase direct recharge, and surplus water supplies from reservoirs and waterways can be used in addition to rainfall to enhance recharge.

In-lieu recharge is a groundwater management practice where surface water is delivered to users who normally rely on pumping groundwater for irrigation or drinking water purposes. Granting access to surface water to previously groundwater-only premises both reduces strain on the aquifer when surface water supplies are plentiful and allows for operational flexibility.

#### **4.1.1 Direct Recharge – Ephemeral Stream Trickle Flow**

Ephemeral stream trickle flow recharge infiltrates excess surface water in dry ephemeral streambeds mimicking the natural recharge when streams are flowing. This method provides direct recharge to the uppermost unconfined aquifer and likely benefits uses/users of shallow groundwater, including domestic wells and interconnected surface water. This method does not require land to be repurposed for recharge.

#### **4.1.2 Direct Recharge – Spreading Basins**

Spreading basins, also called recharge basins or infiltration basins, are designed to hold water and facilitate groundwater recharge. Spreading basins provide direct recharge to the uppermost unconfined aquifer. Strategic placement of spreading basins can provide benefits to beneficial uses/users of shallow groundwater, including domestic wells and interconnected surface water. Spreading basins can help store flood flows from nearby conveyance. In some areas, recharge basins can serve as temporary habitat for migratory birds.

#### **4.1.3 Direct Recharge – Aquifer Storage and Recovery**

Aquifer Storage and Recovery (ASR) is a direct groundwater recharge method in which water is intentionally injected into an aquifer through wells during times of surplus supply, stored underground, and later recovered for use during dry periods of higher demand. Unlike passive recharge methods such as spreading basins, ASR relies on engineered injection wells to place water directly into aquifers, making it particularly useful in areas with limited surface infiltration capacity or where precise control of recharge and recovery is needed. Typically, ASR are used by municipalities and are connected to their treated water supply systems due to the high water quality standards to operate an ASR well. Currently, ASR is not considered to be a practical solution for Dunnigan Water District and the broader SCNY area as there are more cost-effective solutions available.

#### 4.1.4 In-Lieu Recharge

As mentioned above, in-lieu recharge is the practice of using surface water in-lieu of groundwater. The main challenge is most in-lieu recharge projects is conveying surface water to areas that have historically only had access to groundwater. Water purveyors may need to design and construct entirely new turnouts, laterals, ditches, and pipelines to be able to move water to areas with interested landowners.

#### 4.2 Advantages and Disadvantages

The three recharge methods described above were evaluated in the context of the SCNY region. The advantages and disadvantages of each method are summarized in Table 4-1. In-lieu recharge was found to be the most applicable recharge method in the Region due to a high number of farms using exclusively groundwater near the service areas of established water districts. ASR was found not to be viable due to the prohibitive upfront costs and spreading basins being much easier to implement in the area.

**Table 4-1. Comparison of advantages and disadvantages of spreading basins, aquifer storage and recovery (ASR), and in-lieu recharge.**

Method	Advantages	Disadvantages
<b>Direct Recharge – Ephemeral Stream Trickle Flow</b>	<ul style="list-style-type: none"> <li>- Simple, low-cost design</li> <li>- Provides natural filtration of water</li> <li>- Does not require land to be repurposed</li> </ul>	<ul style="list-style-type: none"> <li>- Requires some form of conveyance capable of conveying surface water to the site</li> <li>- Recharge potential limited by soil infiltration rates</li> </ul>
<b>Direct Recharge – Spreading Basins</b>	<ul style="list-style-type: none"> <li>- Simple, low-cost design</li> <li>- Provides natural filtration of water</li> <li>- Often can be classified as multi-benefit (e.g., habitat, flood control, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>- May require large land area needs to be taken out of production</li> <li>- Requires some form of conveyance capable of conveying surface water to the site</li> <li>- Recharge potential limited by soil infiltration rates</li> <li>- Potential for clogging from sediments</li> </ul>
<b>ASR</b>	<ul style="list-style-type: none"> <li>- Effective in areas with limited surface infiltration capacity</li> <li>- Can store treated water underground for later recovery</li> <li>- Reduces evaporation losses compared to spreading basins</li> </ul>	<ul style="list-style-type: none"> <li>- Much higher capital and operational costs compared to other methods</li> <li>- Requires careful water quality management to avoid aquifer contamination</li> <li>- Regulatory and permitting complexity</li> <li>- Recharge potential limited by aquifer characteristics</li> </ul>
<b>In-Lieu Recharge</b>	<ul style="list-style-type: none"> <li>- Cost-saving potential from using existing surface water supplies in-lieu of pumping groundwater</li> <li>- Reduces demand on the aquifer</li> <li>- Flexible and scalable depending on surface water availability</li> <li>- Supports conjunctive use of surface and groundwater</li> </ul>	<ul style="list-style-type: none"> <li>- Requires surface water delivery conveyance that is compatible with on-farm irrigation systems, which could impose steep up-front costs</li> <li>- Lands must be annexed into districts</li> <li>- State and federal permitting bottlenecks</li> </ul>

## 5 IDENTIFICATION OF RECHARGE PROJECTS

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This section discusses the information needs and methods used to identify recharge projects in the District.

### 5.1 Overview

Dunnigan Water District solicited recharge project ideas from local stakeholders but eventually sought to broaden recharge program outreach to all landowners in the SCNY Region, both inside and outside of district boundaries. The District needed a method of outreach that could efficiently collect and organize the required information to determine if recharge projects were feasible.

### 5.2 SCNY Region Project Concept Criteria Questionnaire

In 2025, the SCNY Region Project Concept Criteria Questionnaire was developed using Google Forms to handle project solicitation from landowners for water purveyors in the Region. Google Forms was chosen as they are quick to develop, easy to share, and intuitive to fill out.

#### 5.2.1 Google Form Questions

Other than the questions designed to collect contact information from responders, the questionnaire contains 22 questions written to help responders efficiently communicate the recharge project concept and background data. These questions are listed sequentially below:

1. Provide the location of the proposed project.
2. What is the overlying water district for this project? For this questions, landowners could choose between CCWD, DWD, RD108, Westside Water District, Colusa Drain Mutual Water Company, Colusa County groundwater only area, or Yolo County groundwater only area.
3. What subbasin is your project located in (Colusa or Yolo)?
4. Is your project an in-lieu recharge project, a direct recharge project, or both?
5. Provide the land use of the recharge project area.
6. Write out a brief description that summarizes the project concept.
7. Provide an estimate of the proposed project area in acres.
8. What is the estimated design recharge capacity of the proposed project in acre-feet per year? For this question, landowners were asked to choose between the following ranges: less than 200 AFY, between 200 and 1,000 AFY, and greater than 1,000 AFY.
9. What is the SAGBI rating of the area where recharge will occur? For this question, landowners were provided with a link to the UC Davis Soil Agricultural Groundwater Banking Index web-map<sup>15</sup> and asked to identify the SAGBI score for the project location between ‘Very Poor’ and ‘Excellent’.

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<sup>15</sup> SAGBI web map: <https://casoilresource.lawr.ucdavis.edu/sagbi/>

10. Describe the underlying lithology of the project area. For this, landowners were provided with a link to the DWR Subsurface Viewer<sup>16</sup> and instructed on how to identify
11. What surface water source(s) are available to supply the proposed project?
12. Is there existing infrastructure that can convey water to the project area?
13. Is there a working flow measurement device (e.g., flowmeter, weir, etc.) installed to measure surface water diversions?
14. Will there be any earthwork required to make the project area suitable for recharge?
15. If infrastructure upgrades are needed, are you interested in receiving grant funding for construction?
16. During what time of the year can recharge be conducted at the project site?
17. What is the cost of water for recharge?
18. Will you require reimbursement for labor (to operate the project), land rental fees, or to prepare the recharge site (discing, etc.)?
19. To what extent will this project positively impact issues associated with small water systems or private shallow domestic wells and/or help address the Human Right to Water as defined in California Water Code Section 106.3?
20. To what extent is the proposed project located near areas with known land subsidence. For this question, landowners were provided with a link to the CalGW Live InSAR Subsidence Map<sup>17</sup> and asked to choose if the project was within half a mile of subsidence, within two miles of subsidence, or not near subsidence.
21. From the following list, select possible co-benefits/indirect benefits of the project: (1) flood control, (2) drought mitigation and/or improved water supply reliability, (3) improved resiliency of groundwater dependent ecosystems, (4) provides seasonal habitat for migratory birds, and (5) provides seasonal habitat for anadromous fish.
22. When can recharge start?

In addition to the above questions, landowners were provided with an email address to submit auxiliary files to, such as reports, designs, or GIS files. The Google Form link that was provided to landowners is included below:

<https://docs.google.com/forms/d/e/1FAIpQLScGMoikxa33laqtwc2thaZBbIyEy9RMmQ4Lsiqt11o6-6VeMQ/viewform>

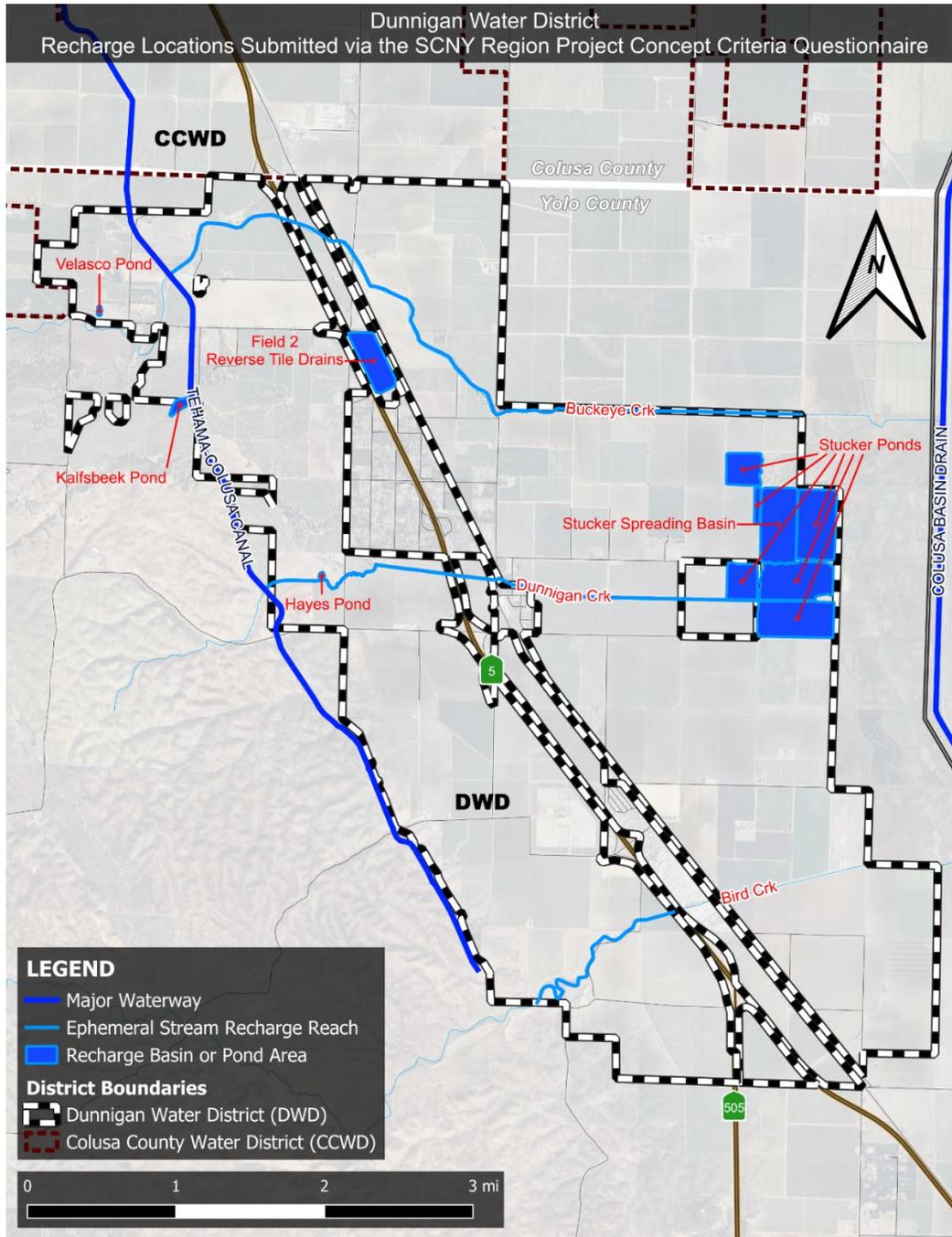
### 5.3 Identified Projects

As of November 30<sup>th</sup>, 2025, a total of nineteen projects were submitted through the SCNY Region Project Concept Questionnaire. Six of these projects were located within Dunnigan Water District as shown on Figure 5-1. Projects included:

<sup>16</sup> DWR Subsurface Viewer: <https://kind-water-0b502ae1e.4.azurestaticapps.net/#/location-select?locationType=County&expanded=false&view=chart&dataType=resistivity>

<sup>17</sup> <https://www.arcgis.com/apps/mapviewer/index.html?webmap=368c33514d9342ee857c6824d373d02c>

1. Buckeye Creek Trickle Flow Recharge
2. Field 2 Reverse Tile Drain System
3. Recharge Ponds (includes up to nine recharge ponds across DWD)
4. Stucker Property Recharge (or Spreading) Basins
5. Dunnigan Creek Trickle Flow Recharge
6. Bird Creek Trickle Flow Recharge



**Figure 5-1. Map of submitted recharge projects for Dunnigan Water District.**

## **6 RECHARGE PRIORITIZATION ANALYSIS**

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This section provides the criteria used for ranking and prioritizing recharge projects submitted via the SCNY Region Project Concept Criteria Questionnaire. The recharge project prioritization analysis may be modified over time to account for any identified fatal flaws, water quality concerns, and infrastructure costs. All projects to date do not have any new infrastructure requirements or the infrastructure funding source has already been identified.

### **6.1 Prioritization Criteria**

In order to decide which recharge project ideas to further pursue, a scoring framework was developed that considers seven different criteria: recharge amount, subsidence mitigation, dry well mitigation, recharge type, recharge suitability, cost sharing, and timeline. This framework emphasizes the project's hydrologic benefits to the Region as well as operational feasibility, giving points based on each category and then ranking projects based on final score. The prioritization criteria are detailed below and summarized in Table 6-1.

#### **6.1.1 Recharge Amount**

The Region needs to increase groundwater storage by 15,000 acre-feet per year (AFY) on average to balance the groundwater budget and achieve sustainability, and some of the water districts of the Region, such as DWD, only need 2,000 AFY. The amount of recharge a project can achieve is the most heavily weighted factor in the prioritization analysis. Projects capable of delivering a high amount of recharge, or more than 1,000 AFY, are given two points. Moderate recharge volumes, between 200 and 1,000 AFY, earn one point. Projects with a capacity below 200 AFY are not prioritized.

#### **6.1.2 Supports Subsidence Mitigation**

Proximity to zones with observed subsidence will be prioritized in effort to mitigate the subsidence problem in the Region. Projects in or near an area with observed land subsidence greater than one foot in the past ten years receive one point. Projects near an area with observed subsidence between 0.25 and one foot receive half a point. Projects that are not in an area with known subsidence problems receive no points.

The only area with subsidence known to be over foot is the Arbuckle area in CCWD, so only projects in the vicinity will receive full points. Subsidence between 0.25 and one foot occurs all over the Region, especially along the Interstate 5 corridor north and south of Arbuckle and north of Woodland.

#### **6.1.3 Supports Dry Domestic Well Mitigation**

Dry domestic well mitigation is incorporated by giving preference to projects located within designated priority areas near Dunnigan and Arbuckle, as these directly address vulnerable water supplies.

#### **6.1.4 Recharge Type**

In-lieu recharge is favored over direct recharge methods, as it reduces pumping in aquifer zones with clays prone to subsidence. Additionally, the cost of in-lieu recharge is offset by reduced PG&E pumping costs and evaporative losses are minimized.

#### **6.1.5 Aquifer Recharge Suitability**

Suitability of recharge sites is assessed based on whether underlying aquifer conditions have been evaluated using geophysical tools such as tTEM or equivalent; projects with observed recharge receive partial credit, while unevaluated sites are not prioritized. The objective of the criteria is to ensure that the recharged water will benefit the regional aquifer system through assessing geologic properties.

#### **6.1.6 In-kind Contributions Provided**

Additional considerations include in-kind contributions, such as labor, land, or infrastructure provided by stakeholders, which strengthen project viability. Full contributions receive maximum points, partial contributions are recognized with reduced credit, and projects without contributions score zero.

#### **6.1.7 Operating Timeline**

Finally, operational timeline is factored into the evaluation, with projects scheduled to begin recharge by fall 2025 prioritized over those with later implementation dates.

### **6.2 Dunnigan Water District Project Rankings**

To provide an example of these prioritization criteria, projects submitted to DWD were ranked and given a score out of eight (see Table 6-2). None of the projects proposed in DWD were in-lieu recharge projects, so none of the projects received a perfect score. The highest scoring project was the Buckeye Creek Ephemeral Stream Trickle Flow project. The Buckeye Creek project has a high capacity for recharge, winds through areas with known subsidence and areas with a high density of domestic wells, are grant funded, and recharge tests have already been conducted on the stream.

The two lowest scoring projects were the other two ephemeral stream flow projects: the Dunnigan Creek and Bird Creek projects. These two creeks differ from Buckeye largely in the areas they course through; Bird Creek is far away from any priority areas and neither creek runs through areas with considerable subsidence. No fatal flaws have been identified for any of the DWD projects.

**Table 6-1. Summary of scoring for recharge project prioritization criteria.**

Category	Category Weight	Description	Points	Weighted Points
<b>Recharge Amount</b>	<b>2</b>	<b>HIGH:</b> Greater than 1,000 AFY	<b>1</b>	<b>2</b>
		<b>MODERATE:</b> Between 200 to 1,000 AFY	<b>0.5</b>	<b>1</b>
		<b>LOW:</b> Less than 200 AFY	<b>0</b>	<b>0</b>
<b>Supports Subsidence Mitigation</b>	<b>1</b>	<b>HIGH:</b> More than 1 foot	<b>1</b>	<b>1</b>
		<b>MODERATE:</b> Between 0.25 and 1 foot	<b>0.5</b>	<b>0.5</b>
		<b>LOW:</b> Less than 0.25 feet	<b>0</b>	<b>0</b>
<b>Supports Dry Domestic Well Mitigation</b>	<b>1</b>	<b>WITHIN</b> Priority Area	<b>1</b>	<b>1</b>
		<b>OUTSIDE</b> Priority Area	<b>0</b>	<b>0</b>
<b>Recharge Type</b>	<b>1</b>	<b>IN-LIEU</b>	<b>1</b>	<b>1</b>
		<b>DIRECT</b> (Reverse Tile Drains, Spreading Basin, etc.)	<b>0</b>	<b>0</b>
<b>Aquifer Recharge Suitability</b>	<b>1</b>	<b>HIGH:</b> Assessed underlying aquifer conditions using tTEM (or equivalent) or In-Lieu Recharge	<b>1</b>	<b>1</b>
		<b>MODERATE:</b> Observed Recharge	<b>0.5</b>	<b>0.5</b>
		<b>LOW:</b> Never Evaluated	<b>0</b>	<b>0</b>
<b>In-Kind Contributions Provided (e.g., labor, land, infrastructure, etc.)</b>	<b>1</b>	<b>YES</b>	<b>1</b>	<b>1</b>
		<b>PARTIAL:</b> Only a portion of costs could be covered	<b>0.5</b>	<b>0.5</b>
		<b>NONE</b>	<b>0</b>	<b>0</b>
<b>Operating Timeline</b>	<b>1</b>	<b>IMMEDIATE:</b> Start Recharge by Fall 2025	<b>1</b>	<b>1</b>
		<b>DELAYED:</b> Start recharge 2026 or later	<b>0</b>	<b>0</b>

**Table 6-2. Ranking of Dunnigan Water District recharge projects based on seven defined criteria. Estimated water costs are provided for each project in dollars per acre-foot.**

Project Name	CATEGORY SCORE								WATER COST (\$/AF)		
	Recharge Amount	Subsidence	Domestic Wells	Recharge Type	Recharge Suitability	In-kind Contribution	Start by Fall 2025	Total Score	Contract Water	3F Water (Tier 2)	Recharge Water
Ephemeral Stream Trickle Flow Recharge: Buckeye Creek	2	0.5	1	0	0.5	1	1	<b>6.0</b>	N/A	N/A	\$60
Field 2 Reverse Tile Drains	1	0	1	0	1	1	1	<b>5.0</b>	\$90	\$76	N/A
Recharge Ponds (includes up to nine recharge basins across DWD)	1	0.5	1	0	0	1	1	<b>4.5</b>	\$90	\$76	N/A
Stucker Spreading Basins	1	0.5	1	0	0.5	0.5	1	<b>4.5</b>	\$90	\$76	N/A
Ephemeral Stream Trickle Flow Recharge: Dunnigan Creek	1	0	1	0	0	1	1	<b>4.0</b>	N/A	N/A	\$60
Ephemeral Stream Trickle Flow Recharge: Bird Creek	1	0	0	0	0.5	1	1	<b>3.5</b>	N/A	N/A	\$60

# 7 RECHARGE PROJECT BENEFIT ASSESSMENT

## 7.1 Recharge Benefits

Dunnigan Water District started recharge in the Fall 2022 and continued through April 2025. Table 7-1 summarizes recharge amounts with surface water purchased by DWR’s Urban and Multibenefit Drought Relief Program. Recharge was conducted primarily on the Stucker Property and within Buckeye Creek (see Figure 5-1 for project locations). In total 5,485 AF was applied during this period with 3,376 AF and 2,007 AF applied on Stucker’s property and Buckeye Creek, respectively. On average, the District applied approximately 1,828 AF per year. Approximately 85% of the amount applied infiltrates into the groundwater aquifer providing benefits for all groundwater uses and users.

**Table 7-1. Applied Surface Water Volumes by Water Year.**

Water Year	Recharge Volume, AF			All Sites
	Stucker Property	Buckeye Creek	Other	
2023	1,494	690	0	2,184
2024	1,401	842	22	2,265
2025	481	475	80	1,036
Total	3,376	2,007	102	5,485
Avg WY	1,125	669	34	1,828

Dunnigan Water District partnered with The Nature Conservancy in the Fall of 2022 and 2024. Attachments F and G provide a detailed summary and benefit assessment of each recharge period. In 2022, the District purchased surface water from senior water right holders between October 28th and November 6th, 2022, and applied ~300 AF for recharge. About 90% of the water applied in the Fall of 2022 provided groundwater recharge; the remaining amount was loss due to surface evaporation. Similarly, in 2024, recharge occurred starting September 3rd through October 9th. Approximately 315 acre-feet, purchased from the District, was applied to approximately 76.3 acres. About 81% of the water applied provided groundwater recharge; the remaining amount was loss due to surface evaporation. Groundwater levels showed a response to the recharge. Photos of the recharge activities are available in Attachment H.

Consistent with Section 2.1, recharge project benefits were evaluated using two different approaches: (1) modeling using DWR’s C2VSimFG version 1.5, and (2) actual well observations (measured data). Both approaches provide valuable insights into water levels, groundwater storage changes, and interconnected surface waters (ISW). Recharge benefits for each SGMA sustainability indicator are further summarized in the following sections.

### 7.1.1 Groundwater Levels & Storage (Modeled)

Groundwater levels and storage were evaluated using DWR’s C2VSimFG v1.5 to a run model scenario with and without recharge to assess the net impact to the SCNY Region. The model scenario was developed in coordination with Colusa County Water District and other SCNY participants to improve inter-basin coordination. The following steps were used:

- Step 1: Estimate future conditions without additional recharge.
- Step 2: Estimate future conditions with additional recharge
- Step 3: Compare results from Steps 1 and 2.
- Step 4: Assess model calibration and identify remaining data gaps.
- Step 5: Share results / findings with stakeholders and DWR.

DWR’s C2VSimFG was projected forward by repeating land use, hydrology, and surface water use from Water Years 2016 through 2021. This period is assumed to be representative of future conditions consisting of a combination of wet, normal, and dry years. Table 7-2 summarizes recharge volumes by model water year.

The with recharge scenario (Step 2) is based on the following assumptions:

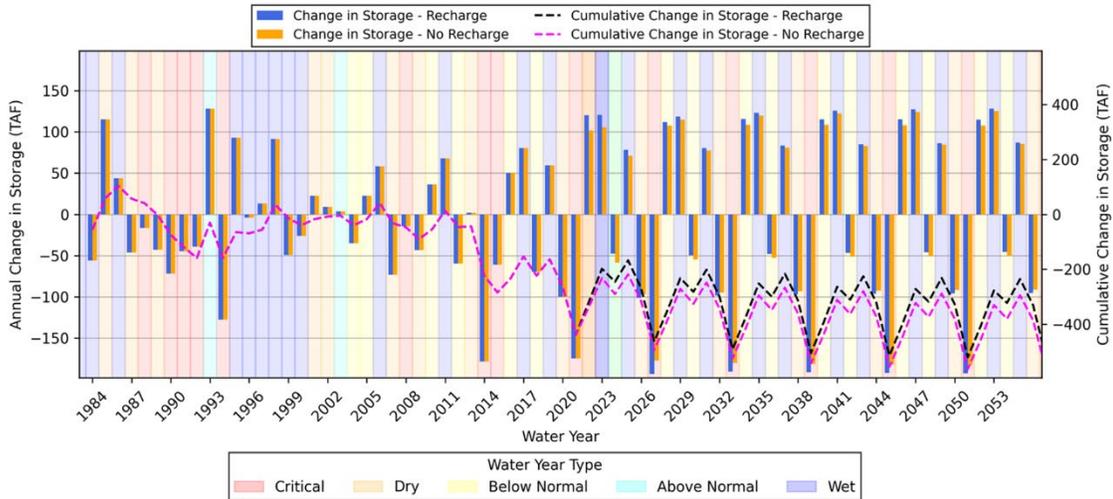
- Recharge goal of 15,000 AF per year (pending surface water availability). Goal is fully met in below normal to wet year types, 50% of the goal is met in dry years, and 0% of the goal is met in critically dry years.
- 75% of the recharge occurred in Colusa County Water District; the remaining 25% occurred in Dunnigan Water District
- The initial six-year cycle was split 75% direct recharge and 25% in-lieu recharge. The following cycles switch to 25% direct recharge and 75% in-lieu recharge.

**Table 7-2. Modeled Recharge Volumes.**

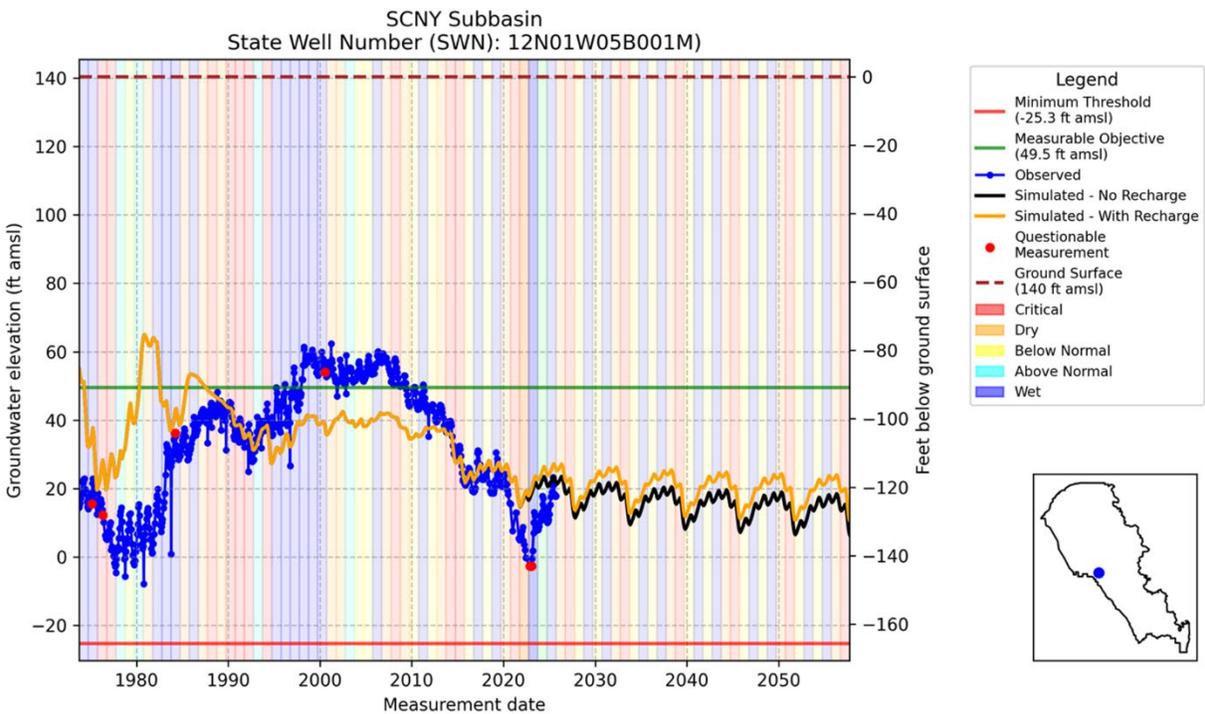
Model WY	Hydrology WY	WY Index	Direct Recharge Volume (AF)		In-lieu Recharge Volume (AF)		Total Recharge Volume (AF)
			CCWD	DWD	CCWD	DWD	
2022	2016	Below Normal	8,438	2,813	2,813	938	15,000
2023	2017	Wet	8,438	2,813	2,813	938	15,000
2024	2018	Below Normal	8,438	2,813	2,813	938	15,000
2025	2019	Wet	8,438	2,813	2,813	938	15,000
2026	2020	Dry	4,219	1,406	1,406	469	7,500
2027	2021	Critical	0	0	0	0	0
2028	2016	Below Normal	2,813	938	8,438	2,813	15,000
2029	2017	Wet	2,813	938	8,438	2,813	15,000
2030	2018	Below Normal	2,813	938	8,438	2,813	15,000
2031	2019	Wet	2,813	938	8,438	2,813	15,000
2032	2020	Dry	1,406	469	4,219	1,406	7,500
2033	2021	Critical	0	0	0	0	0

note: recharge volumes from 2028 through 2033 were repeated into the future.

On average approximately 11,250 AF per year of additional recharge is applied within Colusa County Water District and Dunnigan Water District starting in model Water Year 2022. The recharge implementation positively impacts groundwater storage metrics compared to the model without recharge as shown in Figure 7-1. During water year’s meeting the full recharge goal, the most benefit to groundwater storage is seen, while the dry and critically dry Water Year’s reduce the positive impact greatly. Even with the reduction in benefits from those years, there is an overall increasing trend in storage throughout the modeled time series. Groundwater levels see the same response as storage metrics, when comparing the model with recharge and without as shown in Figure 7-2. The rebound in levels again is reduced during the dry and critically dry Water Years, leading to limited robust increases in levels.



**Figure 7-1. Historical and projected groundwater storage conditions with and without recharge.**



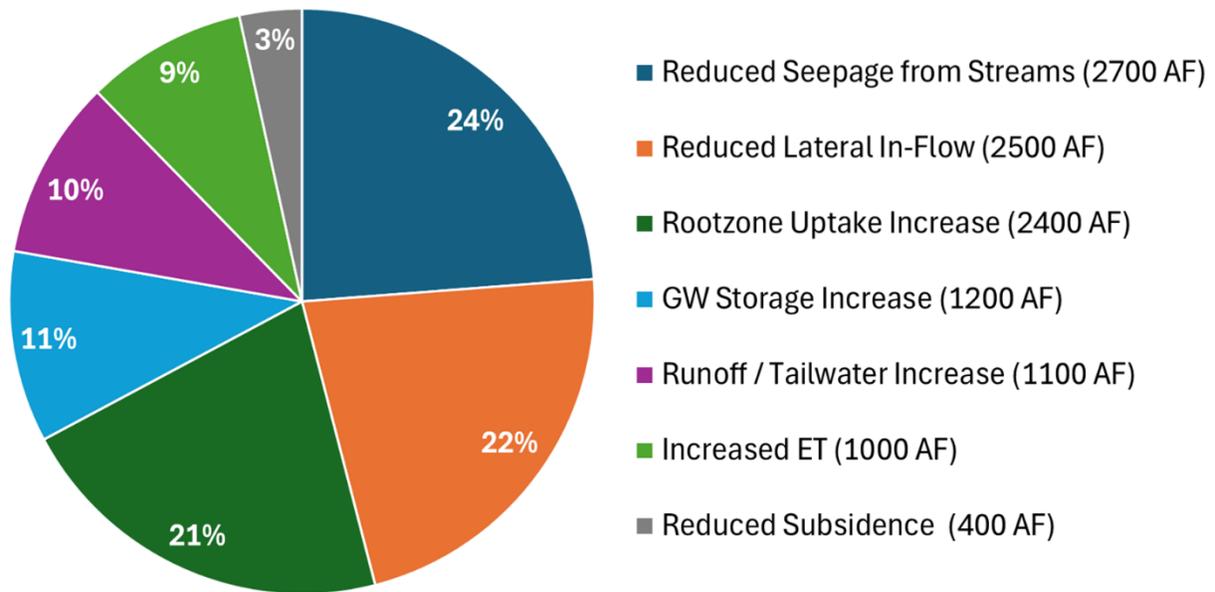
**Figure 7-2. Historical and projected groundwater elevations for Yolo Subbasin monitoring well with and without recharge.**

The average projected recharge amount of 11,250 AF per year leads to an average increase in groundwater storage of 1,200 AF per year (Figure 7-3). The remaining recharge water follows other flow paths outside of groundwater storage mainly seepage to streams, subsurface lateral flow, and rootzone uptake accounting for 2,700 AFY, 2,500 AFY, and 2,400 AFY; respectively.

The results of both models (with and without recharge) are heavily caveated by accuracy and applicability of the C2VSimFG v1.5 in the SCNY region. The model extent covers the entirety of the Central Valley, leading to limited smaller scale calibration and inaccuracies in deliveries, pumping, usage, and other model parameters. The modeled well levels and actual measurements showed major disagreement, leading to the conclusion that the modeled groundwater levels do not accurately depict the actual groundwater levels across the SCNY region. This disagreement was also inconsistent where the model showed both higher and lower groundwater levels for different wells in the region.

The C2VSimFG v1.5 model ends its time series at the end of Water Year 2021, which starts the recharge implementation at an unfair starting point, as the model does not consider any improvements to groundwater levels and storage after Water Year 2021 to present that would significantly alter the results. The actual benefit from recharge is suspected to be far greater than the perceived benefit shown in these model results, where the validity of flow paths for recharge water applied is questionable in assessing the true fate of recharge inside the SCNY region.

In general, the model results illustrate how recharge will improve regional groundwater conditions and provide benefits to all groundwater users including reduced depletions from interconnected surface waters, reduced impacts on neighboring subbasins, and reduced risk of subsidence through stabilizing groundwater levels. The amount of recharge contributing to each flow path will change as additional data is collected and the C2VSimFG model is further calibrated. Dunnigan Water District will work with DWR to complete model improvements for future scenario planning.



**Figure 7-3. Projected boundary flow path changes with recharge (SUBJECT TO CHANGE). Values in parenthesis represent average annual project change in flow path with and without recharge; rounded to the nearest hundred.**

### 7.1.2 Groundwater Levels (Measured)

Groundwater levels are monitored by an extensive groundwater level monitoring network. Dunnigan Water District has installed ten (10) continuous groundwater level sites. These sites are shown on Figure 7-4 (see red stars on map). Dunnigan Water District with RD108 and Colusa County Water District are continuing to expand the monitor network which is expected to be complete by Summer 2026 to include sites identified by the blue, black, and yellow stars, respectively. This will improve regional understanding of the groundwater and enhance inter-basin coordination. Data from the groundwater level monitoring sites are available through an online stakeholder portal (available to DWR upon request). Additionally, the District, in coordination with DWR, has been uploading groundwater level data to DWR’s Water Data Library so data can be incorporated with other local, regional, statewide water management efforts. Groundwater levels increased due to the recharge substantially since Fall 2022. See Sections 2.3.1 and 2.3.2 and Attachments D, F, and G for further information documenting monitoring plans and how recharge activities improved groundwater levels.

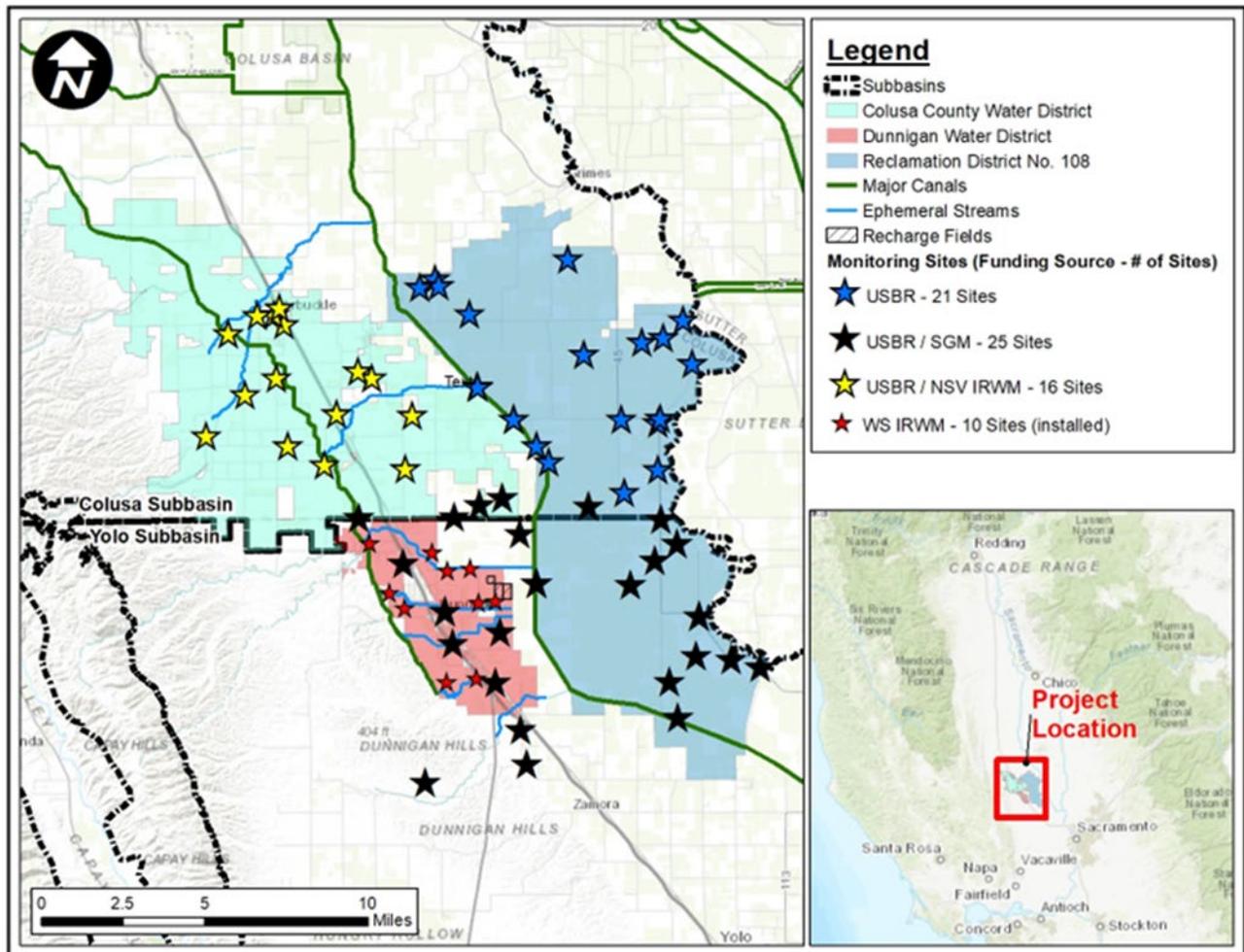


Figure 7-4. Current and Proposed Groundwater Level Monitoring Network.

### **7.1.3 Water Quality**

Dunnigan Water District will continue to monitor water quality conditions as described in Section 2.3.4 to track potential impacts from recharge activities. Water applied for recharge met drinking water standards for the recommended constituents provided by the State Water Resources Control Board. There were localized areas with the groundwater levels sampled positive for high levels of Chromium 6 and TDS near recharge sites. The recharged water will likely improve groundwater quality in these areas. The District will continue to monitor if recharge activities are contributing to the movement of constituents through the groundwater aquifer.

### **7.1.4 Land Subsidence**

As discussed in Section 2.3.5, land subsidence is occurring within Dunnigan Water District and adjacent areas. The District will continue to monitor subsidence using available InSAR data and ground control points as feasible. Recharge activities are expected to reduce risks to subsidence. No measurable amount of subsidence has occurred within the District since 2022.<sup>18</sup> The District will adjust recharge volumes as needed to ensure subsidence does not occur as funding allows.

### **7.1.5 Depletion of Interconnected Surface Water**

Interconnected surface waters near Dunnigan Water District include the Colusa Basin Drain and the Sacramento River as discussed in Section 2.3.6. The District is intentionally recharging along dry ephemeral streambeds away from the connected streams to ensure the recharge water remains in the aquifer to benefit those users who rely on a stable groundwater aquifer such as domestic well users for as long as possible. The model suggests approximately up to 24% of the recharged water benefits ISW. Further data collection and calibration of the model is needed to verify benefits for ISW.

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<sup>18</sup> SGMA Data Viewer: <https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub>

## **8 GROUNDWATER RECHARGE LONG-TERM FUNDING AND INCENTIVES**

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### **8.1 Groundwater Credit System**

DWR is taking a zero-tolerance policy related to subsidence through SGMA regulation. The SCNY Boundary is drawn around the lands with subsidence. The Region over the past 20 years has averaged approximately 15,000 AF of overdraft. Colusa Groundwater Authority is required to have a Groundwater Demand Management program in place by January 1, 2027. Yolo GSA may face similar requirements in the future. Demand Management focuses on limiting groundwater pumping to eliminate overdraft. It will require lower water use crops and/or fallowing. If the GSAs in the Colusa and Yolo Subbasins fail to prevent undesirable results, the State will step in with fees ranging from \$44-\$114 per acre just to write a new plan for the area, which would then be used to limit groundwater pumping. Groundwater Sustainability Agencies have challenging legal criteria around collecting funds to plan and implement projects (what's needed to avoid overdraft discussed above). In other areas of the state where demand management has been implemented, land values have seen significant decreases. Currently, there is insufficient funding available to develop and implement recharge projects to offset the overdraft. The Colusa Groundwater Authority is charging an administrative fee to comply with reporting and administrative requirements of the Sustainable Groundwater Management Act (SGMA). This does not include the cost of implementing projects.

The SCNY group is a voluntary coalition with the goal of implementing groundwater recharge projects to improve groundwater conditions, mitigate land subsidence and avoid other undesirable results. This group is proposing a voluntary, landowner driven approach to fund the most cost-effective program to keep land farming by avoiding demand management and potential State intervention. This group intends to accomplish this by developing, funding, and evaluating projects that improve groundwater levels.

As described in Section 6, an effort was made to solicit potential projects. Projects were ranked and evaluated on a price per acre-foot basis with the highest ranked projects ready for implementation being prioritized to produce a sample budget. Proposed recharge methods include:

- Ephemeral stream trickle flow recharge,
- In-lieu recharge (using surface water instead of groundwater to irrigate), and
- Direct recharge on fields (sometimes in combination with wetland habitat).

Proposed fees were calculated based on a budget to mitigate 15,000 AFY overdraft and assigning dollars proportional to groundwater use above sustainable yield. With the budget and weighting this works out to be:

- Groundwater Only Water Users (sometimes called “White Areas”) - \$24.00 per cropped acre
- Conjunctive Use Areas - \$12.00 per cropped acre
- Sacramento River Settlement Contractors - \$3.00 per cropped acre

As of January 2026, approximately 80,000 acres of farmed lands are enrolled in the voluntary recharge program within the Region and landowners have contributed over \$600,000 in the first year to conduct recharge projects.

This group does not replace the GSAs but works closely with the Yolo and Colusa GSAs to recognize project benefits. Currently, the SCNY group is working with DWR and the Water Data Consortium to pilot the Groundwater Accounting Platform and the Groundwater Recharge Assessment Tool. This work is expected to occur over the next year through 2026. SCNY will continue to work with the GSAs to establish the appropriate accounting platform and recharge credit framework to continue to incentivize participation in local recharge activities.

## 9 ACKNOWLEDGEMENTS

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The successful completion of this Project was possible due to partnerships including with:

- Department of Water Resources
- Westside Sacramento Integrated Regional Water Management (IRWM) Coordinating Committee
- Northern Sacramento Valley IRWM
- California American Water
- Yolo Subbasin Groundwater Agency
- Colusa Groundwater Authority
- Dunnigan Water District
- Colusa County Water District
- Reclamation District No. 108
- The Nature Conservancy
- Colusa Basin Drainage District
- C&H3 Farms
- Gary Driver
- Schaad Family Ranch
- SCNY Operating Team and Participants

The Project was highlighted by the DWR, LA Times, and Governor Newsom which helped expand awareness of the recharge program and in other regions in the Sacramento Valley. Links to publications are provided below:

- DWR: <https://water.ca.gov/News/Blog/2023/Jan-23/Capturing-Water-from-Storms-to-Replenish-Groundwater>
- LA Times: <https://www.latimes.com/environment/story/2023-03-21/california-looks-to-farmland-to-recharge-groundwater>
- Governor Newsom visit: <https://www.gov.ca.gov/2023/03/24/governor-newsom-eases-drought-restrictions/>

## **Attachment A – Buckey Creek Recharge Project (February 2022 Update)**

# Buckeye Creek Recharge Project

## February 2022 Update

### Executive Summary

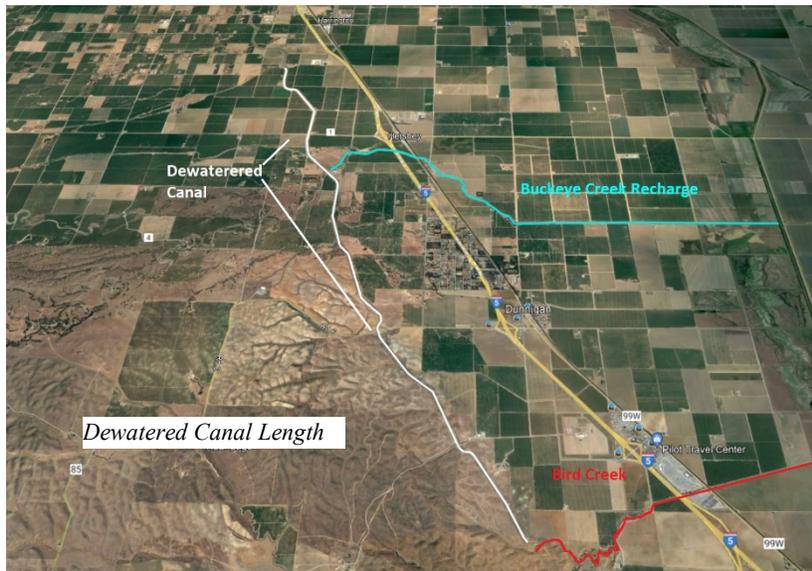
In early February 2022 an opportunity was provided to conduct a test of the Buckeye Creek Trickle Recharge Project. The Tehama-Colusa Canal developed a small leak in the siphon under Buckeye Creek, immediately downstream of the dewatering gate that will be used for the recharge project. In order to conduct the repairs, the Tehama-Colusa Canal had to be dewatered and this was done at two locations, the dewatering gate which empties into Buckeye Creek and out the end of the canal, into Bird Creek, several miles south of Buckeye Creek. Approximately 275 AF of water was discharged into Buckeye Creek, about 200 AF into Bird Creek, over the period of Thursday, February 3<sup>rd</sup> through Friday, February 11<sup>th</sup> with about 50% of the water being discharged in the initial 24-36 hours. Estimates of the recharge are that somewhere between 128 and 211 AF was recharged into the aquifer during that timeframe.



Buckeye Dewatering Gate

### Details

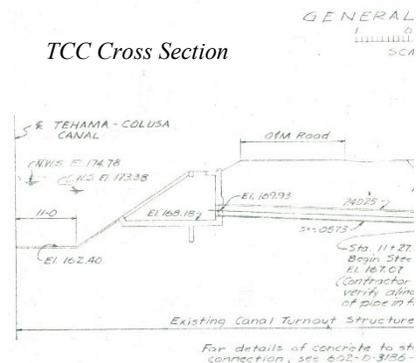
On Wednesday evening, February 2<sup>nd</sup>, Dunnigan Water District Waterman, Steve Soares, discovered a small leak in Buckeye Creek where the Tehama-Colusa Canal (TCC) siphon passes underneath the creek bed. He alerted Tehama-Colusa Canal Authority (TCCA) staff and they determined by Thursday morning the canal needed to be dewatered to allow access for repairs. Around noon and Thursday, February 3<sup>rd</sup>, the TCCA began dewatering the canal into Buckeye Creek and out the end of the canal into Bird Creek. The TCCA had agreed to dewater as slowly as possible to facilitate more infiltration. When the dewatering was started, the water



Dewatered Canal Length

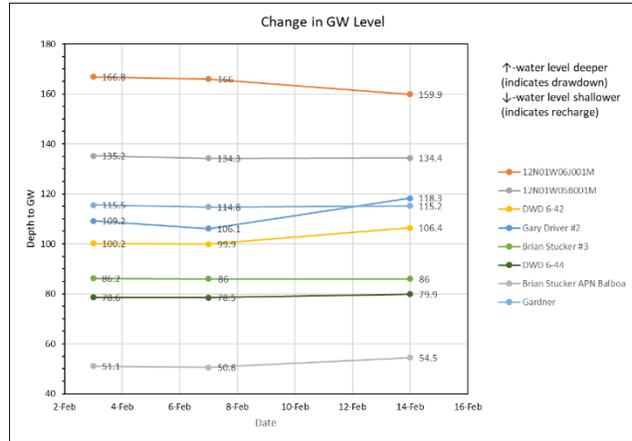
depth in the canal was 13 ft deep, and by Friday the 4<sup>th</sup> around noon the depth was 6 ft. This indicates that around 50% of the water was drained in the first 24 hrs while the remaining 50% drained over the following week, mostly into Buckeye Creek. The TCCA staff estimated around 275 AF was drained into Buckeye Creek and 200 AF drained into Bird Creek which is at the south end of the TCC. Based on as built drawings (see right) in the Dunnigan Water District (DWD) archives, we calculate the quantity of water to be discharged, in total

TCC Cross Section



to be at least 505 AF. During the first day, the flow in Buckeye Creek was going to the Colusa Basin Drain (CBD) but over the weekend, it ceased to flow into the CBD and by Monday the 7<sup>th</sup> had ceased to flow beyond County Road 88.

Readings in the surrounding wells were done on Thursday morning, February 3<sup>rd</sup>, before any recharge would've reached the wells, again on Monday the 7<sup>th</sup> and then again on Monday, February 14<sup>th</sup>, after the recharge was stopped. The majority of readings between the 3<sup>rd</sup> and the 7<sup>th</sup> show a recharge, with a few wells showing drawdown because of nearby production wells pumping. The change from the 3<sup>rd</sup> to the 14<sup>th</sup> however shows a general drawdown which correlates with the irrigation starting and the general bloom happening that week.



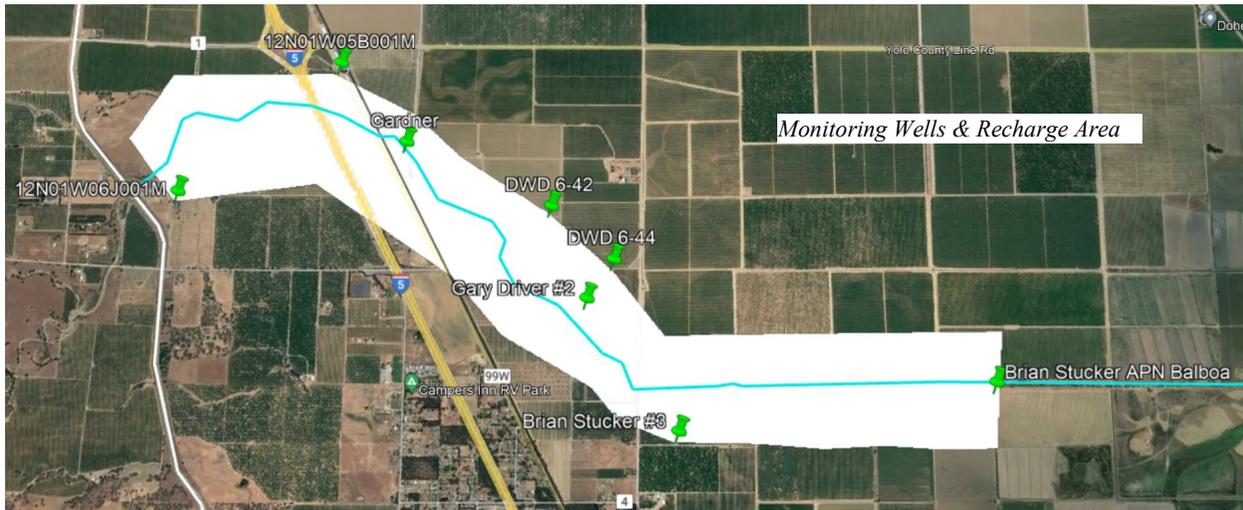
The graph above shows the trend described above of the wells that are in closest proximity to Buckeye Creek and the most likely to be affected by the recharge. The

Well	3-Feb	7-Feb	14-Feb	3 to 7 Δ	3 to 14 Δ
12N01W06J001M	166.8	166	159.9	0.8	6.9
12N01W05B001M	135.2	134.3	134.4	0.9	0.8
DWD 6-42	100.2	99.9	106.4	0.3	-6.2
Gary Driver #2	109.2	106.1	118.3	3.1	-9.1
Brian Stucker #3	86.2	86	86	0.2	0.2
DWD 6-44	78.6	78.5	79.9	0.1	-1.3
Brian Stucker APN Balboa	51.1	50.6	54.5	0.5	-3.4
Gardner	115.5	114.8	115.2	0.7	0.3

Negative change means drawdown | Positive means recharge

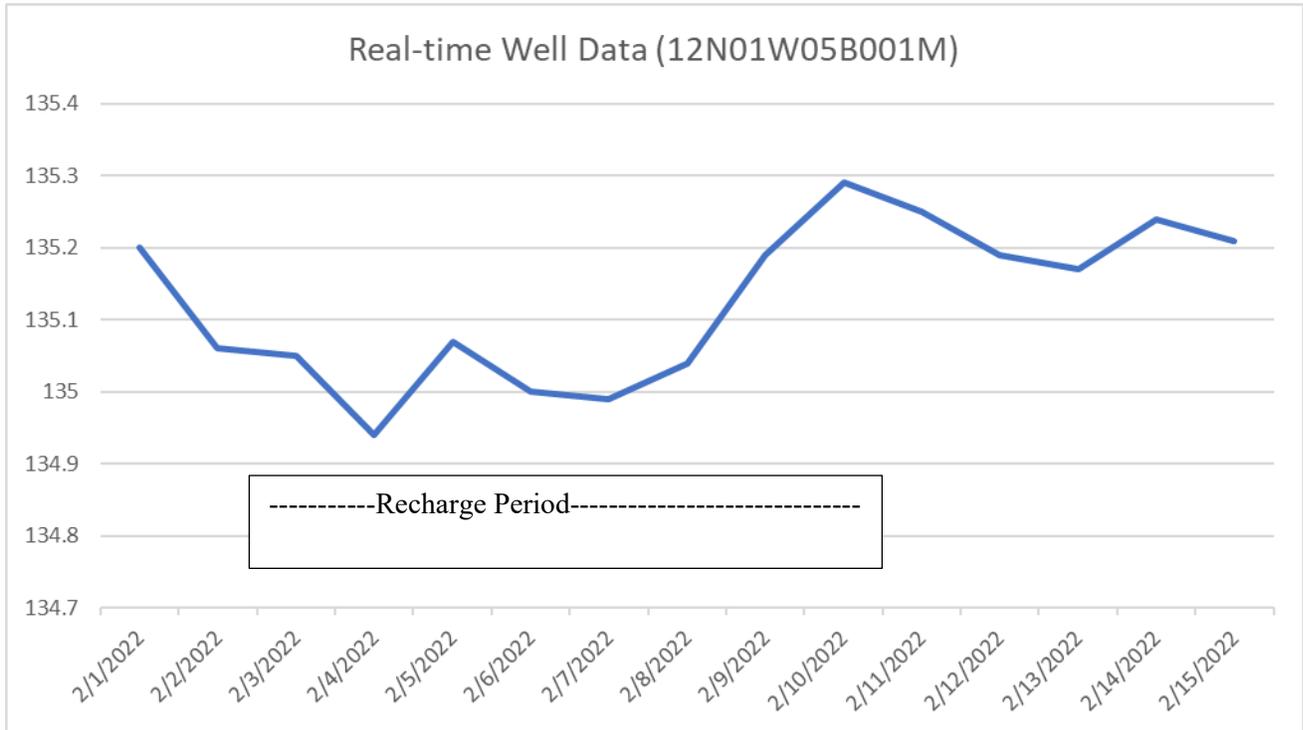
Creek and the most likely to be affected by the recharge. The average difference between the 3<sup>rd</sup> and 7<sup>th</sup> in those wells is 0.825 ft rise with one outlier of 3.1 ft rise. If that outlier is disregarded, the average rise is 0.5 ft. Details of each wells is included in the Table and the photo shows the locations of the wells.

