

April 2026

VINA GROUNDWATER SUSTAINABILITY AGENCY

Technical Memorandum: Vina Subbasin Interconnected Surface Water

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Contents

SECTION	PAGE
SECTION 1: PURPOSE _____	1
SECTION 2: BASIN SETTING _____	2
2.1 Streamflow Depletion and Accretion _____	3
2.1.1 Butte Basin Groundwater Model _____	4
2.1.2 ISW Identification using Groundwater Elevation Data _____	8
2.1.3 ISW Identification through Isotope Sampling _____	16
SECTION 3: SUMMARY AND CONCLUSIONS _____	22
SECTION 4: REFERENCES _____	23

APPENDICES

APPENDIX A. DISCHARGES FROM STREAM GAGES WITHIN THE SUBBASIN

APPENDIX B. SHALLOW MONITORING WELL HYDROGRAPHS

APPENDIX C. SURVEYED TRANSECTS ACROSS STREAMS IN THE VINA SUBBASIN

List of Tables

Table 1: Average Monthly Gains to Streamflow from Groundwater, Water Years 2000 to 2024 (cfs) _____	7
Table 2: Average Monthly Gains to Streamflow from Groundwater, Water Years 2000 to 2024 (TAF) _____	8
Table 3: Preliminary Connected and Disconnected Streams within the Vina Subbasin. _____	22

List of Figures

Figure 1: Illustration of Gaining and Losing Interconnected and Disconnected Stream Reaches (Source: USGS) _____	4
Figure 2: Vina Subbasin Stream Segments as defined in the BBGM. _____	5
Figure 3: Vina Subbasin Gaining and Losing Stream Reaches Based on the BBGM v1.3, Water Years 2000 to 2024. _____	6
Figure 4: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2000. _____	11
Figure 5: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2015. _____	12
Figure 6: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2022. _____	13
Figure 7: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2025. _____	14
Figure 8: Use of Interpolated water surface elevations and LiDAR extracted water surface elevations over the period from 2000 through 2025 to determine the percentage of time in which a given reach is gaining. _____	15
Figure 9: Isotope Sampling Locations along Big Chico and Butte Creeks. _____	16
Figure 10: Radon activity for sampled sites along Big Chico Creek in May through October of 2025 _____	18
Figure 11: Radon activity for sampled sites along Butte Creek in May through October of 2025 _____	19
Figure 12: Dual isotope plot for isotopes of the water molecule at sampled sites along Big Chico and Butte Creeks in May through October of 2025. Delta notation is relative to Vienna Standard Mean Ocean Water (VSMOW). Global Meteoric Water Line (GMWL) is defined by the equation $\delta D = (8 * \delta^{18}O) + 10 \text{‰}$. _____	20
Figure 13: Deuterium excess of Big Chico and Butte Creek samples. Samples taken in June through October of 2025. Deuterium excess defined by the equation $\text{Excess} = \delta D - 8 * \delta^{18}O$. _____	21

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SECTION 1: PURPOSE

Under the Sustainable Groundwater Management Act (SGMA), depletion of interconnected surface water (ISW) is one of six key sustainability indicators for groundwater sustainability agencies (GSAs) to address during Groundwater Sustainability Plan (GSP) implementation. SGMA identifies that an undesirable result occurs if, among other reasons, groundwater use occurring in a basin causes depletions of ISW that significantly and unreasonably impact beneficial uses of the surface water (CWC § 10721(x)(6)). The Department of Water Resources (DWR) defines ISW as “surface water that is hydrologically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.” In practice, this refers to places where groundwater and surface water systems directly influence one another, such as streams and rivers that depend on groundwater to sustain their flows. Depletions of ISW under SGMA are only related to impacts caused by groundwater use. Groundwater pumping causes (1) a reduction of inflow to an ISW from groundwater or (2) an increase in outflow from an ISW to groundwater.

The GSA received grant funding through DWR’s Sustainable Groundwater Management Round 2 Grant Program to address data gaps identified in the 2022 GSP and recommended corrective actions from DWR’s Determination Letter. The 2022 GSP, Sections 3.8 and 4.10, identified several data gaps relevant to ISW, including limited shallow groundwater monitoring near streams, limited understanding of vertical connectivity between shallow and deeper aquifer zones, uncertainty in the location and timing of connected stream reaches, limitations in BBGM calibration for the uppermost model layer, and insufficient data to distinguish groundwater pumping effects from broader watershed, climate, and surface water management influences. New information collected since the adoption of the 2022 GSP includes:

- Establishing and enhancing the shallow groundwater level monitoring network representative of water table conditions which directly influence ISW depletions.
- Isotope study identifying losing and gaining stream reaches.
- Updated Butte Basin Groundwater Model (referred to as BBGM v. 1.3) extended through Water Year 2024.
- Topographic surveys to assess stream-aquifer connectivity.

This technical memorandum describes ISW interactions and presents preliminary results refining the identification of where ISW exist in the Vina Subbasin; the location, timing, and quantity of depletions; and remaining data gaps.

SECTION 2: BASIN SETTING

In the 2022 Vina Groundwater Sustainability Plan (GSP), the GSA acknowledged the need to characterize and monitor ISW. However, because shallow groundwater data was limited, the GSP did not establish Sustainable Management Criteria (SMC) specific to ISW depletion. Instead, groundwater level SMC were used as a proxy. In DWR's review of the GSP, they provided the following recommended corrective actions (RCAs) to address in the 2027 Periodic Evaluation and Plan amendments as necessary:

1. Consider utilizing the interconnected surface water guidance when issued by the Department to establish MTs/MOs/etc. (note: as of March 2026, the Department has not yet released guidance)
2. Continue to fill data gaps, collect additional monitoring data, and implement the current strategy to manage depletions of interconnected surface water and define segments of interconnectivity and timing.
3. Prioritize collaborating and coordinating with local, state, and federal regulatory agencies as well as interested parties to better understand the full suite of beneficial uses and users that may be impacted by pumping induced surface water depletion within the GSA's jurisdictional area.
4. Clarify the groundwater level monitoring sites that will be used for the evaluation of depletions of interconnected surface water and provide site-specific information.
5. Review the model inputs/outputs and provide consistent information regarding stream loss and gains throughout the GSP. Clarify whether these values simply represent the overall interaction between the surface water and groundwater system or the quantity of depletion due to groundwater pumping.

The Subbasin is bounded on the north by the Butte-Tehama County line, the west by the Butte-Glenn County line, the south by a combination of the property boundaries owned by the M&T Ranch, the service area boundaries of RD 2106 and Western Canal Water District, and the eastern boundary is the edge of the alluvium as defined by DWR Bulletin 118 Update 2003. The Sacramento River lies along the western boundary from the Butte-Tehama County line on the north to 21 miles south to the confluence of Big Chico Creek with the Sacramento River. The U.S. Bureau of Reclamation controls Sacramento River flows through releases from Shasta Lake. Butte and Big Chico Creeks are perennial streams that flow from the foothills / Sierras through the central portion of the Subbasin. The Butte Creek watershed provides valuable habitat for wild spring run Chinook salmon, listed as threatened under the California and federal Endangered Species Acts. Pine, Rock, Mud, Little Chico, Dry, Little Dry Creeks flow through the central portion of the Subbasin and are ephemeral. These streams only flow after storm events and are dry in the summer months. The potential for depletions from ephemeral streams is limited to times when streams are flowing and groundwater levels are high (i.e. interconnected). Other waterways within the Subbasin, including Lindo Channel and Comanche Creek, are critical for flood protection and irrigation conveyance. Available streamflow data for the Sacramento River, Mud Creek, Big Chico Creek, Butte Creek, Lindo Channel are provided in Appendix A. The GSA is installing up to twelve additional stream gages to better characterize stream flows across the Subbasin. A map active and new stream gages are shown in Appendix A.

The LWA team addressed the DWR's RCAs listed above by assembling a robust monitoring network for ISW, incorporating new data in preparation for the Periodic Evaluation, and utilizing updated stream depletion estimates from the Butte Basin Groundwater Model (BBGM v.1.3). The remainder of this report describes ISW interactions and presents preliminary results identifying where ISW exist, using multiple lines of evidence (model results, groundwater elevations, water quality isotopes); the location, timing, and quantity of depletions; remaining data gaps; and provides recommendations to develop sustainable management criteria for managing depletions of ISW. ISW were identified using the BBGM, measured groundwater elevation data representative of the shallow aquifer, and an isotope study. Results from each method are presented in the following sections.