The estimation of volume is based on the changes in GW elevation measured in the wells and then spread over an area that covers the recharge area that is covered by the monitoring wells. The recharge area is approximately 1284 acres in size. When the average rise in GW level of 0.825 ft is spread over the recharge



area, we see a gain of almost 212 AF and when an average rise of 0.5 ft (casting out the 3.1 ft outlier) the gain is 128 AF. We therefore conclude that it is reasonable to estimate the total recharge was between 128 AF and 212 AF.

DWR well 12N01W05B001M has real time data that is gathered by the Yolo GSA and is included in the monitoring wells used for this. Real time information from it confirms the local aquifer gain over the recharge period. In the graph below you can see the downward trend prior to the recharge, then the rise from the 3<sup>rd</sup> to 11<sup>th</sup> and a return to downward trending after the recharge ended.





*Buckeye Creek at dewatering gate outfall*



*Buckeye Creek upstream of County Road 89*



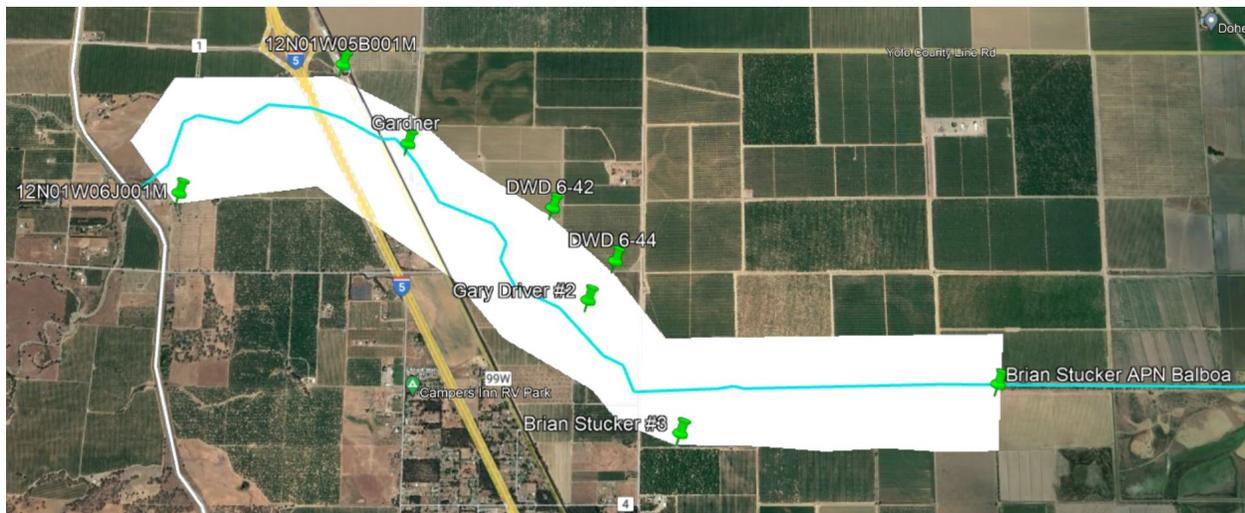
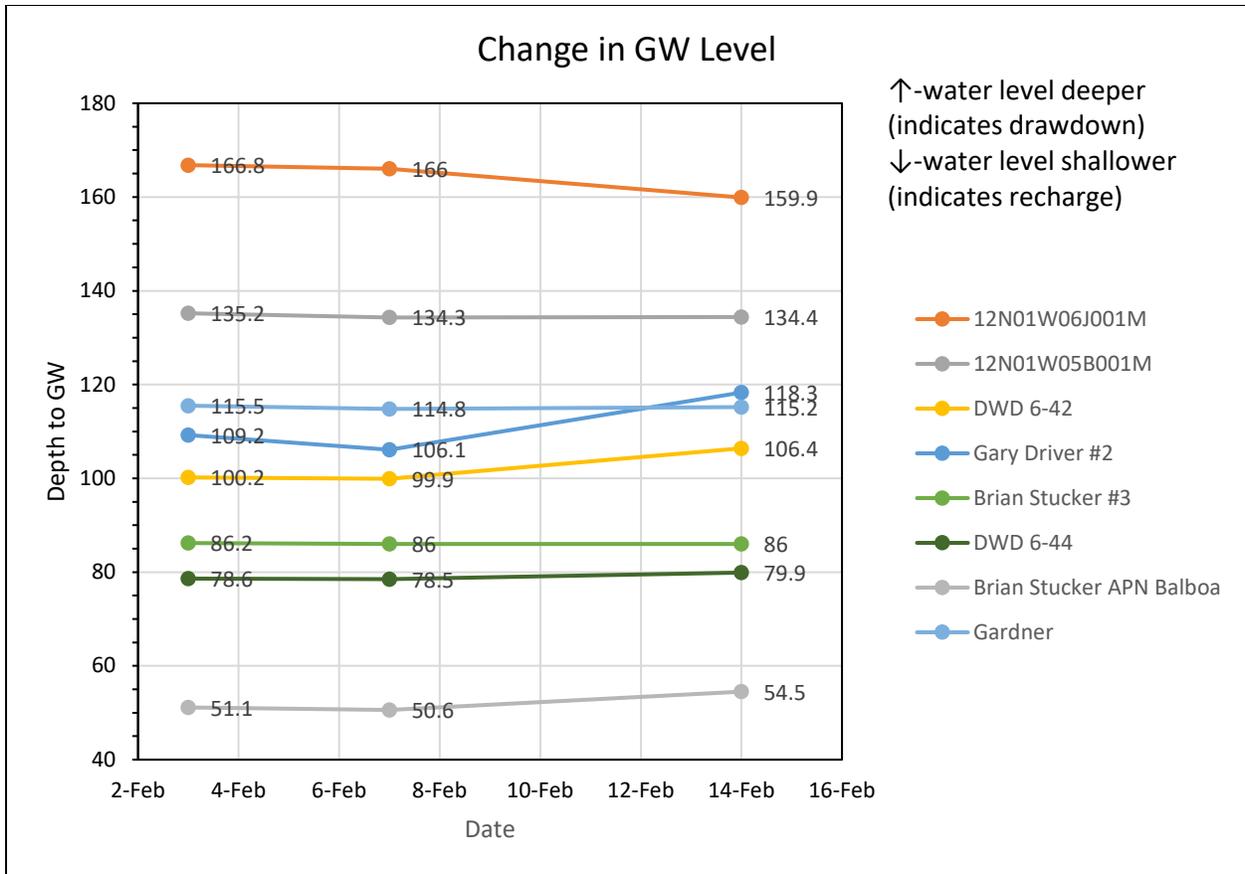
*Buckeye Creek downstream County Road 89*



*Flowing over County Road 88*



*Flow at the downstream end of recharge area.*



Please direct questions to William Vanderwaal at [wvanderwaal@rd108.org](mailto:wvanderwaal@rd108.org) or 530.812.6276.

Appreciation to the following persons and entities for their assistance with this project: RD-108 Board of Trustees, Yolo GSA/YCFCWCD, Dunnigan WD, Tehama-Colusa Canal Authority, Kristin Sicke, Jack Cronin, Steve Soares, David Schaad, Gary Driver, Brian Stucker, Gardner Armstrong, Jeff Sutton, Don Babb, Jordon Navarrot and Lewis Bair.

# **Attachment B – South Colusa – North Yolo (SCNY) Regional Cooperation Agreement**

## South Colusa-North Yolo (SCNY) Regional Cooperation Agreement

This **Regional Cooperation Agreement (Agreement)** is entered into and effective this \_\_\_ day of \_\_\_\_, 2025 by and among the Parties enrolled per Exhibit A (**SCNY Enrollment Form**) attached hereto and which have executed this Agreement (collectively the “**Parties**”).

### Recitals

WHEREAS the 2014 Sustainable Groundwater Management Act (**SGMA**) provides that groundwater basins subject to that Act must be managed under an approved Groundwater Sustainability Plans (**GSP**) on or before certain statutory deadlines, and that those GSPs are subject to periodic review and approval by the California Department of Water Resources; and

WHEREAS, in the event that a subbasin fails to demonstrate sufficient progress toward attaining groundwater sustainability, as set forth by SGMA, that subbasin may be referred to the State Water Resources Control Board (**SWRCB**) for State intervention; and

WHEREAS, the Yolo and Colusa subbasins (DWR basins 05-21.67 and 05-21.52 respectively) operate under GSPs approved by DWR and scheduled for periodic review and update in January 2027; and

WHEREAS, prior DWR reviews have identified specific topics of concern to be addressed in those January 2027 updates, including the implementation of best management practices to encourage reductions in groundwater pumping; specific strategies to reduce or eliminate subsidence; and in the case of the Colusa Subbasin, a commitment to developing and implementing a demand management program if necessary to fend off undesirable results within the subbasin; and

WHEREAS, if the issues identified by DWR are not addressed, the subbasins may be subject to more drastic regulatory intervention, including but not limited to SWRCB proceedings, State-directed groundwater fees, and the implementation of non-voluntary demand management or allocation programs; and

WHEREAS, the undersigned stakeholders within the Colusa and Yolo subbasins wish to collaborate to identify and implement voluntary measures designed to support the sustainable management of their respective groundwater basins, and further to minimize the need for such outside intervention; and

WHEREAS, the geographic area in which these efforts will be focused is reflected in **Exhibit B** (Region of Cooperation), as that exhibit may be amended from time to time; and

WHEREAS, based on the data provided in the approved Yolo GSP and Colusa GSP, Parties have identified 15,000 acre-feet of average annual additional recharge for the Region of Cooperation as a target volume (without including the Yolo Zamora area) which, if achieved,

would meaningfully reduce or mitigate the risk of undesirable results within the Region of Cooperation; and

WHEREAS, although they are not Parties contributing funds under this Agreement, the efforts undertaken pursuant to this Agreement are intended to support the sustainable groundwater management work of the Yolo and Colusa GSAs, and the Parties will commit to regular information sharing and annual reporting.

## AGREEMENT

**NOW, THEREFORE**, the Parties agree as follows:

**1. Term:** The initial term of this Agreement will be through December 31, 2026. It shall extend annually thereafter for one-year terms, except as to any Party that withdraws from the Agreement as provided at paragraph 8 below.

**2. Region of Cooperation:** Work and funding under this Agreement will be tailored to avoid or mitigate undesirable results in the region depicted in Exhibit B (**Region of Cooperation**), with an end goal of achieving the targeted 15,000 acre-feet of additional recharge, as it may be adjusted by the Operating Team, and thereby reducing or fully eliminating the need for more drastic intervention by regulatory bodies, including the GSAs or SWRCB.

**3. Cooperative Structure:** This Agreement does not create a new agency, entity, or regulatory body; and is not intended to supplant or replace the ongoing efforts of the Yolo and Colusa GSAs in implementing SGMA within their respective boundaries. Rather, this Agreement is intended to facilitate cooperation between interested parties, conducted generally as follows:

i. **Coordinator:** The Parties will designate a Coordinator, which shall be responsible for day-to-day administration of funds collected under this Agreement; conveying information regarding projects considered or pursued under this Agreement; and arranging for supporting services as directed by the Operating Team. Dunnigan Water District is designated as the initial Coordinator under this Agreement. The Coordinator may be changed by a majority vote of the Operating Team.

ii. **Operating Team:** An Operating Team will be responsible for identifying potential projects, awarding funding for projects or components of projects, adopting annual budgets for contributions and activities under this Agreement; coordinating with GSAs, providing a forum for the cooperative work of the Parties, and providing strategic direction on behalf of the participating Parties. The Initial Operating Team will be made up of the following:

- *Colusa Basin White Area Landowners*—2 representatives, initially designated by consensus among participating Colusa Basin White Area landowners and elected by participating landowners annually each January thereafter.
- *Colusa County Water District*—1 representative, designated by the District.

- *Dunnigan WD–1* representative, designated by the District.
- *Colusa Drain MWC–1* representative, designated by the Company.
- *Reclamation District No 108–1* representative, designated by the District.

Representatives may be added or the composition of the Operating Team altered to reflect the needs of the participating Parties. Changes to the allocation of representatives on the Operating Team shall be made by a majority vote of the then currently serving Operating Team members. The Operating Team will annually select a Chairperson, who will call and presided over meetings of the Operating Team. The Operating Team shall meet at least quarterly and additionally as called by the Chairperson. Colusa and Yolo GSAs, as well as a representative of DWR, shall be invited to participate in Operating Team meetings in an ex-officio, non-voting basis.

iii. Decision-Making: The Operating Team will seek to make decisions through consensus, but in the absence of consensus, (i) during the Initial Period, one vote per representative, and (ii) thereafter, one vote for each dollar of contributions received during the Initial Period from each of the Parties or landowners within a Party for a particular Representative, which allocation of votes shall be adjusted as of January 1 of each successive year starting January 1, 2026 based on the dollars contributed the prior year by the respective Parties.

**4. Enrolled Lands:** This Agreement has been adopted by the Parties in the spirit of regional cooperation, and in the belief that proactive, voluntary measures to improve groundwater conditions are essential to the success of the entire groundwater basin. Notwithstanding that fact, and in the spirit of the “beneficiary pays” approach used in regional GSA planning efforts, the projects and planning efforts funded pursuant to this Agreement in any given year will be focused on the needs of those lands that have contributed funding to that work under the Agreement (**Enrolled Lands**). Parties will identify lands for enrollment as follows:

i. Initial Period: For the period from the Effective Date of this Agreement through December 31, 2026 (the **Initial Period**), Parties shall identify and enroll their participating lands no later than June 30, 2025, and provide their initial funding contribution for 2025 for those lands no later than July 31, 2025.

ii. Subsequent Enrollment: On an annual basis following the Initial Period, Parties shall identify any addition or alternation to their Enrolled Lands no later than March 1 of that calendar year, and shall provide their funding contribution for those lands pursuant on the schedule identified in Section 5.

**5. Contributions of the Parties:** For budgeting and planning purposes, the Party’s funding contributions are intended to approximate the relative cost of addressing average groundwater deficits within each Party’s class of lands. Funding responsibility is generally weighted as follows, with lands billed according to their cropped acreage:

- *White Areas*: x2

- *Conjunctive Use: x1*
- *Sacramento River Settlement Contract lands: x0.25*

i. 2025 Contributions: For 2025, the contribution by each Party shall be their acreage of Enrolled Lands X \$6.00 X the applicable factor listed above.

ii. Annual Contributions: Following 2025, commencing in 2026, the Operating Team will convene each year in January to develop and adopt an annual budget for activities to be funded pursuant to this Agreement. Parties shall make their contributions based on said budget and the applicable factors listed above in two equal installments no later than July 31 and the following January 10.

iii. In-Kind Contributions: Parties may satisfy a portion of contribution requirements in any given year through an in-kind contribution of water, services, or other consideration, if approved by the Operating Team.

iv. Accounting: Funds contributed under this Agreement will be held and managed by the Coordinator, in a separate bank account, who shall be responsible for providing regular accounting and updates on the collection and expenditure of funds, including credits for contributions by the respective Parties. All administrative policies of Dunnigan Water District shall be followed, unless otherwise specified by the Operating Team.

**6. Work To Be Funded:** Funds collected under this Agreement will be used to advance groundwater-related projects (whether in implementing, planning, or feasibility analyses) for the benefit of the Region of Cooperation generally, and the Enrolled Lands specifically. This work may include:

- Implementing a specific project;
- Funding permitting, environmental review, or planning for one or more projects;
- Preparing, supporting, or funding feasibility studies to evaluate future projects;
- Hiring professionals to support or implement projects, or to administer the planning efforts;
- Or any other action that supports the Region.

Examples of projects that may be funded include, but are not limited to, those listed at Exhibit C (**Project Examples**) attached hereto, provided the Operating Team will select projects with the goal of optimizing use of available funds for the benefit of the region and contributing funders.

**7. Future Credit:** The Parties will work diligently and cooperatively with the appropriate GSAs to recognize and account for the contributions of this working group in the region. To that end, contributions to the efforts under this Agreement will be tracked and accounted for, with the understanding that these voluntary contributions are valuable and should be appropriately incentivized. The Coordinator will produce a bi-annual financial statement, as well as a recharge statement allocating recharged water in proportion to each Parties funding contributions received during that year. At the same time, each and every Party recognizes that entering into this Agreement is not a guarantee of future groundwater or financial credits, in whole or in part.

**8. New or Withdrawing Parties:** A Party executing this Agreement after July 31, 2025, shall be credited for its contribution of funds based on the amount funded, if payment for any Enrolled Lands is received within 60 days of when it was otherwise due. If a Party withdraws Enrolled Lands in any given year, or withdraws from the Agreement entirely, the withdrawing party will not be entitled to a refund of financial contributions made, but will receive proportionate credit for its contributions during the period of those lands' enrollment.

**9. Permitting and Environmental Compliance:** This Agreement is not a commitment to carry out any particular project or activity. Projects advanced under this Agreement should be associated with a public agency sponsor, where applicable, which shall be responsible for carrying out any required permitting or environmental compliance for the project in question. Funds advanced under this Agreement may be applied to off-set the costs of this compliance, whether through targeted reimbursements or an advance grant of funds.

**10. Preservation of Rights:** This Regional Cooperation Agreement is intended to provide a forum for stakeholders to coordinate, pool funding, and identify efficiencies in projects to support sustainable groundwater management within the Region. To support those collaborative efforts, the Parties agree that:

- Nothing in this Agreement modifies rights or priorities to use groundwater or surface water.
- This Agreement is for the sole purpose of planning for and implementing projects and activities on a voluntary basis, in order to help the Region achieve groundwater sustainability.
- This Agreement shall not be admissible as evidence in any future administrative or judicial proceeding; provided, however it may be used to advance and inform updates to GSPs by the respective GSAs.
- Nothing in this Agreement shall be construed to modify or restrict the rights and obligations of the Parties, including the GSAs, as otherwise provided by law.

**11. Miscellaneous Provisions:**

i. **Authority.** Each signatory of this Agreement represents that s/he is authorized to execute this Agreement on behalf of the Party for which s/he signs. Each Party represents that it has legal authority to enter into this Agreement and to perform all obligations under this Agreement.

ii. **Amendment.** Except as otherwise provided herein, this Agreement may be amended or modified only by a written instrument executed by two-thirds (2/3) of each of the Parties, weighted based on contributions received that year.

iii. **Jurisdiction and Venue.** This Agreement shall be governed by and construed in accordance with the laws of the State of California, except for its conflicts of law rules. Any suit, action, or proceeding brought under the scope of this Agreement shall be brought and maintained to the extent allowed by law in Colusa or Yolo Counties, California.

iv. **Headings.** The paragraph headings used in this Agreement are intended for convenience only and shall not be used in interpreting this Agreement or in determining any of the rights or obligations of the Parties.

v. **Construction and Interpretation.** This Agreement has been arrived at through negotiations and each Party has had a full and fair opportunity to revise the terms of this Agreement. As a result, the normal rule of construction that any ambiguities are to be resolved against the drafting Party shall not apply in the construction or interpretation of this Agreement.

vi. **Entire Agreement.** This Agreement constitutes the entire Agreement of the Parties with respect to the subject matter of this Agreement and supersedes any prior oral or written Agreement, understanding, or representation relating to the subject matter of this Agreement.

vii. **Partial Invalidity.** If, after the date of execution of this Agreement, any provision of this Agreement is held to be illegal, invalid, or unenforceable under present or future laws effective during the term of this Agreement, such provision shall be fully severable. However, in lieu thereof, there shall be added a provision as similar in terms to such illegal, invalid or unenforceable provision as may be possible and be legal, valid and enforceable.

viii. **Successors and Assigns.** This Agreement shall be binding on and inure to the benefit of the successors and assigns of the respective Parties. No Party may assign its interests in or obligations under this Agreement, other than a Parties successor owners of property, without the written consent of the Operating Team, which consent shall not be unreasonably withheld or delayed.

ix. **Waivers.** Waiver of any breach or default hereunder shall not constitute a continuing waiver or a waiver of any subsequent breach either of the same or of another provision of this Agreement and forbearance to enforce one or more of the remedies provided in this Agreement shall not be deemed to be a waiver of that remedy.

x. **Necessary Actions.** Each Party agrees to execute and deliver additional documents and instruments and to take any additional actions as may be reasonably required to carry out the purposes of this Agreement.

xi. **Compliance with Law.** In performing their respective obligations under this Agreement, the Parties shall comply with and conform to all applicable laws, rules, regulations and ordinances.

xii. **Third Party Beneficiaries.** This Agreement shall not create any right or interest in any non-Party or in any member of the public as a third party beneficiary.

xiii. **Counterparts.** This Agreement may be executed in one or more counterparts, each of which shall be deemed to be an original, but all of which together shall constitute but one and the same instrument.

xiv. **Notices.** The Parties addresses and email addresses are set forth in Exhibit A. Any notice or instrument required to be given or delivered under this Agreement may be

made by: (a) depositing the same in any United States Post Office, postage prepaid, and shall be deemed to have been received at the expiration of 72 hours after its deposit in the United States Post Office; (b) transmission by electronic mail; or (c) personal delivery to the addresses of the Party. Addresses for mailed or personal delivery and email addresses may be modified from time to time by providing notice to the Coordinator, or as new parties join or withdraw, and the Coordinator from time to time will update Exhibit A without amendment of the Agreement.

xv. **Drafting Agreement.** Downey Brand LLP has drafted this Agreement on behalf of its participating clients, and as a drafting service to the group seeking to develop and implement this Agreement, and in so doing does not create a new attorney-client relationship with any of the Parties not already a client of Downey Brand. All Parties have the option to seek independent legal advice as to whether they should execute this Agreement.

IN WITNESS WHEREOF, the Parties have executed this Agreement on the day and year indicated.

By: \_\_\_\_\_ Date: \_\_\_\_\_

Name/Title: \_\_\_\_\_

Exhibit A - South Colusa / North Yolo (SCNY) Enrollment Form

Contact Information

<u>Name:</u>	<u>Email Address:</u>
<u>Phone Number:</u>	<u>Mailing Address:</u>

Parcel Based Contribution Calculation

APN	County	Irrigated Acreage	Water District (If applicable)	Rate* (\$ / acre)	Parcel based Contribution (Acreage Multiplied by Rate)
Total Contribution:					

\*Rate can be determined as follows: Groundwater Only: \$24/ac, Conjunctive Use: \$12/ac, Settlement Contractor: \$3/ac

In-Kind Contribution

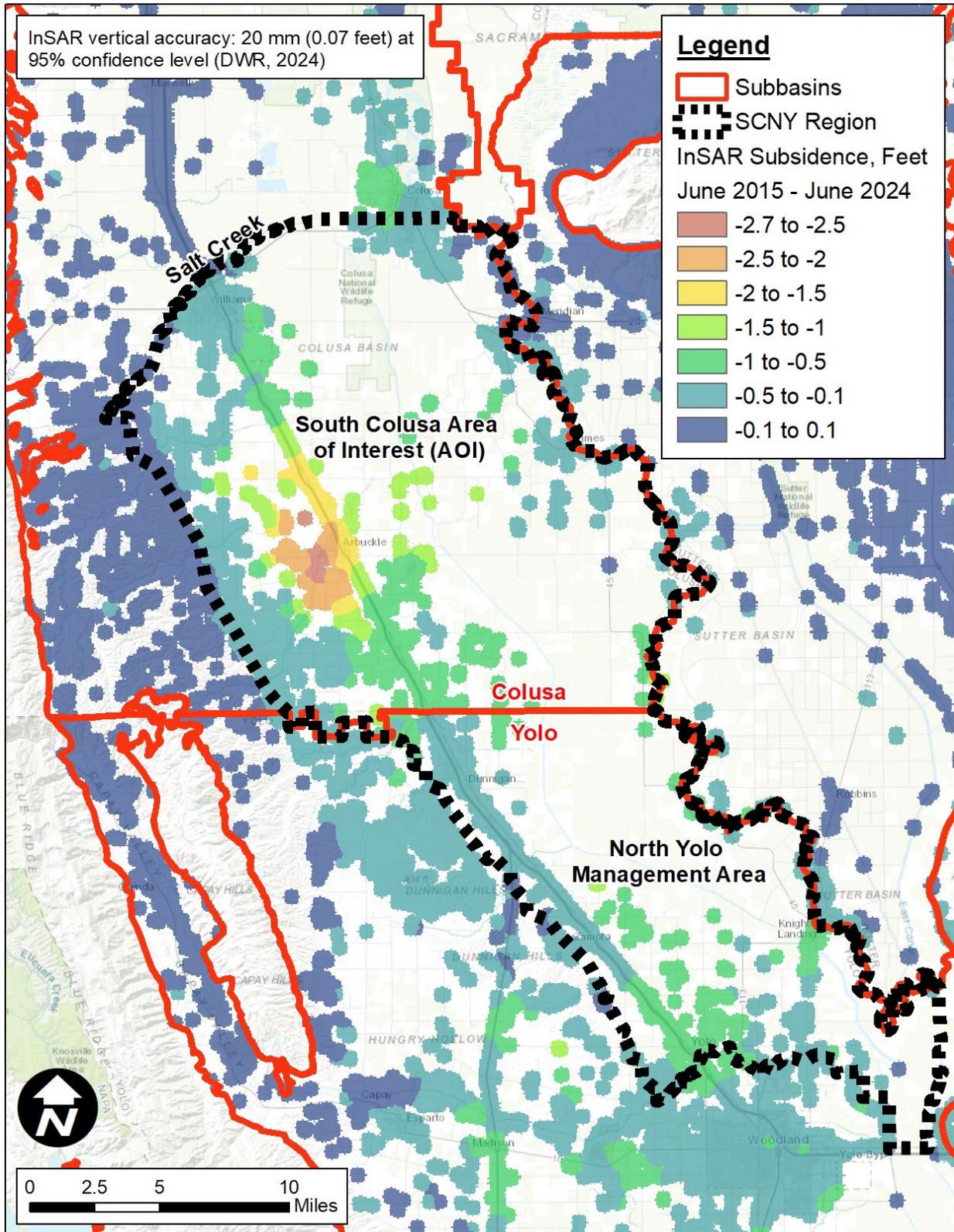
<u>Description:</u>
Total Contribution:

Certification

<div style="border-top: 1px solid black; margin-top: 5px;"></div>	<div style="border-top: 1px solid black; margin-top: 5px;"></div>
participant signature	date

**Mail to Dunnigan Water District, Attn: SCNY Coordinator, PO Box 84, Dunnigan, CA95937**

Exhibit B – Region of Cooperation



## Exhibit C – Project Examples

### General List of Projects:

- **Winter runoff reduction** - minor modifications to fields required to reduce runoff of precipitation such as constructing berms and / or placing boards in rice boxes.
- **Trickle flow ephemeral stream recharge** – Infrastructure improvements may include retrofitting existing turnouts and extending pipelines to streams
- **Flood MAR projects** – Infrastructure improvements may include retrofitting existing turnouts, extending pipelines to recharge areas, and constructing berms around recharge basins.
- **In-lieu recharge (existing customers)** - construct dual source irrigation system including booster pump, filters, and pipe as needed.
- **In-lieu recharge (annexation)** - extend district infrastructure to annexed parcels and construct dual source irrigation system including booster pump, filters, and pipe as needed.

### Detailed List of Projects:

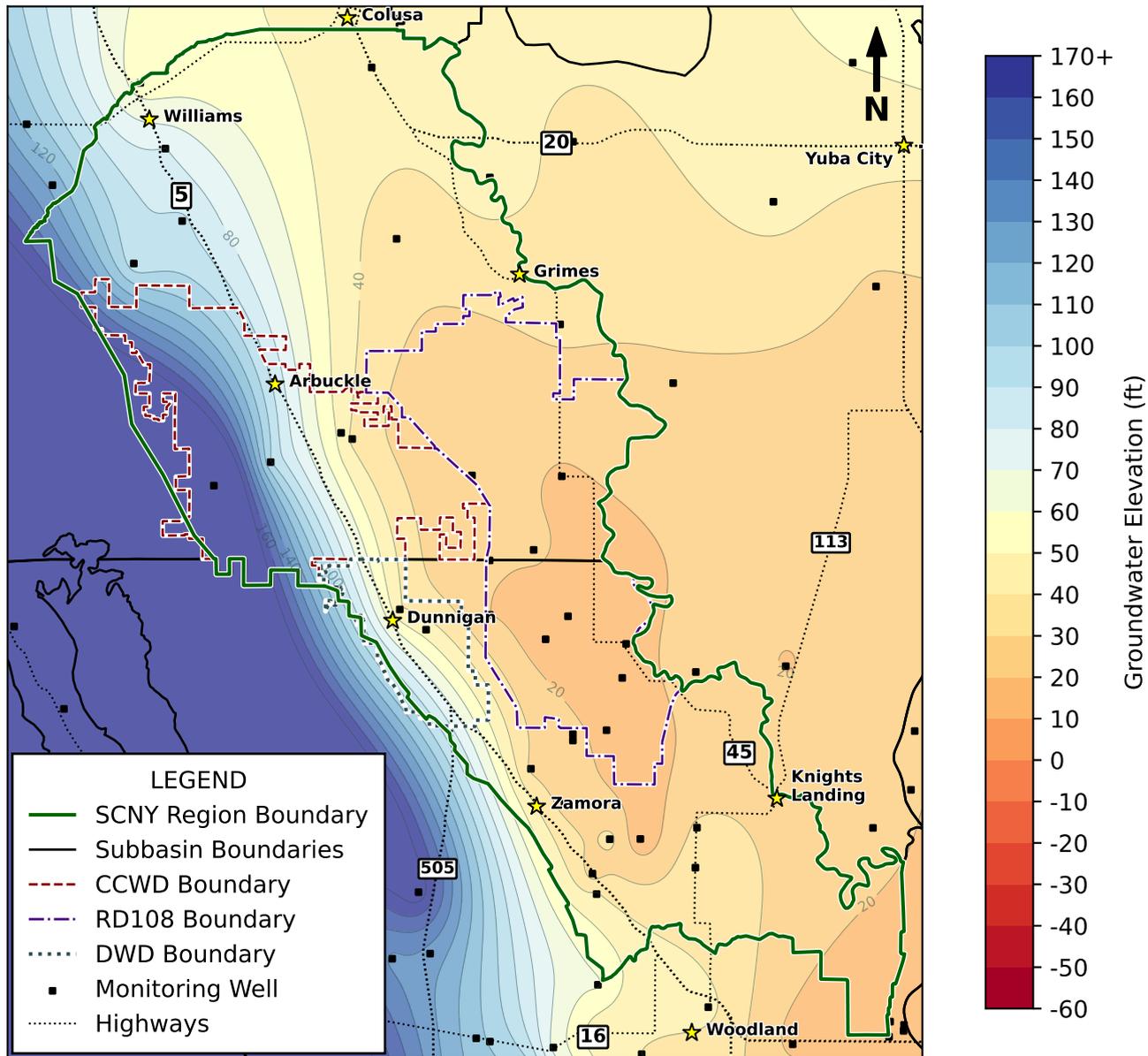
- **In-lieu Recharge Incentive Program**
- **Charter In-lieu Recharge Project**
- **Charter Drains**
- **DWD Subsurface Infiltration Gallery**
- **Strain Gravel Pit (Adjacent to Sand Creek)**
- **DWD Landowner Recharge Ponds**
- **Brian Stucker Direct Recharge Project**
- **Ephemeral Stream Trickle Flow Recharge - Sand Creek**
- **Ephemeral Stream Trickle Flow Recharge - Salt Creek**
- **Ephemeral Stream Trickle Flow Recharge - Clark's Ditch**
- **Ephemeral Stream Trickle Flow Recharge - Whiskey Creek**
- **Ephemeral Stream Trickle Flow Recharge - Elk Creek**
- **Ephemeral Stream Trickle Flow Recharge - Petroleum Creek**
- **Ephemeral Stream Trickle Flow Recharge - Cortina Creek**
- **Ephemeral Stream Trickle Flow Recharge - Buckeye Creek**
- **Ephemeral Stream Trickle Flow Recharge - Dunnigan Creek**
- **Ephemeral Stream Trickle Flow Recharge - Bird Creek**

**Attachment C – DWD Rootzone Water Balance (from C2VSimFG v1.5)**

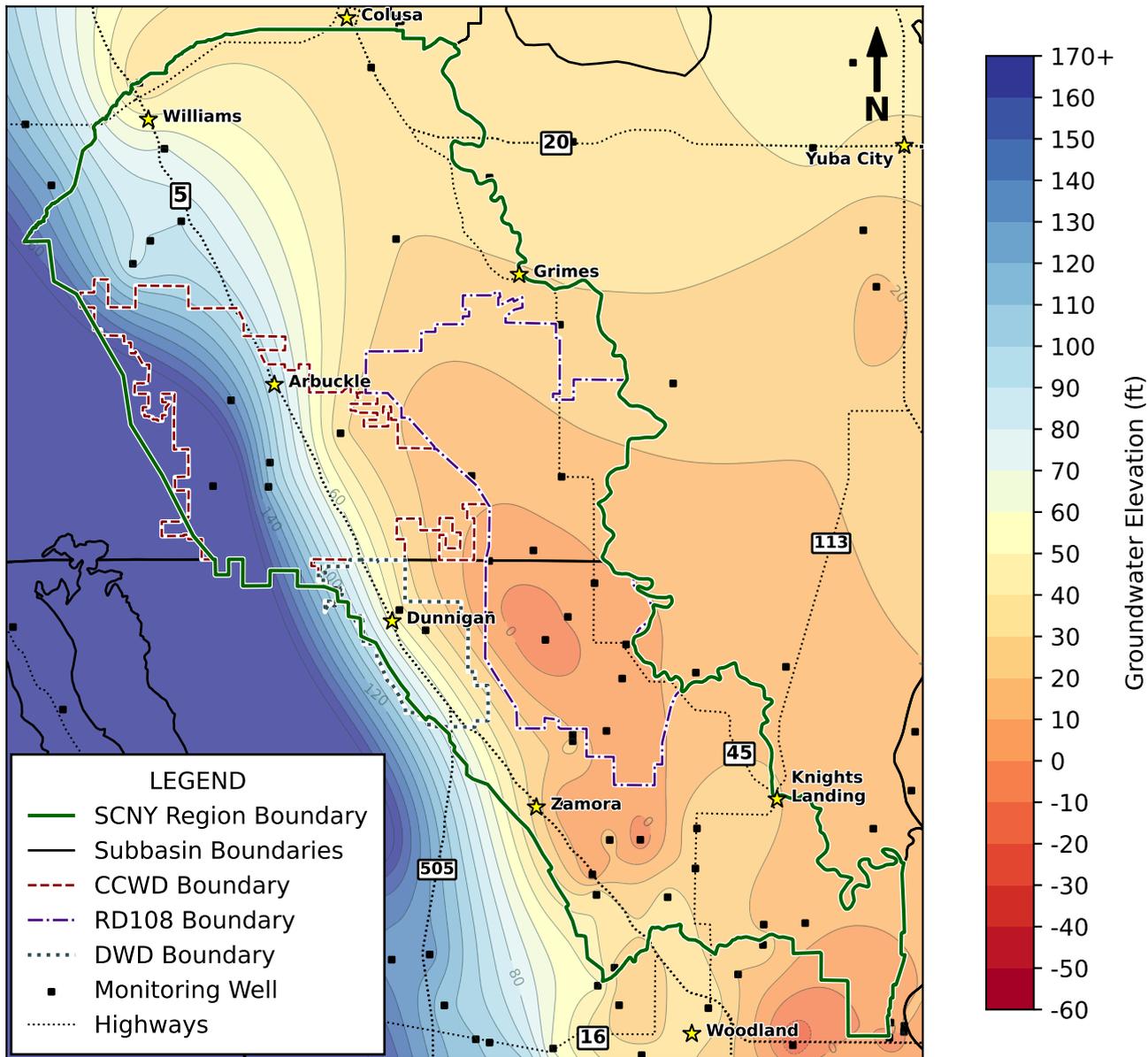
Units	Acres	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF
RootZone Budget																		
Balance																		
Inflows/Outflows																		
Tailwater and Runoff Detail																		
WaterYear	Area	GW Pumping	Inflows				Outflows							Balance Check (Sum of Inflows - Sum of Outflows) + Change of Storage	Total Runoff and Tailwater	Tailwater and Runoff DP (surface flow to groundwater)		
			Surface Water Deliveries	Precipitation	Groundwater Inflow	ETaw (Includes ET from Streams)	ETpr	ETgr	Deep Percolation of Applied Water	Deep Percolation of Precipitation	Runoff and Tailwater Exported	Change in Storage	Net Gain Land Expansion					
1974	10,981	19,673	870	20,452	8	10,487	9,931	8	7,285	3,437	10,204	350	0	0.0	10,204	0		
1975	10,981	22,339	918	19,842	73	11,938	8,715	73	8,505	2,461	11,698	218	0	0.0	11,698	0		
1976	10,981	13,406	12,332	6,524	0	13,343	6,018	0	8,292	808	3,912	111	0	0.0	3,912	0		
1977	10,981	9,794	12,782	7,513	2	11,926	6,132	2	6,143	617	4,893	-377	0	0.0	4,893	0		
1978	10,981	6,059	25,829	25,080	328	13,428	8,462	328	9,756	3,495	21,969	140	0	0.0	21,969	0		
1979	10,981	6,633	23,024	15,492	801	14,271	7,372	801	10,001	2,310	11,280	86	0	0.0	11,280	0		
1980	10,981	1,778	38,316	22,267	1,841	14,251	6,543	1,841	12,511	3,537	24,978	-542	0	0.0	24,978	0		
1981	10,981	281	38,002	13,218	1,989	15,426	5,972	1,989	11,415	2,502	15,830	-356	0	0.0	15,830	0		
1982	10,981	12,305	10,371	27,942	1,771	11,596	8,218	1,771	9,232	4,348	17,242	19	0	0.0	17,242	0		
1983	10,981	9,146	9,508	32,700	973	8,991	9,349	973	7,267	4,543	21,410	207	0	0.0	21,410	0		
1984	10,981	7,377	15,083	17,999	617	11,403	8,450	617	8,041	2,846	10,278	559	0	0.0	10,278	0		
1985	10,981	756	9,311	14,410	652	6,563	8,272	652	1,135	1,770	5,093	-1,644	0	0.0	5,093	0		
1986	10,981	519	7,790	24,144	1,235	5,684	8,471	1,235	1,201	2,406	14,733	41	0	0.0	14,733	0		
1987	10,981	758	14,106	9,562	715	7,730	7,546	715	1,576	1,454	6,623	503	0	0.0	6,623	0		
1988	10,981	583	13,700	15,257	763	8,074	8,541	763	1,941	2,012	8,779	-194	0	0.0	8,779	0		
1989	10,981	502	13,087	15,264	787	9,185	8,414	787	1,236	1,215	7,660	-1,142	0	0.0	7,660	0		
1990	10,981	3,802	9,084	12,576	531	7,860	9,682	531	3,231	2,043	4,428	1,782	0	0.0	4,428	0		
1991	10,981	5,241	5,644	14,188	231	7,707	8,136	231	1,974	927	6,118	-210	0	0.0	6,118	0		
1992	10,981	6,703	5,822	16,402	173	8,536	8,537	173	2,739	1,550	7,878	314	0	0.0	7,878	0		
1993	10,981	617	5,237	27,847	213	4,766	10,166	213	403	2,911	15,493	38	0	0.0	15,493	0		
1994	10,981	12,936	9,924	12,167	219	12,444	9,537	219	6,019	2,448	4,909	329	0	0.0	4,909	0		
1995	10,981	3,599	11,221	30,628	169	9,570	9,667	169	3,906	2,876	18,565	-865	0	0.0	18,565	0		
1996	10,981	4,593	12,594	23,641	447	10,301	10,076	447	4,594	2,707	13,198	49	0	0.0	13,198	0		
1997	10,981	1,265	9,411	20,208	424	8,216	8,263	424	1,171	1,606	11,528	-100	0	0.0	11,528	0		
1998	10,981	1,529	7,118	30,476	624	4,677	9,775	624	2,166	4,234	19,225	954	0	0.0	19,225	0		
1999	10,981	2,919	18,139	13,460	470	11,288	9,878	470	3,647	2,338	6,531	-837	0	0.0	6,531	0		
2000	10,981	3,703	16,338	17,613	269	12,639	8,942	269	4,773	2,104	9,051	-145	0	0.0	9,051	0		
2001	10,981	1,196	11,280	14,341	464	9,779	8,471	464	929	1,267	5,436	-933	0	0.0	5,436	0		
2002	10,981	1,875	11,552	16,029	452	10,247	8,452	452	1,919	1,910	7,121	192	0	0.0	7,121	0		
2003	10,981	4,506	14,384	20,449	314	9,781	9,343	314	6,654	3,368	11,773	1,579	0	0.0	11,773	0		
2004	10,981	3,443	14,490	16,268	572	10,940	8,601	572	1,896	1,775	9,308	-1,681	0	0.0	9,308	0		
2005	10,981	940	11,646	20,392	524	10,405	10,149	524	1,551	2,117	8,719	-36	0	0.0	8,719	0		
2006	10,981	1,458	16,402	23,876	519	11,200	9,192	519	3,256	3,090	15,663	665	0	0.0	15,663	0		
2007	10,981	959	9,591	9,355	419	8,210	7,069	419	1,654	1,077	3,489	1,595	0	0.0	3,489	0		
2008	10,981	3,740	10,000	15,294	404	9,829	7,550	404	1,253	1,323	8,393	-686	0	0.0	8,393	0		
2009	10,981	2,882	8,706	12,865	33	8,699	7,987	33	1,644	1,243	5,856	976	0	0.0	5,856	0		
2010	10,981	2,113	8,958	18,191	90	7,570	9,053	90	1,603	1,847	9,236	48	0	0.0	9,236	0		
2011	10,981	1,992	8,135	22,805	196	6,946	9,394	196	1,709	2,197	12,824	138	0	0.0	12,824	0		
2012	10,981	3,170	12,851	12,111	136	9,698	8,204	136	1,534	961	6,827	-907	0	0.0	6,827	0		
2013	10,981	2,610	9,818	14,950	66	9,458	7,991	66	1,558	1,409	7,152	191	0	0.0	7,152	0		
2014	10,981	7,924	9,779	9,177	70	12,141	6,963	70	1,235	448	5,966	-125	0	0.0	5,966	0		
2015	10,981	7,516	3,814	13,924	0	9,514	7,241	0	1,079	1,233	6,958	770	0	0.0	6,958	0		
2016	10,981	4,738	9,630	15,333	0	11,687	7,692	0	1,035	1,085	7,289	-913	0	0.0	7,289	0		
2017	10,981	2,944	9,905	28,671	41	10,031	9,411	41	1,354	1,962	18,834	72	0	0.0	18,834	0		
2018	10,981	4,479	8,945	12,716	1	11,283	7,881	1	879	782	5,220	-95	0	0.0	5,220	0		
2019	10,981	4,124	13,735	25,406	34	10,769	8,847	34	1,391	1,491	20,161	-606	0	0.0	20,161	0		
2020	10,981	6,649	11,143	9,449	1	13,134	6,803	1	1,330	782	5,755	562	0	0.0	5,755	0		
2021	10,981	10,728	6,683	5,926	0	15,109	5,129	0	885	372	1,720	-122	0	0.0	1,720	0		
<b>Average</b>	<b>10,981</b>	<b>3,615</b>	<b>10,973</b>	<b>17,539</b>	<b>250</b>	<b>10,116</b>	<b>8,445</b>	<b>250</b>	<b>2,097</b>	<b>1,763</b>	<b>9,696</b>	<b>-10</b>	<b>0</b>	<b>0.0</b>	<b>9,696</b>	<b>0</b>		

## **Attachment D – SCNY Groundwater Elevation Maps**

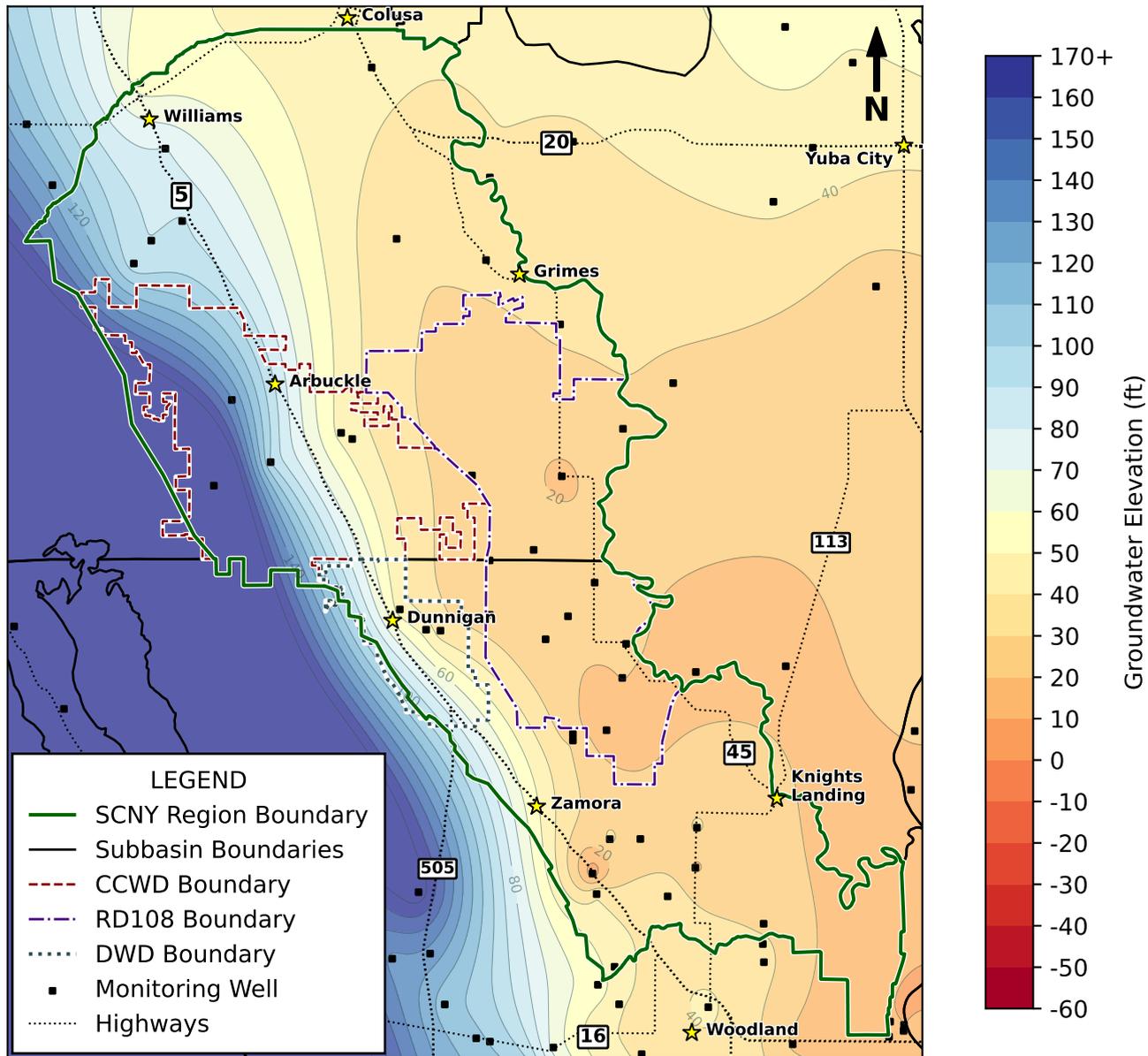
# South Colusa-North Yolo Groundwater Elevation for Spring, 2000



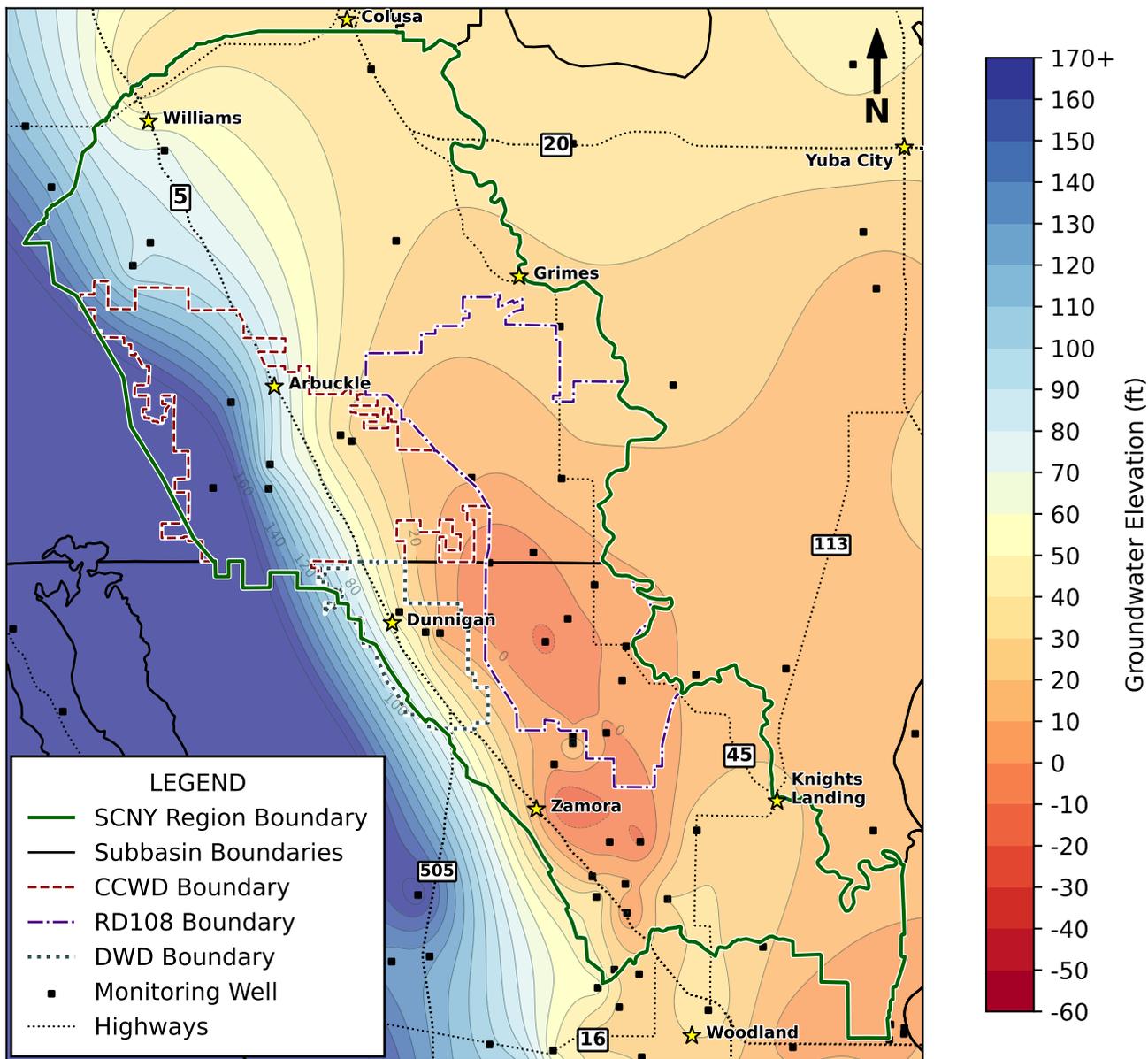
# South Colusa-North Yolo Groundwater Elevation for Fall, 2000