2.1 Streamflow Depletion and Accretion

The term interconnected surface water describes surface water features that are hydraulically connected by a continuous saturated zone to an underlying aquifer such that changes in elevations of either the aquifer or the surface water features propagate throughout the interconnected system. Within the Vina Subbasin, it is likely that certain surface water features are interconnected with the shallow zone of the groundwater system.

Interconnected surface waters are classified as either gaining or losing with respect to the condition of the surface water feature with gaining reaches gaining through accretion of groundwater and losing reaches losing through depletion to groundwater. It is important to recognize that these interconnections are dynamic and are affected by factors including variations in local geology, hydrology and water use. Thus, at a single point in time, a stream may have both gaining and losing reaches and reaches that are gaining under certain seasonal, or long-term hydrologic and water use conditions, or may become losing under others. Moreover, changes in water use or hydrology may cause interconnected surface water features to decouple from the groundwater system (i.e become disconnected).

Direct measurement of interactions between groundwater systems and surface water features is difficult because of the need for a monitoring system that tracks both stream stage and groundwater elevations at nearby locations. The interaction between groundwater systems and surface water features within the Vina Subbasin is analyzed through use of the integrated groundwater-surface water model, BBGM, which integrates information from groundwater monitoring wells and stream stages to model gradients that control flow between surface water and groundwater. Additionally, gaining and losing streams were classified using observed groundwater levels measured at existing shallow monitoring wells.

The difference between gaining and losing reaches is illustrated in Figure 1. For gaining reaches, the water table adjacent to the stream is above the elevation of water in the stream, resulting in flow of water from the groundwater system to the stream (gains or accretions). For losing reaches, the water table adjacent to the stream is below the elevation of water in the stream, resulting in flow of water from the stream to the groundwater system (losses, depletions, or seepage). In both cases, flows in the stream are directly connected to the groundwater system, with no unsaturated zone present beneath the streambed.