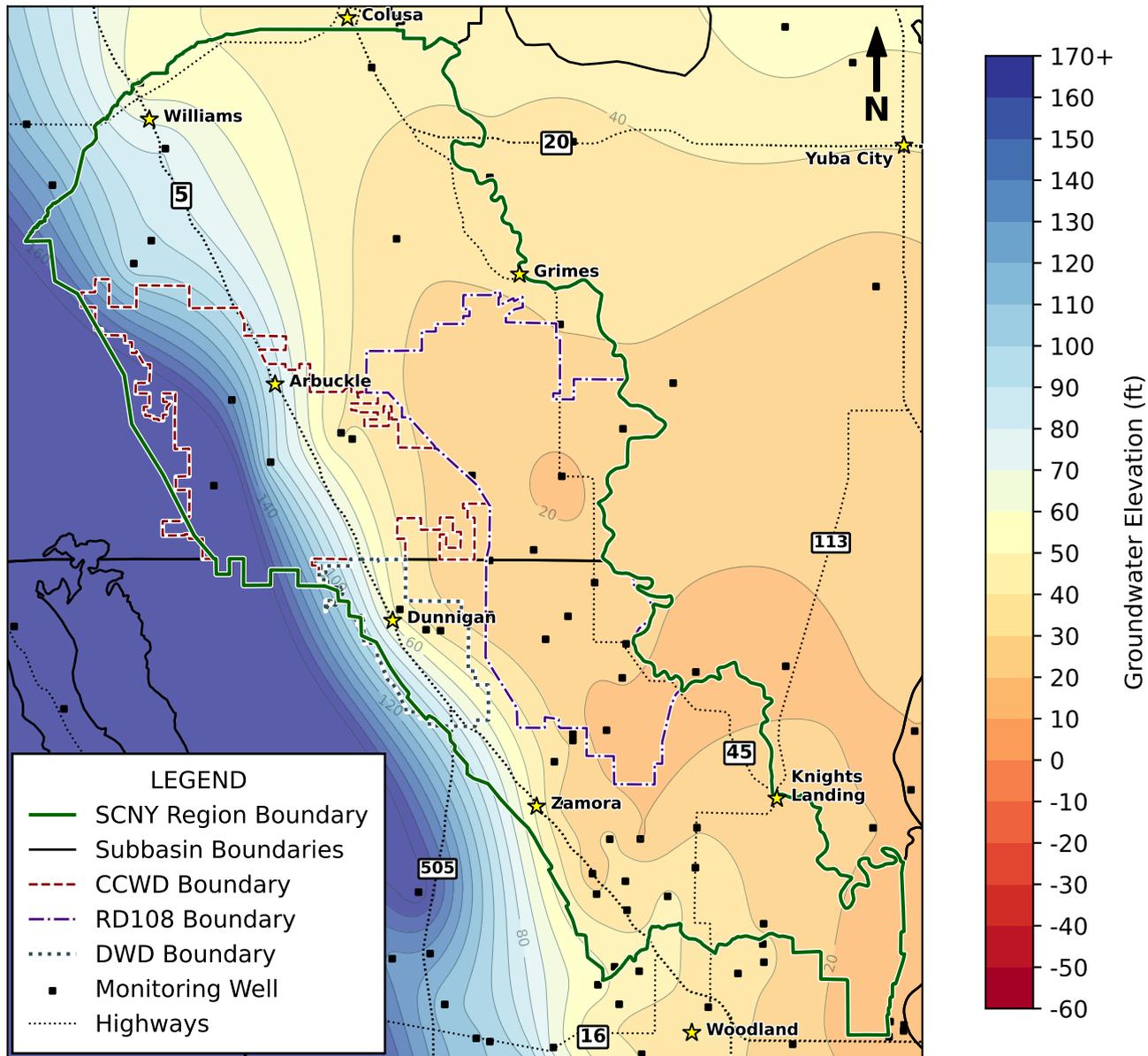
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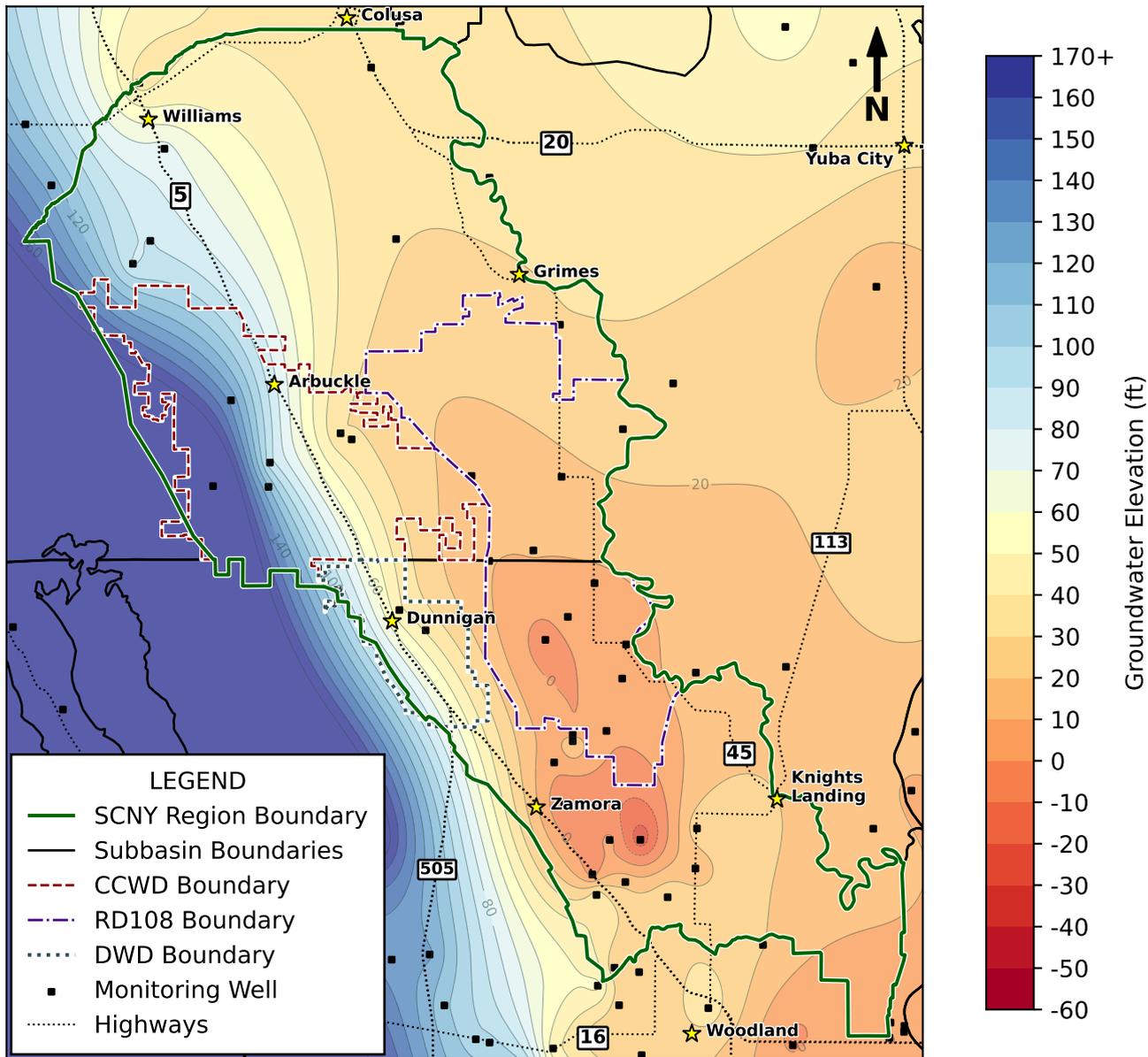
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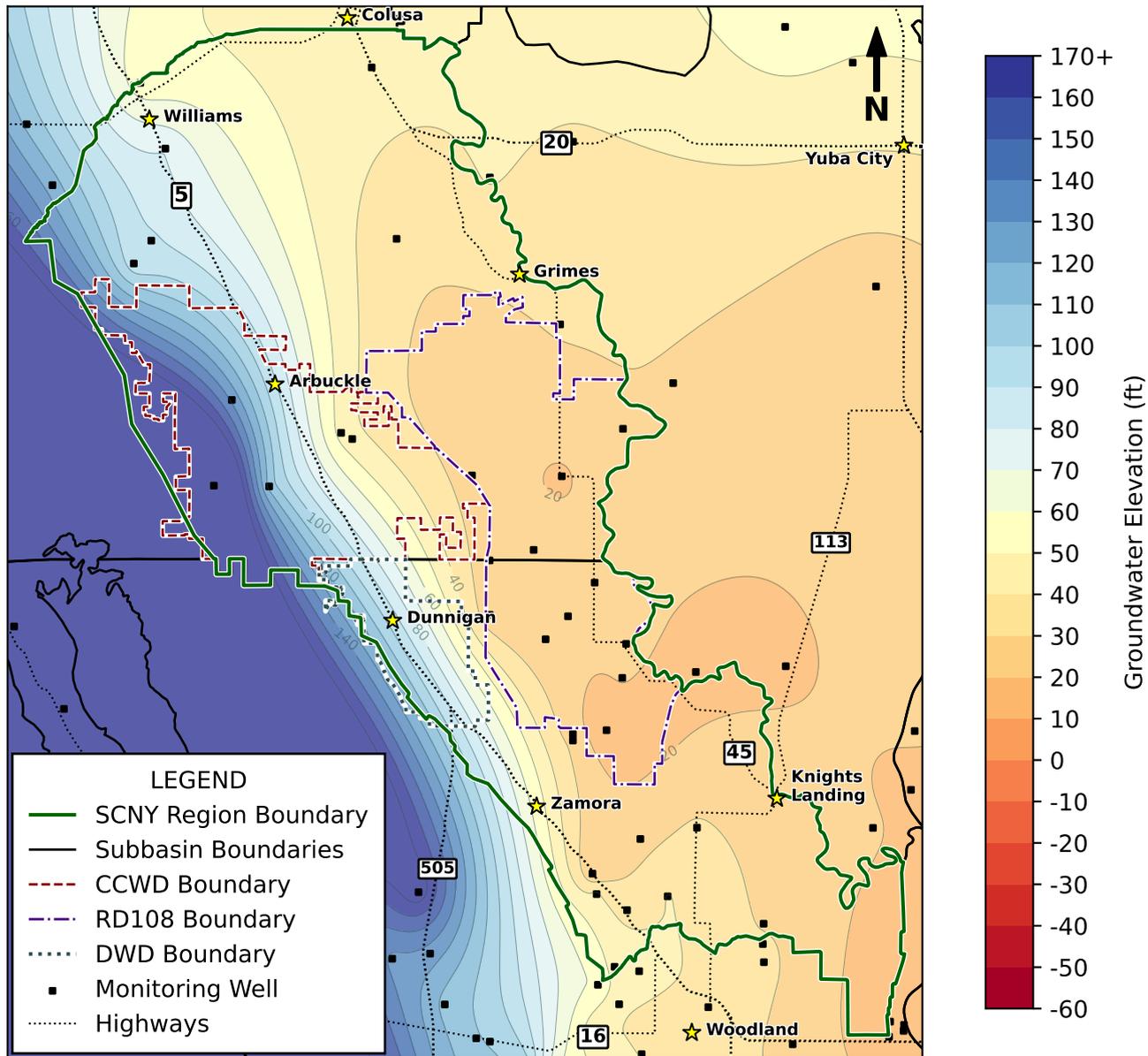
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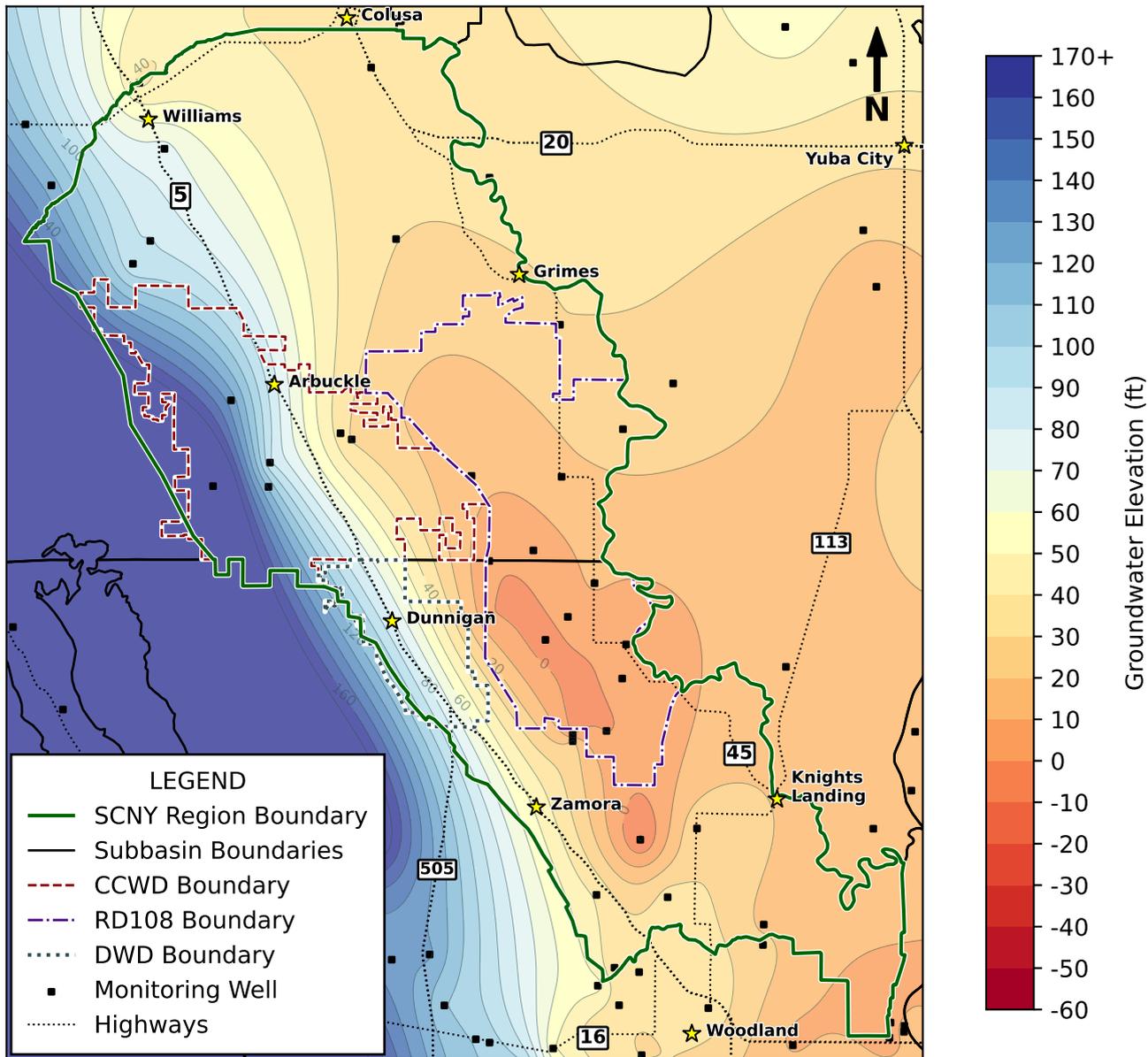
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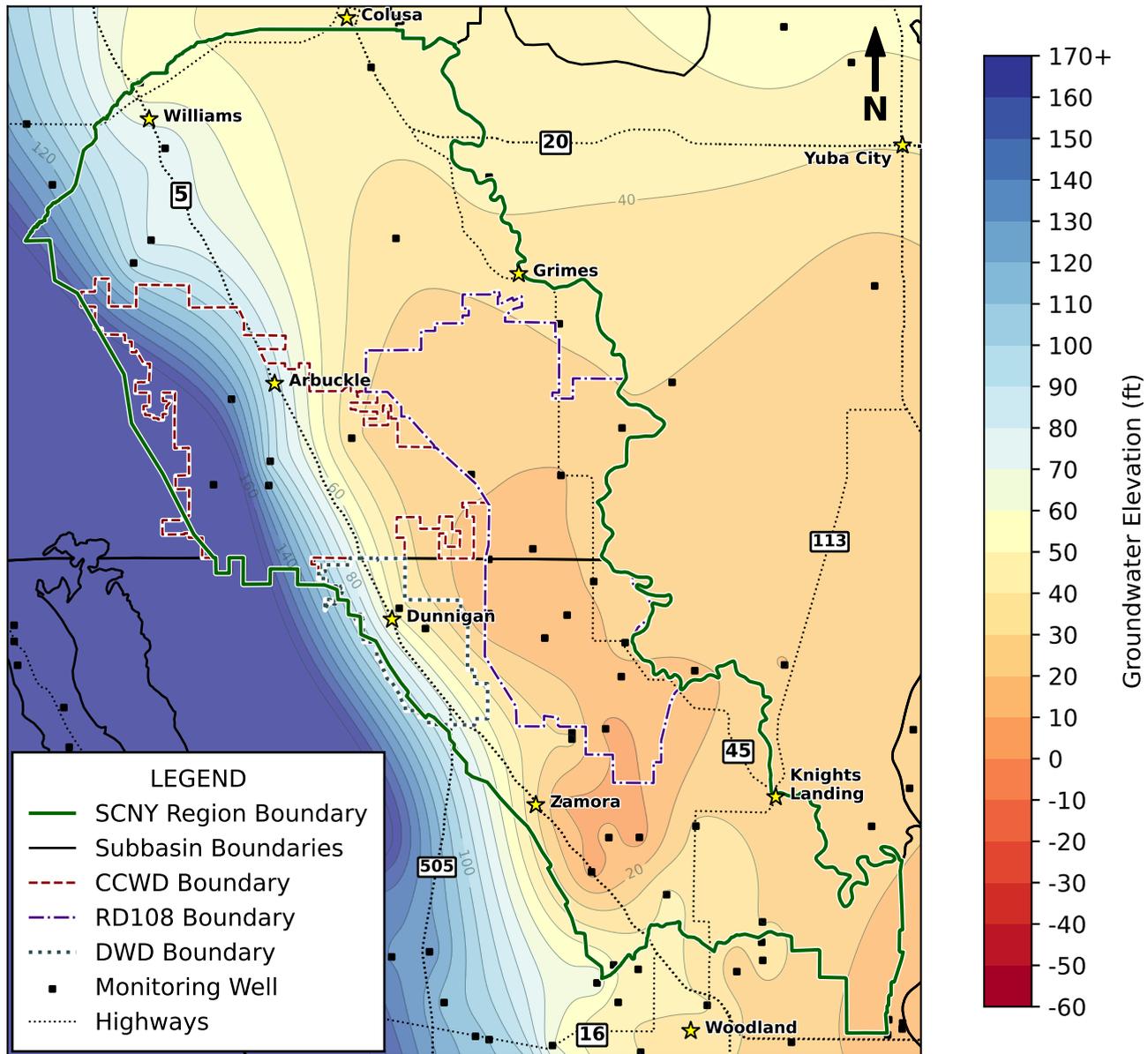
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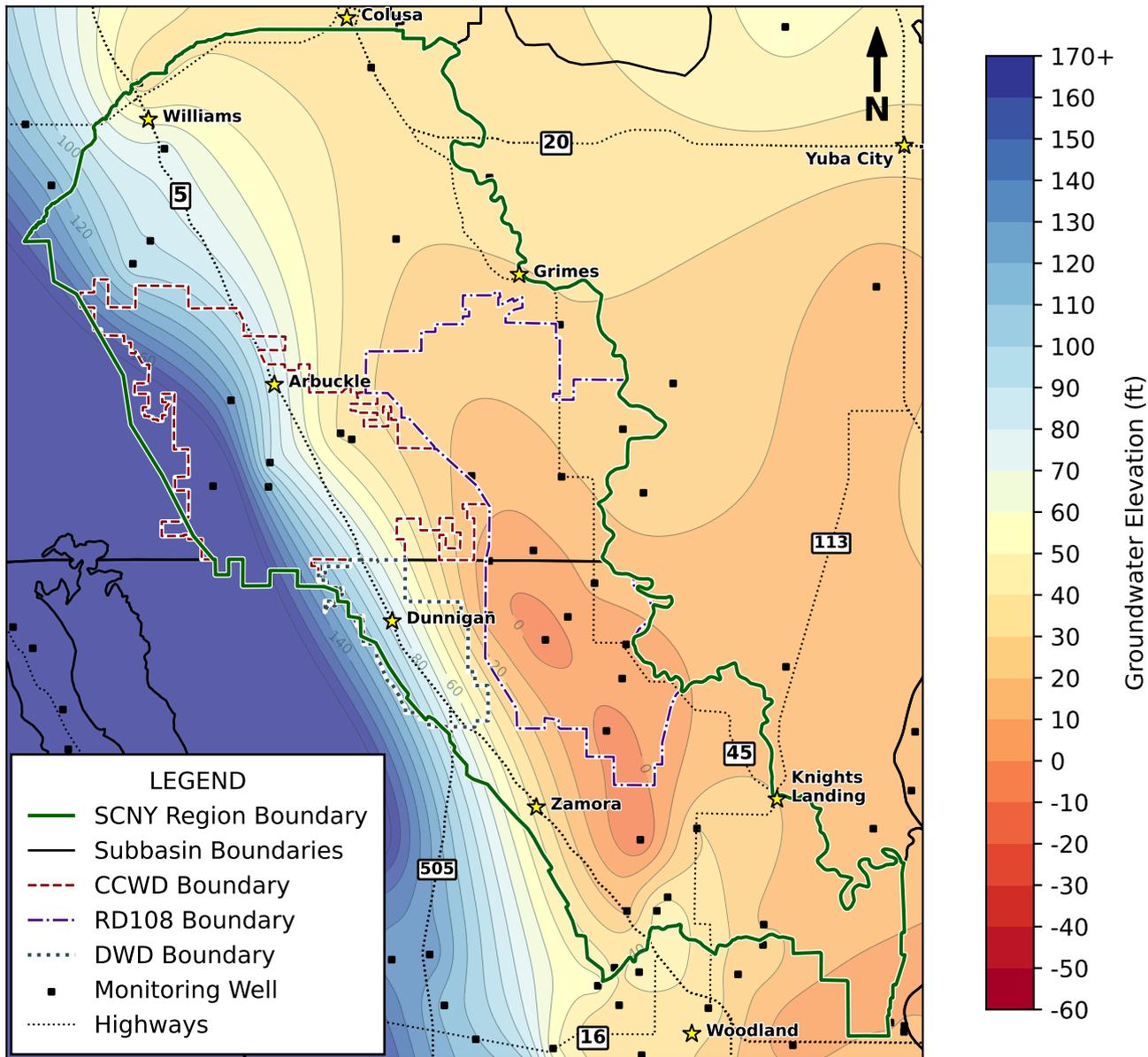
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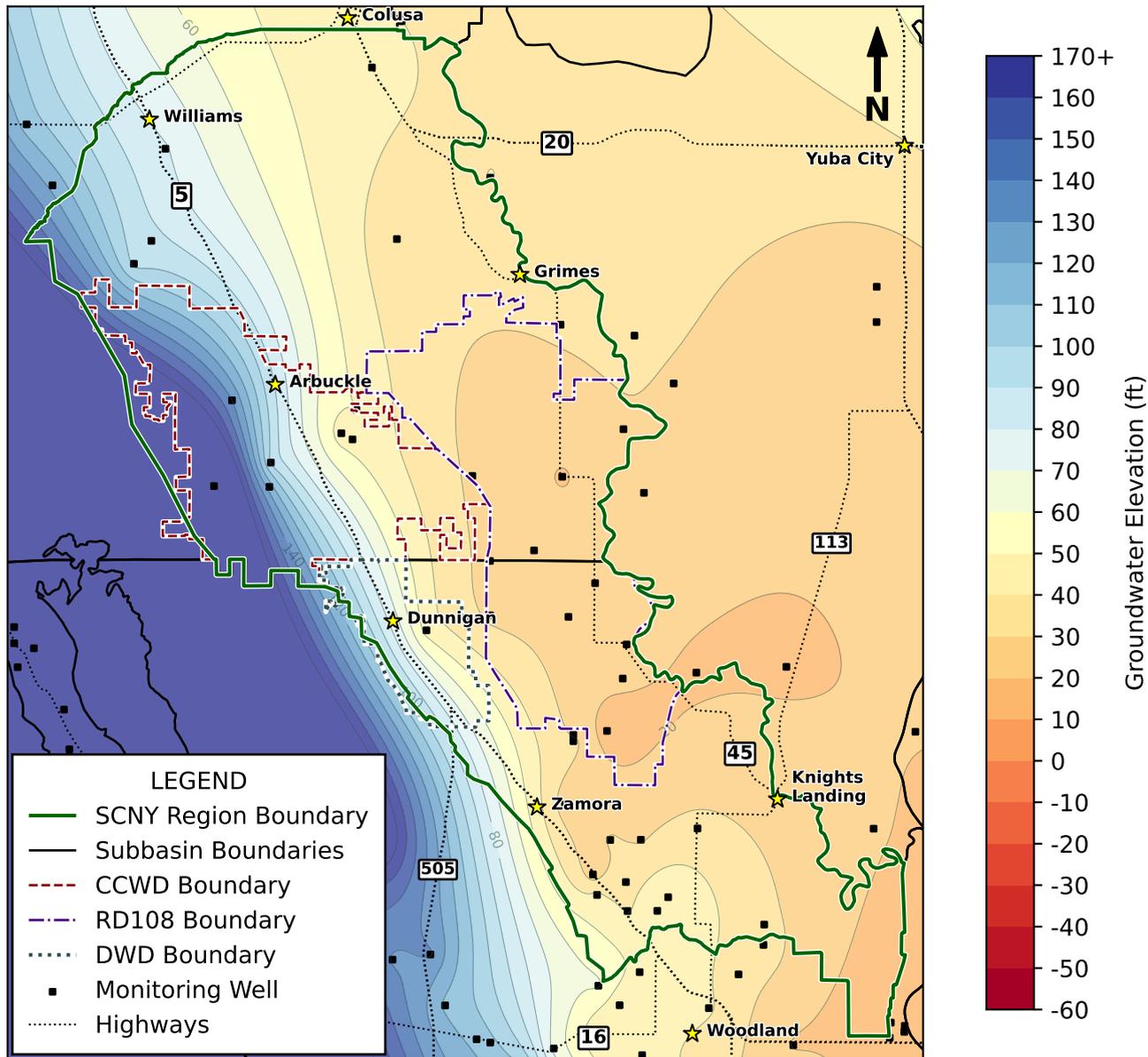
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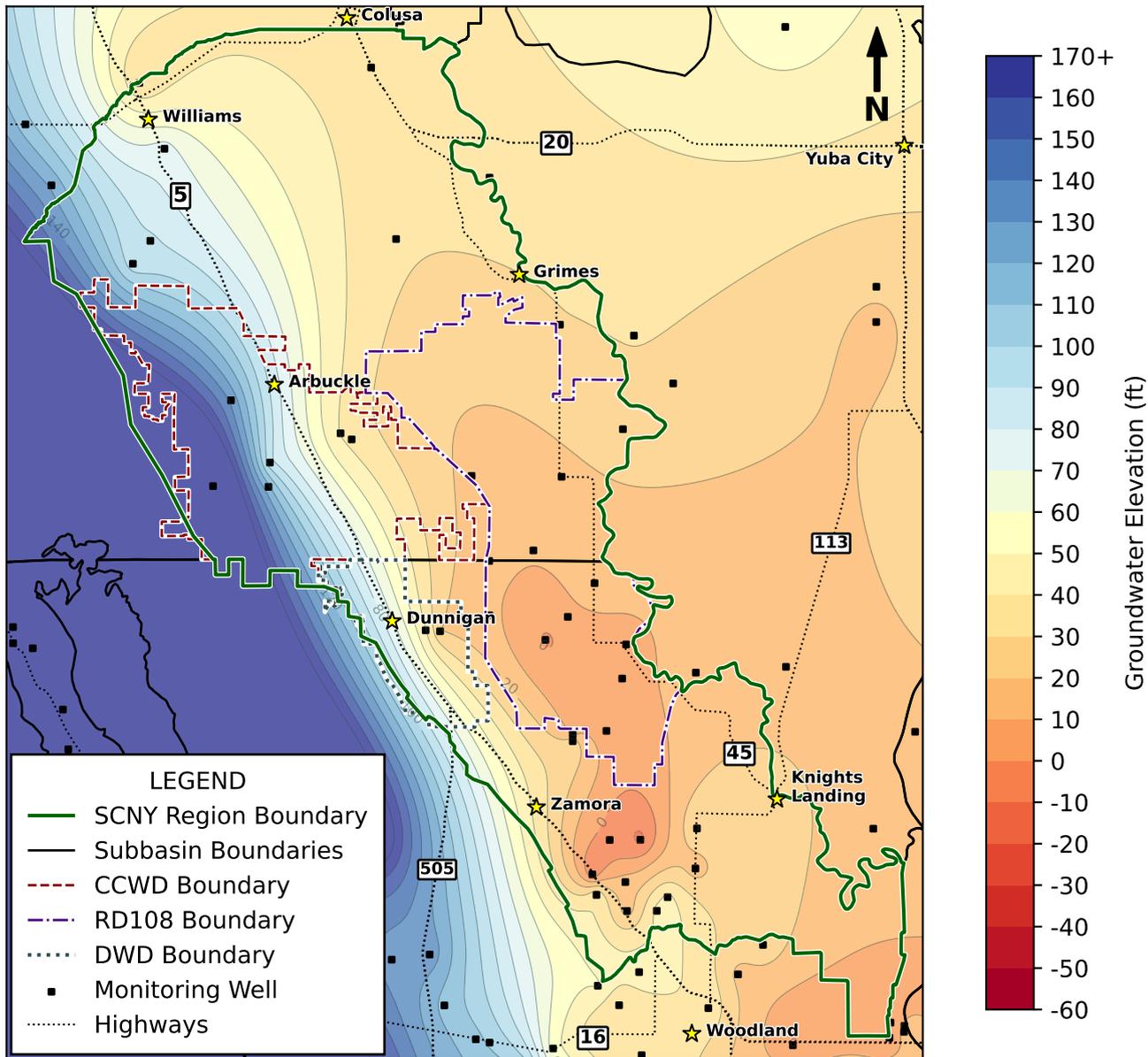
# South Colusa-North Yolo Groundwater Elevation for Fall, 2004



# South Colusa-North Yolo Groundwater Elevation for Spring, 2005

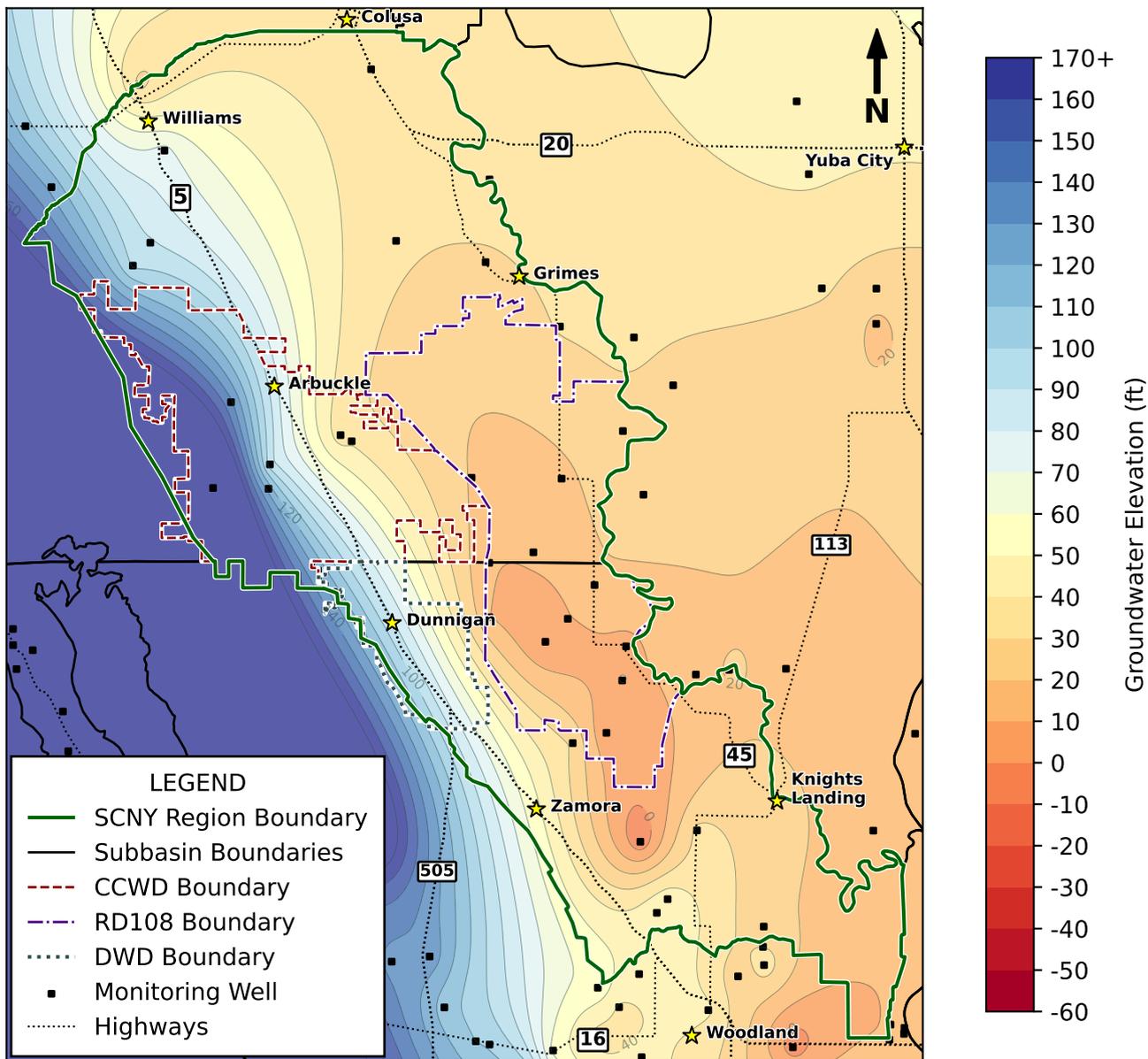


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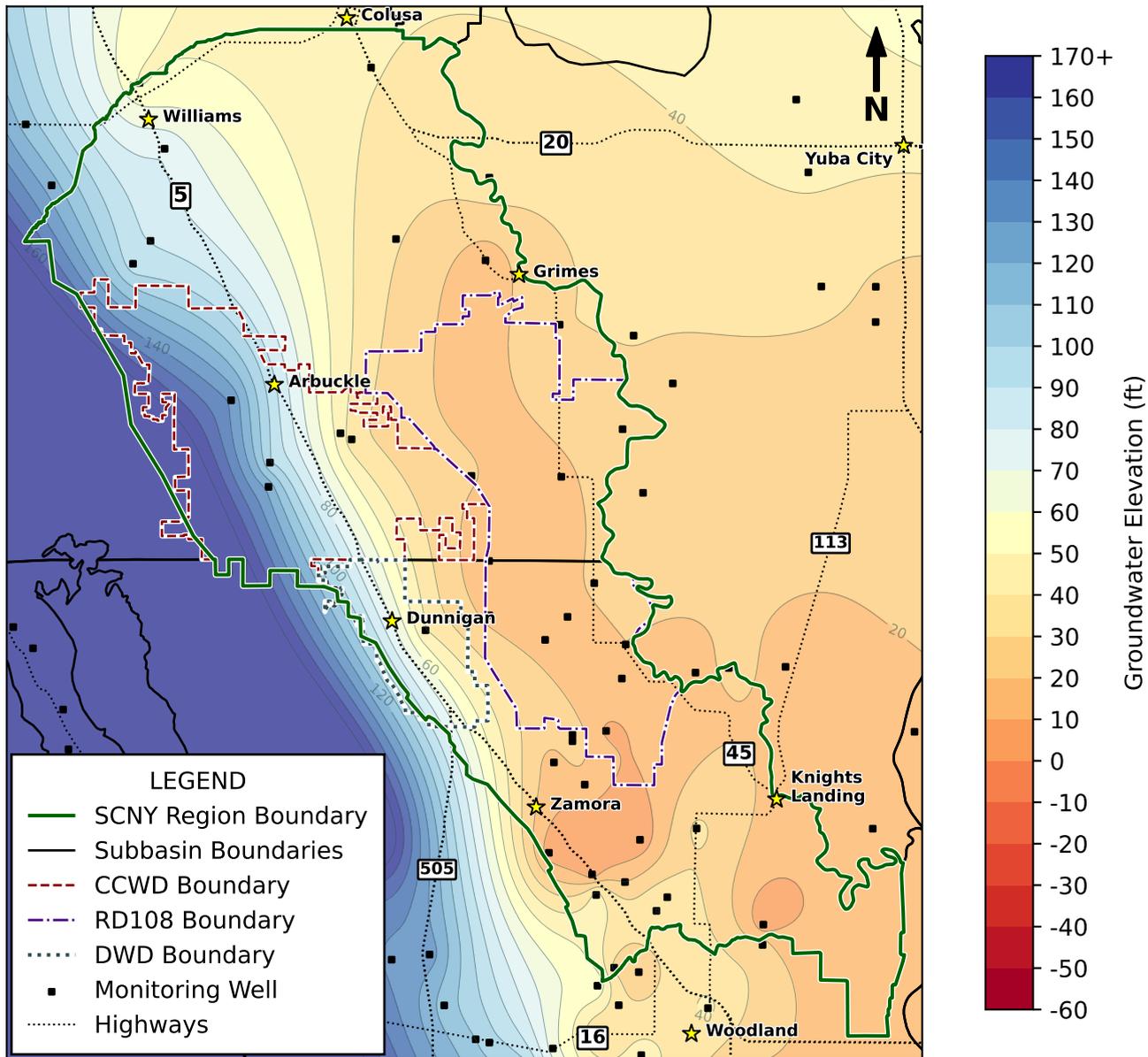




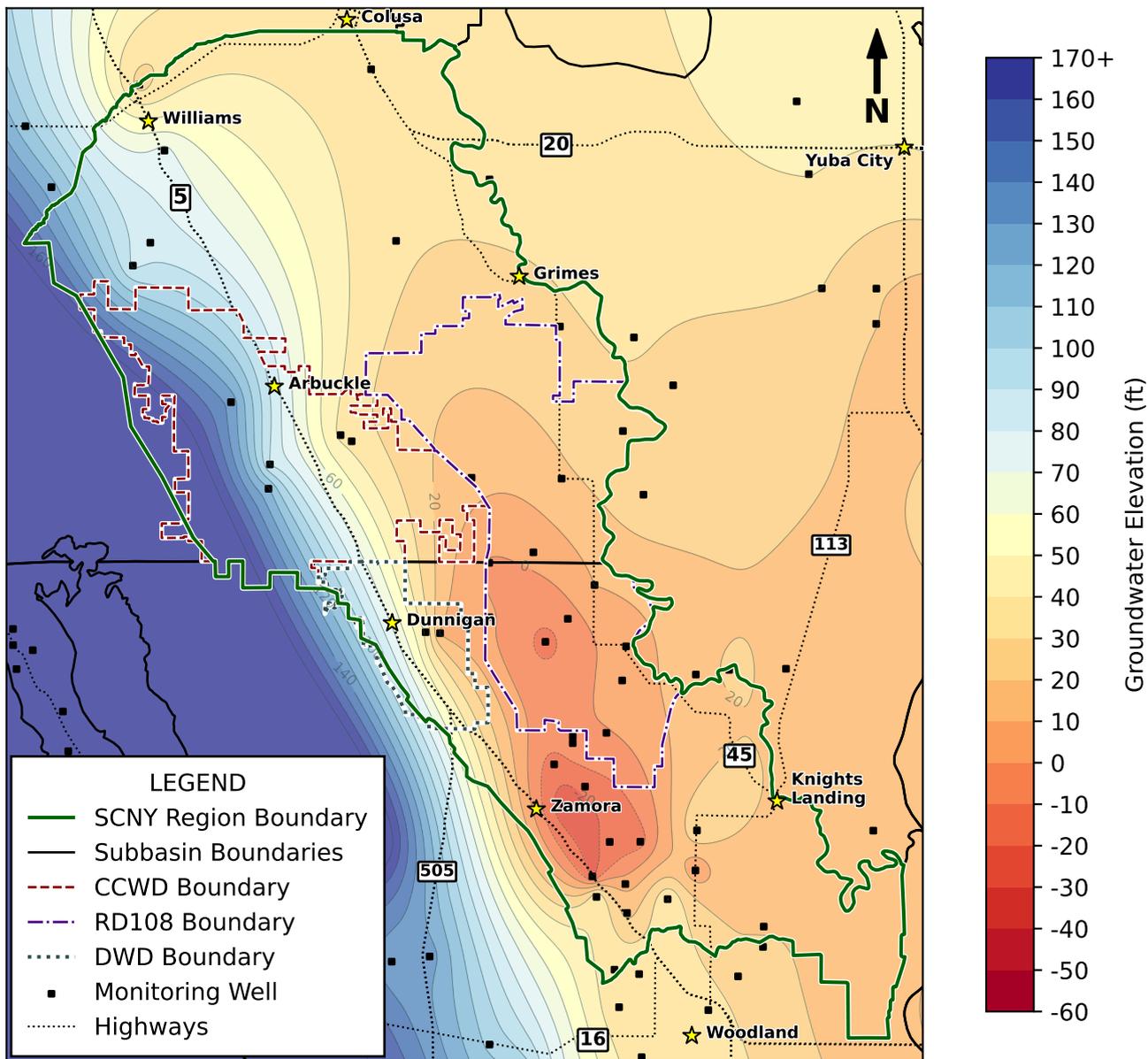
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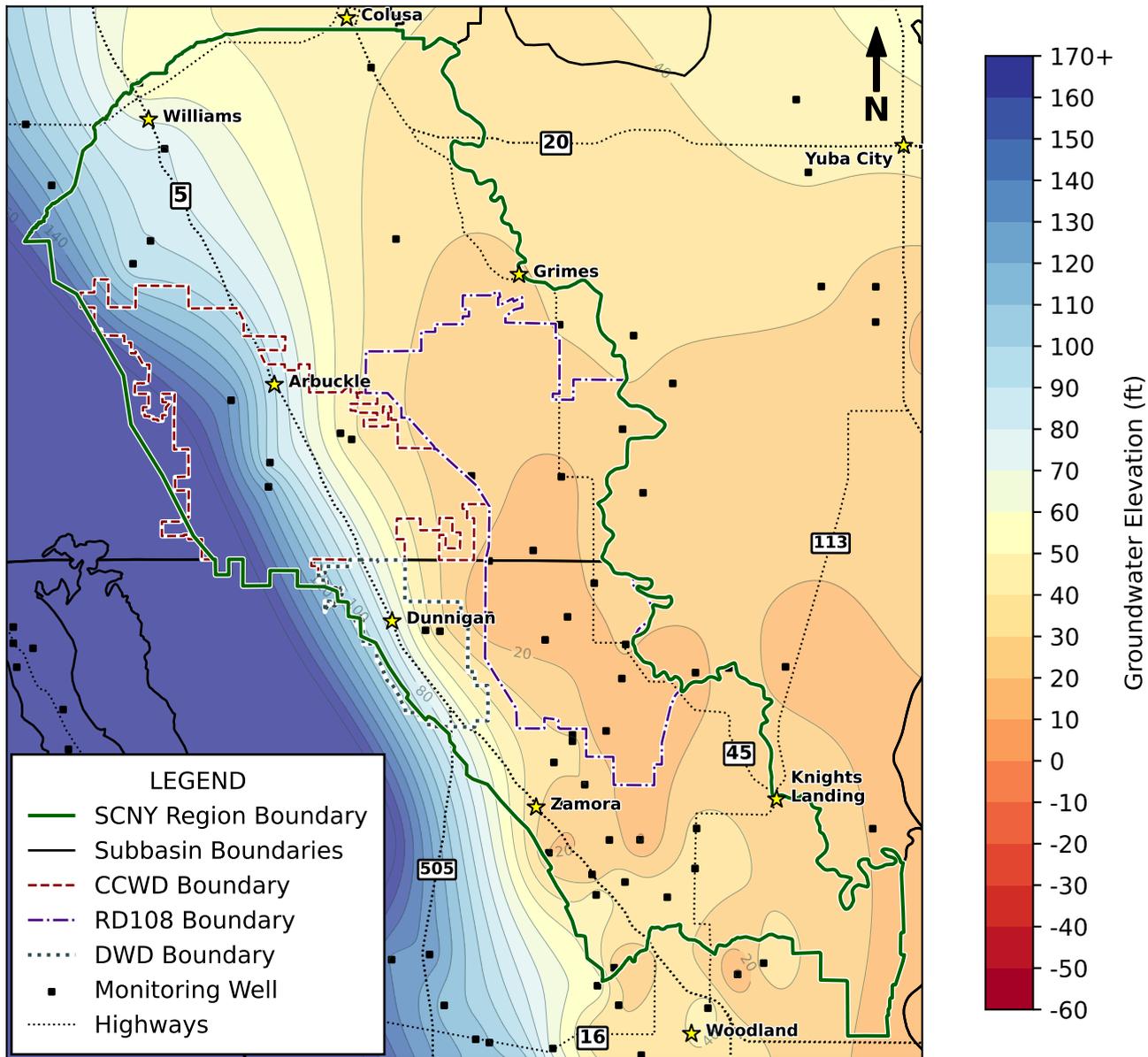
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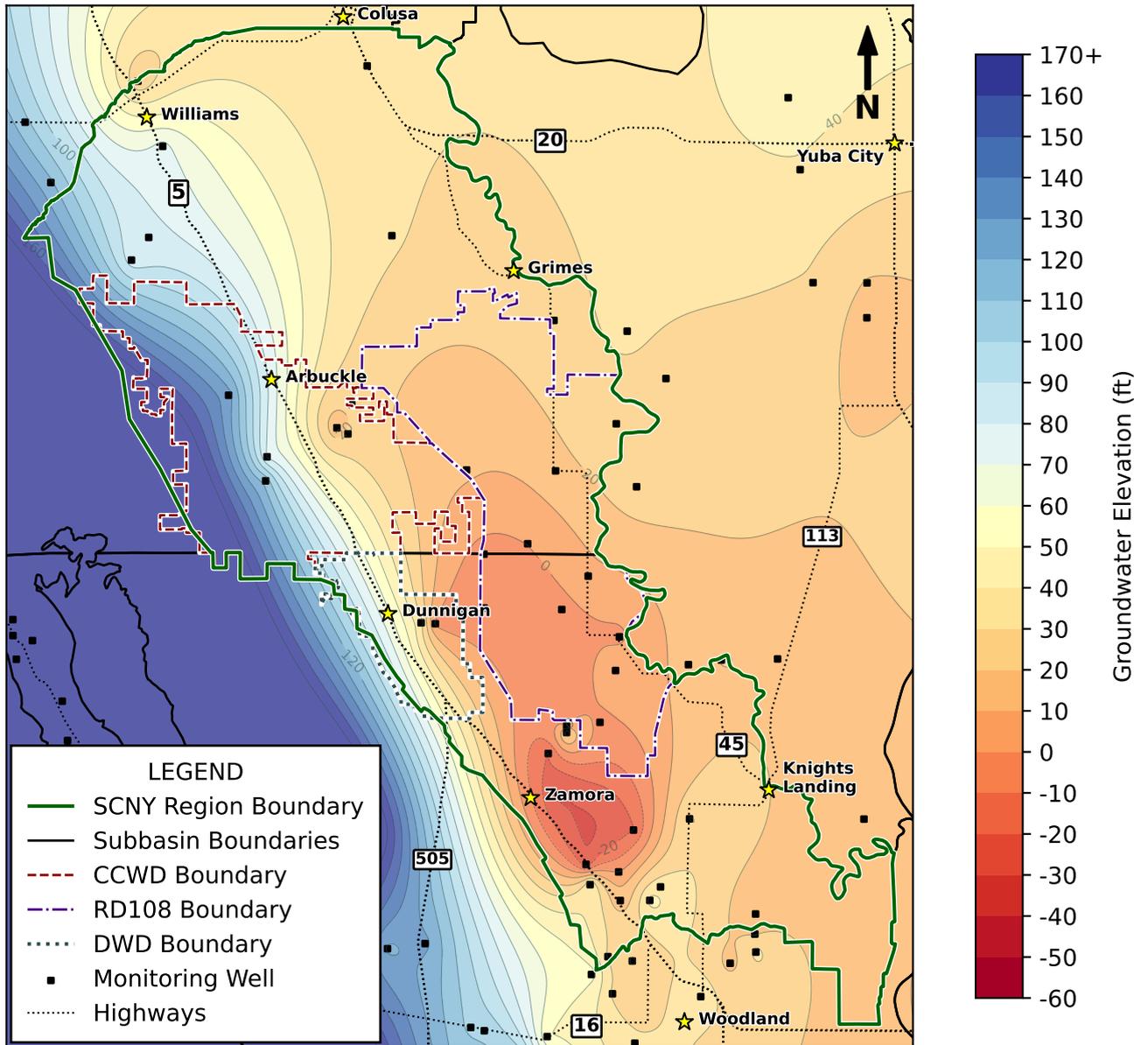
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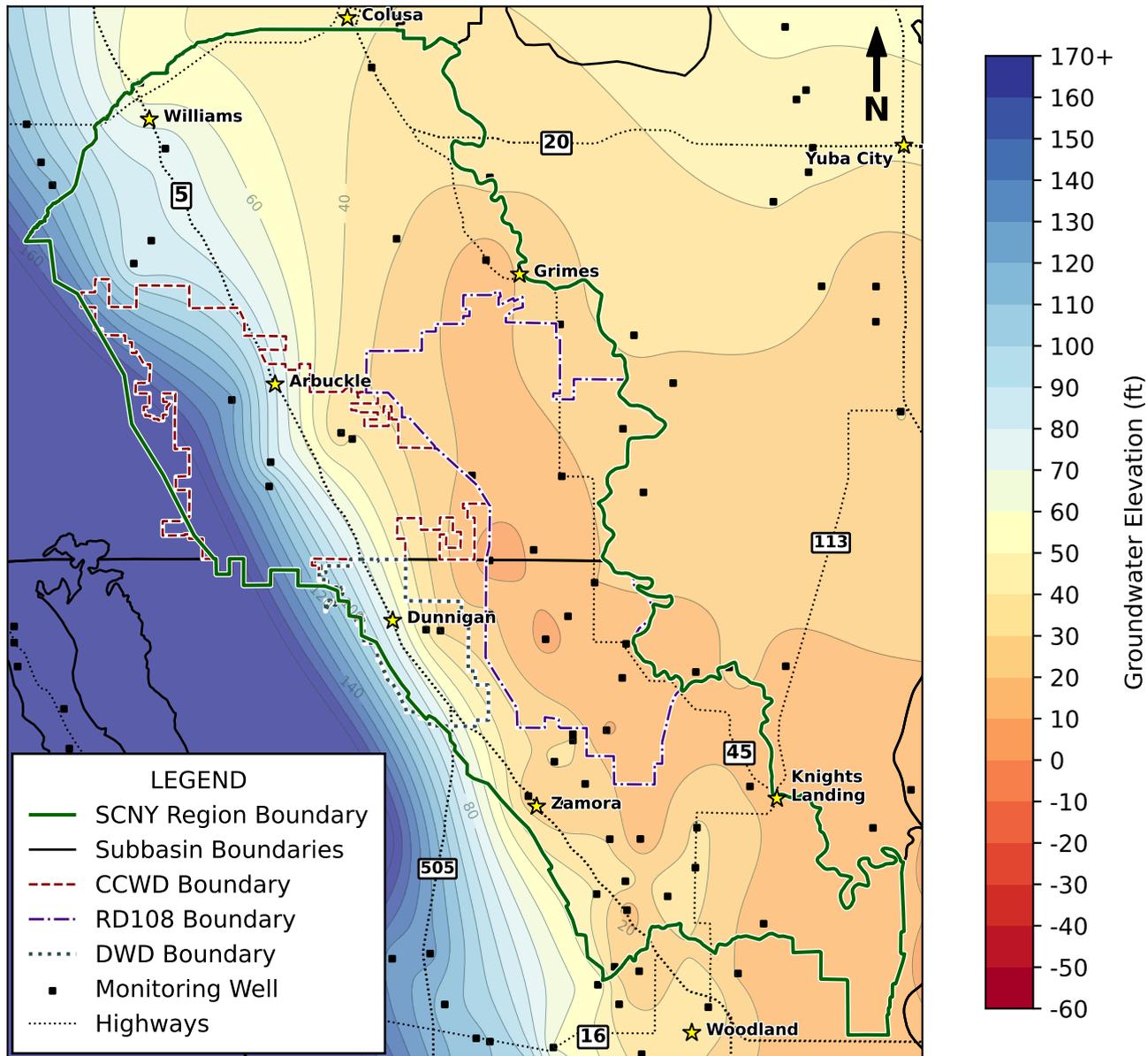
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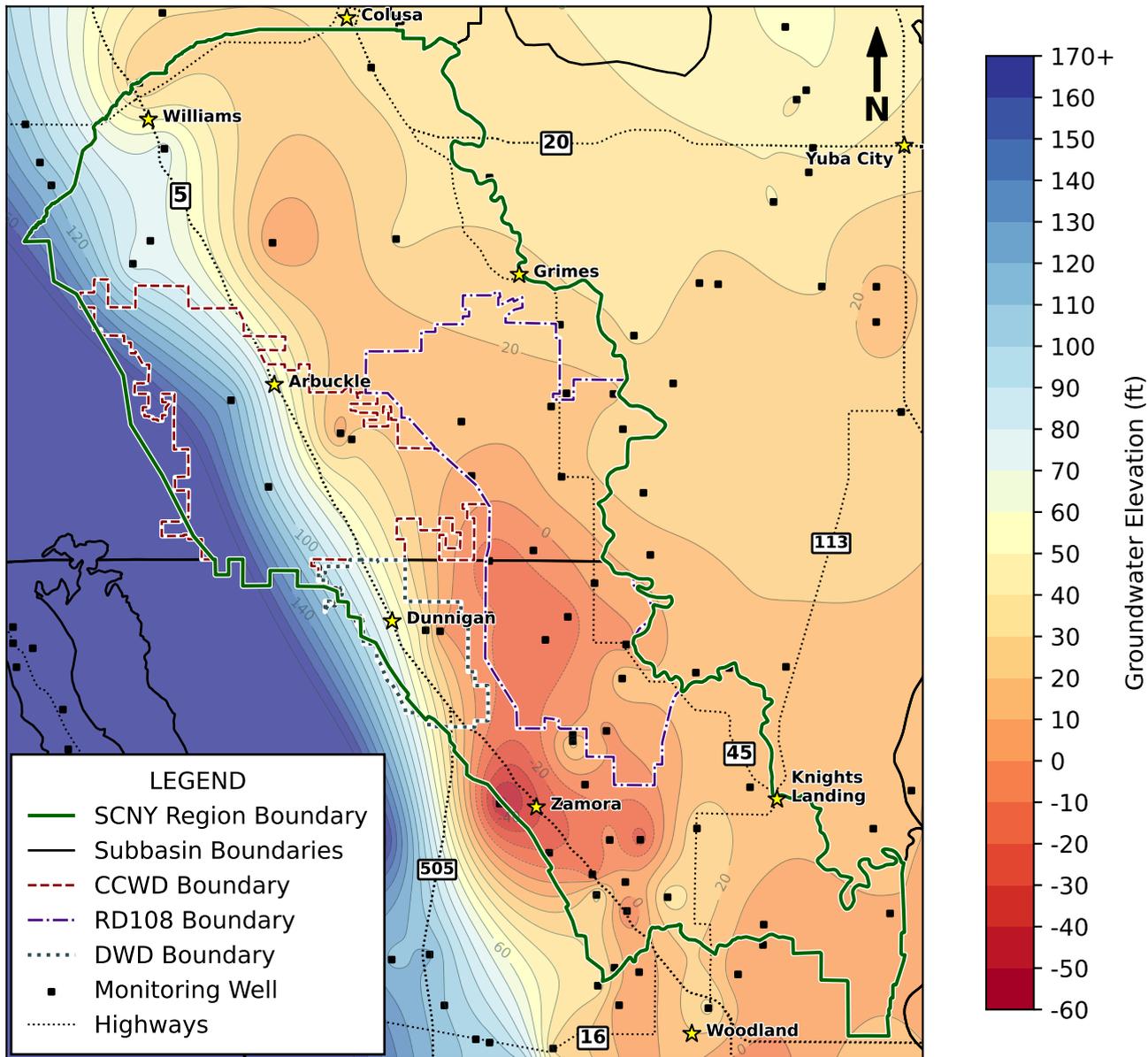
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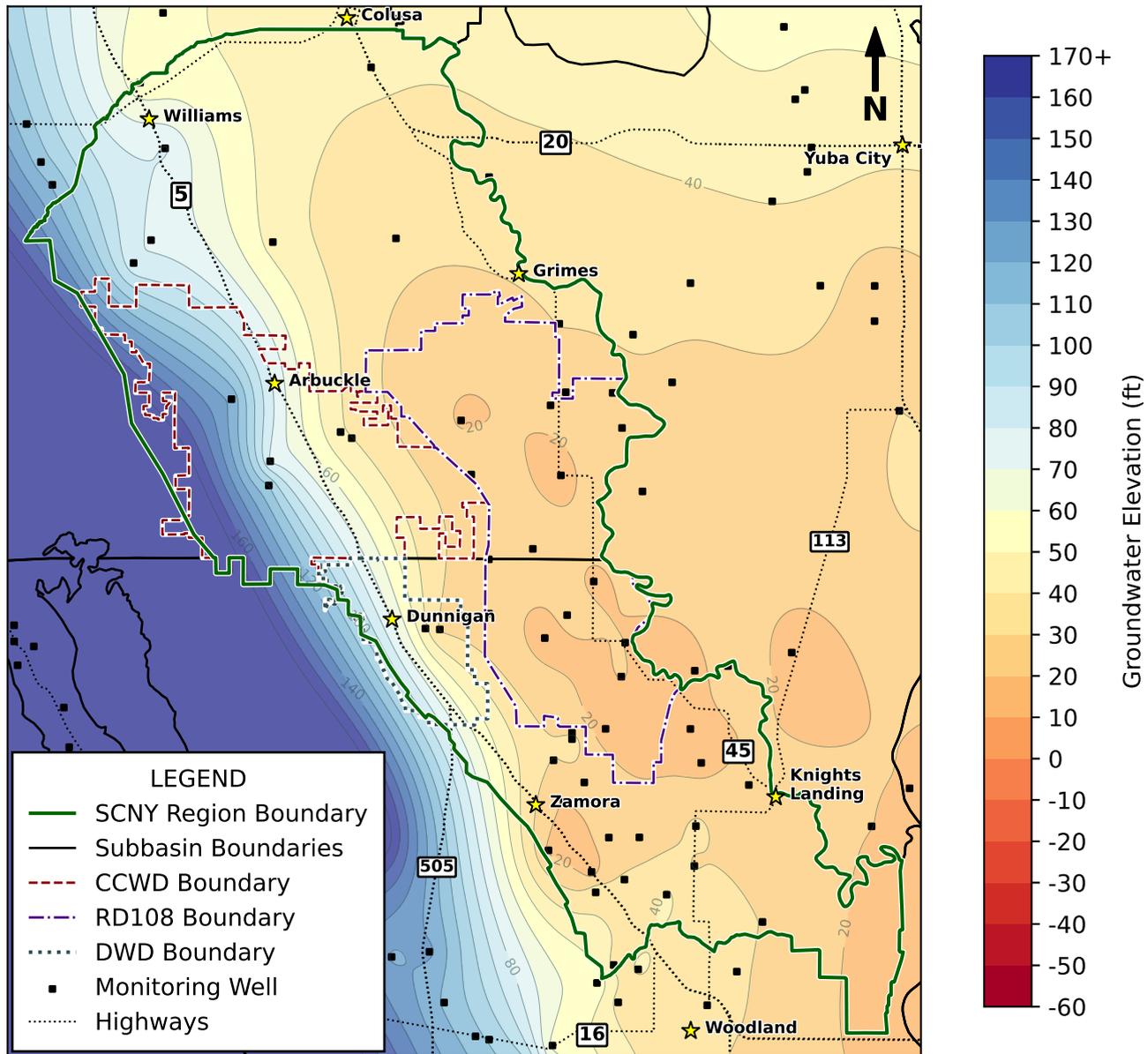
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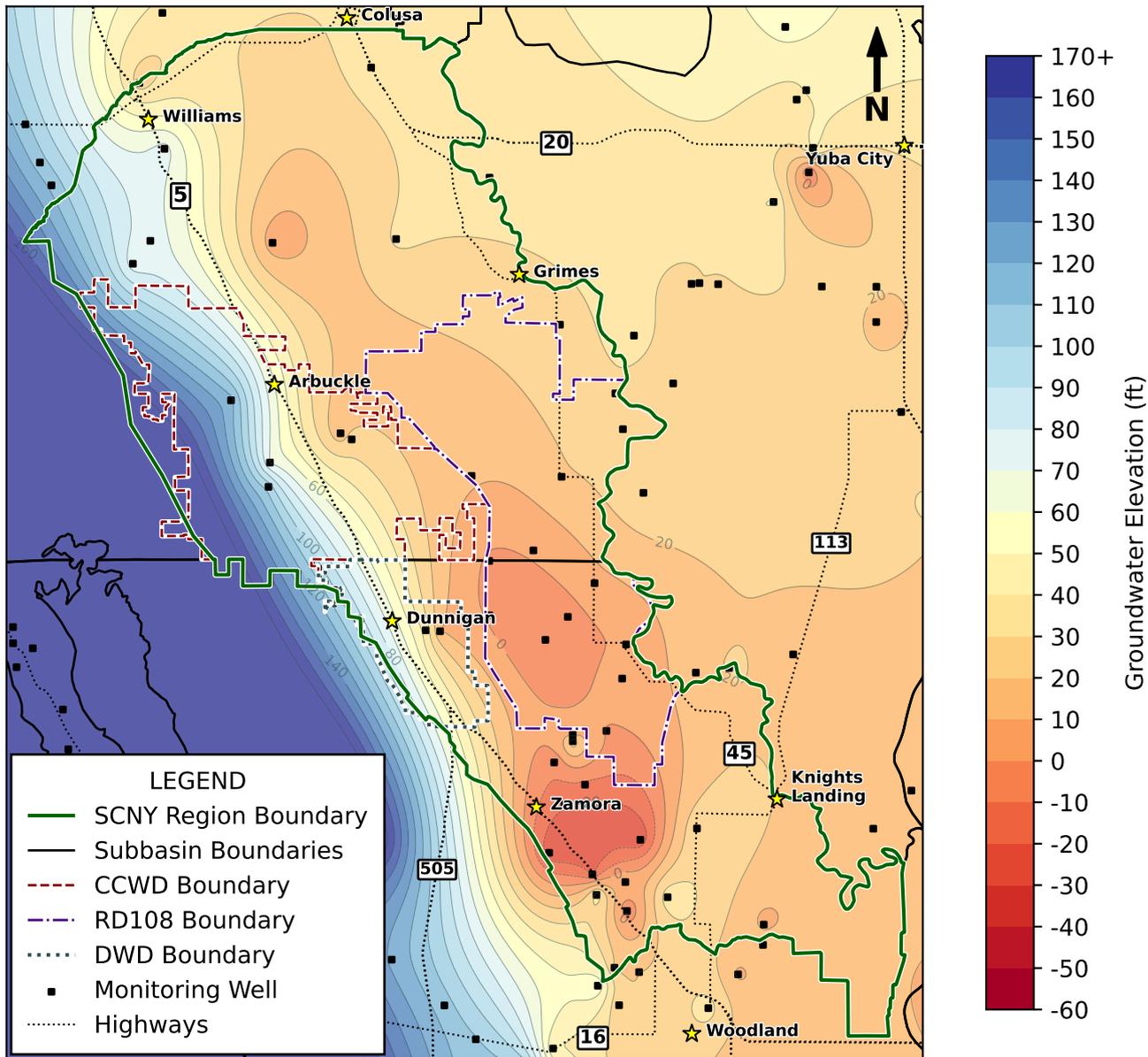
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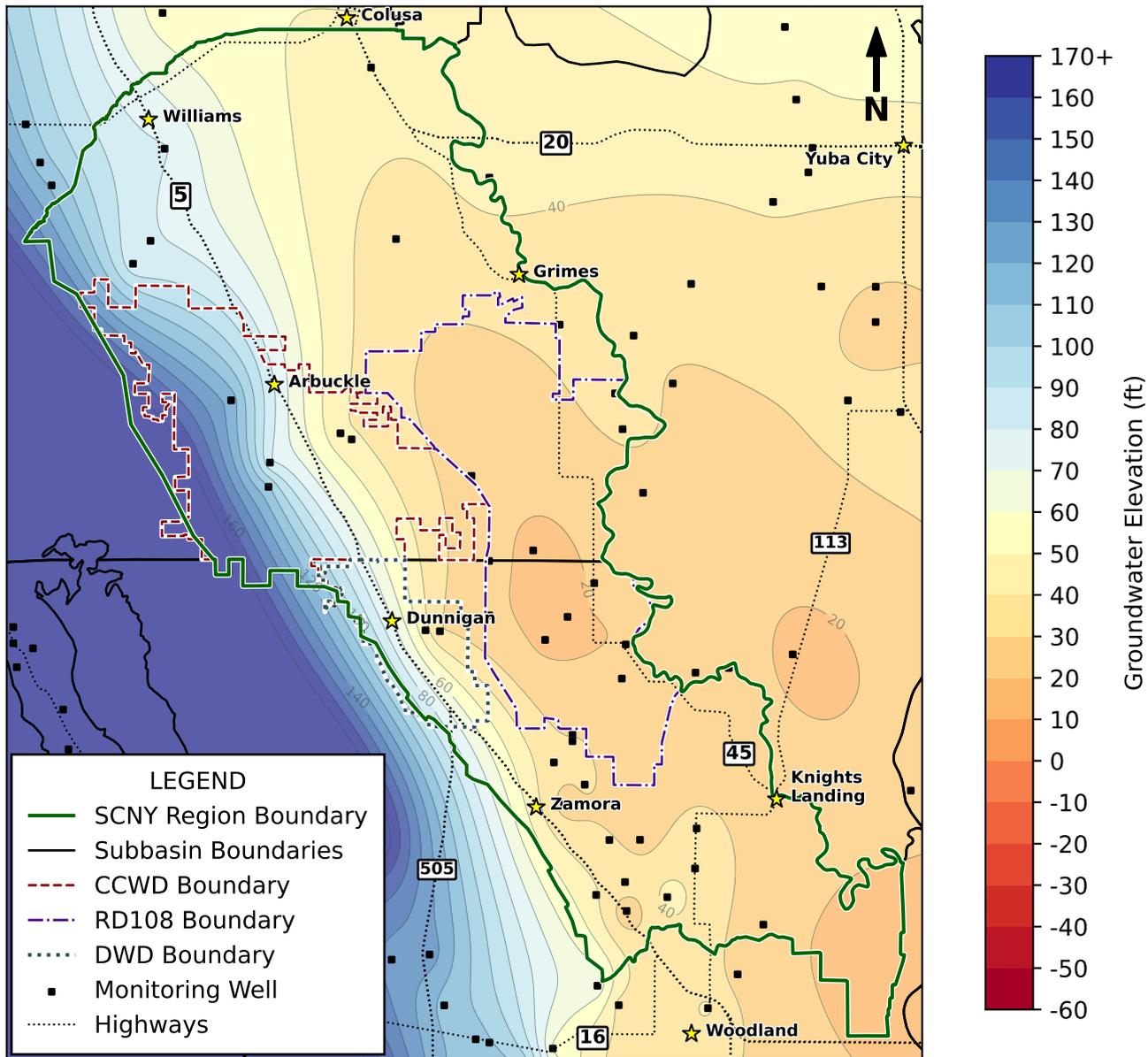
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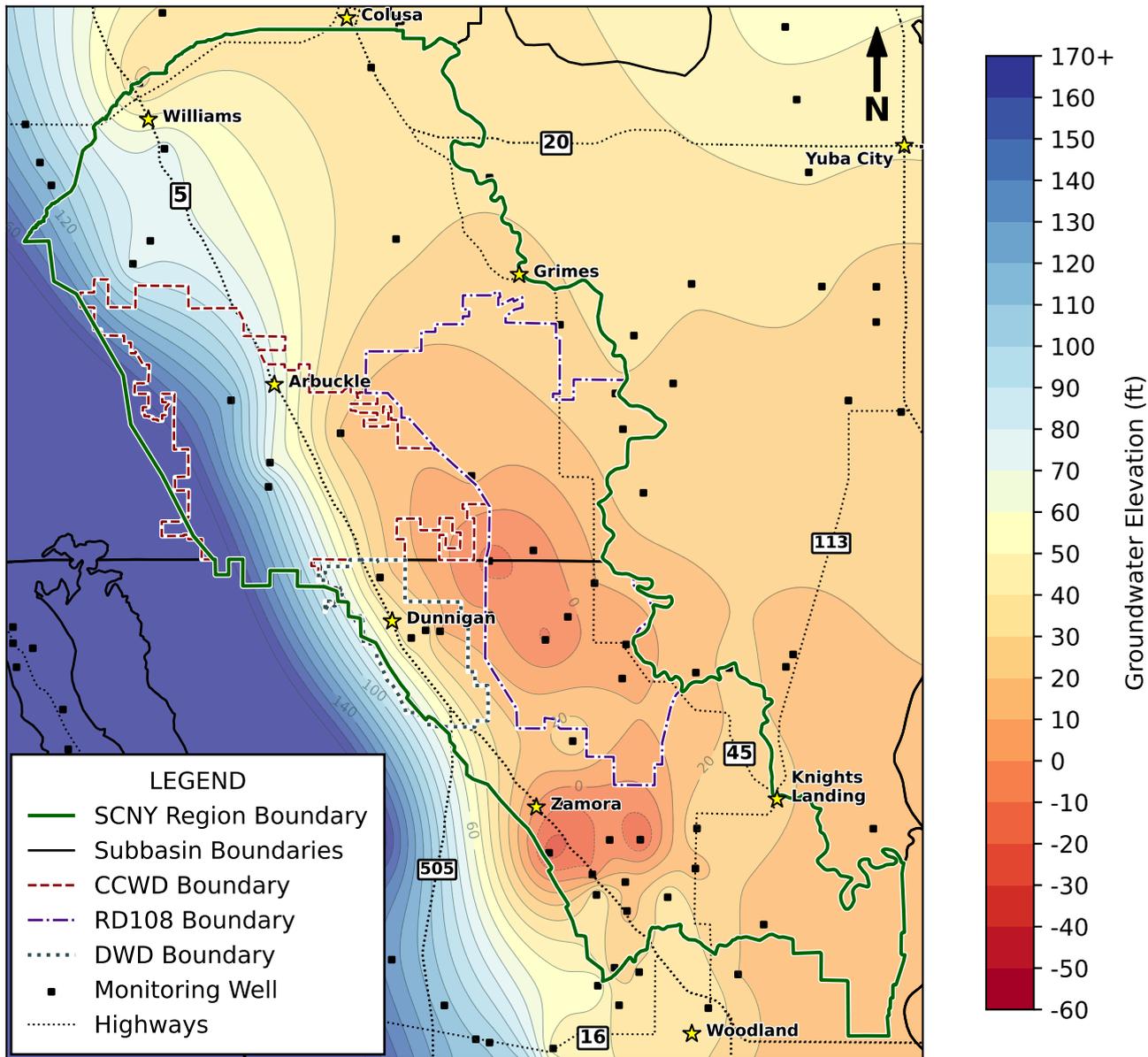
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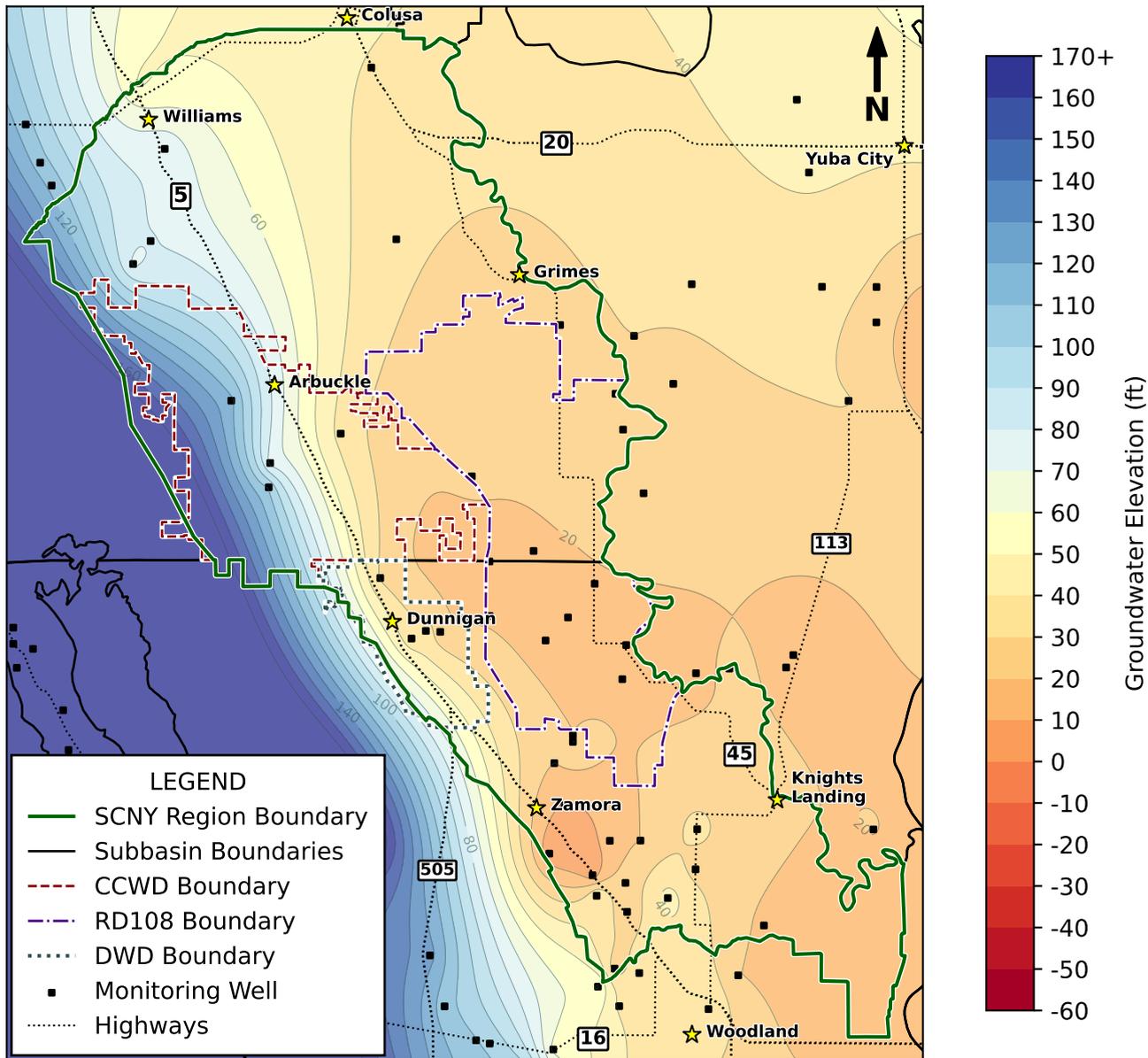
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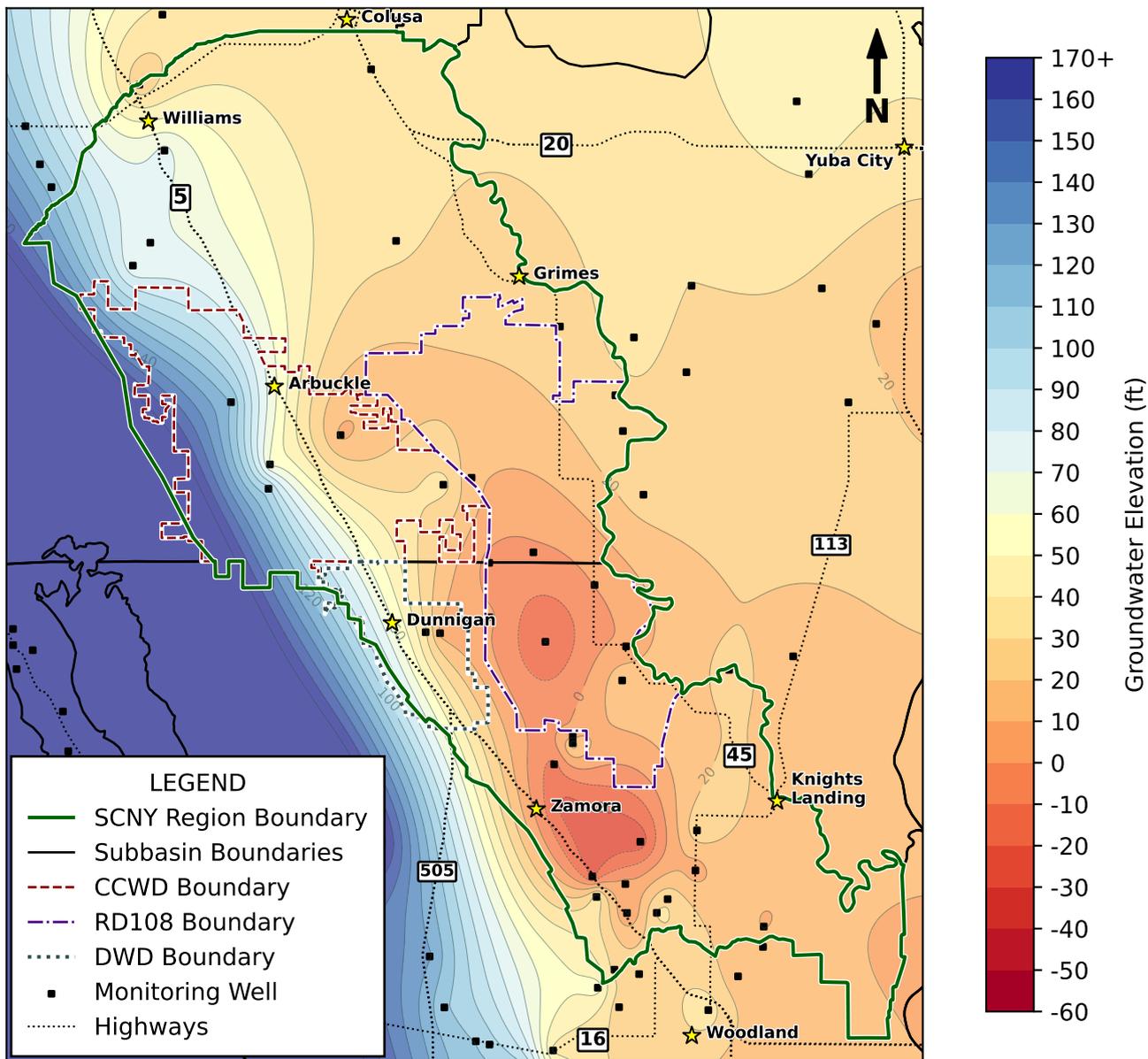
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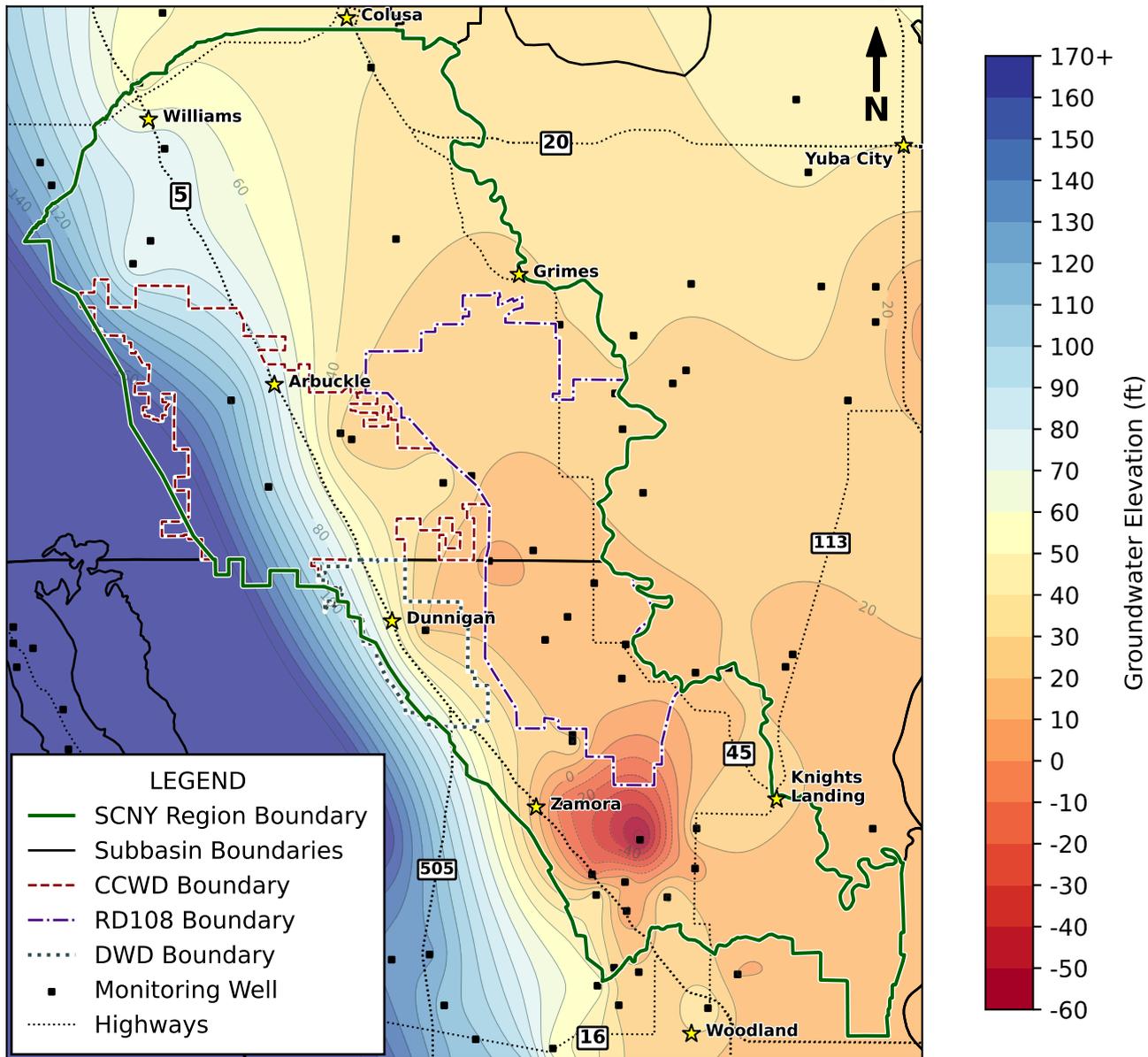
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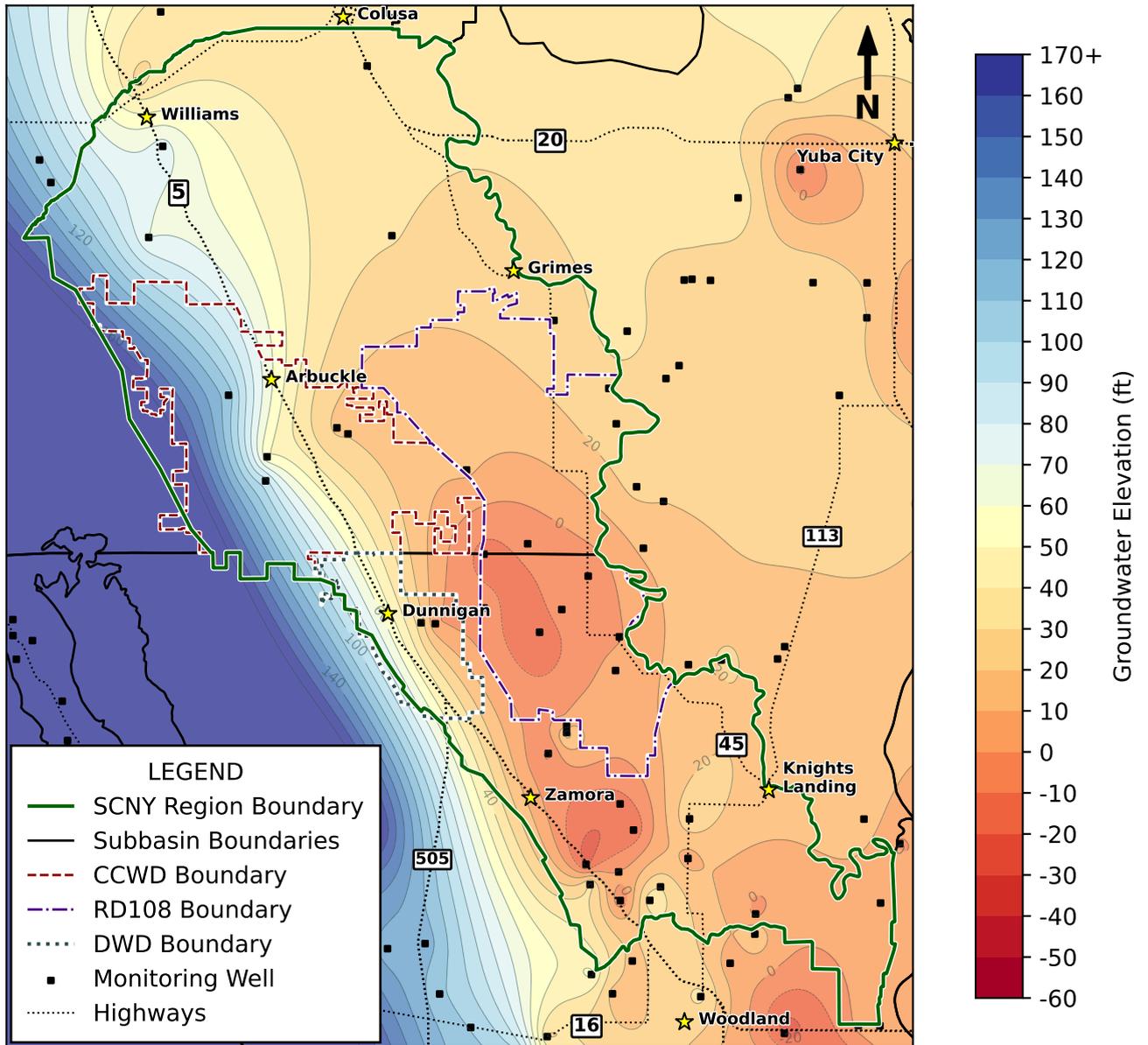
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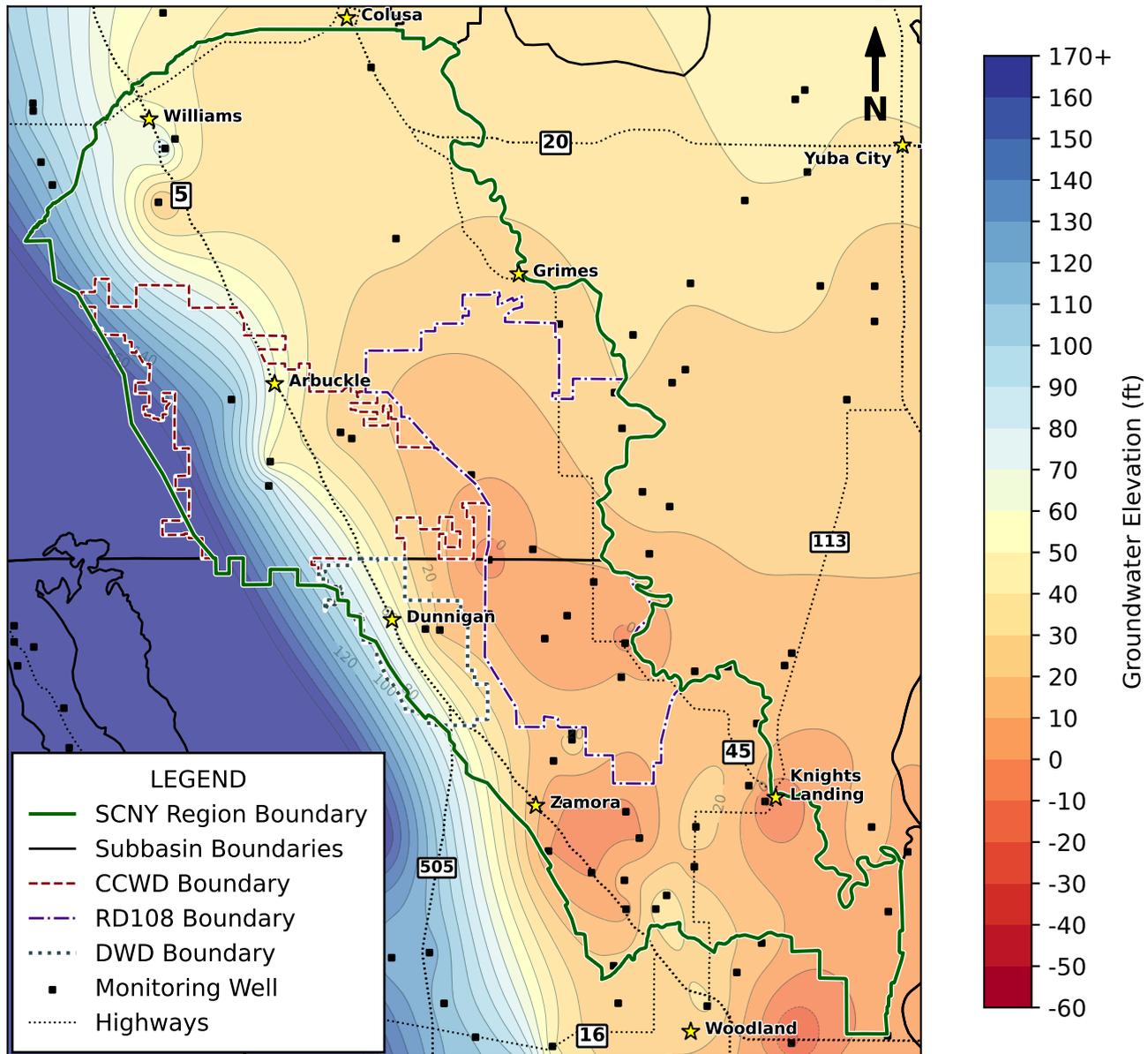
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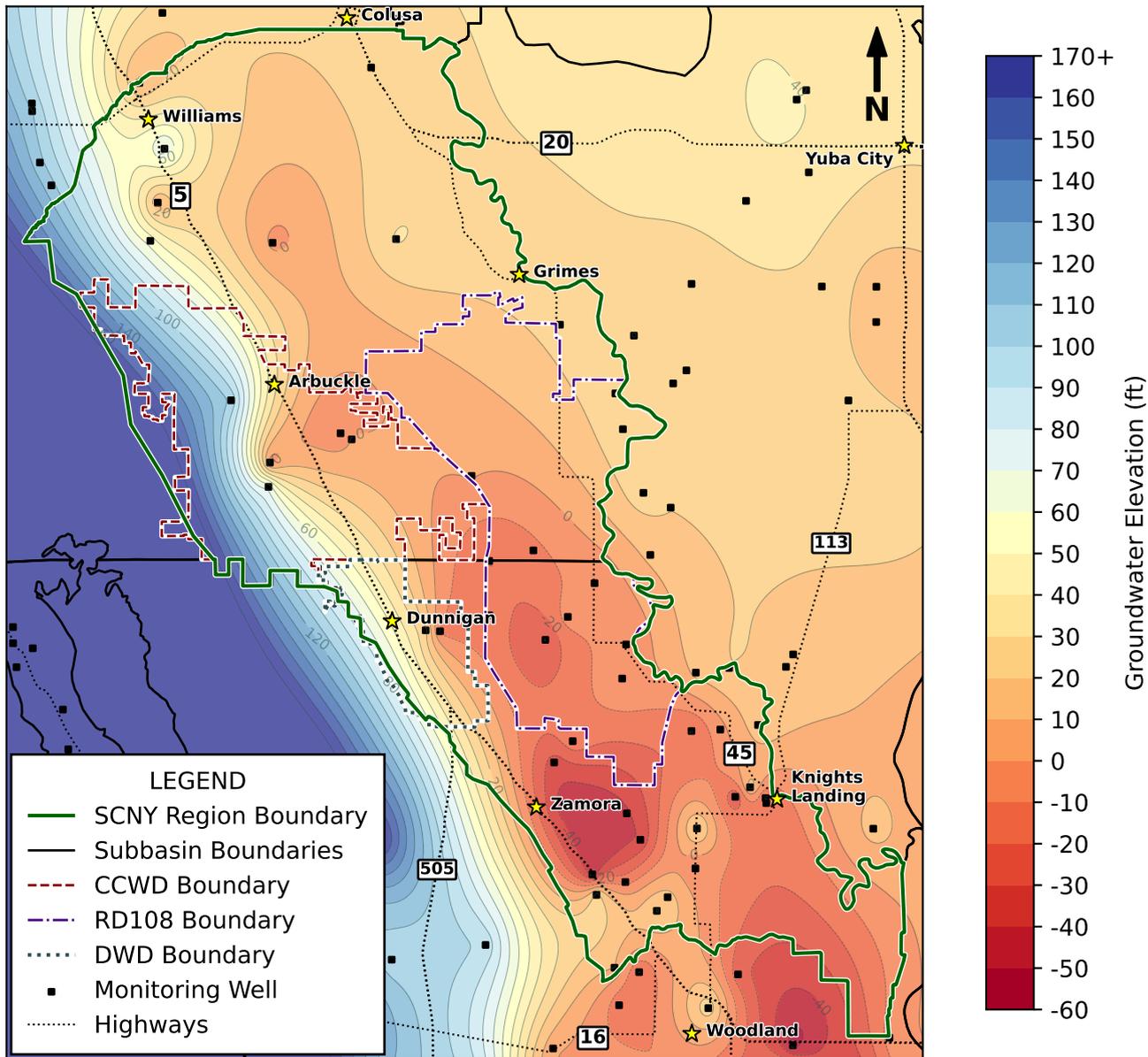
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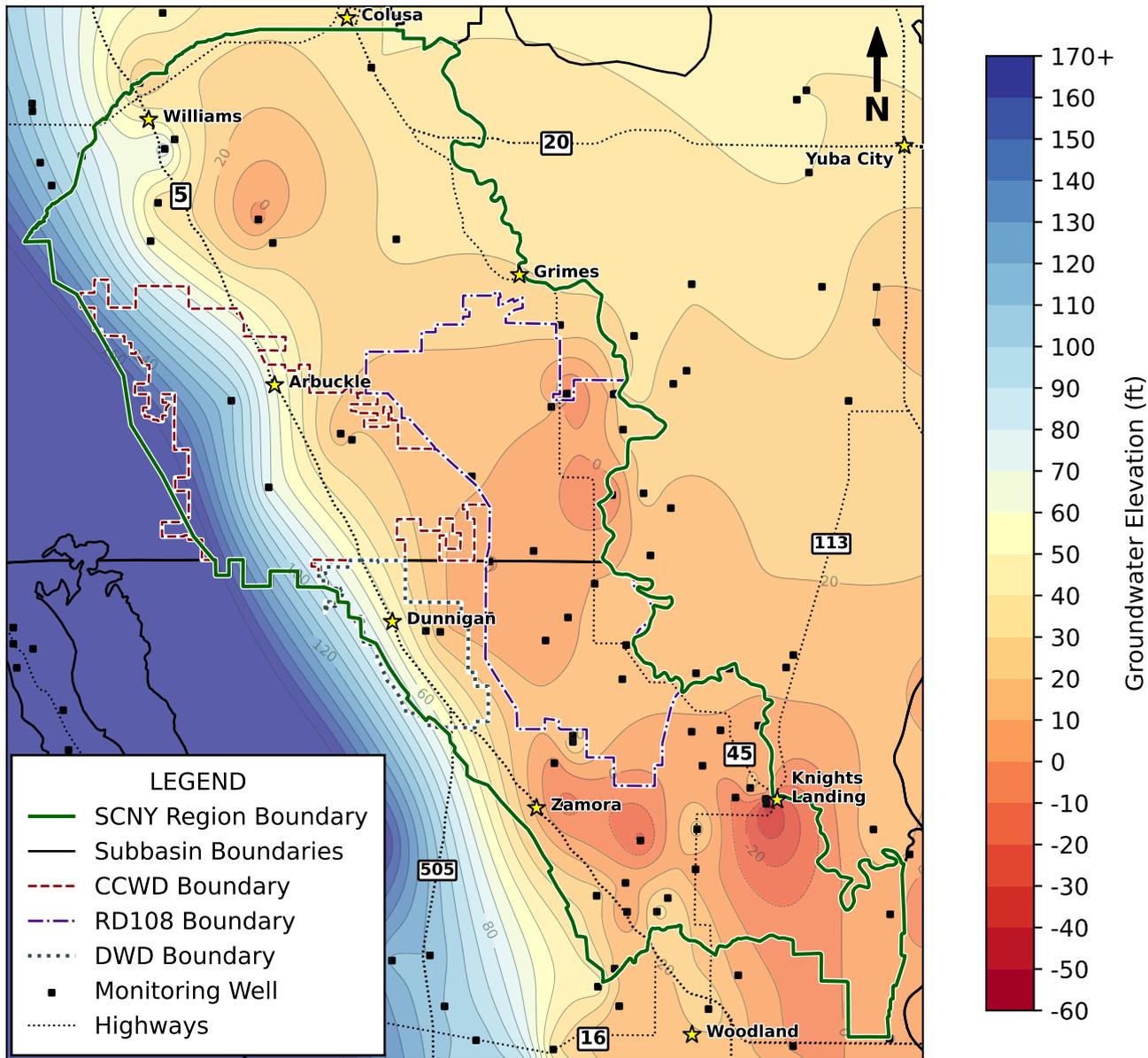
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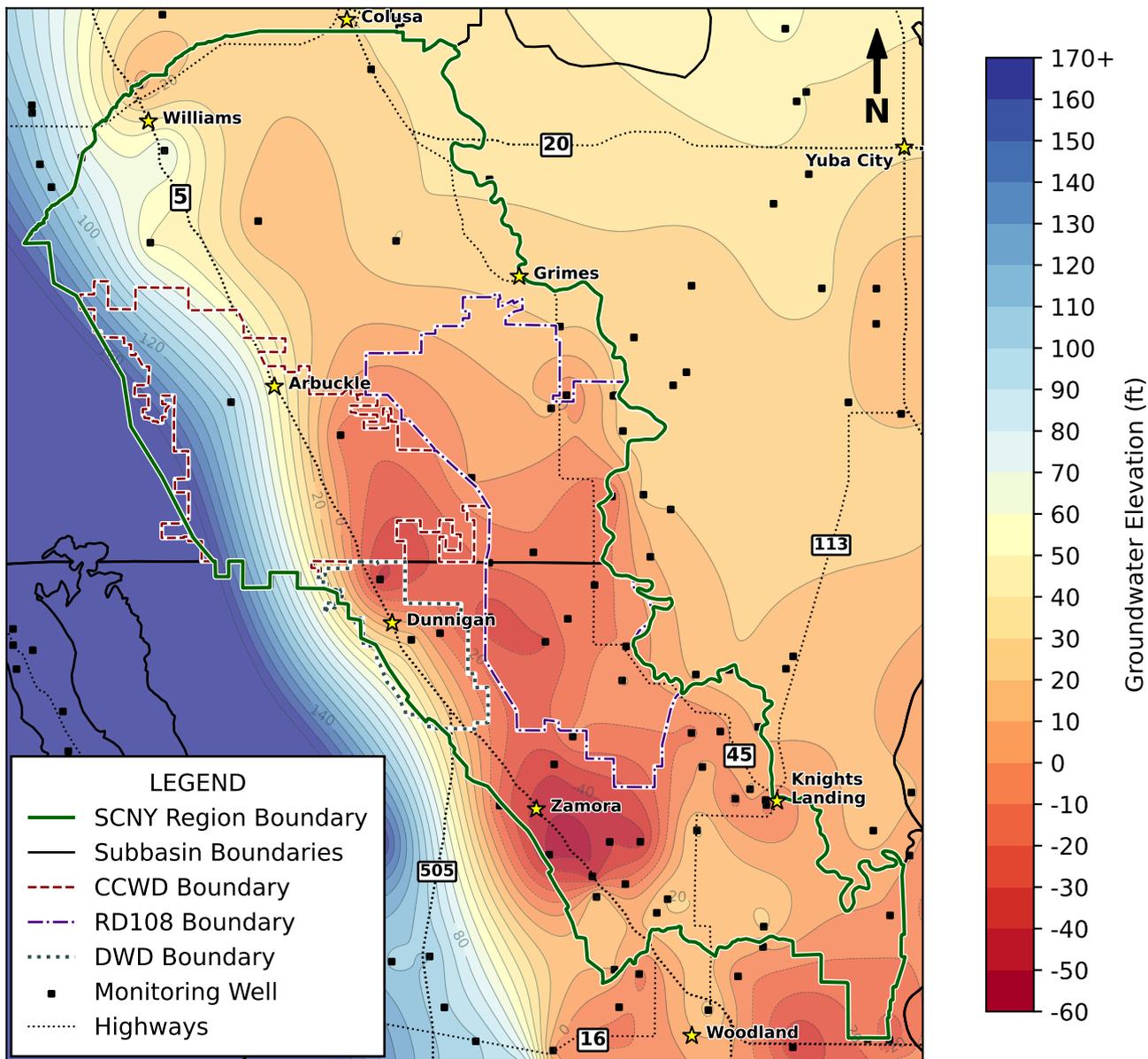
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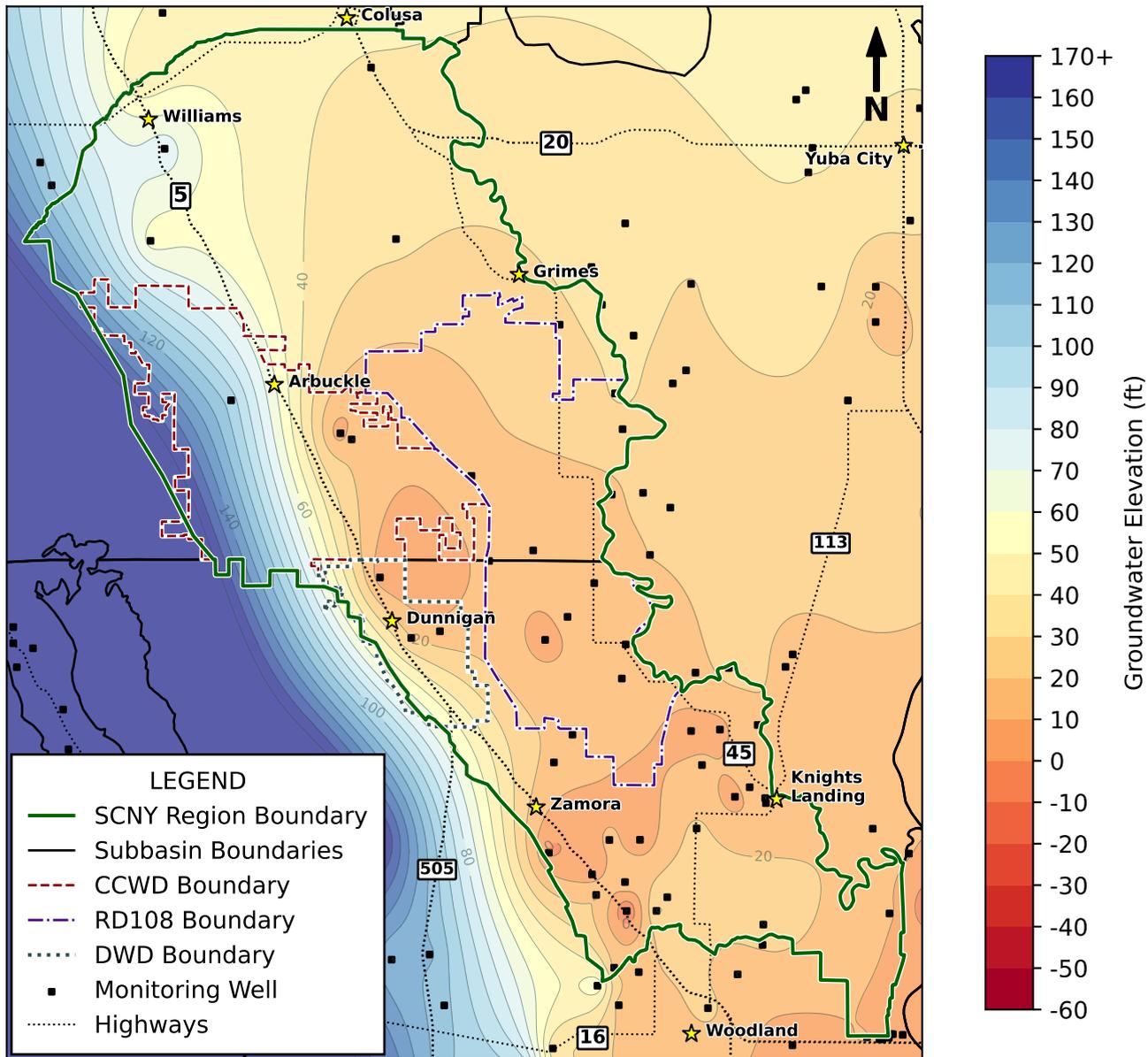
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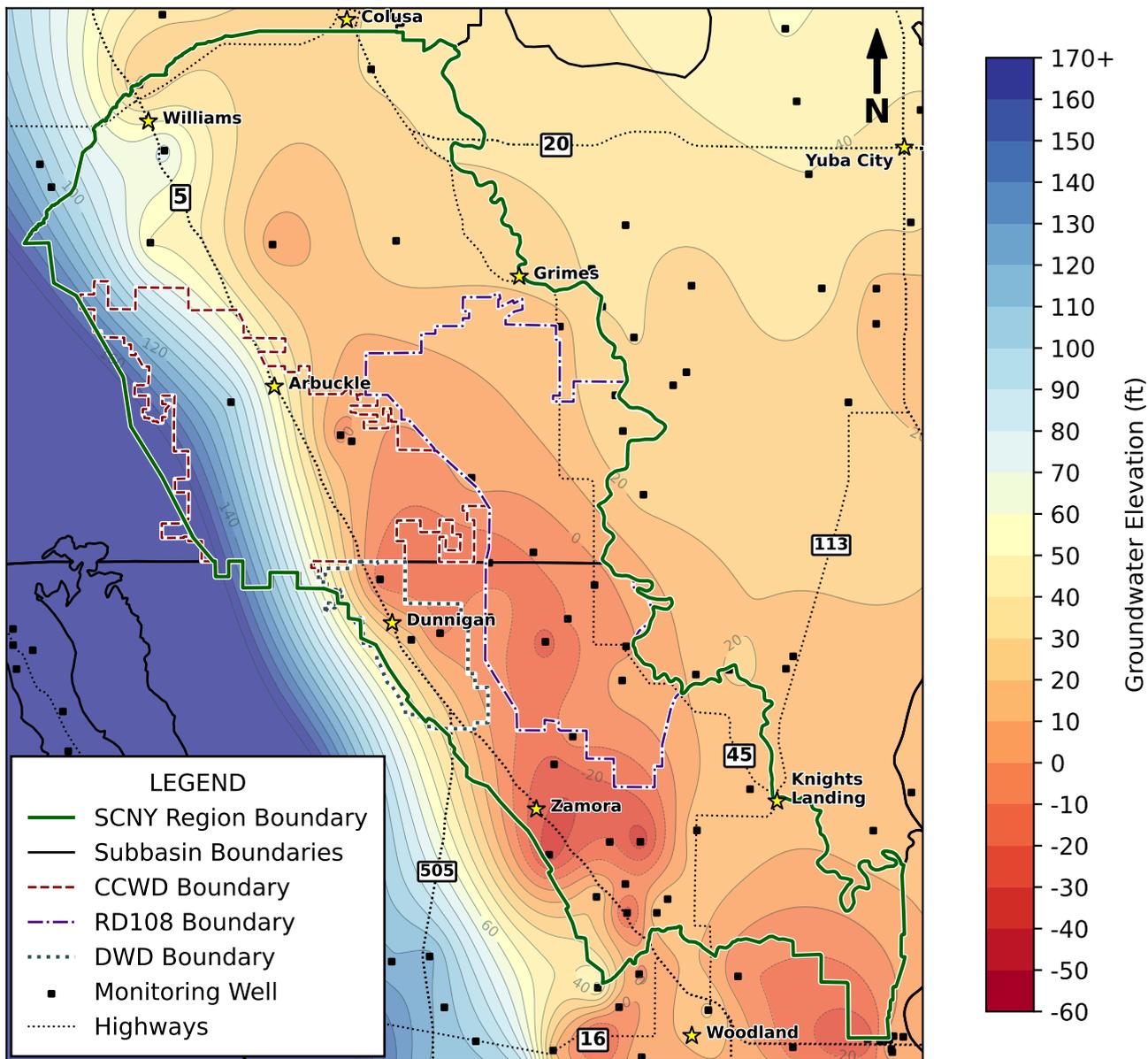
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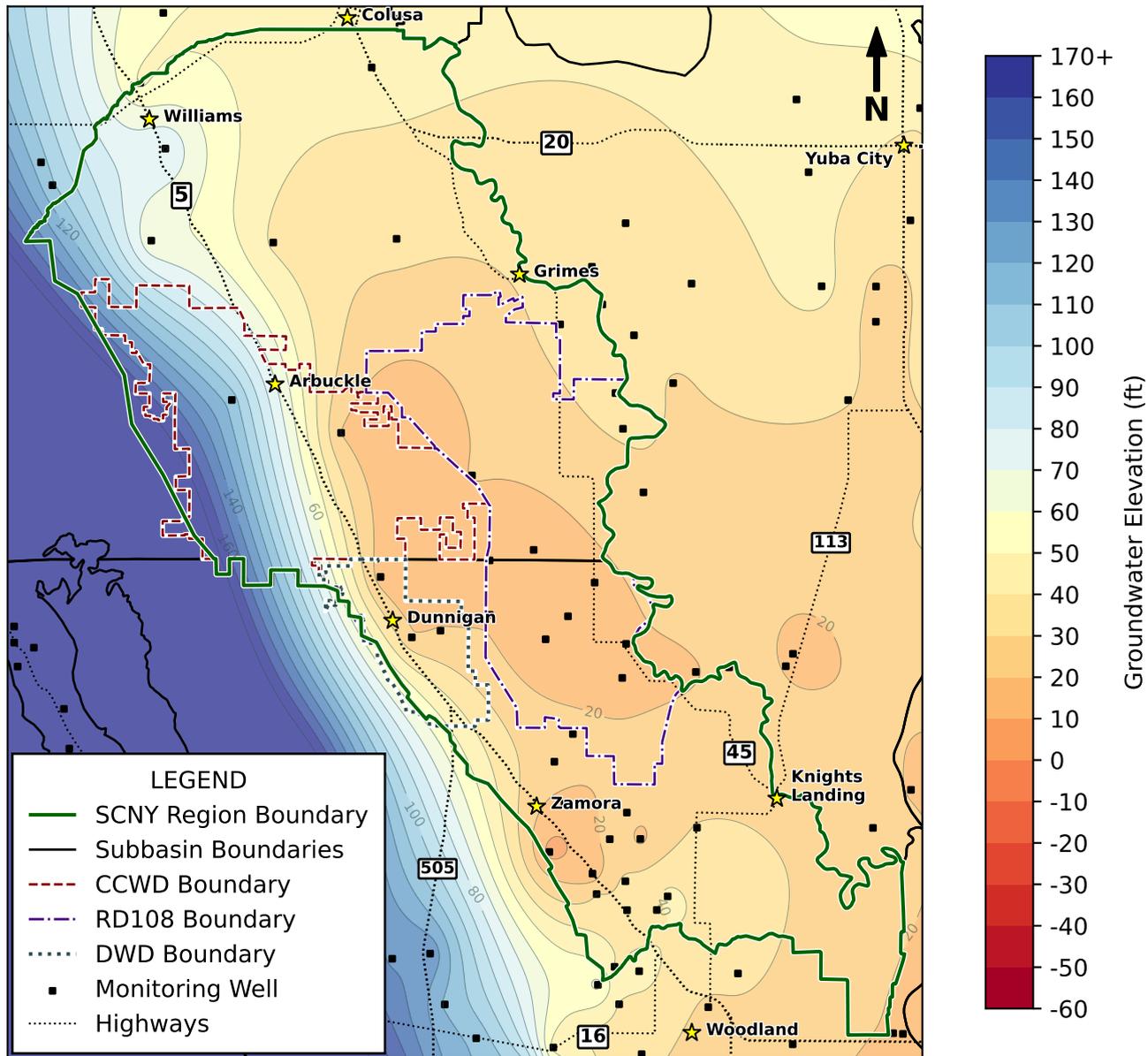
# South Colusa-North Yolo Groundwater Elevation for Spring, 2016