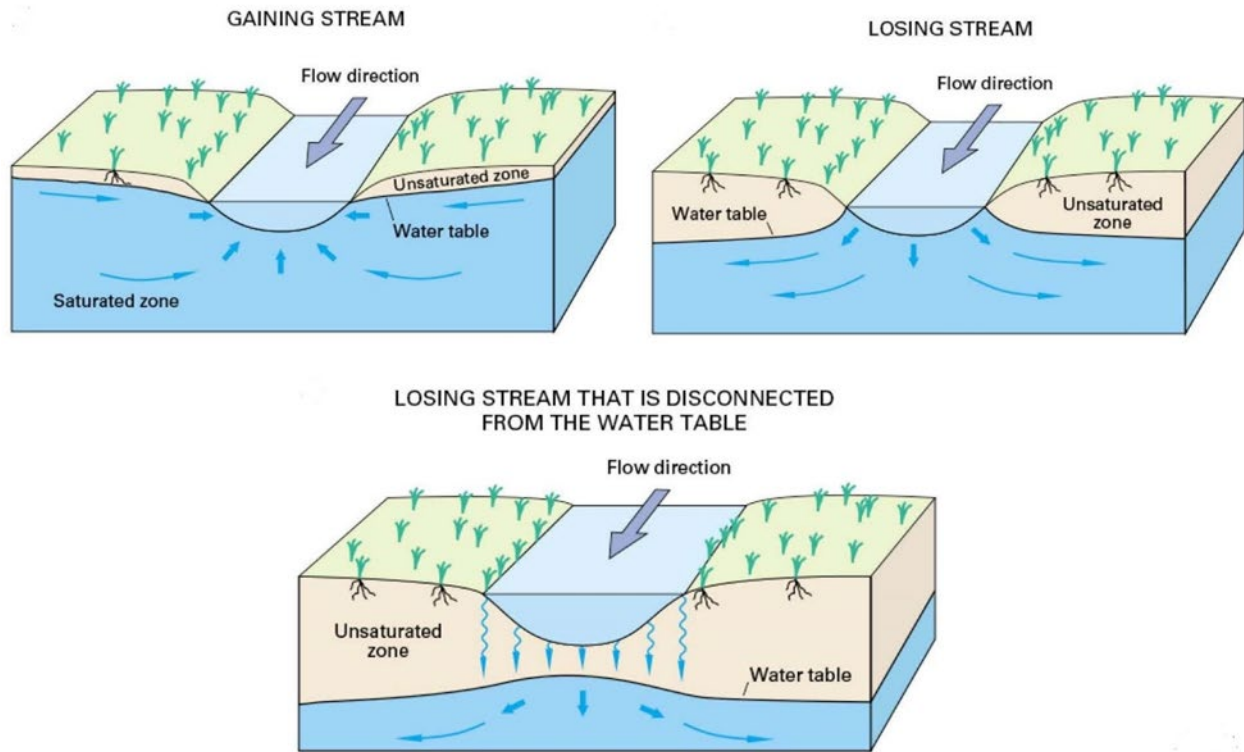


Figure 1: Illustration of Gaining and Losing Interconnected and Disconnected Stream Reaches (Source: USGS)

2.1.1 Butte Basin Groundwater Model

BBGM version 1.3 was utilized to evaluate and classify 32 stream segments, totaling to 115 miles in length, either traversing or bounding the subbasin as being primarily gaining or losing over the historical period from water year 2000 to 2024. A total of seven stream segments traversing or bounding the Subbasin with a total length of approximately 115 miles were defined. Characteristics of the stream segments (cross section, parameters etc.) are described in Butte Basin Groundwater Model Documentation v 1.0 (Butte County, 2021). The segments range in length from 1 to 9 miles with an average length of 3.6 miles and are shown in Figure 2. The results of this analysis are shown in Figure 3. The figure shows the percentage of months for the period from water year 2000 to 2024 with gaining conditions and classifies streams as primarily gaining (gaining conditions more than 80% of the time), primarily losing (losing conditions more than 80% of the time), or mixed. As indicated in Figure 3, stream segments representing the Sacramento River and the lower segments of Pine, Rock, and Mud Creeks are gaining more than 80% of the time while streams in the central and southeastern portions of the subbasin are largely losing.

Based on consideration of the frequency with which stream segments are gaining based on BBGM results and on consideration of the spring depth to groundwater below the estimated streambed depth along each primary stream, it is likely that northwestern stream segments are mostly connected to groundwater, while other stream segments remain disconnected.