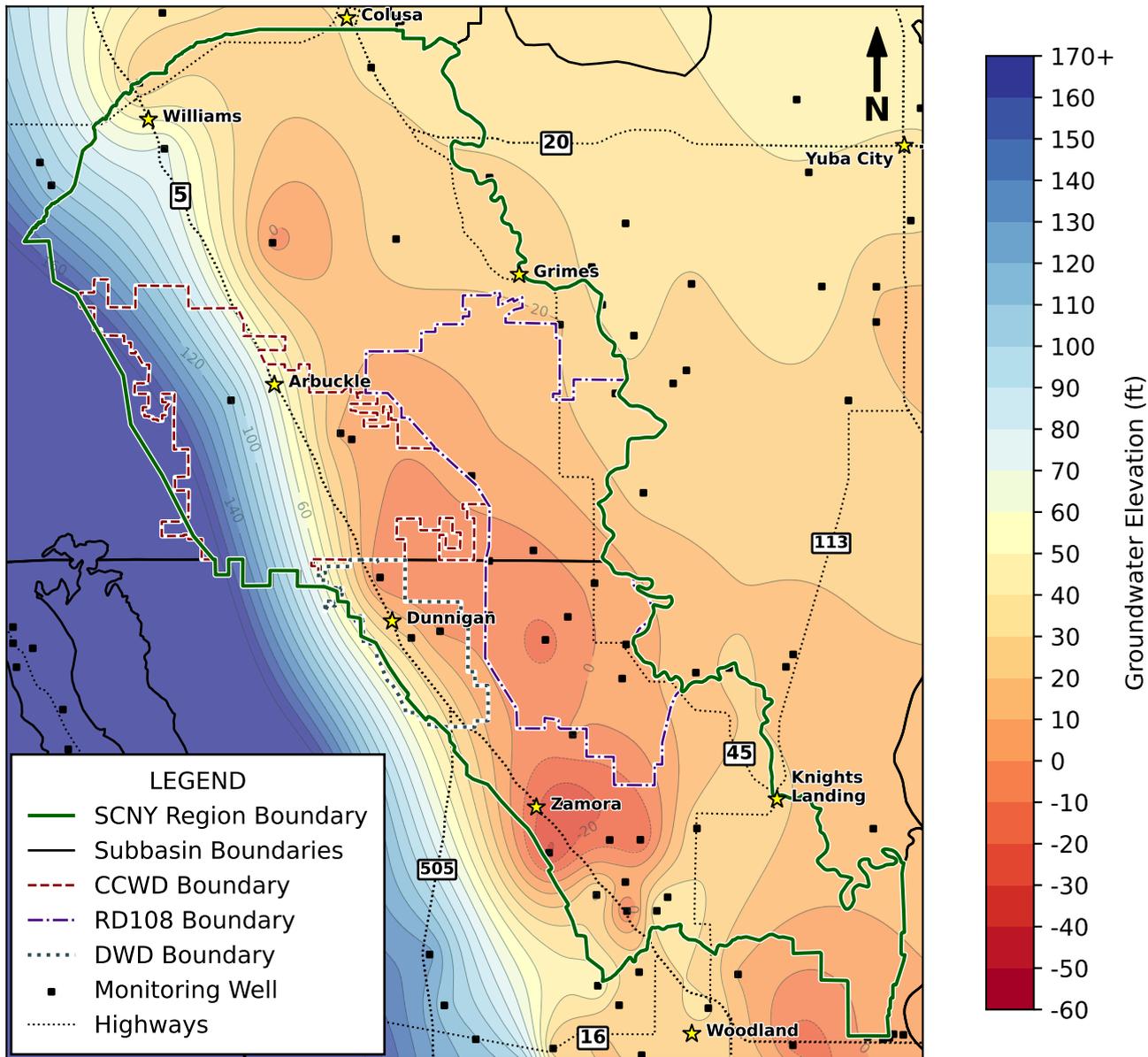
# South Colusa-North Yolo Groundwater Elevation for Fall, 2016



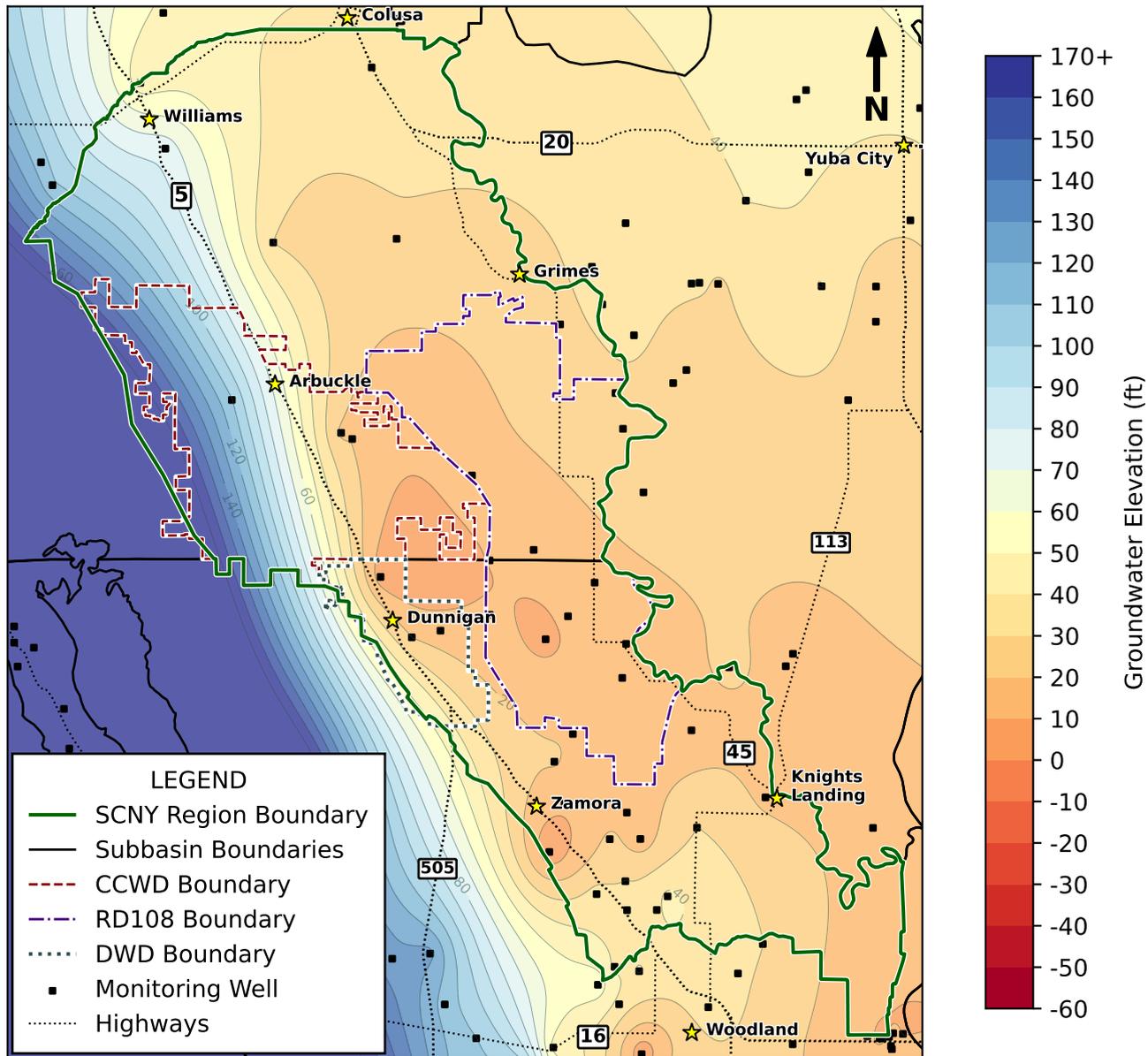
# South Colusa-North Yolo Groundwater Elevation for Spring, 2017



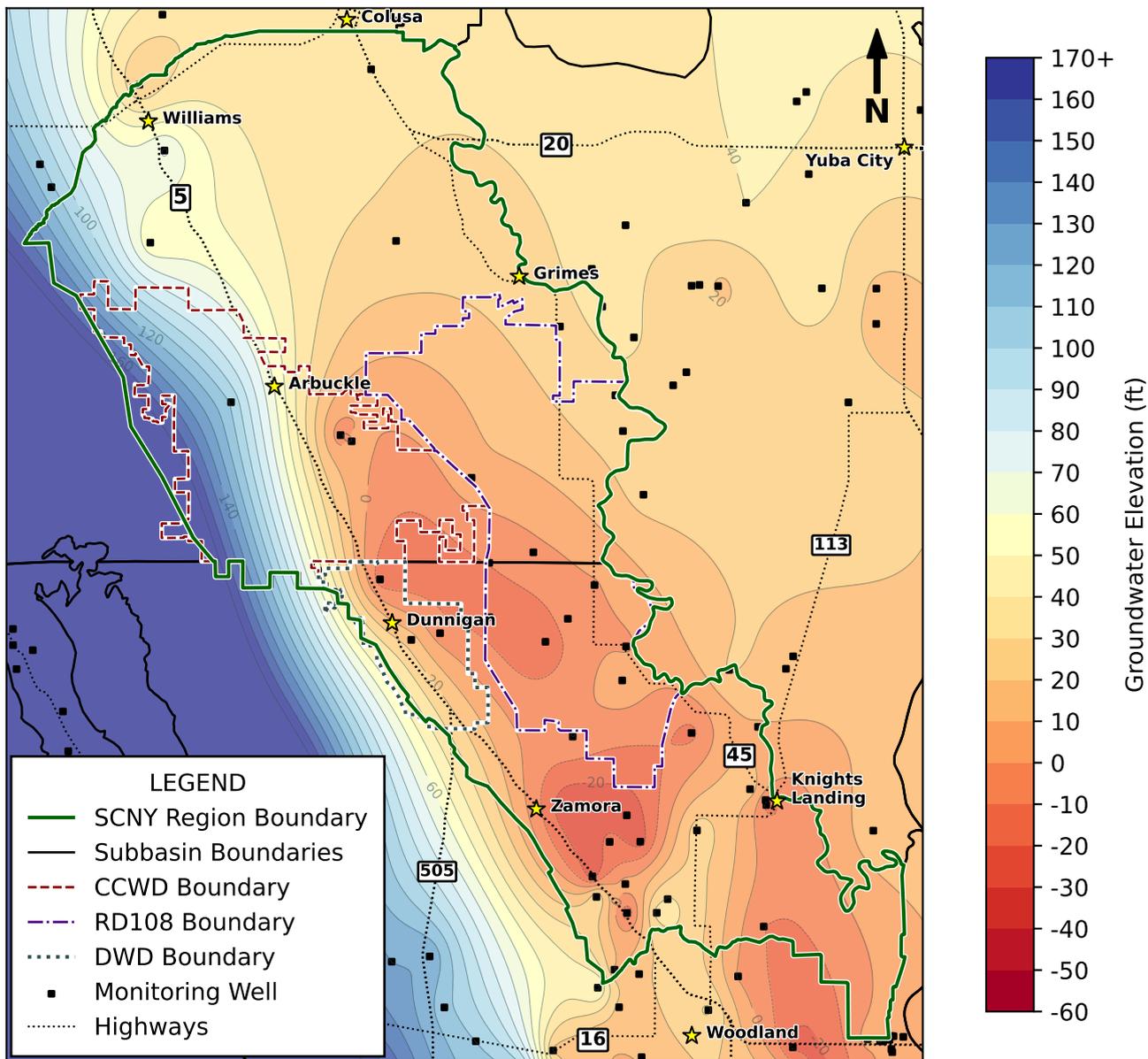
# South Colusa-North Yolo Groundwater Elevation for Fall, 2017



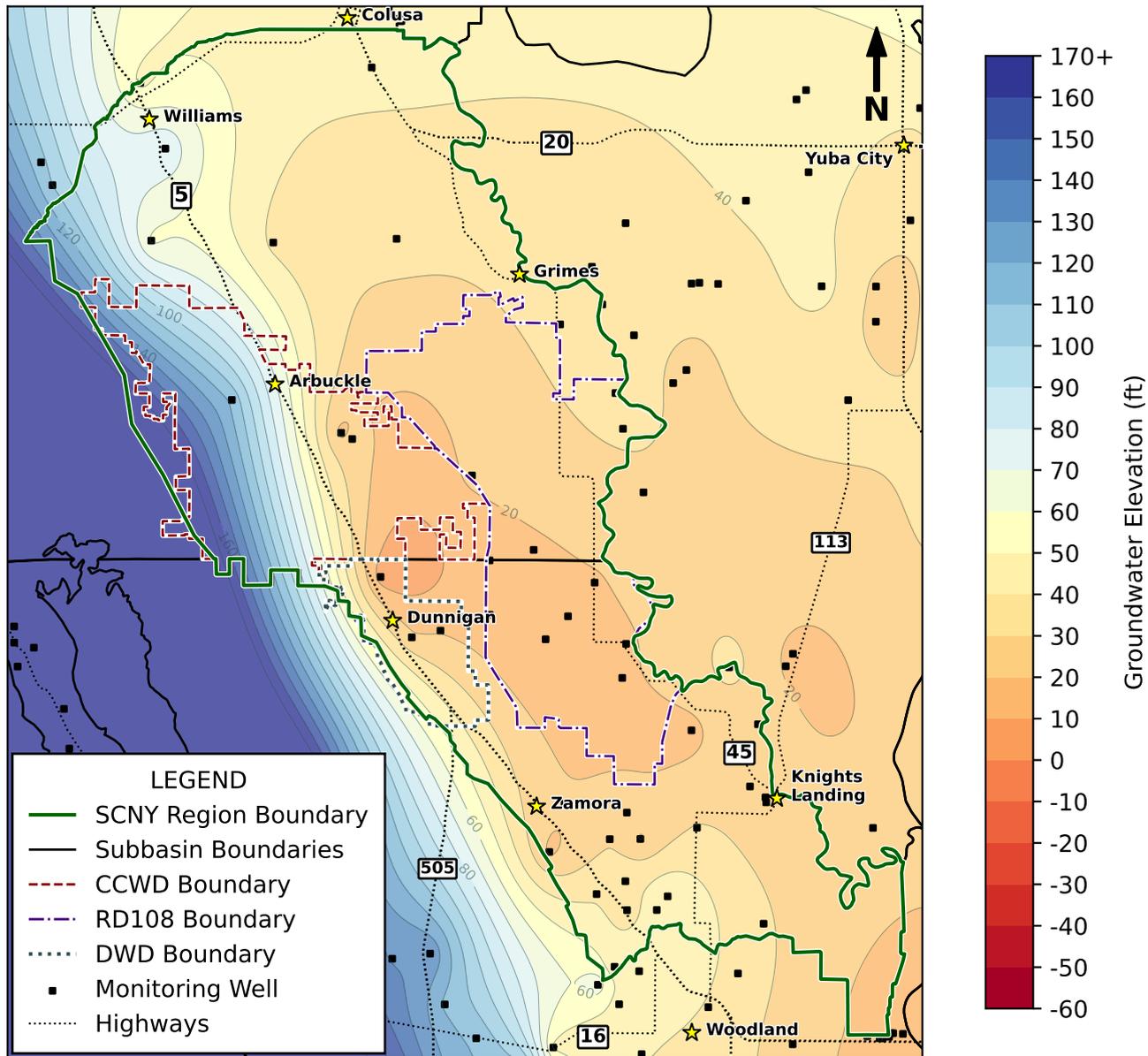
# South Colusa-North Yolo Groundwater Elevation for Spring, 2018



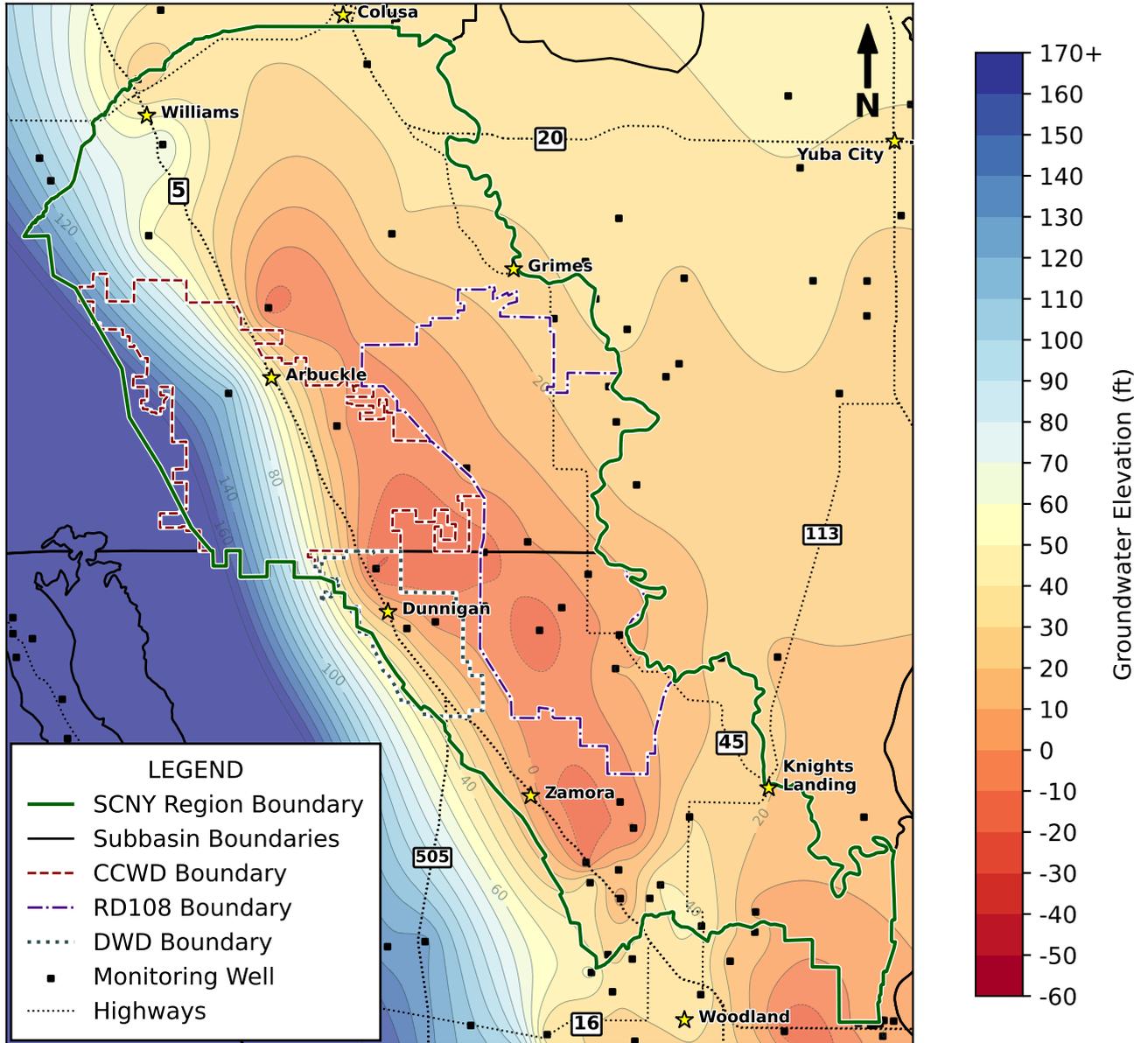
# South Colusa-North Yolo Groundwater Elevation for Fall, 2018



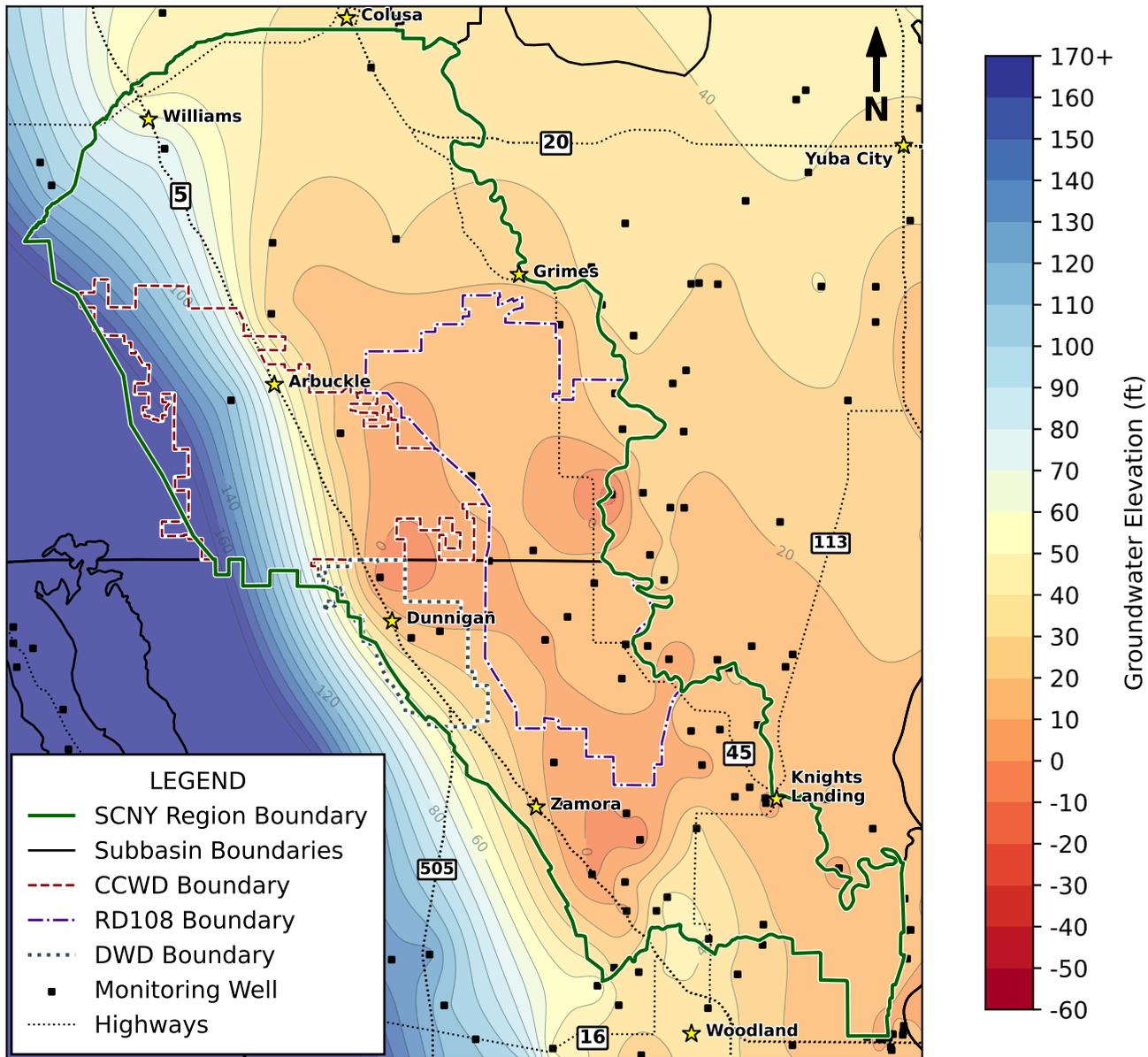
# South Colusa-North Yolo Groundwater Elevation for Spring, 2019



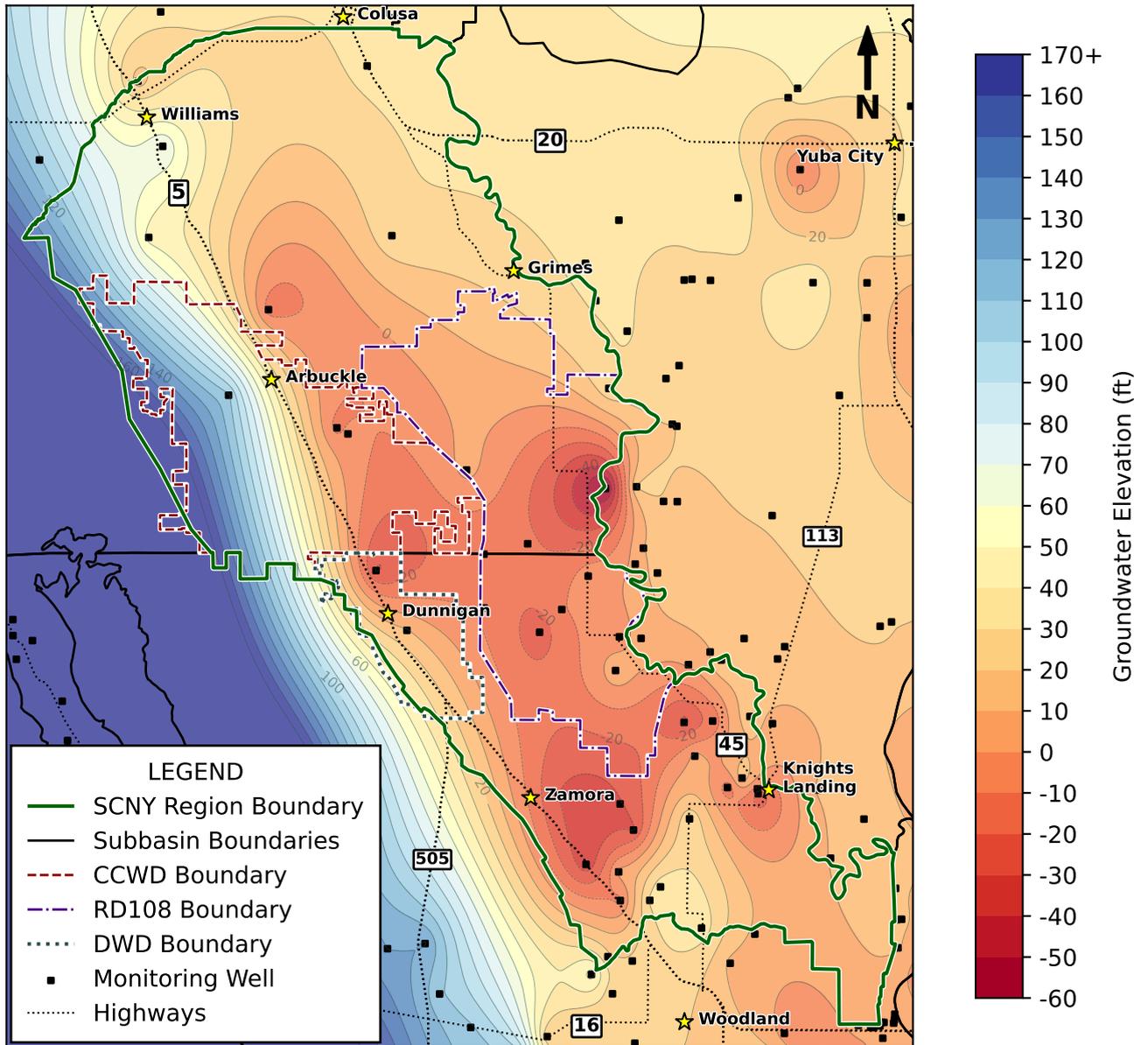
# South Colusa-North Yolo Groundwater Elevation for Fall, 2019



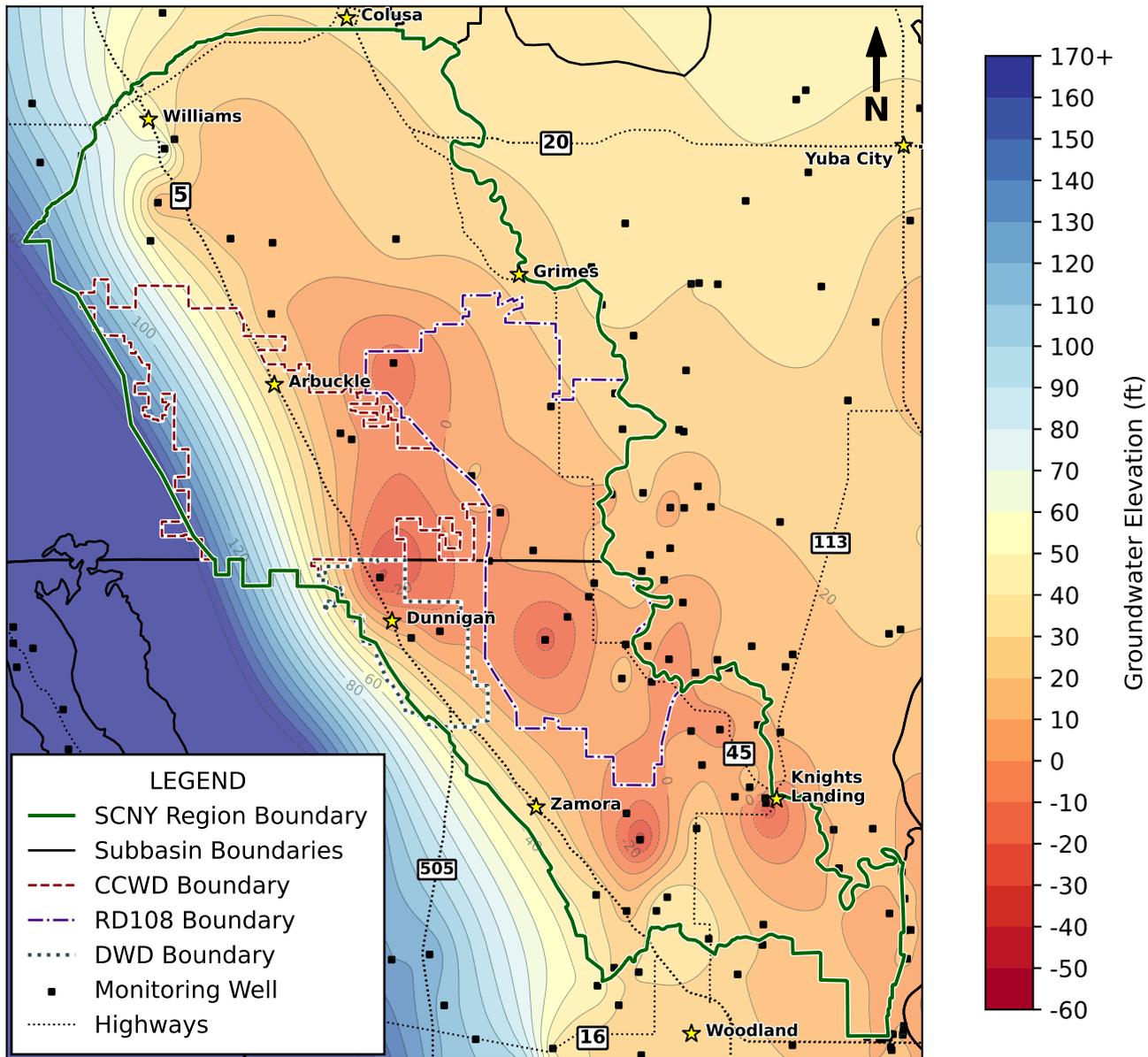
# South Colusa-North Yolo Groundwater Elevation for Spring, 2020



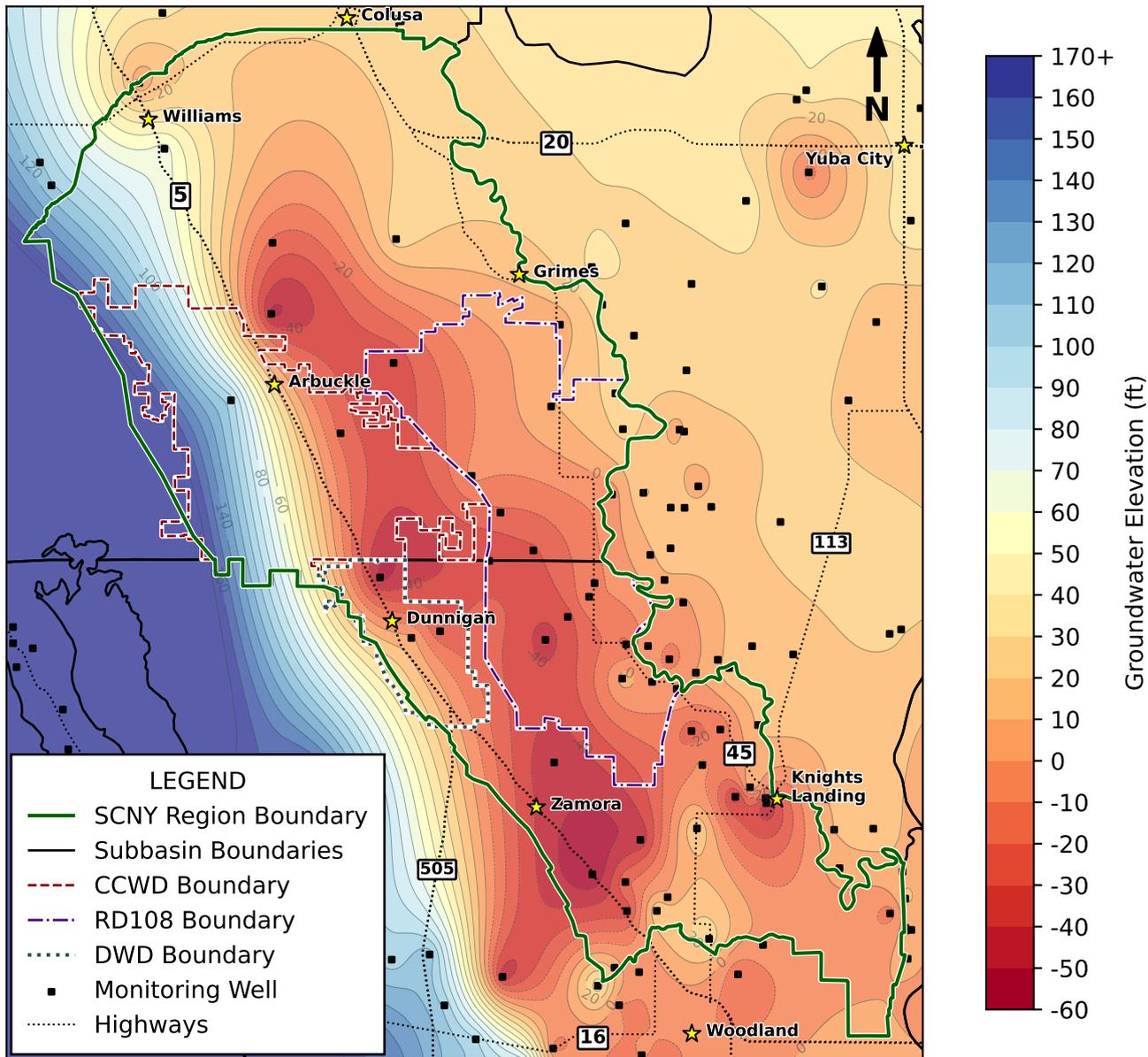
# South Colusa-North Yolo Groundwater Elevation for Fall, 2020



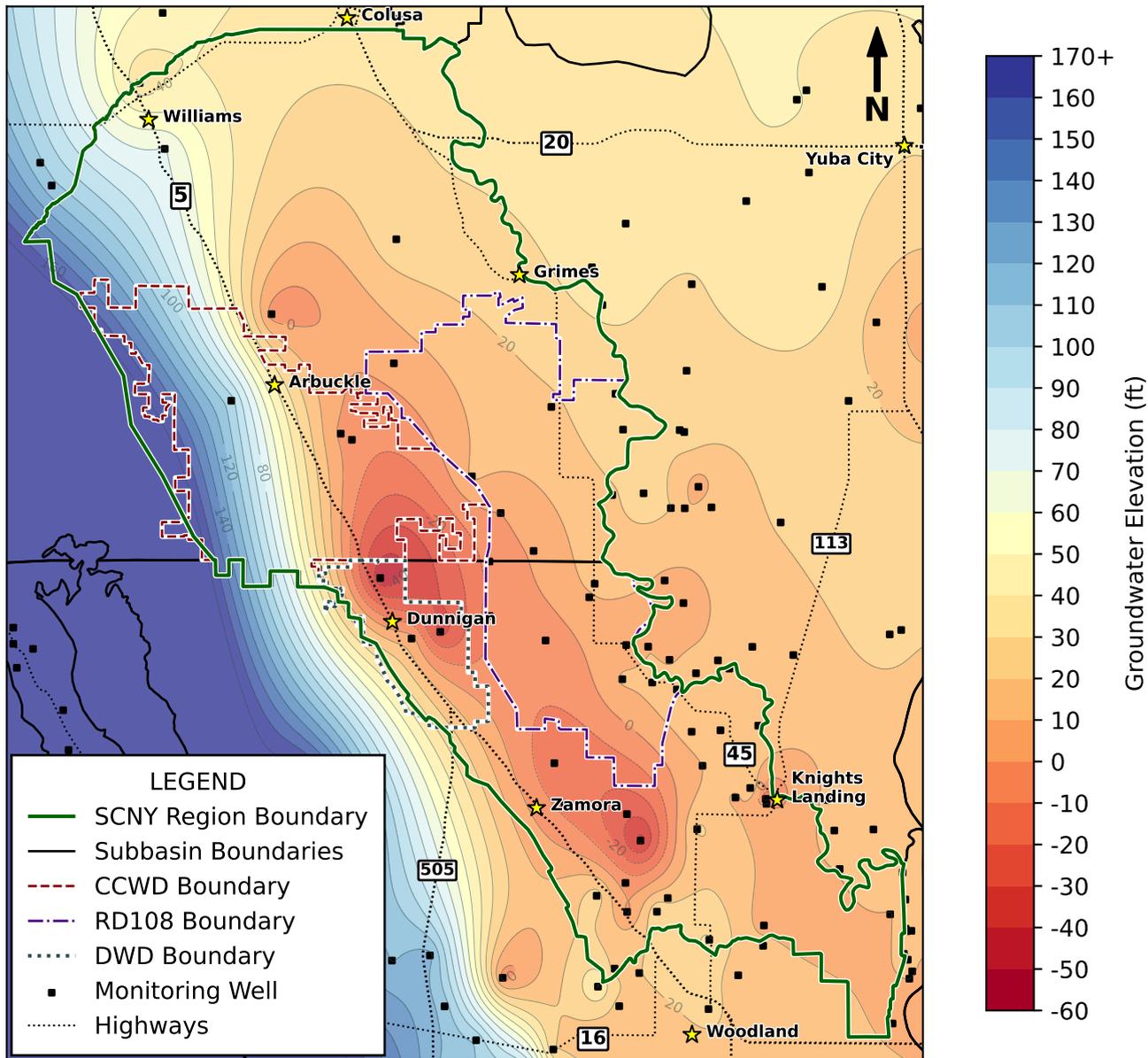
# South Colusa-North Yolo Groundwater Elevation for Spring, 2021



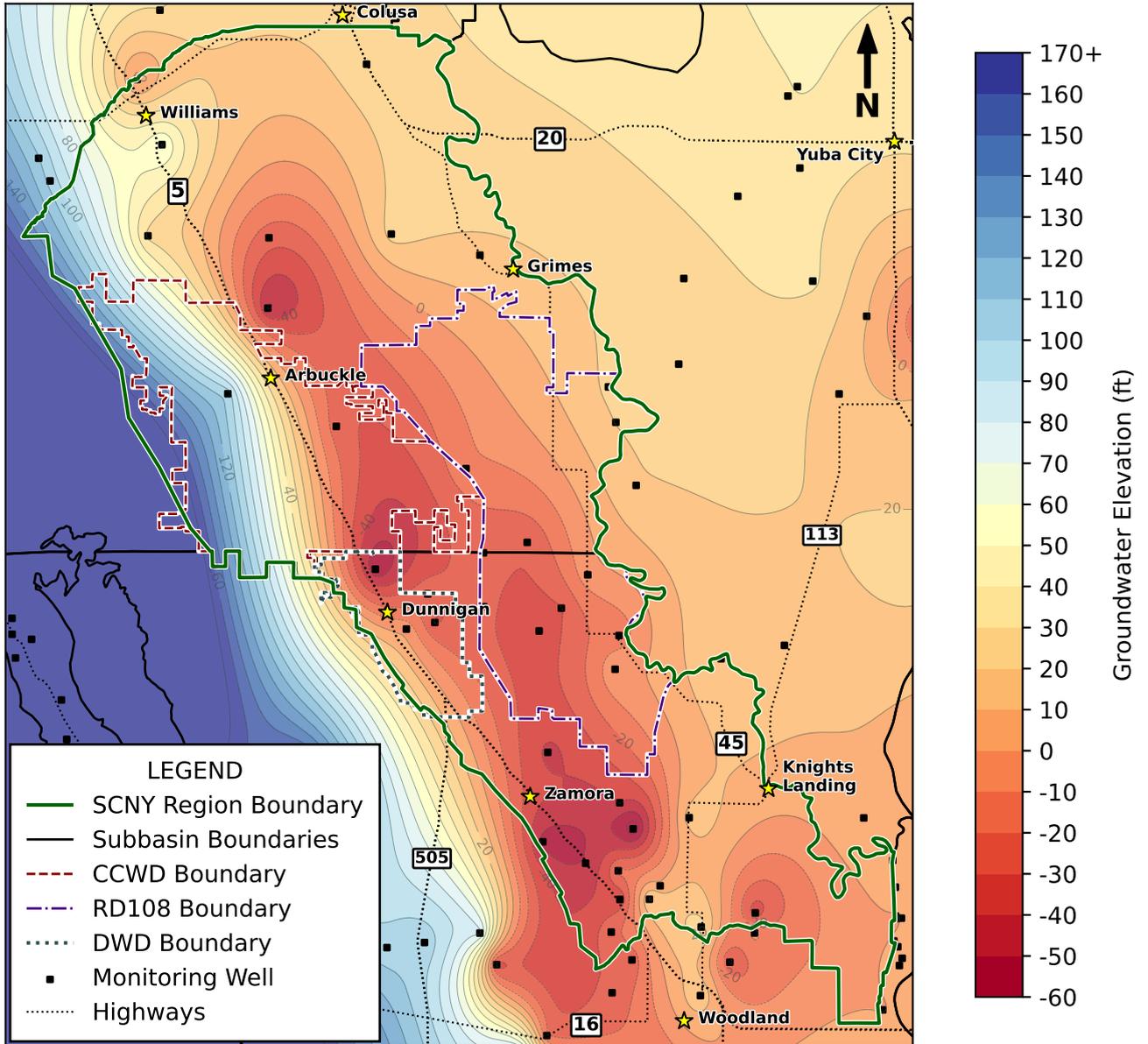
# South Colusa-North Yolo Groundwater Elevation for Fall, 2021



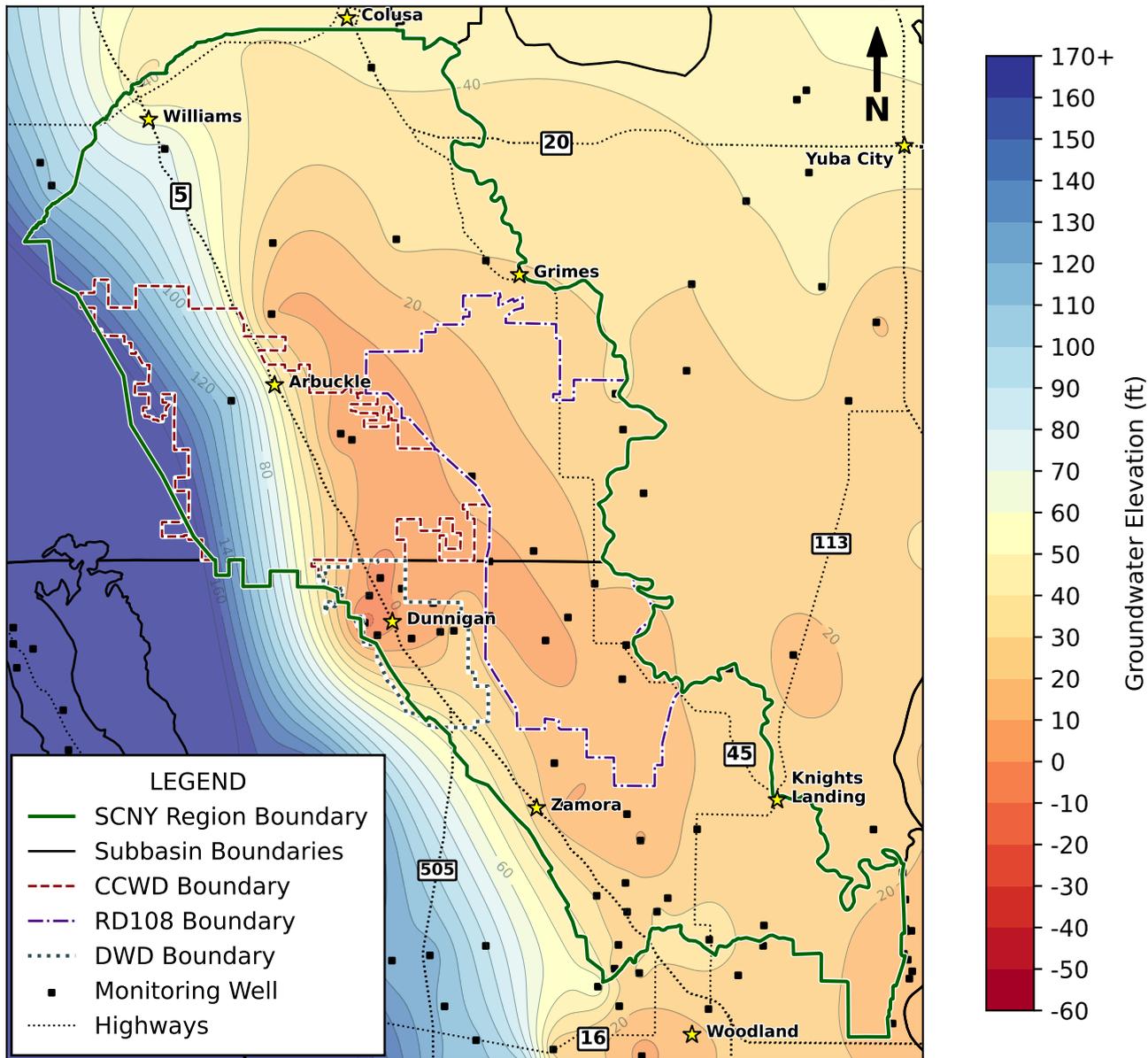
# South Colusa-North Yolo Groundwater Elevation for Spring, 2022



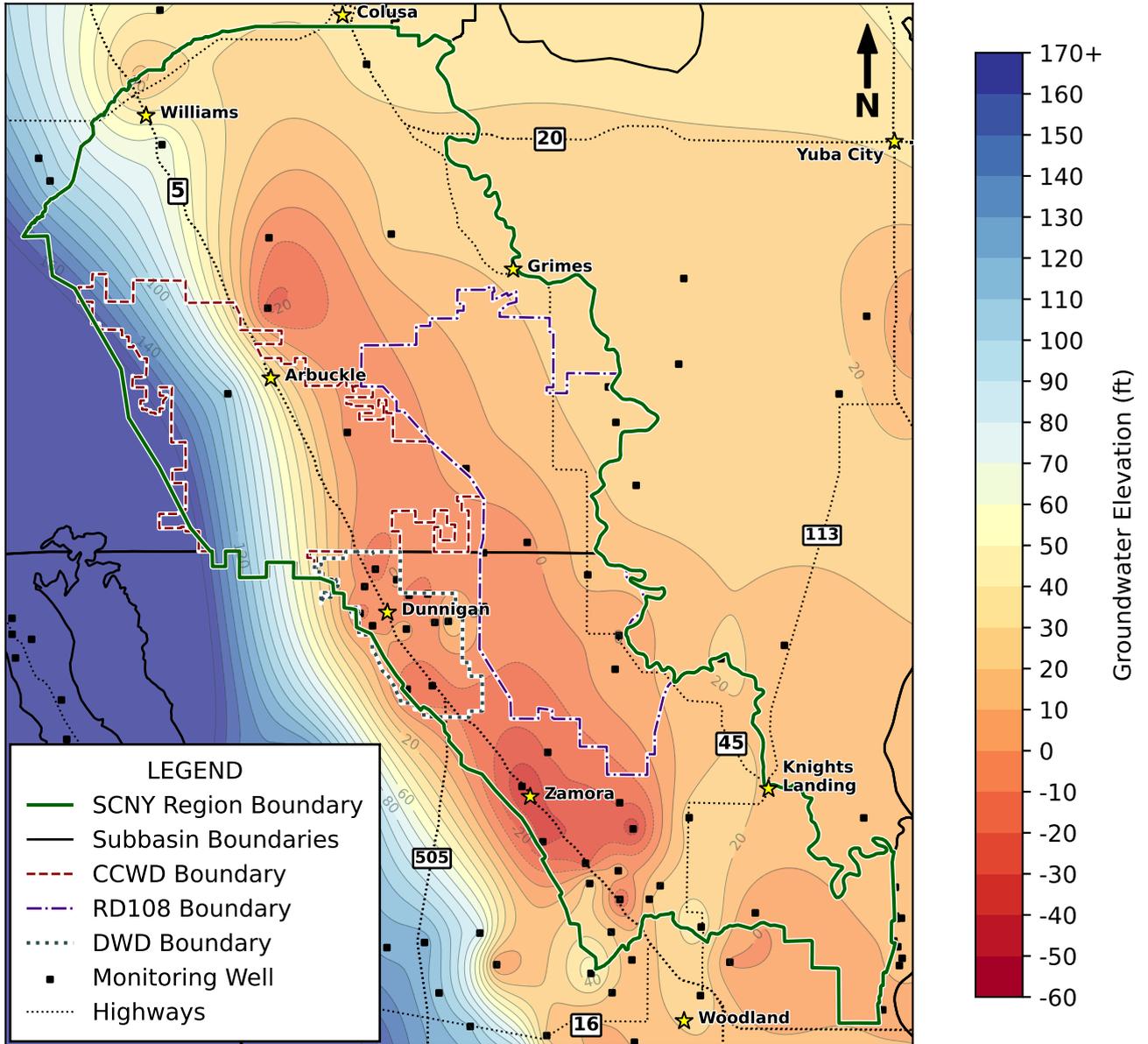
# South Colusa-North Yolo Groundwater Elevation for Fall, 2022



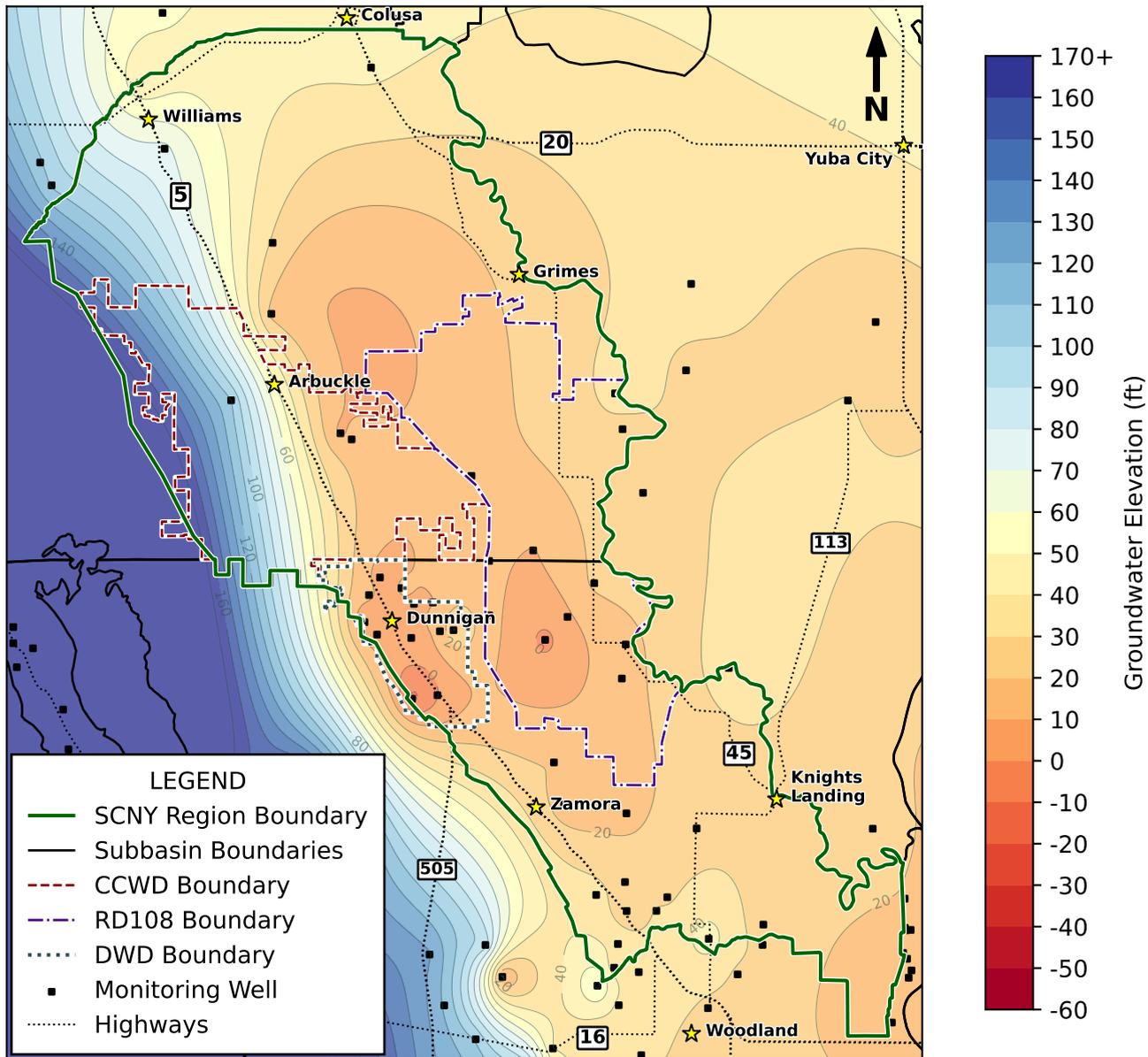
# South Colusa-North Yolo Groundwater Elevation for Spring, 2023



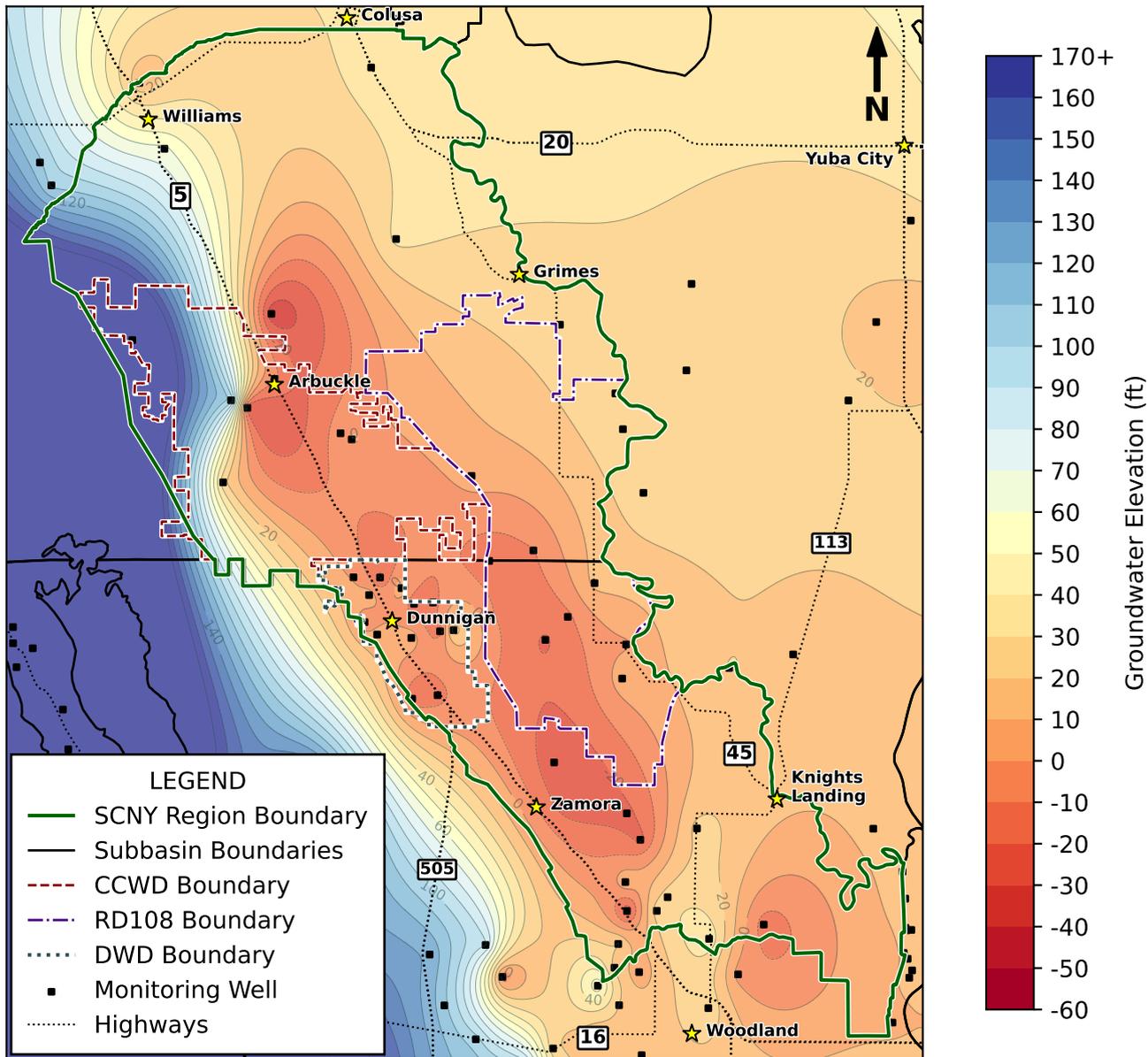
# South Colusa-North Yolo Groundwater Elevation for Fall, 2023



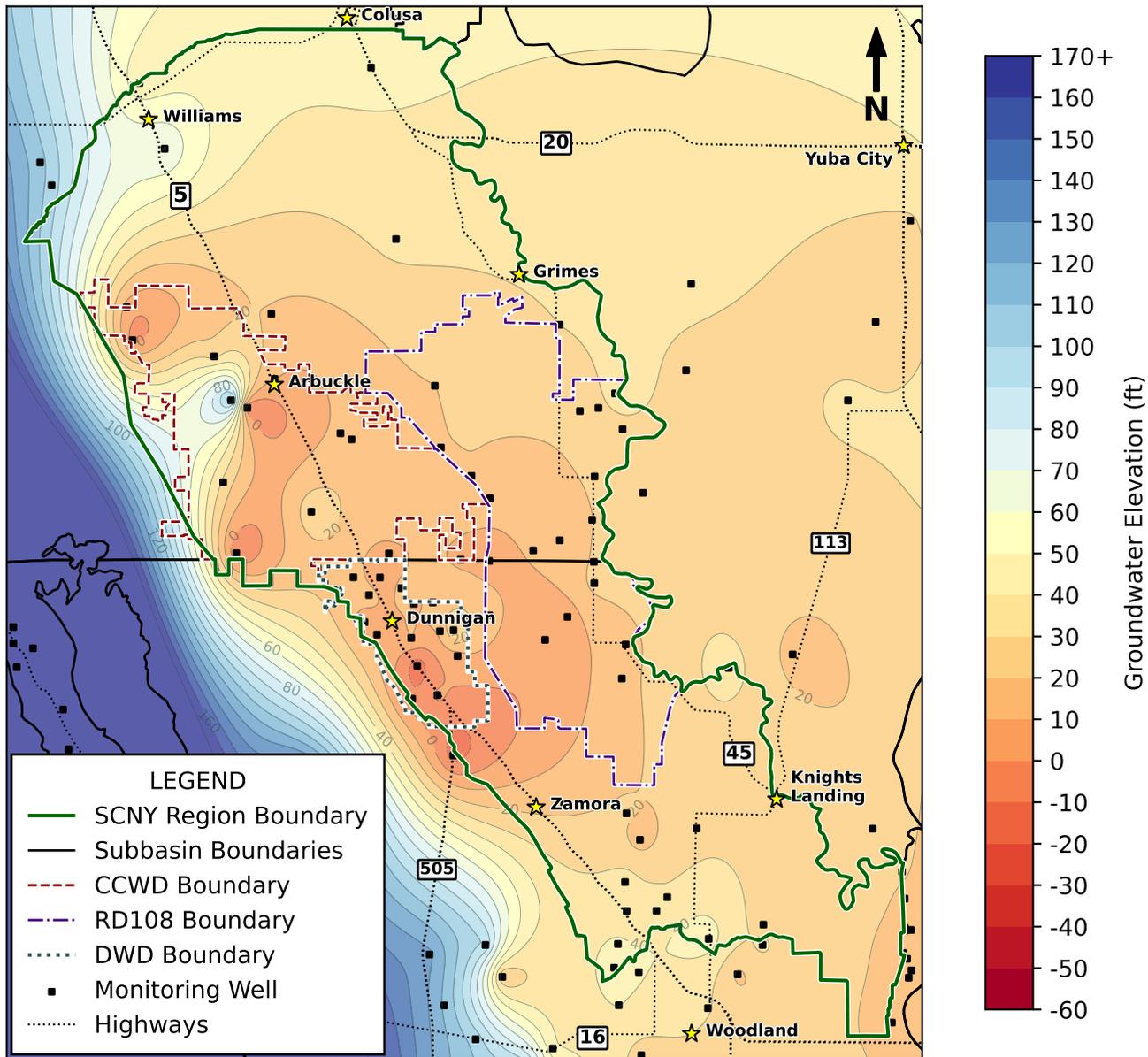
# South Colusa-North Yolo Groundwater Elevation for Spring, 2024



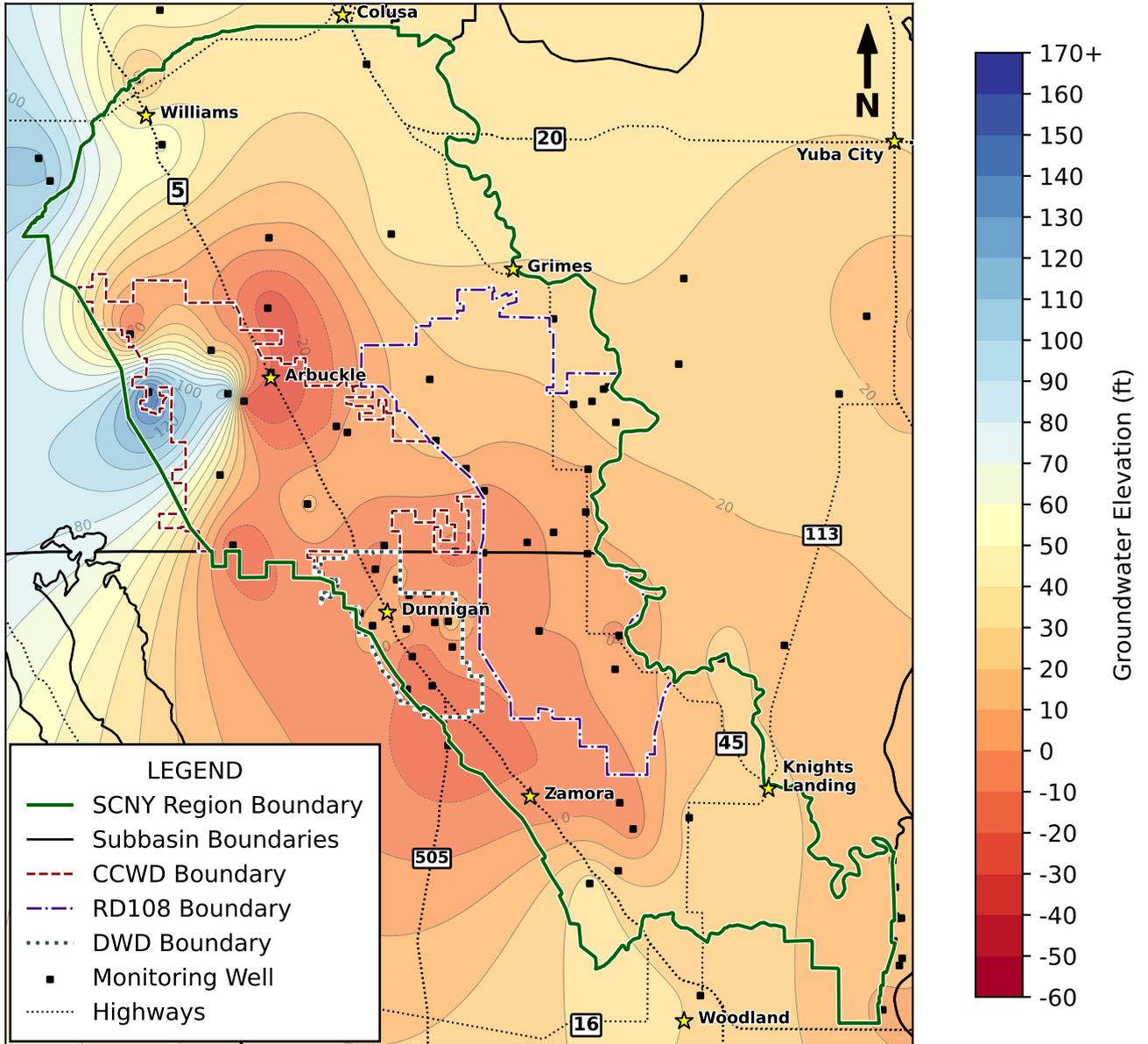
# South Colusa-North Yolo Groundwater Elevation for Fall, 2024



# South Colusa-North Yolo Groundwater Elevation for Spring, 2025



# South Colusa-North Yolo Groundwater Elevation for Fall, 2025



**Attachment E – State Water Resources Control Board – Groundwater  
Quality Considerations for High and Medium Priority Basins**



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## State Water Resources Control Board

November 22, 2022

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### **GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

The State Water Resources Control Board (State Water Board) staff is providing this letter in support of the Department of Water Resources' (DWR) review pursuant to the Sustainable Groundwater Management Act (SGMA) (Water Code § 10720 et seq.) and the regulations implementing SGMA (SGMA regulations) (Cal Code Regs., tit. 23, § 350 et seq.) of groundwater sustainability plans (GSPs) submitted by groundwater sustainability agencies (GSAs) in high and medium priority groundwater basins subject to SGMA.

**This letter is to inform you that, based on an assessment of more than 24 GSPs, State Water Board staff have identified that many of the GSPs do not comprehensively describe or set appropriate sustainable management criteria (SMC) for groundwater quality.**

#### ***Water Quality Impacts on Groundwater and Requirements for GSAs under SGMA***

SGMA is not a remedial statute and does not attempt to resolve all groundwater quality issues but requires that operation of a basin within its sustainable yield, as defined by SGMA, does not cause undesirable results, including water quality degradation. Water Code Section 10727.2 and the SGMA regulations require GSAs to characterize groundwater quality and identify associated undesirable results in the GSPs for their basins. In addition, any projects or management actions adopted by a GSA within their GSP should not cause degradation of water quality that could lead to an undesirable result.

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E. JOAQUIN ESQUIVEL, CHAIR | EILEEN SOBECK, EXECUTIVE DIRECTOR

Both groundwater extraction and the implementation of projects to achieve sustainability may cause impacts from migration of contaminant plumes, changes in the concentration of contaminants due to reduction in the volume of water stored in the basin, or change in groundwater conditions (oxic, suboxic, and anoxic) that could lead to the release of harmful naturally occurring constituents. Declining groundwater levels may draw higher concentrations of shallow constituents (e.g., nitrate, which is commonly found in, but not limited to, the shallow portion of the aquifer) into shallow wells, degrading drinking water quality. Additionally, as wells are drilled and screened deeper into an aquifer, well users may encounter groundwater with higher concentrations of constituents such as arsenic, uranium, and total dissolved solids (TDS), which are commonly present in, but not limited to, deeper portions of aquifers.

Natural and anthropogenically sourced constituent mobilization is dependent on local geology and groundwater environmental conditions that can be influenced by groundwater management processes. Groundwater conditions will likely be highly variable spatially and stratigraphically. A GSA should therefore carefully consider how its management of groundwater might further degrade groundwater quality with respect to each known constituent and its mechanism for mobilization in groundwater.

A GSP must characterize historic and current groundwater quality conditions in principal aquifers as part of the hydrogeologic conceptual model (Cal. Code Regs., tit. 23, § 354.14, subd. (b) (4) (D)) and must address groundwater quality that may affect the supply and beneficial uses of groundwater (Cal. Code Regs., tit. 23, § 354.16, subd. (d)). To determine water quality trends and conditions as of January 1, 2015, a GSP will need to evaluate groundwater quality conditions prior to 2015. A GSP, however, is not required to address undesirable results that occurred before and were not corrected by January 1, 2015 (though a GSA may choose to do so) (Wat. Code, § 10727.2, subd. (b) (4)).

### ***Methodology to Identify Constituents***

In order to recommend a suite of constituents that should be considered in GSPs, State Water Board staff developed a methodology to identify key constituents for each basin. The methodology builds on the process we developed to assess groundwater quality in GSPs we previously reviewed. The methodology uses data from the State Water Board's Groundwater Ambient Monitoring and Assessment Program (GAMA) to determine which constituents exceeded screening criteria related to human health, such as Maximum Contaminant Levels (MCLs) or Health-Based Screening Levels (HBSLs). Constituents that are not related to human health or that are generally not impacted by groundwater management activities are excluded by this methodology. The screening criteria uses information taken from four types of wells (domestic, irrigation/industrial,

municipal, and water supply) as identified by GAMA. If a constituent exceeded screening criteria in the untreated water of three or more of these types of wells basin-wide, it was included as a constituent that should be considered in the GSP.

State Water Board staff encourage DWR, GSAs, and other interested parties to consider the attached list of constituents derived from this methodology when evaluating or updating GSPs. While it may not be appropriate for a GSP to set minimum thresholds and measurable objectives for all constituents identified for the basin, most or all of the constituents should be discussed in the basin setting (Cal. Code Regs., tit. 23, § 354.14, subd. (b) (4) (D) and § 354.16, subd. (d)), since these constituents are present in the basin at concentrations that can impact beneficial users of groundwater. State Water Board staff also encourage DWR, GSAs, and other interested parties to further explore this list of constituents with the [SGMA Groundwater Quality Visualization Tool](https://www.waterboards.ca.gov/sgma/water-quality-visualization-tool.html) (<https://www.waterboards.ca.gov/sgma/water-quality-visualization-tool.html>). For more guidance for GSAs and other interested parties about the role of water quality in SGMA, please see the State Water Board's [Water Quality FAQ](https://www.waterboards.ca.gov/sgma/docs/sgma/sgma_wtr_qual.pdf) ([https://www.waterboards.ca.gov/sgma/docs/sgma/sgma\\_wtr\\_qual.pdf](https://www.waterboards.ca.gov/sgma/docs/sgma/sgma_wtr_qual.pdf)).

For any questions, please contact the Groundwater Management Program at [sgma@waterboards.ca.gov](mailto:sgma@waterboards.ca.gov) or at (916) 322-6508.

Sincerely,



Natalie Stork  
Supervising Engineering Geologist  
Groundwater Management Program  
Office of Research, Planning, and Performance

Enclosure: Table: Groundwater Quality Considerations for High and Medium Priority Groundwater Basins

**GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

<b>Basin Number</b>	<b>Basin/Subbasin</b>	<b>Constituent</b>
1-055.01	Santa Rosa Plain	Arsenic
1-055.01	Santa Rosa Plain	Nitrate as N
1-055.01	Santa Rosa Plain	Trichloroethene (TCE)
2-002.01	Napa Valley	Arsenic
2-002.01	Napa Valley	Nitrate as N
2-002.01	Napa Valley	Nitrite as N
2-002.01	Napa Valley	Trichloroethene (TCE)
2-002.02	Sonoma Valley	Arsenic
2-002.02	Sonoma Valley	Nitrate as N
2-002.02	Sonoma Valley	Total Dissolved Solids
2-009.01	Niles Cone	Nitrite as N
2-009.01	Niles Cone	Perfluorooctanoic acid
2-009.01	Niles Cone	Perfluorooctanoic sulfonate
2-009.01	Niles Cone	Total Dissolved Solids
2-009.02	Santa Clara	Nitrate as N
2-009.02	Santa Clara	Perfluorooctanoic sulfonate
2-010	Livermore Valley	Nitrate as N
2-010	Livermore Valley	Perfluorooctanoic acid
2-010	Livermore Valley	Perfluorooctanoic sulfonate
3-002.01	Pajaro Valley	1,2,3-Trichloropropane (1,2,3 TCP)
3-002.01	Pajaro Valley	Arsenic
3-002.01	Pajaro Valley	Chromium, Hexavalent (Cr6)
3-002.01	Pajaro Valley	Nitrate as N
3-002.01	Pajaro Valley	Nitrate+Nitrite
3-002.01	Pajaro Valley	Total Dissolved Solids
3-003.01	Llagas Area	Nitrate as N
3-003.01	Llagas Area	Nitrate+Nitrite
3-003.01	Llagas Area	Nitrite as N
3-003.01	Llagas Area	Total Dissolved Solids
3-003.05	North San Benito	1,2,3-Trichloropropane (1,2,3 TCP)
3-003.05	North San Benito	Arsenic
3-003.05	North San Benito	Chromium, Hexavalent (Cr6)
3-003.05	North San Benito	Nitrate as N
3-003.05	North San Benito	Nitrate+Nitrite
3-003.05	North San Benito	Total Dissolved Solids
3-004.01	180/400 Foot Aquifer	1,2,3-Trichloropropane (1,2,3 TCP)
3-004.01	180/400 Foot Aquifer	Arsenic
3-004.01	180/400 Foot Aquifer	Chromium, Hexavalent (Cr6)
3-004.01	180/400 Foot Aquifer	Gross Alpha radioactivity
3-004.01	180/400 Foot Aquifer	Nitrate as N
3-004.01	180/400 Foot Aquifer	Nitrate+Nitrite
3-004.01	180/400 Foot Aquifer	Total Dissolved Solids
3-004.02	East Side Aquifer	1,2,3-Trichloropropane (1,2,3 TCP)
3-004.02	East Side Aquifer	Arsenic
3-004.02	East Side Aquifer	Gross Alpha radioactivity
3-004.02	East Side Aquifer	Nitrate as N
3-004.02	East Side Aquifer	Nitrate+Nitrite
3-004.02	East Side Aquifer	Total Dissolved Solids
3-004.04	Forebay Aquifer	1,2,3-Trichloropropane (1,2,3 TCP)
3-004.04	Forebay Aquifer	Nitrate as N
3-004.04	Forebay Aquifer	Nitrate+Nitrite
3-004.04	Forebay Aquifer	Total Dissolved Solids
3-004.05	Upper Valley Aquifer	Gross Alpha radioactivity
3-004.05	Upper Valley Aquifer	Nitrate as N
3-004.05	Upper Valley Aquifer	Nitrate+Nitrite
3-004.05	Upper Valley Aquifer	Total Dissolved Solids
3-004.06	Paso Robles Area	Arsenic
3-004.06	Paso Robles Area	Gross Alpha radioactivity
3-004.06	Paso Robles Area	Nitrate as N

**GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

<b>Basin Number</b>	<b>Basin/Subbasin</b>	<b>Constituent</b>
3-004.06	Paso Robles Area	Nitrate+Nitrite
3-004.06	Paso Robles Area	Total Dissolved Solids
3-004.09	Langley Area	Arsenic
3-004.09	Langley Area	Chromium, Hexavalent (Cr6)
3-004.09	Langley Area	Nitrate as N
3-004.10	Corral De Tierra Area	Arsenic
3-004.10	Corral De Tierra Area	Nitrate+Nitrite
3-004.10	Corral De Tierra Area	Total Dissolved Solids
3-008.01	Los Osos Area	Nitrate as N
3-008.01	Los Osos Area	Nitrate+Nitrite
3-009	San Luis Obispo Valley	Arsenic
3-009	San Luis Obispo Valley	Nitrate as N
3-009	San Luis Obispo Valley	Nitrate+Nitrite
3-009	San Luis Obispo Valley	Perfluorooctanoic acid
3-009	San Luis Obispo Valley	Perfluorooctanoic sulfonate
3-009	San Luis Obispo Valley	Total Dissolved Solids
3-013	Cuyama Valley	Arsenic
3-013	Cuyama Valley	Nitrate as N
3-013	Cuyama Valley	Nitrate+Nitrite
3-013	Cuyama Valley	Total Dissolved Solids
3-014	San Antonio Creek Valley	Arsenic
3-014	San Antonio Creek Valley	Nitrate as N
3-014	San Antonio Creek Valley	Nitrate+Nitrite
3-014	San Antonio Creek Valley	Total Dissolved Solids
3-015	Santa Ynez River Valley	Arsenic
3-015	Santa Ynez River Valley	Chromium, Hexavalent (Cr6)
3-015	Santa Ynez River Valley	Gross Alpha radioactivity
3-015	Santa Ynez River Valley	Nitrate as N
3-015	Santa Ynez River Valley	Nitrate+Nitrite
3-015	Santa Ynez River Valley	Total Dissolved Solids
3-018	Carpinteria	Nitrate+Nitrite
3-018	Carpinteria	Total Dissolved Solids
3-027	Santa Margarita	Arsenic
3-049	Montecito	Nitrate as N
3-049	Montecito	Total Dissolved Solids
4-003.01	Upper Ventura River	Nitrate as N
4-004.02	Oxnard	Gross Alpha radioactivity
4-004.02	Oxnard	Nitrate as N
4-004.02	Oxnard	Selenium
4-004.02	Oxnard	Total Dissolved Solids
4-004.05	Fillmore	Total Dissolved Solids
4-004.06	Piru	Total Dissolved Solids
4-004.07	Santa Clara River Valley East	Perfluorooctanoic acid
4-004.07	Santa Clara River Valley East	Perfluorooctanoic sulfonate
4-004.07	Santa Clara River Valley East	Total Dissolved Solids
4-006	Pleasant Valley	Total Dissolved Solids
4-008	Las Posas Valley	Gross Alpha radioactivity
4-008	Las Posas Valley	Total Dissolved Solids
4-011.01	Santa Monica	Nitrate as N
4-011.01	Santa Monica	Tetrachloroethene (PCE)
4-011.01	Santa Monica	Total Dissolved Solids
4-011.01	Santa Monica	Trichloroethene (TCE)
5-021.50	Red Bluff	Nitrate as N
5-021.50	Red Bluff	Perfluorooctanoic acid
5-021.50	Red Bluff	Perfluorooctanoic sulfonate
5-021.52	Colusa	Arsenic
5-021.52	Colusa	Chromium, Hexavalent (Cr6)
5-021.52	Colusa	Nitrate as N
5-021.52	Colusa	Nitrate+Nitrite

**GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

<b>Basin Number</b>	<b>Basin/Subbasin</b>	<b>Constituent</b>
5-021.52	Colusa	Total Dissolved Solids
5-021.54	Antelope	Nitrate as N
5-021.56	Los Molinos	Arsenic
5-021.57	Vina	1,2,3-Trichloropropane (1,2,3 TCP)
5-021.57	Vina	Arsenic
5-021.57	Vina	Di(2-ethylhexyl)phthalate (DEHP)
5-021.57	Vina	Nitrate as N
5-021.57	Vina	Nitrate+Nitrite
5-021.57	Vina	Nitrite as N
5-021.57	Vina	Perfluorooctanoic acid
5-021.57	Vina	Perfluorooctanoic sulfonate
5-021.57	Vina	Tetrachloroethene (PCE)
5-021.61	South Yuba	1,2,3-Trichloropropane (1,2,3 TCP)
5-021.61	South Yuba	Nitrate as N
5-021.62	Sutter	Arsenic
5-021.62	Sutter	Nitrate as N
5-021.62	Sutter	Nitrate+Nitrite
5-021.62	Sutter	Total Dissolved Solids
5-021.64	North American	1,2,3-Trichloropropane (1,2,3 TCP)
5-021.64	North American	Arsenic
5-021.64	North American	Nitrate as N
5-021.64	North American	Nitrite as N
5-021.64	North American	Perfluorooctanoic acid
5-021.64	North American	Perfluorooctanoic sulfonate
5-021.64	North American	Tetrachloroethene (PCE)
5-021.64	North American	Total Dissolved Solids
5-021.64	North American	Trichloroethene (TCE)
5-021.65	South American	Arsenic
5-021.65	South American	Nitrate as N
5-021.65	South American	Perfluorooctanoic acid
5-021.65	South American	Perfluorooctanoic sulfonate
5-021.65	South American	Total Dissolved Solids
5-021.66	Solano	Arsenic
5-021.66	Solano	Chromium, Hexavalent (Cr6)
5-021.66	Solano	Nitrate as N
5-021.66	Solano	Nitrate+Nitrite
5-021.67	Yolo	Arsenic
5-021.67	Yolo	Chromium, Hexavalent (Cr6)
5-021.67	Yolo	Nitrate as N
5-021.67	Yolo	Nitrate+Nitrite
5-021.67	Yolo	Nitrite as N
5-021.67	Yolo	Total Dissolved Solids
5-021.69	Wyandotte Creek	Nitrate as N
5-021.69	Wyandotte Creek	Perfluorooctanoic acid
5-021.69	Wyandotte Creek	Perfluorooctanoic sulfonate
5-021.70	Butte	1,2,3-Trichloropropane (1,2,3 TCP)
5-021.70	Butte	Arsenic
5-021.70	Butte	Nitrate as N
5-022.01	Eastern San Joaquin	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.01	Eastern San Joaquin	1,2-Dibromo-3-chloropropane (DBCP)
5-022.01	Eastern San Joaquin	Arsenic
5-022.01	Eastern San Joaquin	Gross Alpha radioactivity
5-022.01	Eastern San Joaquin	Nitrate as N
5-022.01	Eastern San Joaquin	Nitrate+Nitrite
5-022.01	Eastern San Joaquin	Nitrite as N
5-022.01	Eastern San Joaquin	Perfluorooctanoic acid
5-022.01	Eastern San Joaquin	Perfluorooctanoic sulfonate
5-022.01	Eastern San Joaquin	Tetrachloroethene (PCE)
5-022.01	Eastern San Joaquin	Uranium

**GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

<b>Basin Number</b>	<b>Basin/Subbasin</b>	<b>Constituent</b>
5-022.02	Modesto	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.02	Modesto	1,2-Dibromo-3-chloropropane (DBCP)
5-022.02	Modesto	Arsenic
5-022.02	Modesto	Gross Alpha radioactivity
5-022.02	Modesto	Nitrate as N
5-022.02	Modesto	Nitrate+Nitrite
5-022.02	Modesto	Nitrite as N
5-022.02	Modesto	Perfluorooctanoic acid
5-022.02	Modesto	Perfluorooctanoic sulfonate
5-022.02	Modesto	Total Dissolved Solids
5-022.02	Modesto	Uranium
5-022.03	Turlock	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.03	Turlock	Arsenic
5-022.03	Turlock	Gross Alpha radioactivity
5-022.03	Turlock	Nitrate as N
5-022.03	Turlock	Nitrate+Nitrite
5-022.03	Turlock	Nitrite as N
5-022.03	Turlock	Perfluorooctanoic sulfonate
5-022.03	Turlock	Total Dissolved Solids
5-022.03	Turlock	Uranium
5-022.04	Merced	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.04	Merced	Arsenic
5-022.04	Merced	Gross Alpha radioactivity
5-022.04	Merced	Nitrate as N
5-022.04	Merced	Nitrate+Nitrite
5-022.04	Merced	Uranium
5-022.05	Chowchilla	Nitrate as N
5-022.05	Chowchilla	Nitrate+Nitrite
5-022.06	Madera	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.06	Madera	1,2-Dibromo-3-chloropropane (DBCP)
5-022.06	Madera	Arsenic
5-022.06	Madera	Gross Alpha radioactivity
5-022.06	Madera	Nitrate as N
5-022.06	Madera	Nitrate+Nitrite
5-022.07	Delta-Mendota	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.07	Delta-Mendota	Arsenic
5-022.07	Delta-Mendota	Chromium, Hexavalent (Cr6)
5-022.07	Delta-Mendota	Gross Alpha radioactivity
5-022.07	Delta-Mendota	Nitrate as N
5-022.07	Delta-Mendota	Nitrate+Nitrite
5-022.07	Delta-Mendota	Total Dissolved Solids
5-022.08	Kings	1,2 Dibromoethane (EDB)
5-022.08	Kings	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.08	Kings	1,2-Dibromo-3-chloropropane (DBCP)
5-022.08	Kings	Arsenic
5-022.08	Kings	Chromium, Hexavalent (Cr6)
5-022.08	Kings	Gross Alpha radioactivity
5-022.08	Kings	Nitrate as N
5-022.08	Kings	Nitrate+Nitrite
5-022.08	Kings	Nitrite as N
5-022.08	Kings	Perfluorooctanoic acid
5-022.08	Kings	Perfluorooctanoic sulfonate
5-022.08	Kings	Tetrachloroethene (PCE)
5-022.08	Kings	Total Dissolved Solids
5-022.08	Kings	Trichloroethene (TCE)
5-022.08	Kings	Uranium
5-022.09	Westside	Total Dissolved Solids
5-022.11	Kaweah	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.11	Kaweah	Arsenic

**GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

<b>Basin Number</b>	<b>Basin/Subbasin</b>	<b>Constituent</b>
5-022.11	Kaweah	Gross Alpha radioactivity
5-022.11	Kaweah	Nitrate as N
5-022.11	Kaweah	Nitrate+Nitrite
5-022.11	Kaweah	Perfluorooctanoic acid
5-022.11	Kaweah	Perfluorooctanoic sulfonate
5-022.11	Kaweah	Tetrachloroethene (PCE)
5-022.11	Kaweah	Total Dissolved Solids
5-022.11	Kaweah	Uranium
5-022.12	Tulare Lake	Arsenic
5-022.12	Tulare Lake	Gross Alpha radioactivity
5-022.12	Tulare Lake	Nitrate as N
5-022.12	Tulare Lake	Nitrate+Nitrite
5-022.12	Tulare Lake	Total Dissolved Solids
5-022.12	Tulare Lake	Uranium
5-022.13	Tule	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.13	Tule	1,2-Dibromo-3-chloropropane (DBCP)
5-022.13	Tule	Arsenic
5-022.13	Tule	Gross Alpha radioactivity
5-022.13	Tule	Nitrate as N
5-022.13	Tule	Nitrate+Nitrite
5-022.13	Tule	Nitrite as N
5-022.13	Tule	Uranium
5-022.14	Kern County	1,2 Dibromoethane (EDB)
5-022.14	Kern County	1,2,3-Trichloropropane (1,2,3 TCP)
5-022.14	Kern County	1,2-Dibromo-3-chloropropane (DBCP)
5-022.14	Kern County	Arsenic
5-022.14	Kern County	Benzene
5-022.14	Kern County	Gross Alpha radioactivity
5-022.14	Kern County	Nitrate as N
5-022.14	Kern County	Nitrate+Nitrite
5-022.14	Kern County	Nitrite as N
5-022.14	Kern County	Perfluorooctanoic acid
5-022.14	Kern County	Perfluorooctanoic sulfonate
5-022.14	Kern County	Selenium
5-022.14	Kern County	Total Dissolved Solids
5-022.14	Kern County	Uranium
5-022.15	Tracy	Arsenic
5-022.15	Tracy	Chromium, Hexavalent (Cr6)
5-022.15	Tracy	Gross Alpha radioactivity
5-022.15	Tracy	Nitrate as N
5-022.15	Tracy	Nitrate+Nitrite
5-022.15	Tracy	Perfluorooctanoic acid
5-022.15	Tracy	Perfluorooctanoic sulfonate
5-022.15	Tracy	Total Dissolved Solids
5-022.16	Cosumnes	Arsenic
5-022.16	Cosumnes	Nitrate as N
5-022.18	White Wolf	Nitrate as N
5-022.19	East Contra Costa	Arsenic
5-022.19	East Contra Costa	Gross Alpha radioactivity
5-022.19	East Contra Costa	Nitrate as N
5-022.19	East Contra Costa	Nitrate+Nitrite
5-022.19	East Contra Costa	Total Dissolved Solids
6-005.01	Tahoe South	Arsenic
6-005.01	Tahoe South	Gross Alpha radioactivity
6-005.01	Tahoe South	Tetrachloroethene (PCE)
6-005.01	Tahoe South	Uranium
6-054	Indian Wells Valley	Arsenic
6-054	Indian Wells Valley	Nitrate as N
7-021.01	Indio	Arsenic

**GROUNDWATER QUALITY CONSIDERATIONS FOR HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS**

<b>Basin Number</b>	<b>Basin/Subbasin</b>	<b>Constituent</b>
7-021.01	Indio	Chromium, Hexavalent (Cr6)
7-021.01	Indio	Gross Alpha radioactivity
7-021.01	Indio	Nitrate as N
7-021.01	Indio	Total Dissolved Solids
7-021.01	Indio	Uranium
7-021.02	Mission Creek	Chromium, Hexavalent (Cr6)
7-021.02	Mission Creek	Gross Alpha radioactivity
7-021.04	San Gorgonio Pass	Nitrate as N
8-001	Coastal Plain Of Orange County	Arsenic
8-001	Coastal Plain Of Orange County	Gross Alpha radioactivity
8-001	Coastal Plain Of Orange County	Nitrate as N
8-001	Coastal Plain Of Orange County	Perfluorooctanoic acid
8-001	Coastal Plain Of Orange County	Perfluorooctanoic sulfonate
8-001	Coastal Plain Of Orange County	Total Dissolved Solids
8-002.07	Yucaipa	Nitrate as N
8-002.09	Temescal	1,2,3-Trichloropropane (1,2,3 TCP)
8-002.09	Temescal	Gross Alpha radioactivity
8-002.09	Temescal	Nitrate as N
8-002.09	Temescal	Perfluorooctanoic acid
8-002.09	Temescal	Perfluorooctanoic sulfonate
8-002.09	Temescal	Total Dissolved Solids
8-004.01	Elsinore Valley	Arsenic
8-005	San Jacinto	1,2,3-Trichloropropane (1,2,3 TCP)
8-005	San Jacinto	Gross Alpha radioactivity
8-005	San Jacinto	Nitrate as N
8-005	San Jacinto	Perfluorooctanoic acid
8-005	San Jacinto	Perfluorooctanoic sulfonate
8-005	San Jacinto	Total Dissolved Solids
9-007.01	Upper San Luis Rey Valley	Nitrate as N
9-007.01	Upper San Luis Rey Valley	Total Dissolved Solids

# **Attachment F – Dunnigan Area Recharge Program – Fall 2022 Update**

# TECHNICAL MEMORANDUM



**RYAN FULTON**

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**DATE:** April 4, 2023  

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**TO:** William Vanderwaal, Manager  

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**COPY TO:** The Nature Conservancy  

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**SUBJECT: Dunnigan Area Recharge Program – Fall 2022 Update**

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## 1 Background and Summary

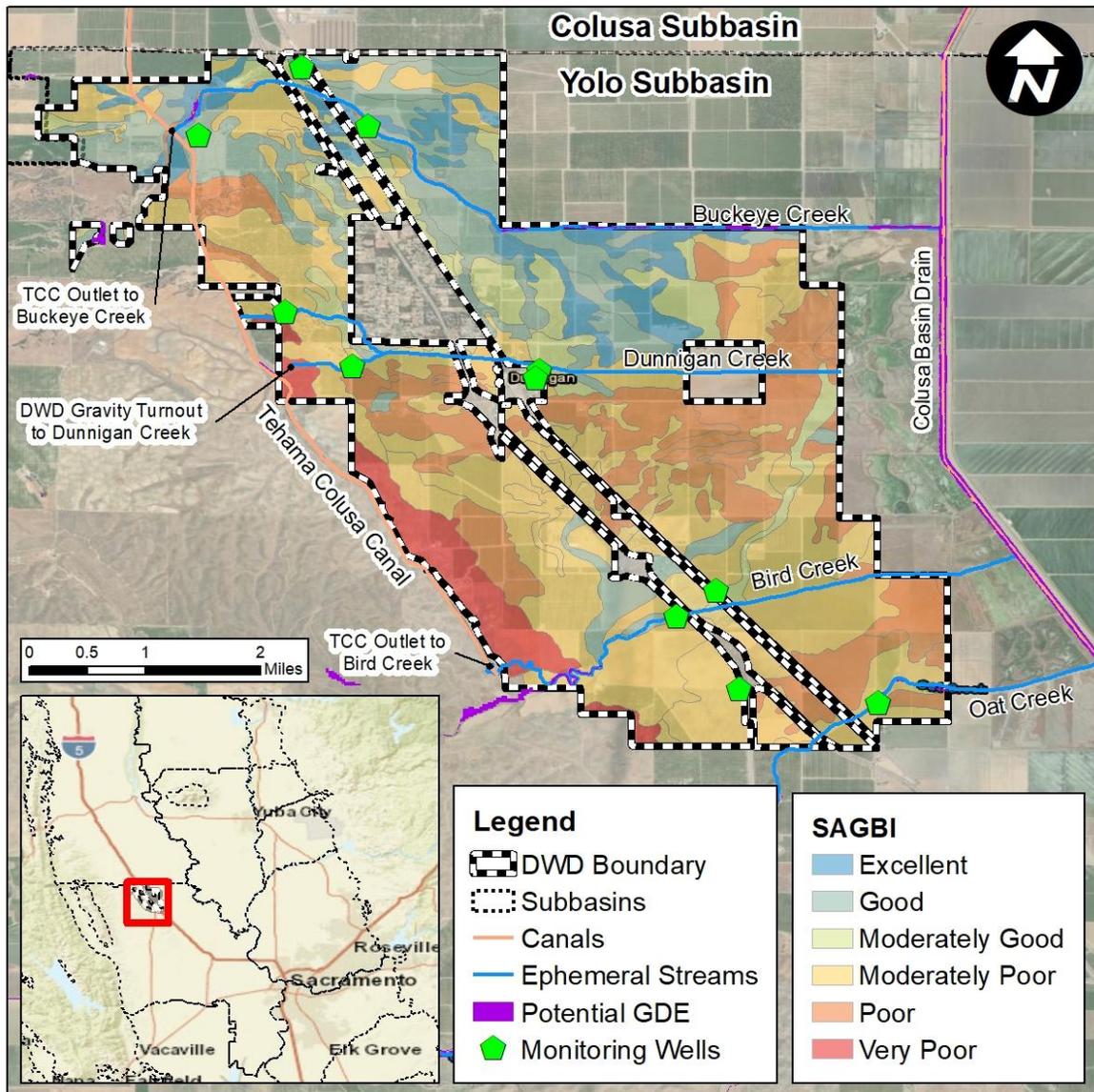
Drought resiliency can be built through groundwater recharge in accordance with California’s prioritization of groundwater recharge projects as codified by Governor Newsom’s Executive Orders N-7-22, N-3-23, and N-4-23. In the Dunnigan area, historical low groundwater levels are threatening water supply for both agricultural and domestic users and causing land subsidence. The subsidence is damaging nearby infrastructure, including the Tehama-Colusa Canal (TCC) and Interstate 5, both provide critical support for the agricultural industry and residents. Groundwater levels between the Fall of 2010 and Fall 2020 declined by over 30 feet in areas. DWR reports total subsidence between June of 2015 and January of 2023 up to -1.05 feet. Approximately 207 domestic wells are in the area, of which up 19 (or 9%) were susceptible of going dry in the recent drought. Domestic and public supply wells range from approximately 100 feet to over 700 feet. Wells susceptible of going dry generally range from approximately 100 feet to 200 feet.

The Dunnigan Area Recharge Program (DARP or Program) seeks to immediately address the unprecedented drought conditions impacting the disadvantaged community of Dunnigan. The Program will develop a strategic roadmap to implement groundwater recharge projects at large scale by diverting excess surface water to ephemeral streams and agricultural lands. The Program utilizes Section 215 water, excess Central Valley Project (CVP) contract water from Dunnigan Water District (DWD or District), and purchased surface water from senior water right holders.

A pilot project was performed in February 2022 when the TCC was emptied to complete repairs. Approximately 275 AF of water was discharged into Buckeye Creek, which increased

groundwater levels by approximately 5 inches at nearby monitoring wells. Further information on the Buckeye Creek Trickle Recharge Project from February 2022 is available in Attachment A.

The District in collaboration with the Westside Sacramento Integrated Regional Water Management (IRWM) Program, Yolo Subbasin Groundwater Agency, California American Water, and The Nature Conservancy (TNC) are continuing to demonstrate multi-benefit, managed aquifer recharge (MAR). Surface water will be diverted from the TCC into Buckeye, Dunnigan, Bird, and Oat Creeks (i.e., ephemeral streams) and on to fallow farmland enrolled in TNC’s multi-benefit recharge program. The Project will improve water supply reliability for the disadvantaged community of Dunnigan; provide habitat for migratory waterfowl; enhance groundwater-dependent ecosystems; and reduce the risk of subsidence. A map of the Program is shown in Figure 1.



**Figure 1. Dunnigan Area Recharge Program.**

An initial study for the Program was conducted on four (4) fields in DWD’s service area to begin analyzing and quantifying groundwater recharge and shorebird habitat benefits. The effort built upon the successful implementation of TNC Multi-Benefit Groundwater Recharge Project conducted within Colusa County from 2018 through 2021. TNC, technical consultants, landowner, and District staff met on October 20, 2022, to review field preparation (i.e., tilling) and flooding requirements and discussed monitoring methods and procedures. Information was collected before, during, and after flooding of the fields to understand baseline and post-project conditions. This technical memorandum provides methods, results, and discussion regarding multi-benefit groundwater recharge, data gaps, and recommendations for scaling up the program and monitoring network as the DARP continues and expands. The DARP was recently highlighted by DWR<sup>1</sup>, the Los Angeles Times<sup>2</sup>, and shared by many others.

The selected fields were flooded starting October 28<sup>th</sup> through November 6<sup>th</sup>, 2022. Approximately 300 acre-feet, purchased from senior water right holders, was applied to 170 acres. Ponded depths were maintained at four inches per TNC’s specification to the extent possible. Fields 1 and 4 achieved a ponding depth of approximately 4 inches. Fields 2 and 3 did not reach the desired ponding depth but were saturated. Only a portion of Field 3 was flooded due to limited water availability and the water quickly moved through the dry soil profile. TNC reported the saturated soil provided habitat benefits.

Deep percolation for each field was calculated using a mass balance approach with all flow paths being measured, estimated, or assumed negligible. Depth to groundwater in adjacent wells were measured pre- and post- flooding to assess benefit to groundwater levels. Four groundwater monitoring sites were installed. Two of the four groundwater monitoring sites and one precipitation station were installed with telemetry. Information is displayed in near real-time on an online Stakeholder Data Portal. A map of the fields is shown in Figure 2 with boundaries, district turnouts, ditches, and outflow sites marked. The total applied water, precipitation, evapotranspiration, and deep percolation of precipitation and applied water is summarized in Table 1. The total estimated deep percolation of applied water is 273 AF, which results in 91% of the surface water applied being recoverable and recharging the groundwater aquifer. This is consistent with previous studies conducted by the University of California in Davis and Scott Valley, California where over 90% of the water applied to sites percolated to recharge groundwater.<sup>3</sup>

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<sup>1</sup> DWR article: <https://water.ca.gov/News/Blog/2023/Jan-23/Capturing-Water-from-Storms-to-Replenish-Groundwater> (accessed March 31, 2023).

<sup>2</sup> Los Angeles Times article: <https://news.yahoo.com/amid-soaking-storms-california-turns-120010829.html> (accessed March 31, 2023).

<sup>3</sup> Managed winter flooding of alfalfa recharges groundwater with minimal crop damage. Helen E. Dahlke, Andrew G. Brown, Steve Orloff, Daniel Putnam and Toby O’Geen. website: <https://escholarship.org/uc/item/6g62x05j> (accessed March 31, 2023)

**Table 1. Estimated deep percolation and change in groundwater level.**

Field No.	Acres	Surface Water Applied, AF	Precipitation, AF <sup>1</sup>	Total ET, AF <sup>2</sup>	Total DP, AF <sup>3</sup>	DP of Precipitation, AF <sup>4</sup>	DP of Applied Water, AF <sup>5</sup>	DP of AW, AF/ac	DP of AW / Applied Water
1	31.6	25.9	2.8	5.2	23.6	2.33	21.3	0.67	82%
2 & 3 <sup>6</sup>	103.5	204.8	9.3	16.9	197.1	8.58	188.6	1.82	92%
4	34.8	68.9	3.1	5.7	66.4	2.88	63.5	1.82	92%
<b>Total:</b>	<b>170</b>	<b>300</b>	<b>15.3</b>	<b>27.8</b>	<b>287</b>	<b>13.9</b>	<b>273</b>	<b>1.61</b>	<b>91%</b>

<sup>1</sup>Precipitation is measured using a station located near the recharge sites. The station recorded 0.45 inches and 0.63 inches on November 7<sup>th</sup> and 8<sup>th</sup>, respectively, between October 28<sup>th</sup> through November 21<sup>st</sup> (total 1.08 inches).

<sup>2</sup>Total EvapoTranspiration (ET) is the sum of evaporation and transpiration that occurred between October 28<sup>th</sup> through November 21<sup>st</sup>. Per TNC field observations, fields were dry by November 21<sup>st</sup>. ET was estimated by multiplying the reference ET from the Woodland CIMIS Station (#226) by 1.05, the crop coefficient for open water surfaces less than 2 meters deep (Source: FAO56). Reference ET from October 28<sup>th</sup> through November 21<sup>st</sup> is equal to 1.87 inches.

<sup>3</sup>Total deep percolation (DP) is equal to applied surface water plus precipitation minus total ET, and deep percolation of precipitation. It is assumed the change in rootzone and surface storage is negligible as the water will eventually percolate through the vadose zone with additional precipitation/applied water.

<sup>4</sup>DP of precipitation is assumed equal to the ratio of precipitation to total inflow (surface water plus precipitation) times total deep percolation.

<sup>5</sup>DP of applied water is assumed to be the difference between total DP and DP of precipitation.

<sup>6</sup>The landowner started to apply water to Fields 2 and 3 and realized there was insufficient water to flood both fields. The water budget assumed the entire Field 3 was saturated (77.5 acres) and 33% of Field 4 was saturated (26 acres). The saturated area of Field 3 was estimated based on a November 3, 2022, satellite image.

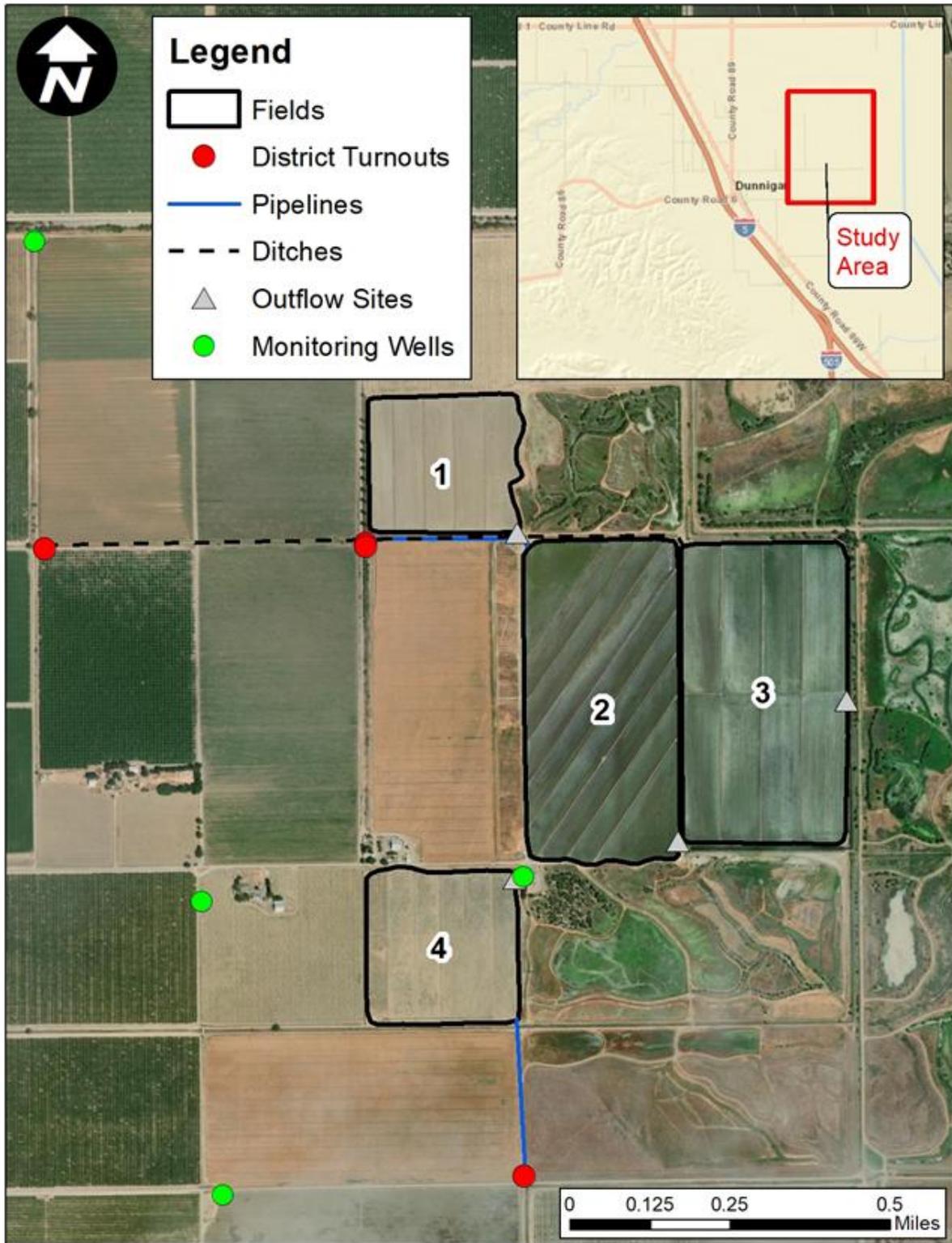


Figure 2. Project field boundaries, district turnouts, ditches, field outflows, and groundwater monitoring sites.

## 2 Water Budget Methods and Results

### 2.1 Water Budget Methods

Total deep percolation was estimated as the ‘closure’ term using a cumulative mass balance approach for the entire study period (October 28<sup>th</sup> through November 21<sup>st</sup>). The mass balance states the sum of the inflows minus the sum of the outflows equals the change in storage. It is assumed the change in root zone storage is negligible as applied surface water stored in the root zone would eventually deep percolate as rainfall occurs after the recharge event. The fields initial and final ponding depth was 0, so the change in surface storage is negligible.

**Table 2. Mass balance variables and methods used to quantify flowpaths.**

Flowpath	Type	Measured or estimated
Surface Inflow	Inflow	Measured
Precipitation	Inflow	Measured
Change in Root Zone Storage	Negligible	Estimated (assumed 0)
Change in Surface Storage	Negligible	Estimated (assumed 0)
Surface Outflow	Outflow	Measured
Evapotranspiration	Outflow	Estimated
Deep Percolation	Outflow	Estimated (“closure”)

#### 2.1.1 Surface Water Inflow

DWD diverted surface water from the Sacramento River/TCC through their distribution system to the recharge sites. Surface water inflows were measured at four (4) District delivery points. Each delivery is equipped with a propeller meter with an estimated accuracy of +/- 5 to 10 percent. District staff, in coordination with the landowner, provided daily flow and volumetric meter readings available in Attachment B. The landowner tracked how the water was being distributed across the fields and reported to the consultant team when water was switched between fields.

#### 2.1.2 Precipitation

Precipitation was measured using a tipping bucket rain gauge datalogger installed near the recharge fields about a quarter mile to the west of Field 4. The site was equipped with telemetry so records can be viewed in near real-time through an online, Stakeholder Data Portal. The station was periodically visited to ensure the site was functioning properly. Precipitation totals from November and December 2022 and January 2023, were measured at 1.08 inches, 7.48 inches, and 9.50 inches, respectively. A screenshot from the Stakeholder Data Portal showing precipitation timeseries is available in Attachment C.

### 2.1.3 Change in Root Zone Storage

The change in root zone storage was assumed negligible due to the amount and timing of precipitation that occurred following the recharge event. Applied surface water either deep percolates through the effective root zone during the recharge event or is stored in the root zone until it evapotranspires or is moved downward by precipitation. Evapotranspiration is assumed to be negligible at the end of the study period as TNC reported a dry soil surface on November 21<sup>st</sup>.

The primary soil type across the fields is silty clay loam based on the NRCS’s Soil Survey Geographic Database (SSURGO).<sup>4</sup> Typical soil parameters are provided in Table 3. Assuming a root zone depth defined as the top five (5) feet and the initial soil moisture content prior to recharge at wilting point, the root zone profile could hold up to 9.21 inches of water. Approximately 18 inches of precipitation occurred between November 2022 through January 2023, which significantly exceeded the available water holding capacity of the effective, five-foot root zone. This further supports the change in root zone storage can be assumed negligible as stored surface water in the root zone would be replaced by precipitation.

**Table 3. Root zone soil characteristics for silty clay loam, the primary soil type across the fields, according to the NRCS Soil Survey Geographic Database.**

Primary Soil Type	Silty Clay Loam
Water Content at Wilting Point (% by volume)	23%
Water Content at Field Capacity (% by volume)	39%
Water Content at Saturation (% by volume)	47%
Available Water Holding Capacity (% by volume)	16%
Available Water Holding Capacity, inches (assumes 5ft root zone)	9.21

### 2.1.4 Change in Surface Storage

Change in surface storage is negligible for the mass balance. The fields surfaces were dry at the start and end of the study period. Ponding depths were monitored by TNC throughout the project to assess habitat benefits.