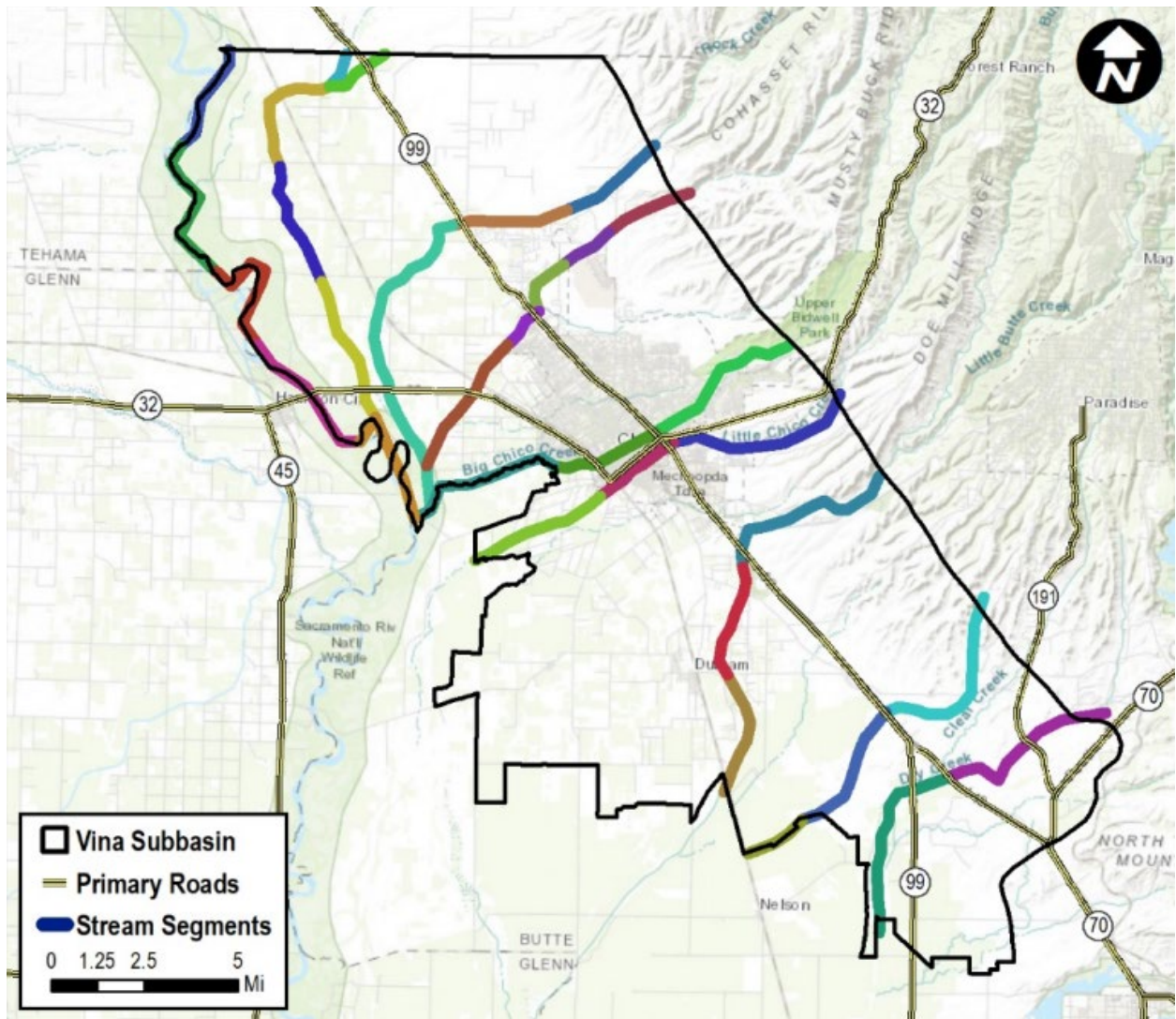


Figure 2: Vina Subbasin Stream Segments as defined in the BBGM.

2.1.1.1 Timing and Amount of Surface Water – Groundwater Interaction

The timing and amount of surface water–groundwater interaction was estimated using the BBGM v.1.3 for the primary streams in the Subbasin shown in Figures 2 and 3. Monthly net gains to streamflow from groundwater were estimated monthly for the historical period from water year 2000 to 2024 and are summarized in Tables 1 and 2. Average monthly gains to streamflow are expressed in cubic feet per second (cfs) and thousand acre-feet, respectively. Negative values denote average losses from streamflow to groundwater (i.e., seepage).

Table 1: Average Monthly Gains to Streamflow from Groundwater, Water Years 2000 to 2024 (cfs)

Stream	Month												Average
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Angel Slough	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Chico Creek	-1	-2	-5	-5	-5	-6	-3	-2	-1	-1	-1	-1	-3
Butte Creek	-8	-11	-18	-19	-19	-22	-20	-17	-12	-9	-7	-7	-14
Dry Creek	-1	-1	-3	-2	-2	-2	-1	0	0	0	0	0	-1
Little Chico Creek	-1	-1	-3	-2	-2	-2	-2	-1	-1	-1	-1	-1	-2
Little Dry Creek	-3	-4	-7	-7	-7	-7	-5	-4	-3	-3	-3	-3	-5
Mud Creek	2	2	1	3	3	5	5	5	3	2	2	2	3
Pine Creek	2	3	3	9	11	16	16	12	7	4	3	2	7
Rock Creek	-1	-1	-1	1	1	3	3	2	1	0	0	0	1
Sac. River	128	132	125	164	136	182	175	166	137	125	124	118	143
Singer Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	116	116	93	141	117	167	169	161	131	118	116	110	130

Table 2: Average Monthly Gains to Streamflow from Groundwater, Water Years 2000 to 2024 (TAF)