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<sup>4</sup> Natural Resources Conservation Service (NRCS), USDA. Web Soil Survey. <https://websoilsurvey.nrcs.usda.gov/>

### 2.1.5 Surface Outflow

Surface outflows from each field were measured. There was one outflow site per field where excess water flowed over a weir structure. Water levels were continuously monitored every 15-minutes at each location, and flow rate and volume were estimated using the standard weir equation. Approximately 1.2 AF and 1.4 AF overflowed Field 1 on November 3<sup>rd</sup> and 4<sup>th</sup>, respectively. Excess water flowed into Field 3. Fields 2, 3, and 4 did not have any outflow.

### 2.1.6 Evapotranspiration

EvapoTranspiration (ET) is the sum of evaporation and transpiration that occurred between October 28th through November 21st. Per TNC field observations, field surfaces were dry by November 21<sup>st</sup>. ET was estimated by multiplying the grass-based, reference ET (ET<sub>o</sub>) from the Woodland CIMIS Station (#226) by 1.05, the crop coefficient for open water surfaces less than 2 meters deep.<sup>5</sup> Reference ET from October 28th through November 21<sup>st</sup> is equal to 1.87 inches. Use of the crop coefficient of 1.05 is a conservative assumption when ponded water on the fields was not observed. Total ET from October 28<sup>th</sup> through November 21<sup>st</sup> is equal to 1.96 inches.

### 2.1.7 Deep Percolation

Deep percolation was calculated as the closure term of the mass balance using Equation 1, which assumes change in root zone and surface storage is zero. Deep percolation of applied water was estimated by multiplying deep percolation by the ratio of applied water to the total net inflow. Deep percolation of precipitation was estimated as the difference between total deep percolation and deep percolation of applied water.

$$\text{Deep Percolation} = \text{Applied Surface Water} + \text{Precipitation} - \text{Surface Outflow} - \text{ET} \quad (\text{EQ. 1})$$

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<sup>5</sup> Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56 (website: <https://www.fao.org/3/X0490E/x0490e00.htm>)

## 2.2 Water Budget Results

Water budget results for Fields 1, 2 and 3, and 4 are presented in Tables 4, 5, and 6; respectively. All volumes are expressed on a per acre basis in units of inches for comparison. Additionally, estimated uncertainties for each flowpath and calculated uncertainty of the closure (i.e., deep percolation) are shown. Uncertainty of the estimated/measured flowpaths and closure are based on professional experience and weighted based on volume. Application depths ranged from approximately 10 inches on Field 1 to 24 inches on Fields 2 and 3 and 4. On average the district applied 21.2 inches across all the fields between October 28<sup>th</sup> through November 6<sup>th</sup>. The calculated deep percolation of applied water for Fields 1, 2 and 3, and 4 are 8.1 inches, 21.9 inches, and 21.9 inches, respectively.

**Table 4. Field 1 water budget summary.**

<b>Field 1</b>	<b>Value</b>	<b>Uncertainty</b>
Inflow (in.)	10.8	10%
Outflow (in.)	1.0	15%
Precipitation (in.)	1.1	5%
Evapotranspiration (in.)	2.0	15%
Change in Surface Storage (in.)	0.0	15%
Change in Root Zone Storage (in.)	0.0	15%
Calculated Deep Percolation (in.)	9.0	13%
Calculated Deep Percolation of Precipitation (in)	0.9	13%
Calculated Deep Percolation of Applied Water (in)	8.1	13%
Calculated Deep Percolation (af)	23.6	13%
Calculated Deep Percolation of Precipitation (af)	2.3	13%
Calculated Deep Percolation of Applied Water (af)	21.3	13%

**Table 5. Fields 2 and 3 water budget summary.**

<b>Fields 2 and 3</b>	<b>Value</b>	<b>Uncertainty</b>
Inflow (in.)	23.7	10%
Outflow (in.)	0.0	15%
Precipitation (in.)	1.1	5%
Evapotranspiration (in.)	2.0	15%
Change in Surface Storage (in.)	0.0	15%
Change in Root Zone Storage (in.)	0.0	15%
Calculated Deep Percolation (in.)	22.9	10%
Calculated Deep Percolation of Precipitation (in)	1.0	10%
Calculated Deep Percolation of Applied Water (in)	21.9	10%
Calculated Deep Percolation (af)	197.1	10%
Calculated Deep Percolation of Precipitation (af)	8.6	10%
Calculated Deep Percolation of Applied Water (af)	188.6	10%

**Table 6. Field 4 water budget summary.**

Field 4	Value	Uncertainty
Inflow (in.)	23.8	10%
Outflow (in.)	0.0	15%
Precipitation (in.)	1.1	5%
Evapotranspiration (in.)	2.0	15%
Change in Surface Storage (in.)	0.0	15%
Change in Root Zone Storage (in.)	0.0	15%
Calculated Deep Percolation (in.)	22.9	10%
Calculated Deep Percolation of Precipitation (in)	1.0	10%
Calculated Deep Percolation of Applied Water (in)	21.9	10%
Calculated Deep Percolation (af)	66.4	10%
Calculated Deep Percolation of Precipitation (af)	2.9	10%
Calculated Deep Percolation of Applied Water (af)	63.5	10%

### 2.3 Infiltration Rates

Calculated deep percolation rates were estimated using measured ponding depths and deep percolation estimates from Section 2.2 above. Water levels were continuously monitored every 15 minutes at one location within each field and periodic measurements were taken by TNC. Figure 3 shows continuous records for Fields 1 and 4 and TNC’s periodic spot measurements. Continuous records are not available for Fields 2 and 3 since the fields did not pond at the point where the water level sensors were located. Differences between the continuous measurements and TNC spot measurements are likely due to soil variability across the fields as measurements were not taken at the same location. Instead, the measurements provide insights in how percolation rates can vary across the field and how it takes time for water to travel across the fields. The continuous sites are located near the tail end of the fields.

Deep percolation rates are summarized in Table 7. Rates vary from 0.1 inches per hour on Field 1 to 0.3 inches per hour on Field 4. It was assumed Fields 2 and 3 remained saturated for approximately the same period as Fields 1 and 4 resulting in higher uncertainty in the estimated deep percolation rate of 0.3 inches per hour. The higher percolation rate observed in Field 4 may be a result of an underlying sandy or gravelly stratum extending from Buckeye Creek. Prior to Buckeye Creek being redirected to the east near County Road 89, aerial imagery and landowner input suggests the creek may have flowed southeast through Field 4. DWR’s airborne electromagnetic (AEM) surveys, along with other local geologic information, will be reviewed for further validation.<sup>6</sup>

<sup>6</sup> DWR Airborne Electromagnetic (AEM) Survey Data website: <https://data.cnra.ca.gov/dataset/aem>

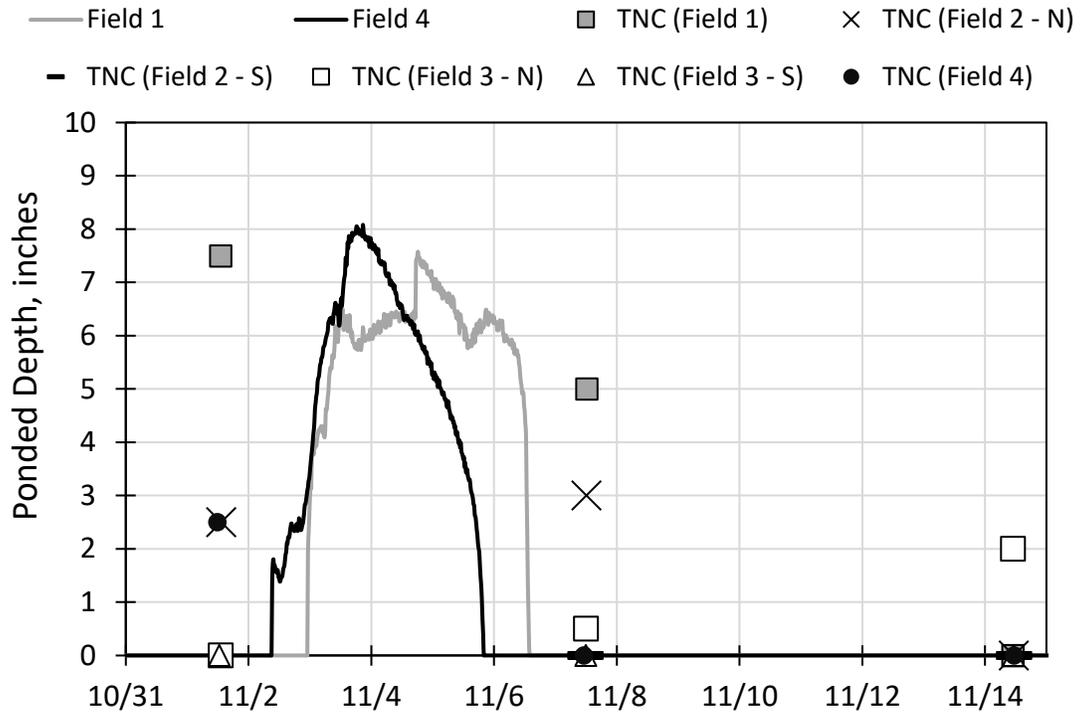


Figure 3. Measured ponding depths.

Table 7. Estimated deep percolation rates.

Field No.	Deep Percolation (inches)	Estimated Time (hours)	Calculated Deep Percolation Rate (inches/hour)
1	9.0	86.5	0.104
2 & 3	22.9	84.5	0.270
4	22.9	82.5	0.277
Total	20.3	84.5	0.240

### 3 Groundwater Level Assessment

#### 3.1 Hydrographs

Depth to groundwater is monitored in active and abandoned wells surrounding the recharge sites. Yolo Subbasin Groundwater Agency's monitoring network is being used to monitor groundwater levels to the extent information is available. Additional monitoring sites are being integrated into the District's monitoring network. An online Stakeholder Data Portal was developed to display groundwater level hydrographs in near real-time (Attachment C). Monitoring sites will remain active following recharge events to observe groundwater trends over time. Water levels were recorded at fifteen-minute intervals and averaged to daily intervals as shown in Figures 4 and 5.

The monitoring site shown in Figure 4 is located on the northeast corner of Field 4 and southwest of Fields 2 and 3. Groundwater levels increased by approximately 8.4 feet in about one week. A groundwater mound formed towards the end of the recharge period and then groundwater levels started to subside once recharging stopped. The depth to groundwater ranged from 10 to 20 feet, which suggests there may be a perched aquifer in this vicinity.

Figure 5 shows hydrographs for two monitoring sites. The hydrograph for site 'YOL\_080' (the purple line) is located approximately one mile northwest of the fields. The hydrograph for site 'YOL\_088' (the blue line) is located approximately a quarter mile west of Field 4. Groundwater elevations increased by approximately 5 to 8 feet during the study period. Varying factors such as precipitation events may have contributed to the increase in groundwater levels. Nearby wells were turned on around November 3<sup>rd</sup> and 13<sup>th</sup> causing groundwater levels to decline and then rebound once turned off. Starting on November 21<sup>st</sup>, the landowner started to pump groundwater for habitat. Groundwater levels declined by approximately two feet as groundwater was being pumped for habitat. Hydrographs shown in Figure 5 are available in near real-time via the Portal. Access to the Portal is available upon request and approval.

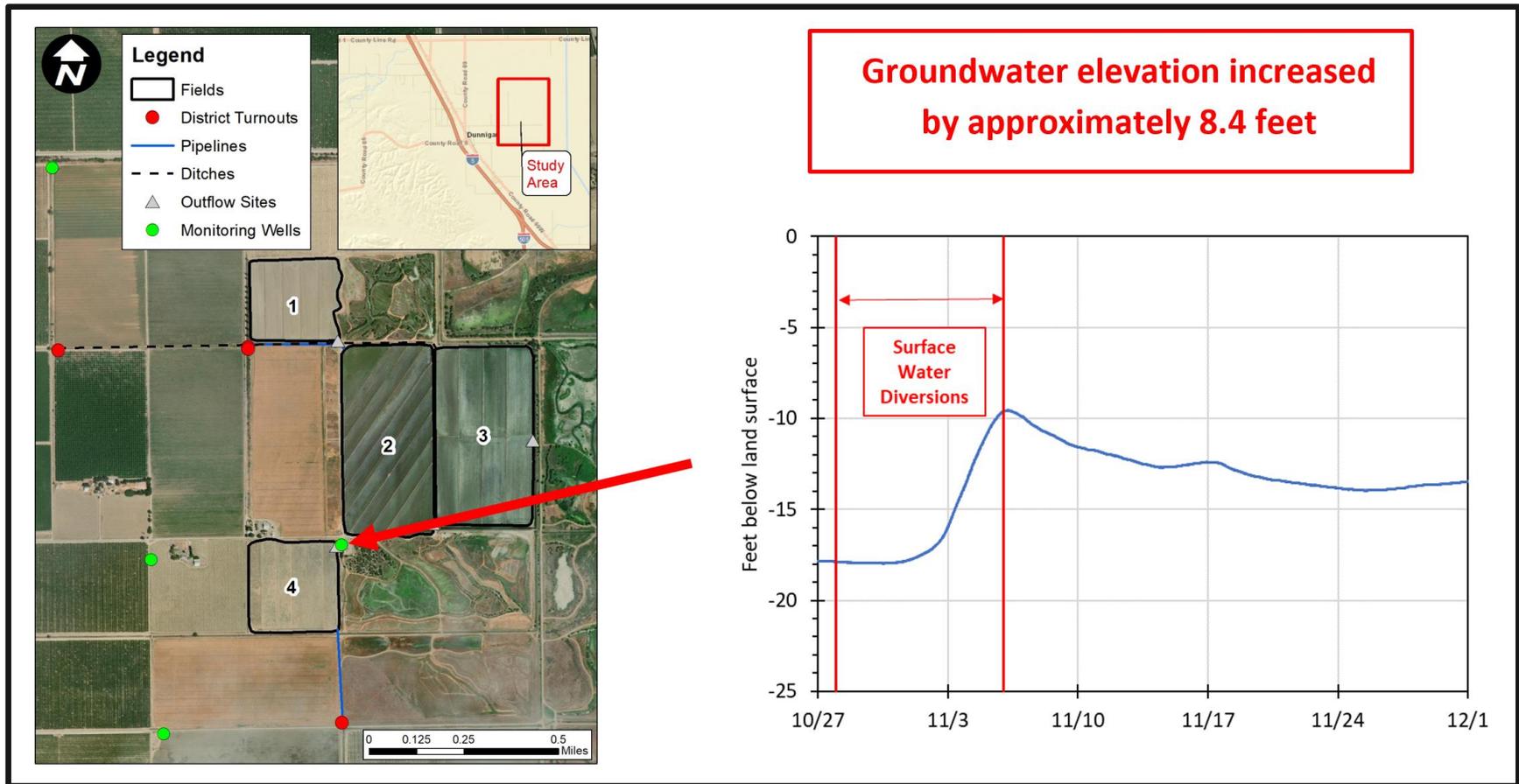


Figure 4. Groundwater monitoring site located on the northeast corner of Field 4 and southwest of Fields 2 and 3.

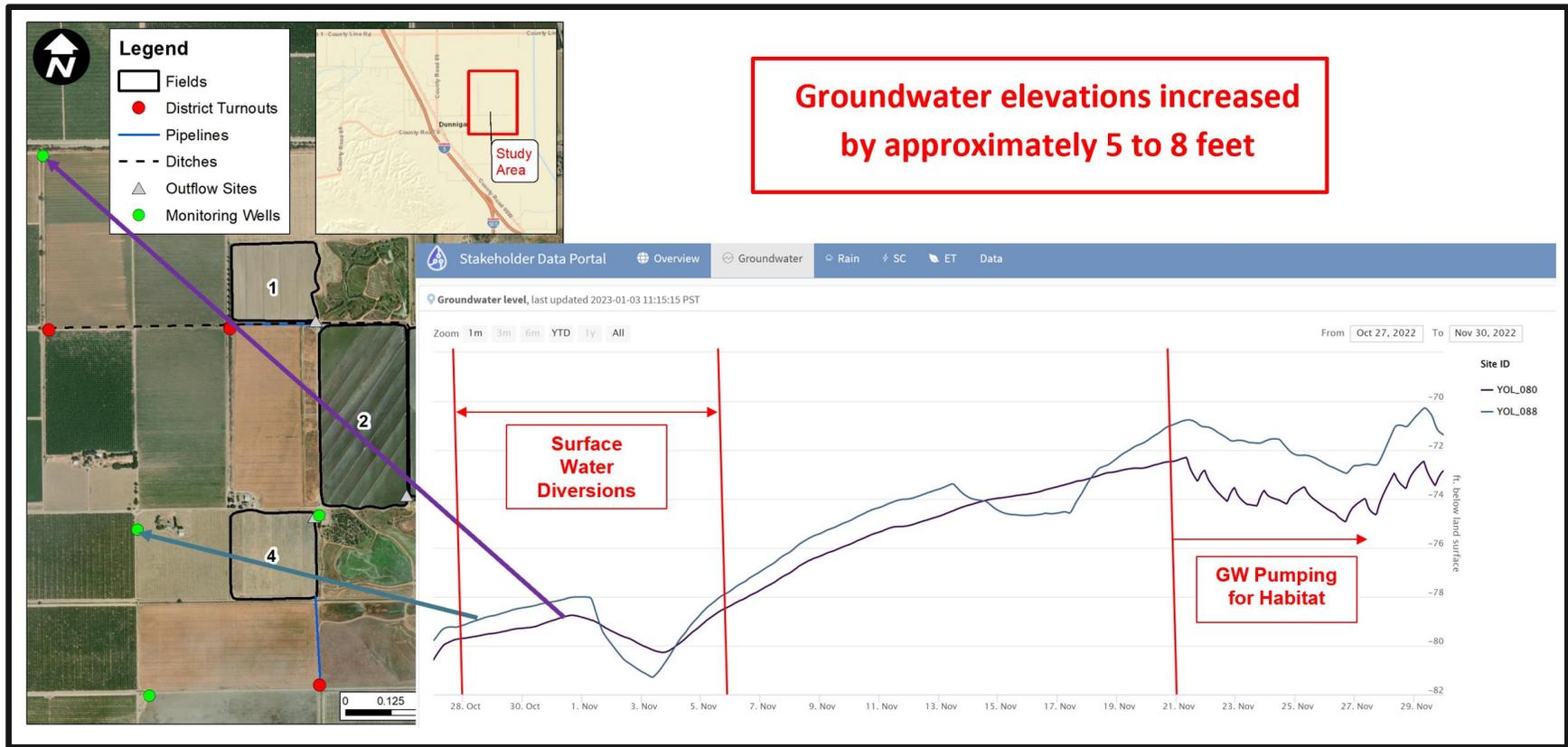


Figure 5. Groundwater monitoring sites west and northwest of recharge sites.

### 3.2 Groundwater Gradients

The direction of the groundwater gradient supports the determination of groundwater recharge beneficiaries. Once groundwater percolates through the unsaturated vadose zone and reaches the groundwater aquifer it will generally move laterally from high elevation to low elevation. Gradients were evaluated using publicly available information through DWR’s SGMA Data Viewer.<sup>7</sup> Based on Fall 2021 groundwater elevations, as shown in Figure 6, a groundwater cone of depression formed from approximately Arbuckle to the north to approximately Zamora on the south. The DARP is located within the middle of the cone of depression with the lowest elevations observed in the Zamora area. Groundwater gradients are subject to change over time and should be periodically reviewed to determine how gradients change depending on extractions and recharge activities. The DARP monitoring network, once fully established, will support further evaluation of localized gradients and benefits.

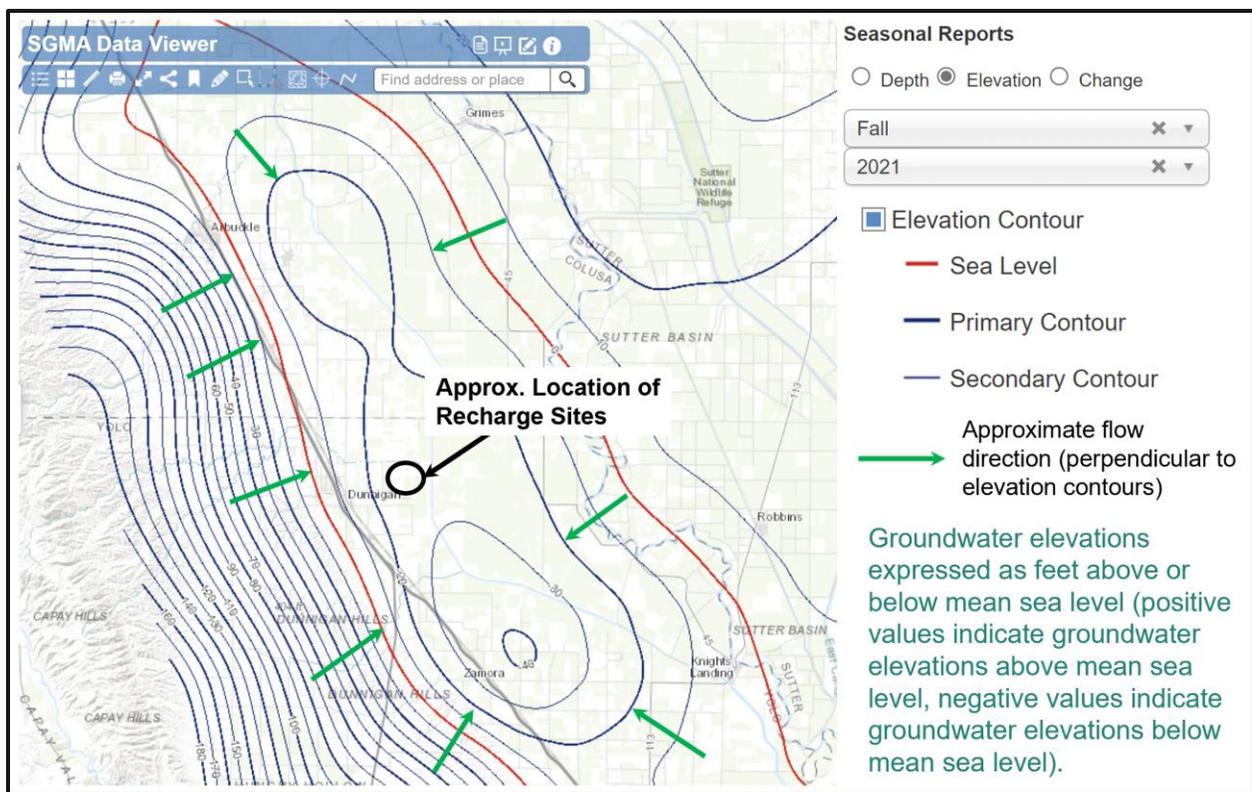


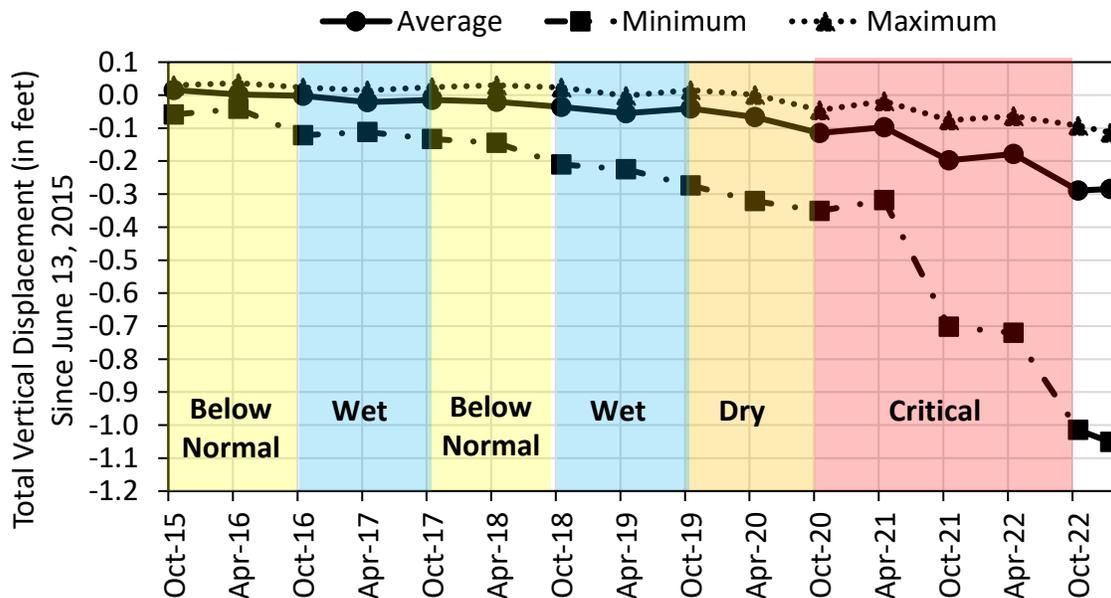
Figure 6. Fall 2021 groundwater elevations contours from DWR’s SGMA Data Viewer.

<sup>7</sup> SGMA Data Viewer: <https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions> (accessed March 10, 2023).

## 4 Subsidence

There are two types of land subsidence: inelastic and elastic. Elastic subsidence is recoverable as groundwater conditions improve. Inelastic subsidence is unrecoverable. The District is monitoring subsidence to 1.) identify if the local subsidence is elastic or inelastic and 2.) quantitatively assess how recharge activities and precipitation are impacting subsidence. Datasets available through DWR (e.g., TRE ALTAMIRA InSAR Dataset) along with local surveys and extensometers, to the extent available, will be used to evaluate subsidence. InSAR datasets are point data that represent average vertical displacement values for 100-meter by 100-meter areas, as well as GIS rasters that were interpolated from the point data. Monthly datasets are available to assess subsidence trends.<sup>8</sup> InSAR data accurately models change in ground elevation to an accuracy of 18mm (or 0.06 feet) at 95% confidence (Towill, 2021).

InSAR vertical displacement values within the District’s service area were extracted and summarized. Figure 7 plots the average, minimum, and maximum total vertical displacement since June 13, 2015. Negative values represent areas where subsidence is occurring; thus, the ‘minimum’ and ‘maximum’ lines represent areas with the most and least amount of subsidence, respectively. InSAR reported total subsidence from June 2015 to January 2023 up to -1.05 feet in areas with the average vertical displacement equal to -0.29 feet. Subsidence increased starting in water year 2020 through 2022 with multiple, consecutive dry and critically dry years. As shown in Figure 8, the areas with the highest subsidence are towards the north end of the District and on neighboring lands.



**Figure 7. InSAR average, minimum, and maximum total vertical displacement since June 13, 2015, within the District’s service area.**

<sup>8</sup> TRE ALTAMIRA InSAR Dataset: <https://sgma.water.ca.gov/webgis/config/custom/html/SGMADDataViewer/doc/#tre-altamira-insar-dataset>

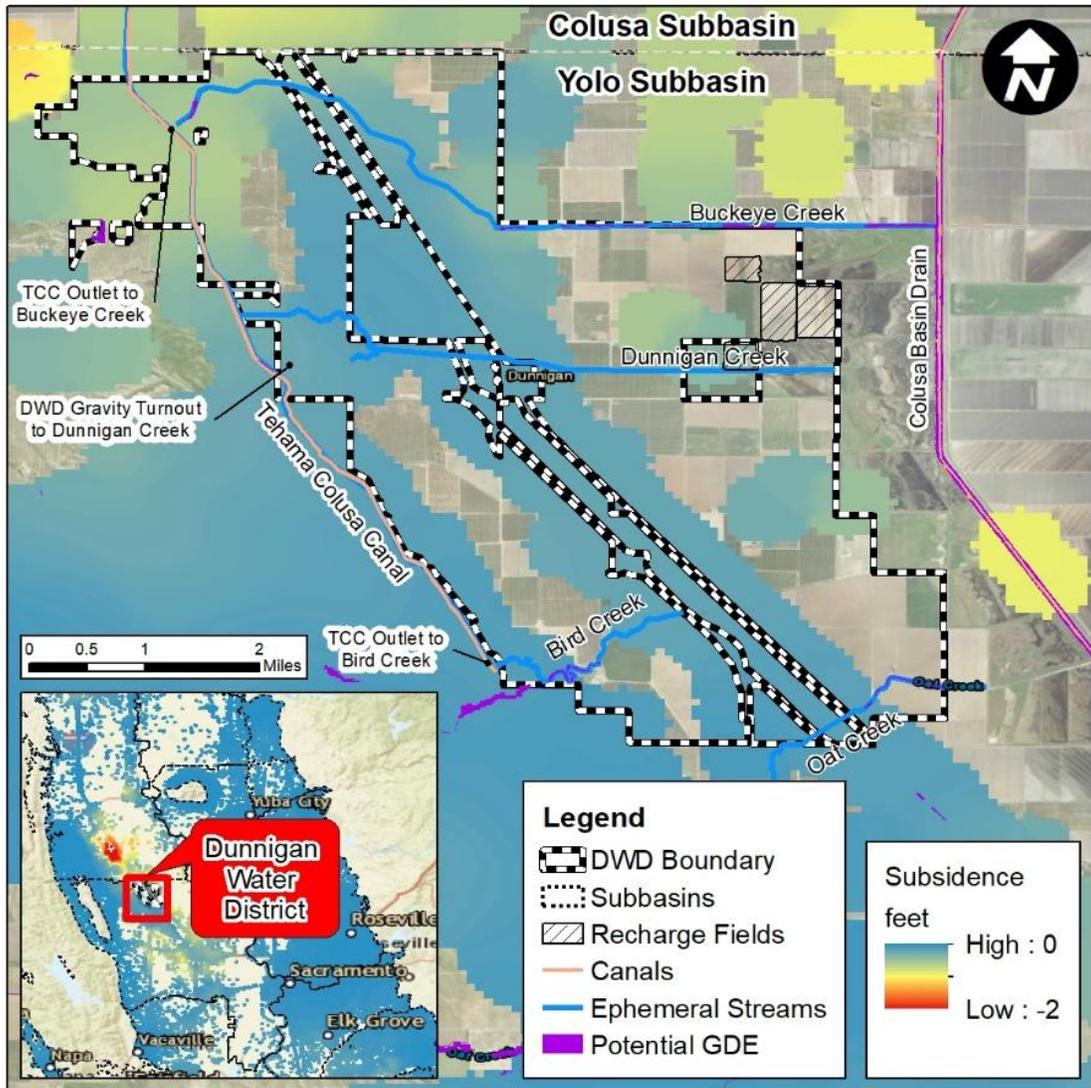


Figure 8. Dunnigan Water District subsidence map.

## 5 Recommendations

TNC's Multi-Benefit Groundwater Recharge Project conducted within Colusa County from 2018 through 2021 listed several lessons learned, improvements for further testing and analysis, and recommendations for implementation at a larger scale (Davids Engineering, 2022). Dunnigan Water District, as one of the first water districts to adopt and implement a multi-benefit recharge program at large-scale, reviewed the recommendations, and provided further input based on preliminary findings and conclusions and with stakeholder input, as described below.

Recommendations for future pilot projects:

- In accordance with Governor Newsom's Executive Orders N-7-22, N-3-23, and N-4-23; there are opportunities to use natural infrastructure (e.g., ephemeral streams, gravel pits, etc.) to conduct multi-benefit groundwater recharge. Projects may improve water supply reliability for disadvantaged communities, provide habitat for migratory waterfowl, enhance groundwater-dependent ecosystems and inter-connected surface waters, and reduce the risk of subsidence damaging nearby infrastructure. Further pilot studies are needed to assess the benefits and feasibility of large-scale implementation. As of March 8, 2023, the District recharged 533 AF into Buckeye Creek in Water Year 2023.
- There is a learning curve to help landowners know how much and when to apply water. Per TNC's recommendations to maximize habitat benefits, water should be initially applied at a high rate and then adjusted to a constant rate until the end of the recharge period to maintain a 4-inch ponding depth. Recharge should occur when migratory shorebirds are resting in the area along the Pacific Flyway. This corresponds to March/April or October/November time periods.
- It should be communicated to landowners that to maximize recharge for a given site, they should maximize the net applied water (inflow minus outflow) as feasible. This includes programs such as RD108's "boards in" program which is intended to capture and infiltrate precipitation runoff from rice grounds.
- The ideal application method is dependent on available surface water supplies; existing infrastructure, including high flow capacity and flow control to fields; and desired objectives (e.g., habitat, recharge, water supply reliability, etc.).

Recommendations for further analysis:

- Incorporate recharge scenarios into hydrologic models to simulate benefits for groundwater levels, groundwater dependent ecosystems, and inter-connected surface waters.
- Expand groundwater monitoring network, as needed, to track groundwater levels and gradients/direction spatial and temporal variability to determine beneficiaries of groundwater recharge.
- Assess the use of ephemeral streams as recharge sites and as an alternative water source by capturing and storing high stormflows.
- Conduct an isotope study to understand the sources, flow paths, and rates of recharge to the groundwater basin.

- Review DWR’s airborne electromagnetic (AEM) surveys, along with other local geologic information, to identify and prioritize recharge sites.
- Evaluate the correlations between SAGBI ratings or other field characteristics and calculated deep percolation.

Recommendations for scaling-up:

- Coordinate with local groundwater sustainability agencies, agricultural and urban water suppliers, landowners, and other stakeholders to promote direct and in-lieu groundwater recharge, maximize benefits, leverage resources, and streamline monitoring and reporting.
- Identify available water sources, associated costs, and funding mechanisms early in the process.
- Groundwater sustainability agencies, county governments, and other local and regional agencies should consider incentivizing groundwater recharge through well permitting and water credit programs.
- GSAs and/or irrigation districts should consider developing or supporting DWR in the development and implementation of a Groundwater Accounting Platform, as described in the DWR article “California Water Agencies Collaborate on Groundwater Digital Platform to Help Address Dry Wells and Water Supply Shortages.”<sup>9</sup> As stated in the article, Yolo County Flood Control and Water Conservation District, along with others, are currently piloting the Groundwater Accounting Platform.
- Identify methods to streamline the water budget process and associated costs. Similar programs in the San Joaquin Valley are crediting landowners a percentage (e.g., 75% or 90%) of the applied water to account for any losses. Water that is not lost through evapotranspiration is recoverable and available to all downstream users (e.g., groundwater pumpers, groundwater dependent ecosystems, and inter-connected surface waters).

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<sup>9</sup> DWR article: <https://water.ca.gov/News/News-Releases/2022/Dec-22/California-Water-Agencies-Collaborate-on-Groundwater-Digital-Platform> (accessed March 31, 2023).

**Attachment A: Buckeye Creek Recharge Project – February 2022 Update**

**Attachment B: Daily Flow Meter Readings**

**Table B-1. Applied Water by Turnout Summary.**

Site	Totalizer Reading		Delivered, AF
	Start	End	
Freddie North	60	89	28.5
Freddie South	767	866	98.9
McAravey	1342	1419	77.4
Road 6	142	237	94.8
Total Delivered:			299.6

**Table B-2. Meter Readings by Turnout.**

Site	Date	Reading Time	Totalizer, AF	Flow, CFS
Freddie North	10/27/2022	4:00 PM	60.489	0.0
Freddie North	10/28/2022	9:45 AM	60.506	0.0
Freddie North	10/29/2022	11:00 AM	65.190	5.6
Freddie North	10/31/2022	7:40 AM	74.800	4.5
Freddie North	11/1/2022	9:30 AM	79.580	4.4
Freddie North	11/2/2022	2:20 PM	84.600	2.8
Freddie North	11/3/2022	2:10 PM	87.027	1.5
Freddie North	11/4/2022	10:20 AM	88.200	1.4
Freddie North	11/5/2022	5:30 PM	88.474	0.0
Freddie North	11/5/2022	2:30 PM	88.790	2.0
Freddie North	11/6/2022		88.972	0.0
Freddie South	10/27/2022	4:00 PM	766.944	0.0
Freddie South	10/28/2022	9:45 AM	773.070	6.2
Freddie South	10/29/2022	11:00 AM	781.060	3.4
Freddie South	10/31/2022	7:40 AM	799.030	7.2
Freddie South	11/1/2022	9:30 AM	813.130	7.1
Freddie South	11/2/2022	2:20 PM	829.300	7.8
Freddie South	11/4/2022	10:20 AM	858.090	9.2
Freddie South	11/5/2022		864.340	6.1
Freddie South	11/5/2022	2:30 PM	865.340	3.1
Freddie South	11/6/2022		865.888	0.0
McAravey	10/27/2022	3:15 PM	1341.760	0.0
McAravey	10/28/2022	9:45 AM	1341.760	0.0
McAravey	10/29/2022	11:00 AM	1350.450	5.9
McAravey	10/31/2022	7:30 AM	1369.280	5.0
McAravey	11/1/2022	9:15 AM	1379.280	5.1
McAravey	11/2/2022	2:00 PM	1390.640	5.5

Site	Date	Reading Time	Totalizer, AF	Flow, CFS
McAravey	11/4/2022	10:10 AM	1409.960	5.6
McAravey	11/5/2022	10:15 AM	1417.550	3.4
McAravey	11/5/2022	2:20 PM	1418.530	3.2
McAravey	11/6/2022		1419.141	0.0
Road 6	10/27/2022		142.143	0.0
Road 6	10/28/2022	9:00 AM	144.920	6.0
Road 6	10/29/2022		153.466	0.0
Road 6	10/29/2022	10:40 AM	153.500	6.0
Road 6	10/31/2022	8:10 AM	177.660	5.9
Road 6	11/1/2022	9:40 AM	186.520	5.9
Road 6	11/2/2022	10:40 AM	198.120	5.9
Road 6	11/3/2022	11:15 AM	209.600	6.2
Road 6	11/3/2022	2:40 PM	211.080	6.0
Road 6	11/4/2022	10:40 AM	221.380	6.9
Road 6	11/5/2022	10:00 AM	233.570	6.9
Road 6	11/5/2022	2:00 PM	235.700	6.9
Road 6	11/6/2022		236.942	0.0

**Attachment C: Stakeholder Data Portal**

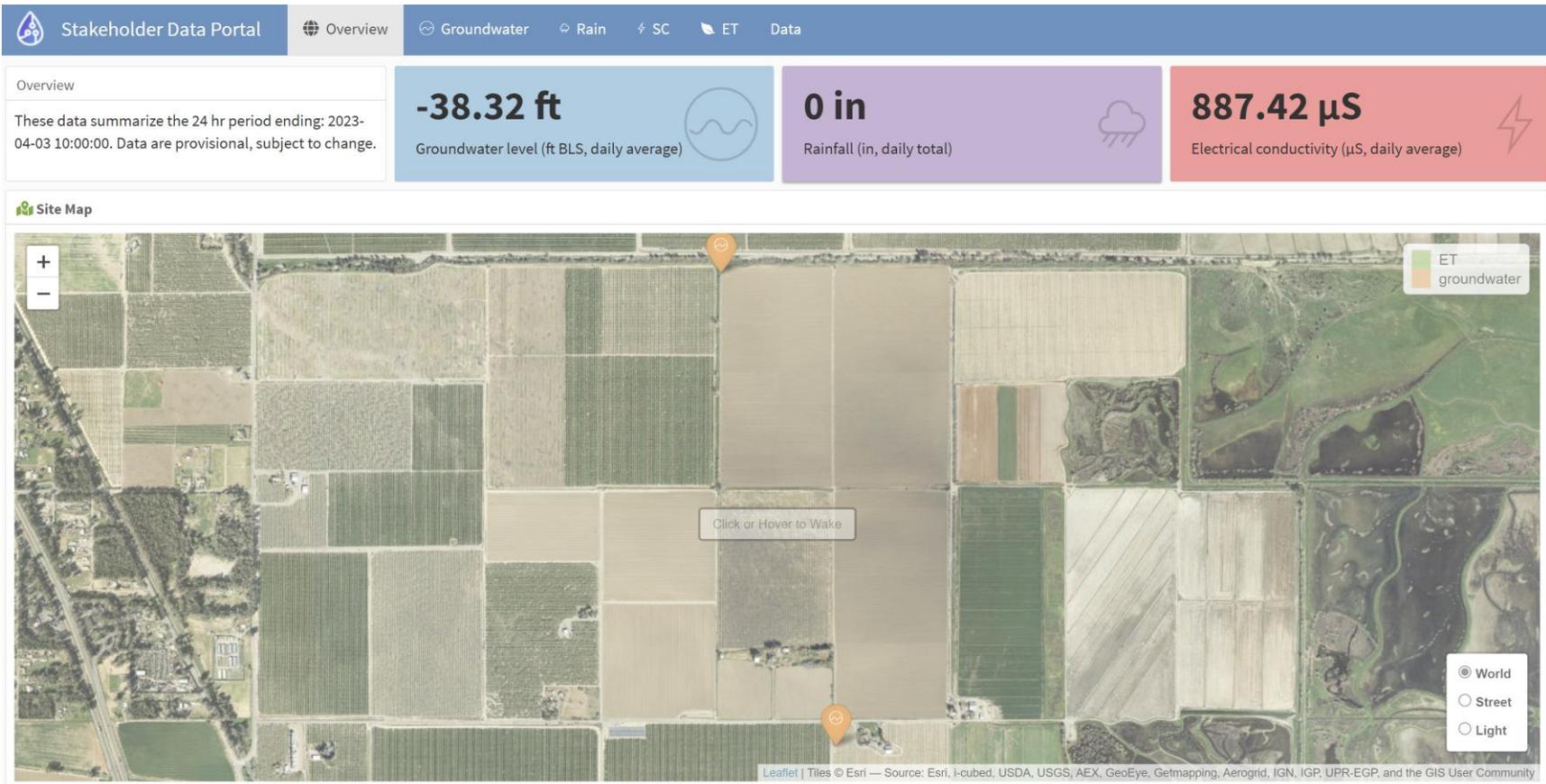
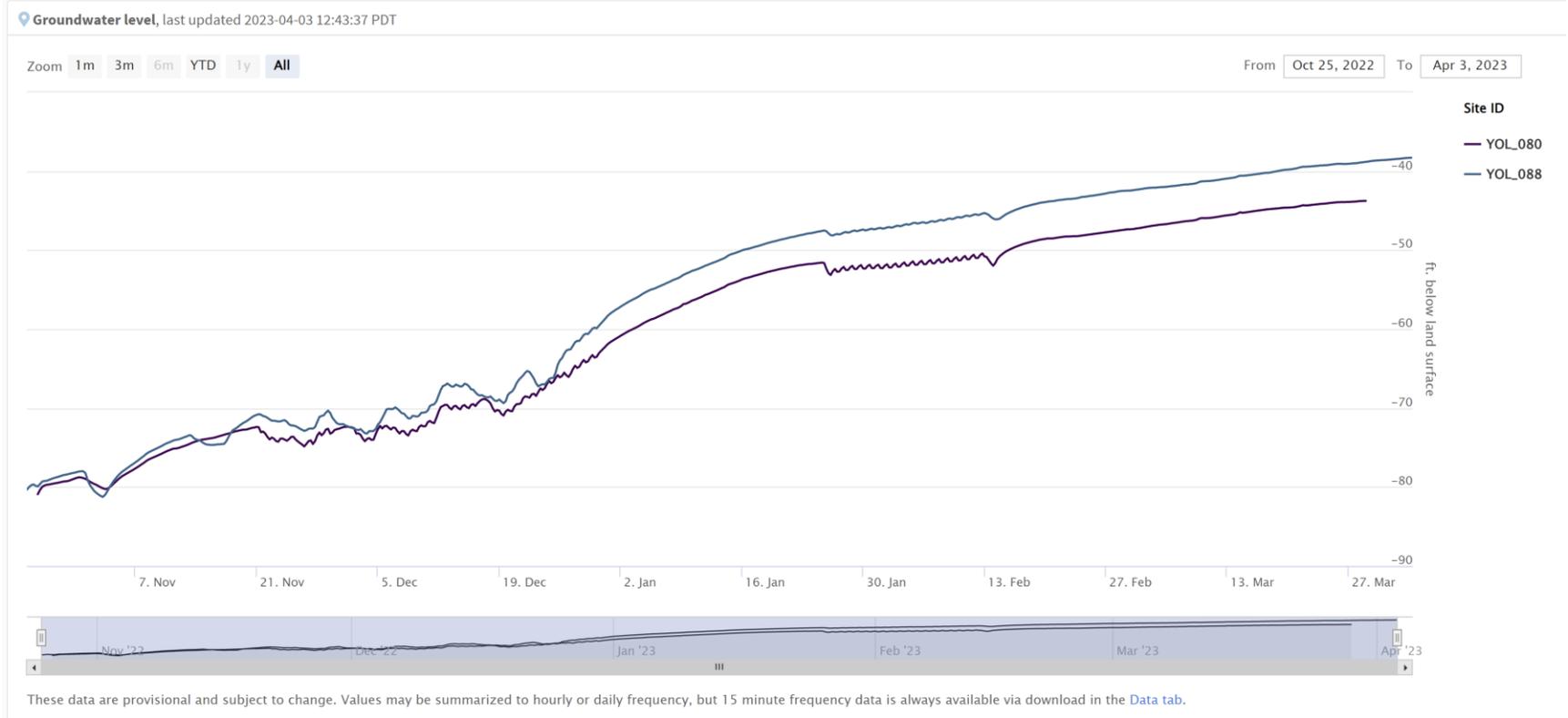
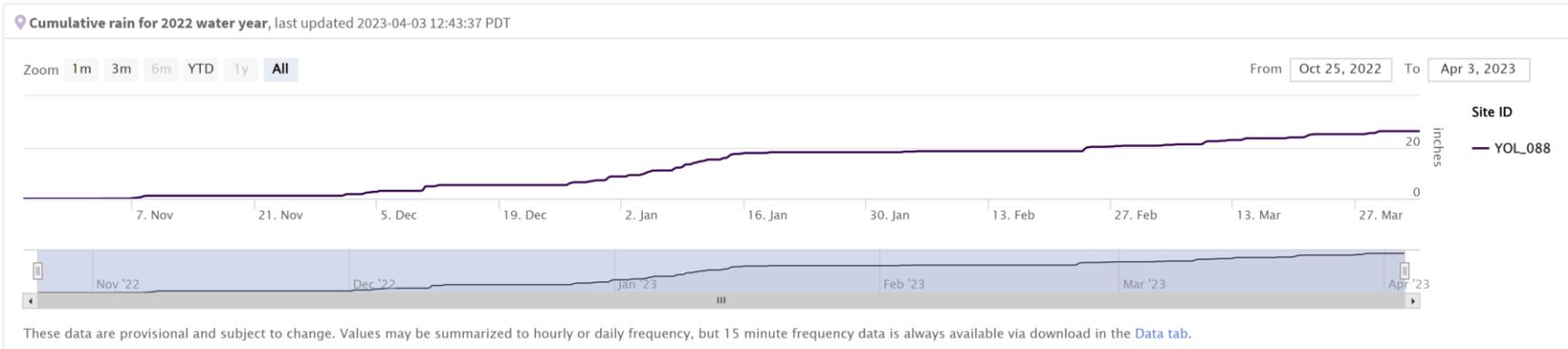
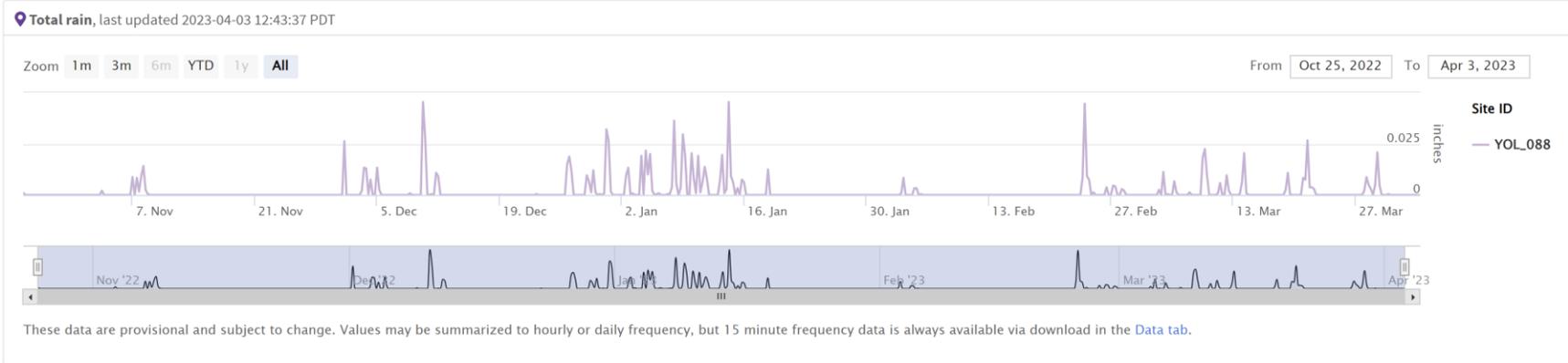


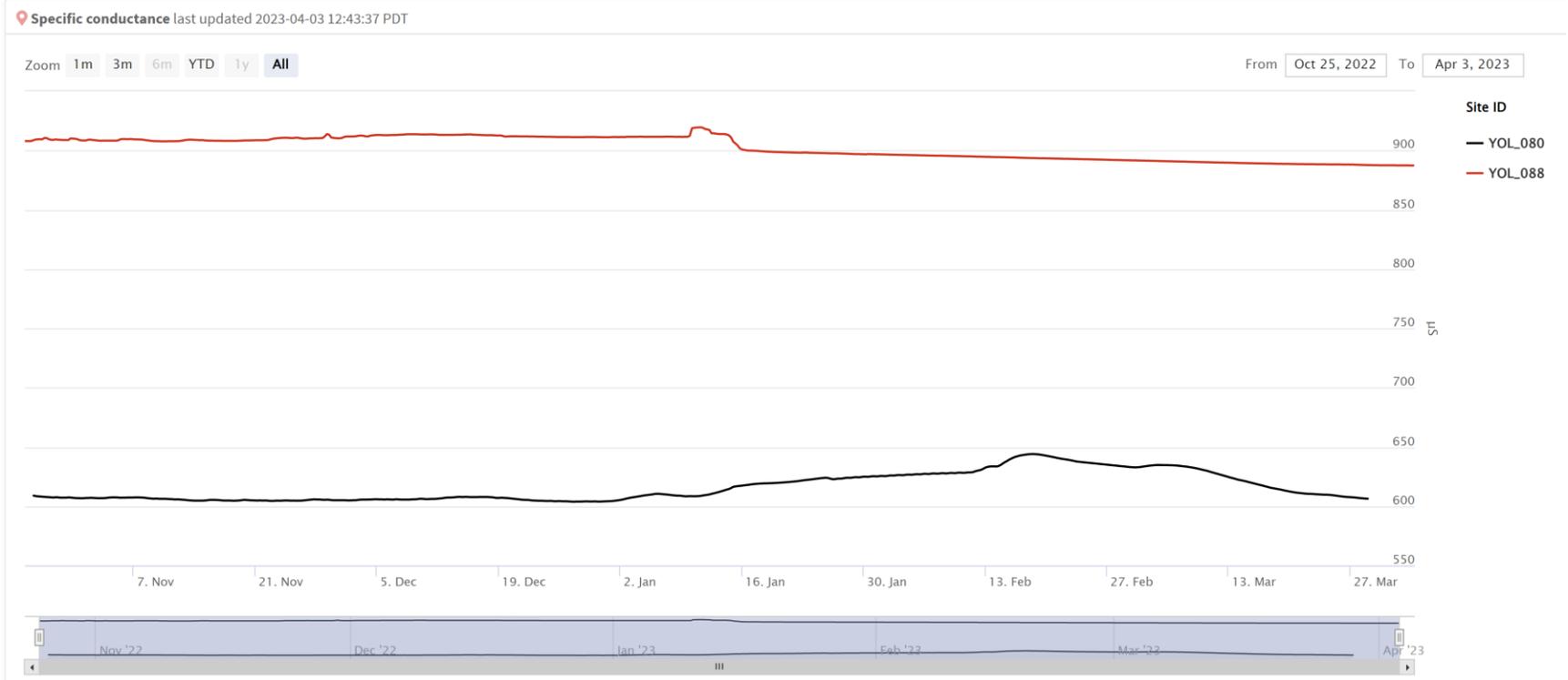
Figure C-1. Stakeholder Data Portal Overview Page.



**Figure C-2. Stakeholder Data Portal Groundwater Level Hydrograph.**



**Figure C-3. Stakeholder Data Portal Groundwater Precipitation Time-Series.**



These data are provisional and subject to change. Values may be summarized to hourly or daily frequency, but 15 minute frequency data is always available via download in the Data tab.

**Figure C-4. Stakeholder Data Portal Specific Conductance.**

**Download data**



All data for stations presented in this dashboard, last updated 2023-04-03 12:43:37 PDT.

**Frequently Asked Questions**

Are these data exact?

Why is my daily data summary on the "Overview" tab not showing data from today?

Where does this data come from?

**Contact**



Larry Walker Associates  
1480 Drew Avenue, Suite 100  
Davis, CA 95618  
Phone: 530.753.6400  
Email: [info@lwa.com](mailto:info@lwa.com)

Figure C-5. Stakeholder Data Portal Data Download Page.

## **Attachment G – Dunnigan Area Recharge Program – Fall 2024 Update**

# TECHNICAL MEMORANDUM



**DATE:** December 20, 2024  
\_\_\_\_\_  
**TO:** Jordon Navarrot, Manager  
\_\_\_\_\_  
**COPY TO:** The Nature Conservancy  
\_\_\_\_\_

**RYAN FULTON**  
1480 Drew Ave., Suite 100  
Davis, CA 95618  
530.753.6400  
530.753.7030 fax  
RyanF@LWA.com

**SUBJECT: Dunnigan Area Recharge Program – Fall 2024 Update**

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## 1 Background and Summary

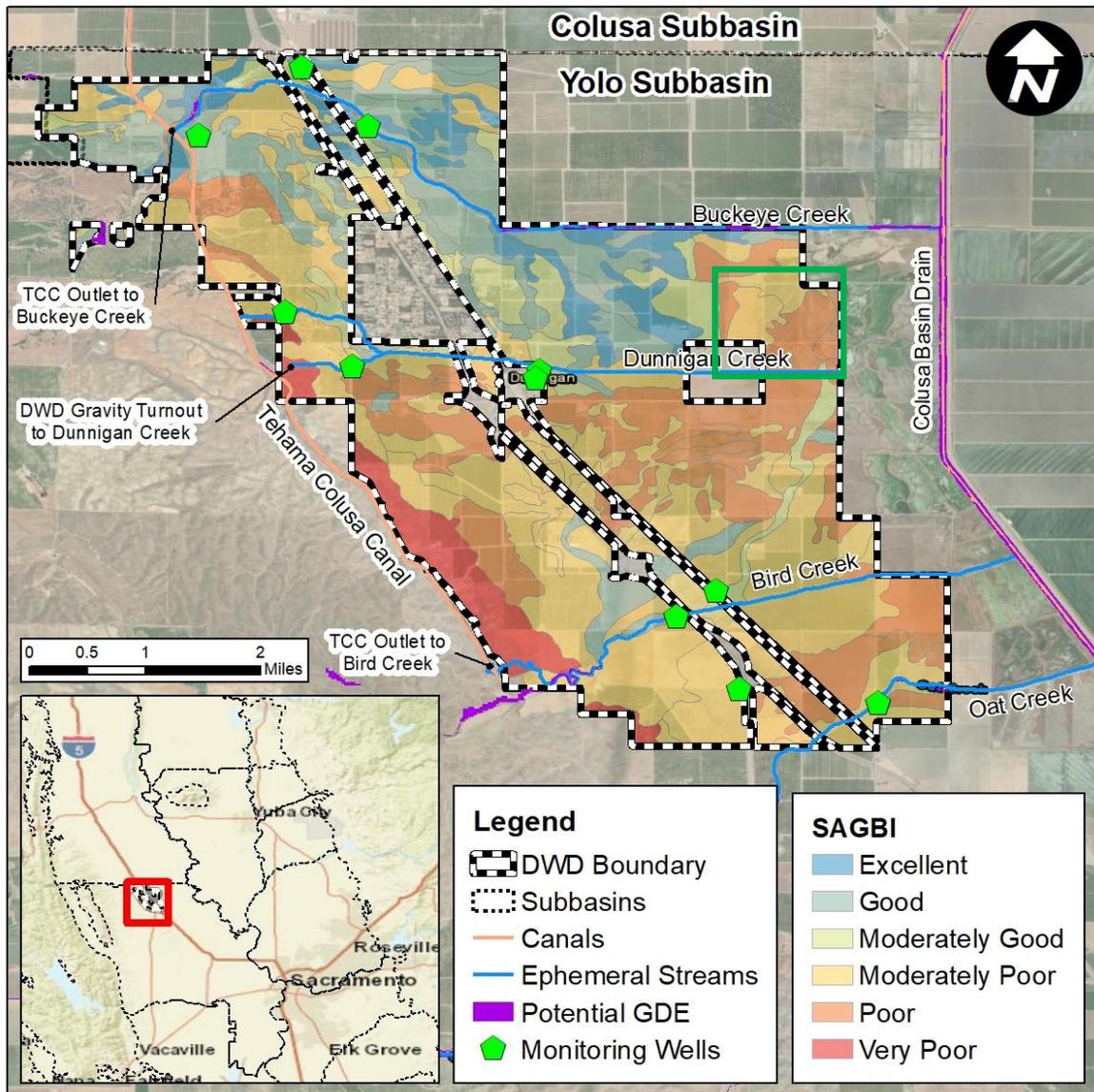
Drought resiliency can be built through groundwater recharge in accordance with California’s prioritization of groundwater recharge projects as codified by Governor Newsom’s Executive Orders N-7-22, N-3-23, and N-4-23. In the Dunnigan area, historically low groundwater levels are threatening the water supply for both agricultural and domestic users and causing land subsidence. The subsidence is damaging nearby infrastructure, including the Tehama-Colusa Canal (TCC) and Interstate 5, both provide critical support for the agricultural industry and residents. Groundwater levels between the Fall of 2010 and Fall 2020 declined by over 30 feet in areas. DWR reports total subsidence between June of 2015 and January of 2023 up to -1.05 feet. Approximately 207 domestic wells are in the area, of which 19 (or 9%) were susceptible to going dry in the recent drought. Domestic and public supply well depths range from approximately 100 feet to over 700 feet. Wells susceptible of going dry generally range from approximately 100 feet deep to 200 feet deep.

The Dunnigan Area Recharge Program (DARP or Program) seeks to immediately address the unprecedented drought conditions impacting the disadvantaged community of Dunnigan. The Program will develop a strategic roadmap to implement groundwater recharge projects at large scale by diverting excess surface water to ephemeral streams and agricultural lands. The Program utilizes high flow from the Sacramento River (e.g., 3F water), excess Central Valley Project (CVP) contract water from Dunnigan Water District (DWD or District), and purchased surface water from senior water right holders as needed.

A pilot project was performed in February 2022 when the TCC was emptied to complete repairs. Approximately 275 AF of water was discharged into Buckeye Creek, which increased

groundwater levels by approximately 5 inches at nearby monitoring wells. Further information on the Buckeye Creek Trickle Recharge Project from February 2022 is available in Attachment A.

The District in collaboration with the Westside Sacramento Integrated Regional Water Management (IRWM) Program, Yolo Subbasin Groundwater Agency, California American Water, and The Nature Conservancy (TNC) are continuing to demonstrate multi-benefit, managed aquifer recharge (MAR). Surface water will be diverted from the TCC into Buckeye, Dunnigan, and Bird Creeks (i.e., ephemeral streams) and on to fallow farmland enrolled in TNC’s multi-benefit recharge program. The Project will improve water supply reliability for the disadvantaged community of Dunnigan; provide habitat for migratory waterfowl; enhance groundwater-dependent ecosystems; and reduce the risk of subsidence. A map of the Program is shown in Figure 1.



**Figure 1. Dunnigan Area Recharge Program map. Fields enrolled in TNC’s multi-benefit recharge program are in the green box.**

In Fall 2022, an initial study for the Program was conducted on four (4) fields in DWD's service area to begin analyzing and quantifying groundwater recharge and shorebird habitat benefits in partnership with TNC (LWA, 2023). The effort built upon the successful implementation of TNC Multi-Benefit Groundwater Recharge Project conducted within Colusa County from 2018 through 2021. Due to the successful attempts to perform groundwater recharge in the past, TNC and District representatives agreed to conduct recharge again in Fall 2024. Information was collected before, during, and after flooding of the fields to understand baseline and post-project conditions. This technical memorandum provides methods, results, and discussion regarding multi-benefit groundwater recharge, data gaps, and recommendations for scaling up the program and monitoring network as the DARP continues and expands.

Recharge occurred starting September 3<sup>rd</sup> through October 9<sup>th</sup>, 2024. Approximately 315 acre-feet, purchased from the District, was applied to approximately 76.3 acres. Ponded depths were maintained by the landowner at four inches per TNC's specification to the extent possible. The landowner adjusted flows, when necessary, to match infiltration and evaporative demand. TNC reported that the saturated soil provided habitat benefits after ponding depths receded.

Deep percolation for each field was calculated using a mass balance approach with all flow paths being measured, estimated, or assumed negligible. Depth to groundwater in adjacent wells were measured pre- and post- flooding to assess benefit to groundwater levels. Three groundwater monitoring sites were previously installed where data is collected, uploaded, and displayed in near real-time on an online Stakeholder Data Portal. A map of the fields is shown in Figure 2 with boundaries, district turnouts, ditches, and outflow sites marked. Recharge occurred on Fields 1, 4, and 5. Recharge was not performed on Fields 2 and 3. The total applied water, precipitation, evapotranspiration, and deep percolation of precipitation and applied water is summarized in Table 1. The total estimated deep percolation of applied water is 257 AF, which results in 81% of the surface water applied being recoverable and recharging the groundwater aquifer. This is consistent with previous recharge results from Fall 2022 which determined 91% of surface water applied to the fields was recoverable and effectively recharging the groundwater aquifer (LWA, 2023). Higher evaporative losses this year caused the recoverable percentage to decrease.

**Table 1. Estimated deep percolation and change in groundwater level.**

Field No.	Field Acres	Ponded Acres	Surface Water Applied, AF	Surface Outflow, AF <sup>2</sup>	Precip., AF <sup>3</sup>	Total ET, AF <sup>4</sup>	Total DP, AF <sup>5</sup>	DP of Precip., AF <sup>6</sup>	DP of Applied Water, AF <sup>7</sup>	DP of AW, AF/ac	DP of AW / Applied Water
1	36.5	31.9	55.4	5.6	0	22.0	27.9	0	27.9	0.9	50%
4	33.2	31.3	190.7	0	0	21.6	169.2	0	169.2	5.4	89%
5	6.6	6.2	69.4	5.0	0	4.3	60.1	0	60.1	9.7	87%
Total:	76.3	69.4	315.6	10.6	0	47.8	257.2	0	257.2	3.7	81%

<sup>1</sup>Ponded acres represent field wetted areas calculated as field acres minus area of outside field perimeter berms / roads.

<sup>2</sup>Surface outflow was estimated based primarily on discussions with the landowner and periodic field visits with additional information available through monitoring water level and outflow board heights.

<sup>3</sup>Precipitation is measured using a station located near the recharge sites. Between September 3<sup>rd</sup> through October 9<sup>th</sup>, the station recorded zero precipitation. Trace amount of precipitation was recorded on October 12<sup>th</sup>, 13<sup>th</sup>, and 16<sup>th</sup> which was assumed negligible.

<sup>4</sup>Total EvapoTranspiration (ET) is the sum of evaporation and transpiration that occurred between September 3<sup>rd</sup> through October 17<sup>th</sup>. Per TNC field observations, Fields 4 and 5 had zero ponding depth by October 17<sup>th</sup>. Field 1 ponded depths were maintained beyond the study period for additional recharge and habitat. For estimating recharge, it was assumed Field 1 would not have been ponded by October 17<sup>th</sup>. ET was estimated by multiplying the reference ET from the Woodland CIMIS Station (#226) by 1.05, the crop coefficient for open water surfaces less than 2 meters deep (Source: FAO56). Reference ET from September 3<sup>rd</sup> through October 17<sup>th</sup> is equal to 7.87 inches.

<sup>5</sup>Total deep percolation (DP) is equal to applied surface water plus precipitation minus total ET and surface outflow. It is assumed the change in rootzone and surface storage is negligible as the water will eventually percolate through the vadose zone with additional precipitation/applied water.

<sup>6</sup>DP of precipitation is assumed equal to the ratio of precipitation to total inflow (surface water plus precipitation) times total deep percolation.

<sup>7</sup>DP of applied water is assumed to be the difference between total DP and DP of precipitation.

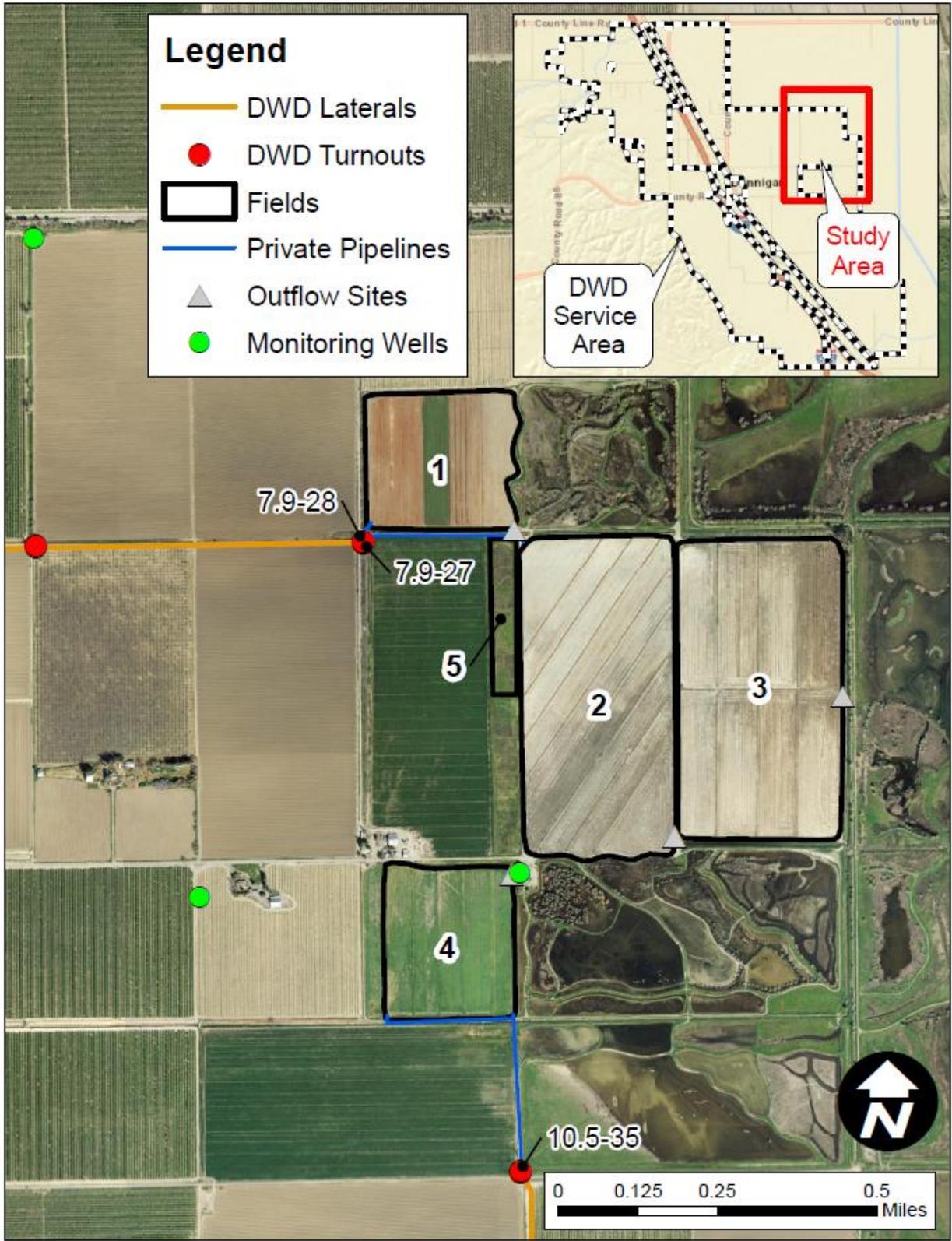


Figure 2. Project field boundaries, district turnouts, ditches, field outflows, and groundwater monitoring sites.

## 2 Water Budget Methods and Results

### 2.1 Water Budget Methods

Total deep percolation was estimated as the ‘closure’ term using a cumulative mass balance approach for the entire study period (September 3<sup>rd</sup> through October 17<sup>th</sup>). The mass balance states the sum of the inflows minus the sum of the outflows equals the change in storage. It is assumed the change in root zone storage is negligible as applied surface water stored in the root zone would eventually deep percolate as rainfall occurs after the recharge event. The fields initial and final ponding depth was 0, so the change in surface storage is negligible.

**Table 2. Mass balance variables and methods used to quantify flowpaths.**

Flowpath	Type	Measured or estimated
Surface Inflow	Inflow	Measured
Precipitation	Inflow	Measured
Change in Root Zone Storage	Negligible	Estimated (assumed 0)
Change in Surface Storage	Negligible	Estimated (assumed 0)
Surface Outflow	Outflow	Measured
Evapotranspiration	Outflow	Estimated
Deep Percolation	Outflow	Estimated (“closure”)

#### 2.1.1 Surface Water Inflow

DWD diverted surface water from the Sacramento River/TCC through their distribution system to the recharge sites. Surface water inflows were measured at three (3) District delivery points. Each delivery is equipped with a propeller meter with an estimated accuracy of +/- 5 to 10 percent. District staff, in coordination with the landowner, provided daily flow and volumetric meter readings available in Attachment A. The landowner tracked how the water was being distributed across the fields and reported to the consultant team if / when changes were made.

#### 2.1.2 Precipitation

Precipitation was measured using a tipping bucket rain gauge datalogger installed near the recharge fields about a quarter mile to the west of Field 4. The site was equipped with telemetry so records can be viewed in near real-time through an online, Stakeholder Data Portal. The station was periodically visited to ensure the site was functioning properly. Precipitation totals from September 3<sup>rd</sup> through October 17<sup>th</sup> were measured at 0.01 inches, which was assumed negligible.

### 2.1.3 Change in Root Zone Storage

The change in root zone storage was assumed negligible due to the amount and timing of precipitation that occurred following the recharge event. Applied surface water either deep percolates through the effective root zone during the recharge event or is stored in the root zone until it evapotranspires or is moved downward by precipitation. Evapotranspiration is assumed to be negligible at the end of the study period as TNC reported a non-ponded surface by October 17<sup>th</sup>.

The primary soil type across the fields is silty clay loam based on the NRCS's Soil Survey Geographic Database (SSURGO).<sup>1</sup> Typical soil parameters are provided in Table 3. Assuming a root zone depth defined as the top five (5) feet and the initial soil moisture content prior to recharge at wilting point, the root zone profile could hold up to 9.21 inches of water. Less than 0.1 inches of precipitation occurred, which is significantly less than the available water holding capacity of the effective, five-foot root zone. This further supports the change in root zone storage can be assumed negligible as stored surface water in the root zone would be replaced by precipitation.

**Table 3. Root zone soil characteristics for silty clay loam, the primary soil type across the fields, according to the NRCS Soil Survey Geographic Database.**

Primary Soil Type	Silty Clay Loam
Water Content at Wilting Point (% by volume)	23%
Water Content at Field Capacity (% by volume)	39%
Water Content at Saturation (% by volume)	47%
Available Water Holding Capacity (% by volume)	16%
Available Water Holding Capacity, inches (assumes 5ft root zone)	9.21

### 2.1.4 Change in Surface Storage

Change in surface storage is negligible for the mass balance. The fields surfaces were dry at the start and end of the study period. Ponding depths were monitored by TNC throughout the project to assess habitat benefits.

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<sup>1</sup> Natural Resources Conservation Service (NRCS), USDA. Web Soil Survey. <https://websoilsurvey.nrcs.usda.gov/>

### 2.1.5 Surface Outflow

Surface outflows from each field were measured and adjusted based on landowner feedback. There was one outflow site per field where excess water flowed over a weir structure. Water levels were continuously monitored every 15-minutes at each location, and flow rate and volume were estimated using the standard weir equation. Approximately 5.6 AF overflowed Field 1 throughout the duration of the study. Field 4 did not have any outflow. Approximately 5 AF left Field 5.

### 2.1.6 Evapotranspiration

EvapoTranspiration (ET) is the sum of evaporation and transpiration that occurred between September 3<sup>rd</sup> through October 17<sup>th</sup>. Per TNC field observations, field surfaces were dry (or non-ponded) by October 17<sup>th</sup>. ET was estimated by multiplying the grass-based, reference ET (ET<sub>o</sub>) from the Woodland CIMIS Station (#226) by 1.05, the crop coefficient for open water surfaces less than 2 meters deep.<sup>2</sup> Reference ET from September 3<sup>rd</sup> through October 17<sup>th</sup> is equal to 7.87 inches. Use of the crop coefficient of 1.05 is a conservative assumption when ponded water on the fields was not observed. Total ET from September 3<sup>rd</sup> through October 17<sup>th</sup> is equal to 8.26 inches.

### 2.1.7 Deep Percolation

Deep percolation was calculated as the closure term of the mass balance using Equation 1, which assumes change in root zone and surface storage is zero. Deep percolation of applied water was estimated by multiplying deep percolation by the ratio of applied water to the total net inflow. Deep percolation of precipitation was estimated as the difference between total deep percolation and deep percolation of applied water.

$$\text{Deep Percolation} = \text{Applied Surface Water} + \text{Precipitation} - \text{Surface Outflow} - \text{ET} \quad (\text{EQ. 1})$$

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<sup>2</sup> Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56 (website: <https://www.fao.org/3/X0490E/x0490e00.htm>)

## 2.2 Water Budget Results

Water budget results for Fields 1, 4, and 5 are presented in Tables 4, 5, and 6; respectively. All volumes are expressed on a per acre basis in units of inches for comparison. Additionally, estimated uncertainties for each flowpath and calculated uncertainty of the closure (i.e., deep percolation) are shown. Uncertainty of the estimated/measured flowpaths and closure are based on professional experience and weighted based on volume. Application depths ranged from approximately 20.9 inches on Field 1 to 134.3 inches on Fields 5. On average the district applied 54.6 inches across all the fields between September 3<sup>rd</sup> through October 9<sup>th</sup>. Due to precipitation volumes being negligible during the recharge period, the calculated deep percolation of applied water is equivalent to total deep percolation. Deep percolation for Fields 1, 4, and 5 are 10.5 inches, 64.9 inches, and 116.4 inches, respectively.

**Table 4. Field 1 water budget summary.**

Field 1	Value	Uncertainty
Inflow (in.)	20.9	10%
Outflow (in.)	2.1	20%
Precipitation (in.)	0.0	5%
Evapotranspiration (in.)	8.26	15%
Change in Surface Storage (in.)	0.0	15%
Change in Root Zone Storage (in.)	0.0	15%
Calculated Deep Percolation (in.)	10.5	23%
Calculated Deep Percolation of Precipitation (in)	0.0	23%
Calculated Deep Percolation of Applied Water (in)	10.5	23%
Calculated Deep Percolation (af)	27.9	23%
Calculated Deep Percolation of Precipitation (af)	0.0	23%
Calculated Deep Percolation of Applied Water (af)	27.9	23%

**Table 5. Field 4 water budget summary.**

<b>Field 4</b>	<b>Value</b>	<b>Uncertainty</b>
Inflow (in.)	73.1	10%
Outflow (in.)	0.0	5%
Precipitation (in.)	0.00	5%
Evapotranspiration (in.)	8.26	15%
Change in Surface Storage (in.)	0.0	15%
Change in Root Zone Storage (in.)	0.0	15%
Calculated Deep Percolation (in.)	64.9	11%
Calculated Deep Percolation of Precipitation (in)	0.0	11%
Calculated Deep Percolation of Applied Water (in)	64.9	11%
Calculated Deep Percolation (af)	169.2	11%
Calculated Deep Percolation of Precipitation (af)	0.0	11%
Calculated Deep Percolation of Applied Water (af)	169.2	11%

**Table 6. Field 5 water budget summary.**

<b>Field 5</b>	<b>Value</b>	<b>Uncertainty</b>
Inflow (in.)	134.3	10%
Outflow (in.)	9.7	20%
Precipitation (in.)	0.0	5%
Evapotranspiration (in.)	8.26	15%
Change in Surface Storage (in.)	0.0	15%
Change in Root Zone Storage (in.)	0.0	15%
Calculated Deep Percolation (in.)	116.4	12%
Calculated Deep Percolation of Precipitation (in)	0.0	12%
Calculated Deep Percolation of Applied Water (in)	116.4	12%
Calculated Deep Percolation (af)	60.1	12%
Calculated Deep Percolation of Precipitation (af)	0.0	12%
Calculated Deep Percolation of Applied Water (af)	60.1	12%

### 3 Groundwater Level Assessment

#### 3.1 Hydrographs

Depth to groundwater is monitored in active and abandoned wells surrounding the recharge sites. Yolo Subbasin Groundwater Agency's monitoring network is being used to monitor groundwater levels to the extent information is available. Additional monitoring sites are being integrated into the District's monitoring network. An online Stakeholder Data Portal was developed to display groundwater level hydrographs in near real-time (Attachment B). Monitoring sites will remain active following recharge events to observe groundwater trends over time. Water levels were recorded at fifteen-minute intervals and averaged to daily intervals as shown in Figures 4 and 5.

The monitoring site shown in Figure 4 ('YOL\_135') is located on the northeast corner of Field 4. Groundwater levels increased by approximately 8 feet during the recharge period. A groundwater mound formed towards the end of the recharge period and then groundwater levels started to subside once recharging stopped. The depth to groundwater ranged from 4 to 13 feet, which suggests there may be a perched aquifer in this vicinity.

Figure 5 shows hydrographs for two monitoring sites. The hydrograph for site 'YOL\_080' (the purple line) is located approximately one mile northwest of the fields. The hydrograph for site 'YOL\_088' (the blue line) is located approximately a quarter mile west of Field 4. The groundwater elevation increase was negligible during the study period due to potentially being impacted by groundwater pumping. Nearby wells were turned on throughout the recharge period, causing groundwater levels to decline and then rebound once turned off.

Hydrographs shown in Figures 4 and 5 are available in near real-time via the Portal. Access to the Portal is available upon request and approval.

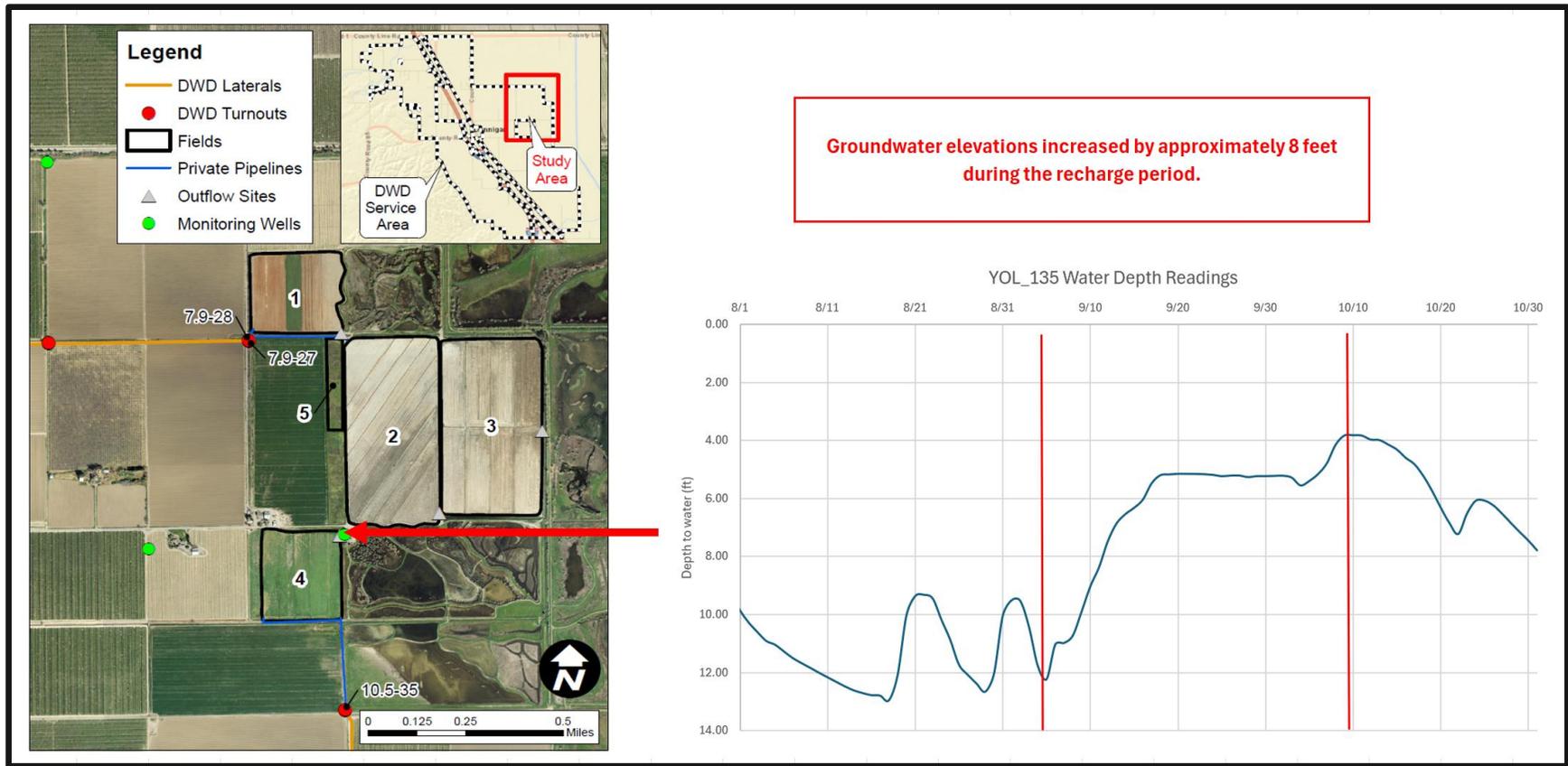


Figure 4. Groundwater monitoring site located on the northeast corner of Field 4 and southwest of Fields 2 and 3.

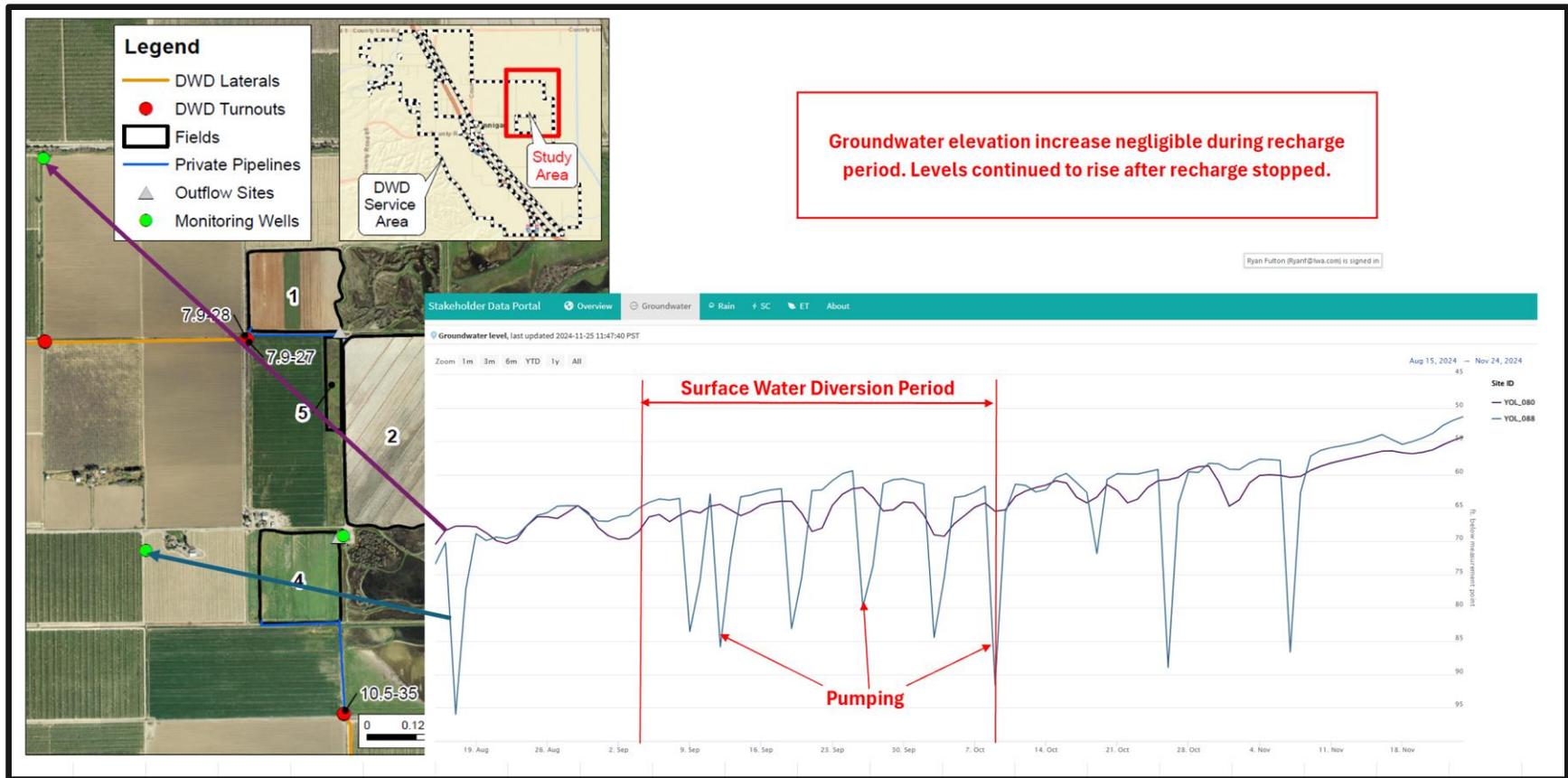


Figure 5. Groundwater monitoring sites west and northwest of recharge sites.

### 3.2 Groundwater Gradients

The direction of the groundwater gradient supports the determination of groundwater recharge beneficiaries. Once groundwater percolates through the unsaturated vadose zone and reaches the groundwater aquifer it will generally move laterally from high elevation to low elevation. Gradients were evaluated using publicly available information through DWR’s SGMA Data Viewer.<sup>3</sup> Based on Fall 2023 groundwater elevations, as shown in Figure 6, a groundwater cone of depression formed from approximately Arbuckle to the north to approximately Zamora on the south. The DARP is located within the middle of the cone of depression with the lowest elevations observed in the Zamora area. Groundwater gradients are subject to change over time and should be periodically reviewed to determine how gradients change depending on extractions and recharge activities. The DARP monitoring network, once fully established, will support further evaluation of localized gradients and benefits.

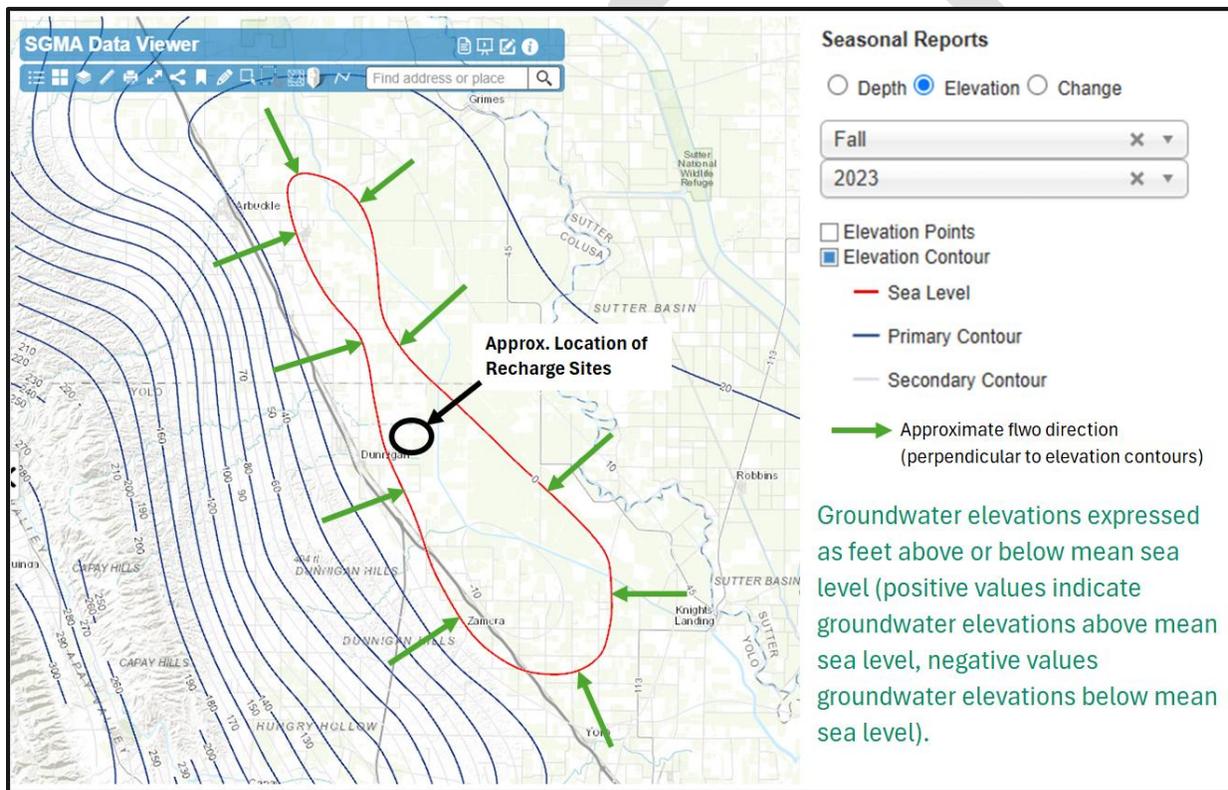


Figure 6. Fall 2023 groundwater elevations contours from DWR’s SGMA Data Viewer.

<sup>3</sup> SGMA Data Viewer: <https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions> (accessed March 10, 2023).

## 4 Recommendations

TNC's Multi-Benefit Groundwater Recharge Project conducted within Colusa County from 2018 through 2024 listed several lessons learned, improvements for further testing and analysis, and recommendations for implementation at a larger scale (Davids Engineering, 2022). Dunnigan Water District, as one of the first water districts to adopt and implement a multi-benefit recharge program at large-scale, reviewed the recommendations, and provided further input based on preliminary findings and conclusions and with stakeholder input, as described below.

Recommendations for future pilot projects:

- In accordance with Governor Newsom's Executive Orders N-7-22, N-3-23, and N-4-23; there are opportunities to use natural infrastructure (e.g., ephemeral streams, gravel pits, etc.) to conduct multi-benefit groundwater recharge. Projects may improve water supply reliability for disadvantaged communities, provide habitat for migratory waterfowl, enhance groundwater-dependent ecosystems and inter-connected surface waters, and reduce the risk of subsidence damaging nearby infrastructure. Further pilot studies are needed to assess the benefits and feasibility of large-scale implementation.
- There is a learning curve to help landowners know how much and when to apply water. Per TNC's recommendations to maximize habitat benefits, water should be initially applied at a high rate and then adjusted to a constant rate until the end of the recharge period to maintain a 4-inch ponding depth. Recharge should occur when migratory shorebirds are resting in the area along the Pacific Flyway. This corresponds to March/April or September/October time periods.
- It should be communicated to landowners that to maximize recharge for a given site, they should maximize the net applied water (inflow minus outflow) as feasible. This includes programs such as RD108's "boards in" program which is intended to capture and infiltrate precipitation runoff from rice grounds.
- The ideal application method is dependent on available surface water supplies; existing infrastructure, including high flow capacity and flow control to fields; and desired objectives (e.g., habitat, recharge, water supply reliability, etc.).

Recommendations for further analysis:

- Incorporate recharge scenarios into hydrologic models to simulate benefits for groundwater levels, groundwater dependent ecosystems, and inter-connected surface waters.
- Expand groundwater monitoring network, as needed, to track groundwater levels and gradients/direction spatial and temporal variability to determine beneficiaries of groundwater recharge.
- Assess the use of ephemeral streams as recharge sites and as an alternative water source by capturing and storing high stormflows.
- Conduct an isotope study to understand the sources, flow paths, and rates of recharge to the groundwater basin.
- Review DWR's airborne electromagnetic (AEM) surveys, along with other local geologic information, to identify and prioritize recharge sites.

- Evaluate the correlations between SAGBI ratings or other field characteristics and calculated deep percolation.

Recommendations for scaling-up:

- Coordinate with local groundwater sustainability agencies, agricultural and urban water suppliers, landowners, and other stakeholders to promote direct and in-lieu groundwater recharge, maximize benefits, leverage resources, and streamline monitoring and reporting.
- Identify available water sources, associated costs, and funding mechanisms early in the process.
- Groundwater sustainability agencies, county governments, and other local and regional agencies should consider incentivizing groundwater recharge through well permitting and water credit programs.
- GSAs and/or irrigation districts should consider developing or supporting DWR in the development and implementation of a Groundwater Accounting Platform, as described in the DWR article “California Water Agencies Collaborate on Groundwater Digital Platform to Help Address Dry Wells and Water Supply Shortages.”<sup>4</sup> As stated in the article, Yolo County Flood Control and Water Conservation District, along with others, are currently piloting the Groundwater Accounting Platform.
- Identify methods to streamline the water budget process and associated costs. Similar programs in the San Joaquin Valley are crediting landowners a percentage (e.g., 75% or 90%) of the applied water to account for any losses. Water that is not lost through evapotranspiration is recoverable and available to all downstream users (e.g., groundwater pumpers, groundwater dependent ecosystems, and inter-connected surface waters).

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<sup>4</sup> DWR article: <https://water.ca.gov/News/News-Releases/2022/Dec-22/California-Water-Agencies-Collaborate-on-Groundwater-Digital-Platform> (accessed March 31, 2023).

**Attachment A: Daily Flow Meter Readings**

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**Table B-1. Applied Water by Turnout Summary.**

Site	Totalizer Reading		Delivered, AF
	Start	End	
7.9-27	1,926.424	1,995.833	69.409
7.9-28	389.436	444.874	55.438
10.5-35	1,377.300	1,568.040	190.740
Total Delivered:			315.587

**Table B-2. Meter Readings by Turnout.**

Site	Date	Reading Time	Totalizer, AF	Flow, CFS
7.9-27	9/3/2024	9:15:00 AM	1,926.424	0.0
7.9-27	9/4/2024	8:15:00 AM	1,932.100	3.4
7.9-27	9/6/2024	10:45:00 AM	1,934.600	0.8
7.9-27	9/10/2024	10:15:00 AM	1,940.060	0.8
7.9-27	9/12/2024	10:30:00 AM	1,943.250	1.0
7.9-27	9/16/2024	10:30:00 AM	1,953.625	1.0
7.9-27	9/18/2024	3:00:00 PM	1,958.540	3.1
7.9-27	9/20/2024	3:00:00 PM	1,960.920	1.0
7.9-27	9/23/2024	11:45:00 AM	1,965.990	1.0
7.9-27	9/25/2024	1:30:00 PM	1,969.530	1.0
7.9-27	9/30/2024	2:20:00 PM	1,979.320	0.9
7.9-27	10/2/2024	3:45:00 PM	1,982.880	1.2
7.9-27	10/4/2024	11:00:00 AM	1,986.400	1.4
7.9-27	10/7/2024	2:00:00 PM	1,993.690	1.9
7.9-27	10/8/2024	11:30:00 AM	1,994.900	1.0
7.9-27	10/9/2024	9:20:00 AM	1,995.833	0.0
7.9-28	9/3/2024	9:15:00 AM	389.436	0.0
7.9-28	9/4/2024	8:15:00 AM	393.580	5.4
7.9-28	9/6/2024	10:45:00 AM	405.360	3.9
7.9-28	9/10/2024	10:15:00 AM	418.200	2.2
7.9-28	9/12/2024	10:30:00 AM	420.165	0.5
7.9-28	9/16/2024	11:30:00 AM	423.493	0.5
7.9-28	9/18/2024	3:00:00 PM	424.883	0.9
7.9-28	9/20/2024	3:00:00 PM	425.881	0.9
7.9-28	9/23/2024	11:30:00 AM	427.812	0.9
7.9-28	9/25/2024	11:30:00 AM	429.150	0.8
7.9-28	9/30/2024	2:20:00 PM	432.300	0.8
7.9-28	10/2/2024	3:45:00 PM	433.600	0.9
7.9-28	10/4/2024	11:00:00 AM	434.730	0.9

Site	Date	Reading Time	Totalizer, AF	Flow, CFS
7.9-28	10/7/2024	2:00:00 PM	442.888	3.5
7.9-28	10/8/2024	11:30:00 AM	444.170	1.3
7.9-28	10/9/2024	9:15:00 AM	444.874	0.0
10.5-35	9/3/2024		1,377.300	0.0
10.5-35	9/4/2024	12:00:00 PM	1,383.860	5.0
10.5-35	9/6/2024	10:15:00 AM	1,403.140	5.1
10.5-35	9/10/2024	11:00:00 AM	1,437.450	1.6
10.5-35	9/12/2024	11:30:00 AM	1,450.430	3.5
10.5-35	9/13/2024	11:30:00 AM	1,454.970	2.4
10.5-35	9/16/2024	11:30:00 AM	1,469.370	3.4
10.5-35	9/18/2024	2:00:00 PM	1,478.520	2.2
10.5-35	9/20/2024	10:30:00 AM	1,486.220	2.2
10.5-35	9/23/2024	8:45:00 AM	1,498.350	2.2
10.5-35	9/25/2024	12:00:00 PM	1,507.150	2.2
10.5-35	9/30/2024	10:35:00 AM	1,527.210	2.1
10.5-35	10/2/2024	3:30:00 PM	1,534.800	0.7
10.5-35	10/3/2024	8:00:00 AM	1,535.620	2.1
10.5-35	10/4/2024	10:30:00 AM	1,541.800	3.0
10.5-35	10/7/2024	11:30:00 AM	1,560.550	3.5
10.5-35	10/8/2024	10:15:00 AM	1,564.110	2.4
10.5-35	10/9/2024	10:30:00 AM	1,568.040	0.0

**Attachment B: Stakeholder Data Portal**

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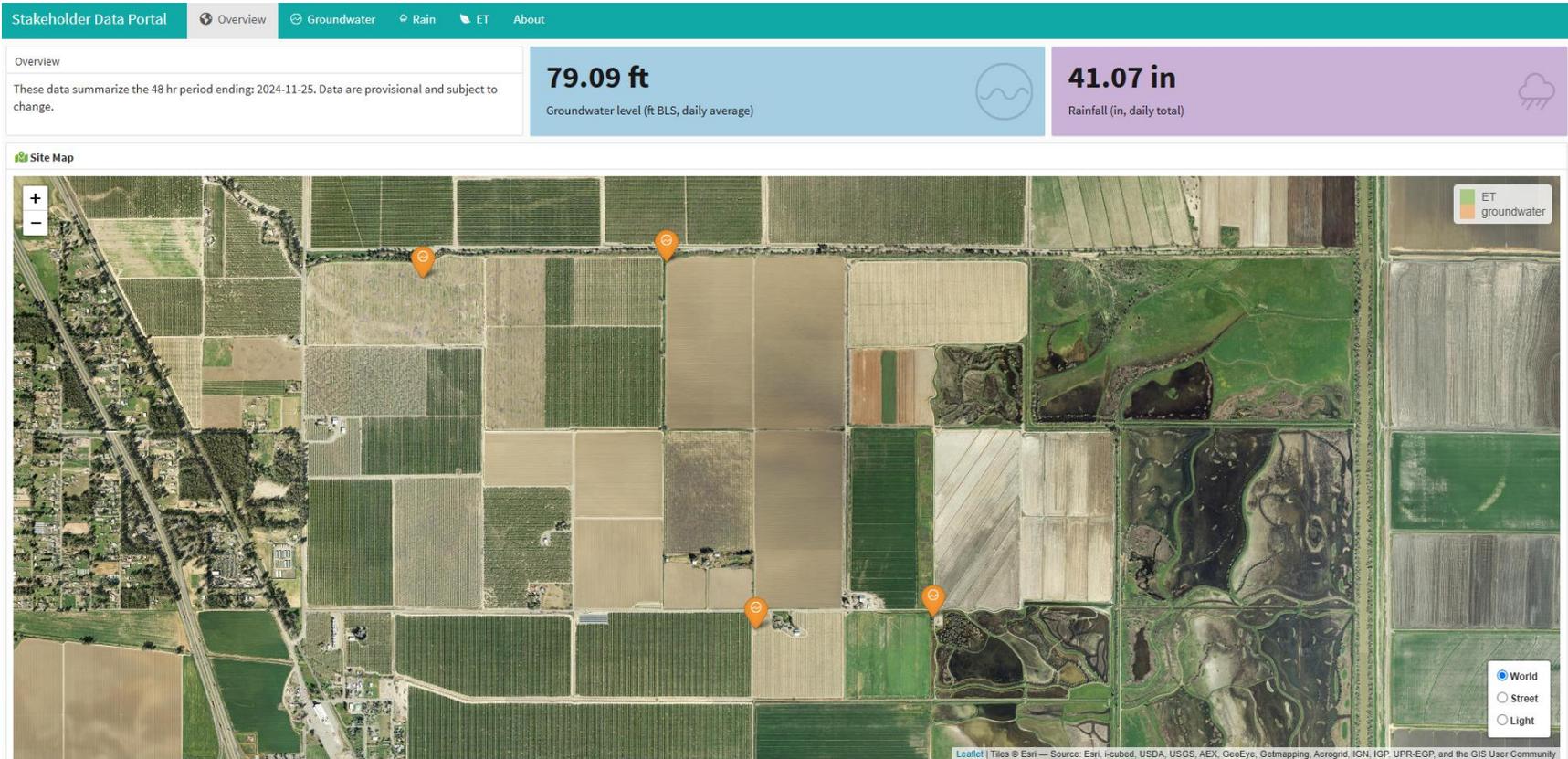
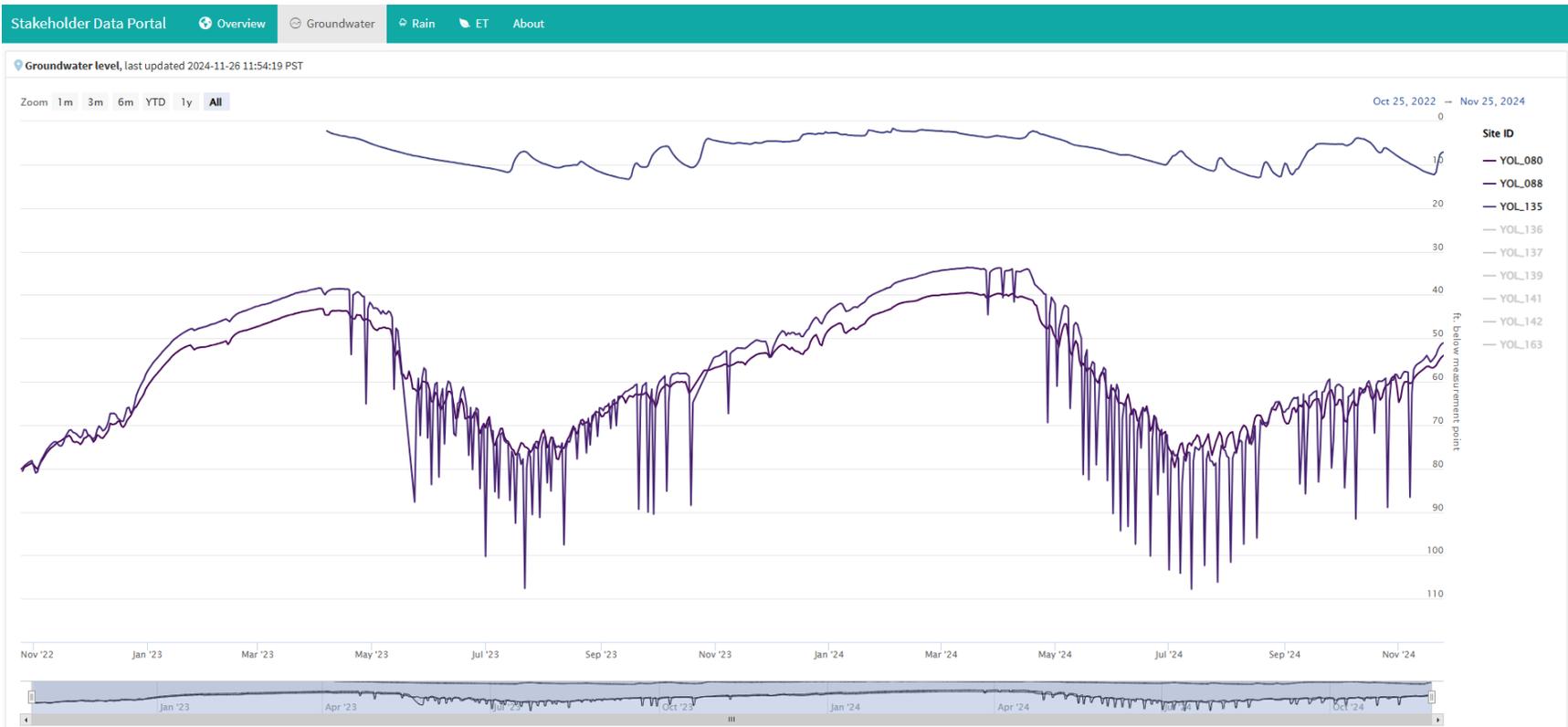


Figure C-1. Stakeholder Data Portal Overview Page.



**Figure C-2. Stakeholder Data Portal Groundwater Level Hydrograph.**

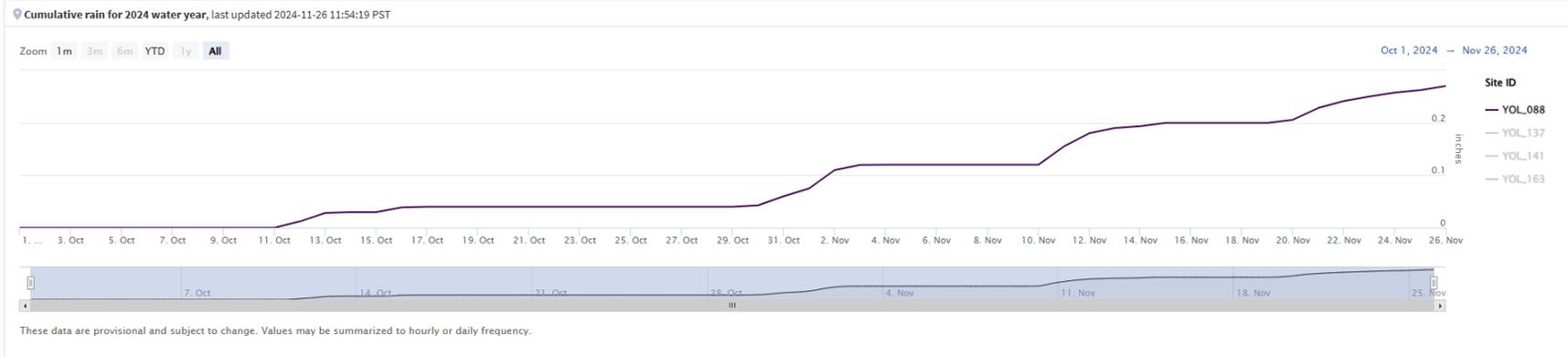
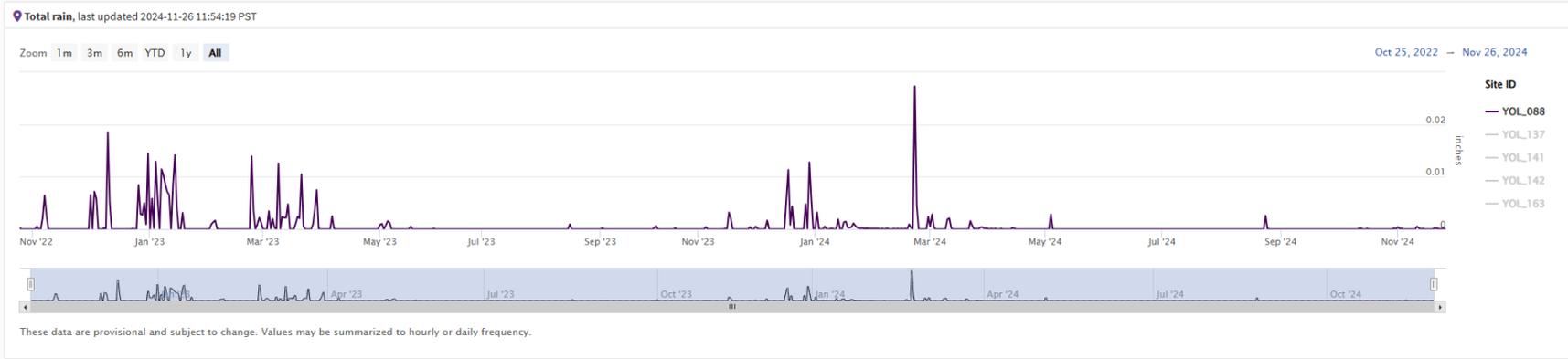


Figure C-3. Stakeholder Data Portal Groundwater Precipitation Time-Series.

## Attachment H – Recharge Photos



**Figure H.1. Multi-benefit recharge.**



**Figure H.2. Ephemeral stream recharge.**



**Figure H.3. Ephemeral stream recharge (photo taken within Buckeye Creek).**



**Figure H.4. Flooded farmland for multi-benefit groundwater recharge. Photo taken November 3, 2022.**



**Figure H.5. Flooded farmland for multi-benefit groundwater recharge including habitat for migratory shorebirds. Photo taken November 3, 2022.**



**Figure H.6. An egret flying over multi-benefit recharge site (Los Angeles Times, March 2023).**



**Figure H.7. Flooded farmland for multi-benefit groundwater recharge serving as feeding area for American avocets (Los Angeles Time, March 2023).**



**Figure H.8. Multi-benefit recharge conducted on furrow irrigated field. Photo taken November 16, 2023. Water accumulated on the southeast corner of the field due to steep field conditions.**



**Figure H.9. Multi-benefit recharge conducted on furrow irrigated field. Photo taken November 16, 2023, of water flowing across the field within the furrows.**