Stream	Month												Annual Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Angel Slough	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Big Chico Creek	-0.1	-0.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-2.0
Butte Creek	-0.5	-0.6	-1.1	-1.1	-1.2	-1.4	-1.2	-1.0	-0.7	-0.5	-0.4	-0.4	-10.1
Dry Creek	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.8
Little Chico Creek	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-1.2
Little Dry Creek	-0.2	-0.2	-0.4	-0.4	-0.4	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-3.4
Mud Creek	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.1	0.1	0.1	2.1
Pine Creek	0.1	0.2	0.2	0.5	0.7	0.9	0.9	0.8	0.4	0.3	0.2	0.1	5.4
Rock Creek	0.0	0.0	-0.1	0.0	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.5
Sac. River	7.7	8.0	7.6	9.9	8.2	11.0	10.6	10.0	8.3	7.6	7.5	7.1	103.4
Singer Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Total	7.0	7.0	5.6	8.5	7.0	10.1	10.2	9.7	7.9	7.1	7.0	6.7	94.0

On average, streams traversing or bounding the subbasin are currently estimated to gain approximately 130 cfs on average, or approximately 94 TAF annually. Average monthly gains from groundwater are greatest for the Sacramento River, at approximately 143 cfs. Gains are least between June and December (~127 CFS), due to relatively low groundwater elevations resulting from summer pumping. Gains tend to be greatest between late winter and spring (~165 CFS between January to May), due to higher groundwater elevations relative to river stage and reduced groundwater pumping. It is estimated by difference that the Sacramento River gains approximately 38 CFS (or 16 TAF per year) less between June through December on average due to pumping within Vina and adjacent subbasins. This represents the groundwater that would have entered the stream if groundwater pumping in the summer (primarily for irrigation) did not occur. This additional depletion is less than 1% of the total flow of approximately 7,500,000 AFY on the Sacramento River. Based on the relatively small volume of additional depletions, the relatively low level of depletions as a percentage of the total streamflow, and based on the managed nature of the Sacramento River, the risk of additional depletions from the Sacramento River are not currently considered to have the potential to have significant and unreasonable impacts on beneficial uses of the river.

2.1.2 ISW Identification using Groundwater Elevation Data

To identify the location of ISW reaches within the basin and ground truth BBGM modeled results we used seasonally interpolated shallow groundwater elevations, created from monitoring well data, in conjunction with LiDAR extracted surface water elevations. There are 28 existing shallow groundwater monitoring

wells within the Subbasin. A map of well locations and hydrographs are provided in Appendix B. Additional shallow monitoring wells were used from Corning (two wells) and Butte (twenty-six wells) Subbasins to improve the interpolation across the basin boundaries. Groundwater elevations were interpolated between monitoring wells to develop spatial datasets across the entire Subbasin. Groundwater elevation rasters were developed for the spring and fall from 2000 through 2025. LiDAR, or Light Detection and Ranging, is a technology that allows for precise measuring of ground surface elevations by using laser light pulses from aircraft. Longer pulse return times indicate distances farther from the aircraft, and thus lower elevations. Due to the wavelength of light used for LiDAR surveys in the Vina Subbasin, water penetration was limited and it is assumed that the returned elevations of surface water bodies reflect their stage rather than their bottom elevations. To account for this uncertainty as well as uncertainty related to capillary effects below losing streams, a conservative threshold of 20 feet was used to determine connectivity (DWR, 2024). Whether inaccuracies in LiDAR measurements would change connectivity determinations is then done by comparing results generated by manual survey measurement at select locations on Pine Creek, Butte Creek, Mud Creek, Dry Creek, and Little Chico Creek. Manual survey results are provided in appendix C. Streams, with the exception of the Sacramento River, were classified as either likely disconnected or connected based on the following criteria:

1. Likely Disconnected: Interpolated groundwater levels are greater than 20 feet below the extracted surface water elevation
2. Likely Connected: Interpolated groundwater levels are less than 20 feet below the extracted surface water elevation

A threshold of 10 feet, instead of 20 feet, was used for the Sacramento River to be conservative due to uncertainties with the LiDAR data. We then use this classification in a similar way to the BBGM model results, and define three categories of Gaining, Mixed, and Losing based on the percentage of time connected and disconnected:

1. Gaining: Reach is likely gaining greater than 80% of the time
2. Mixed: Reach is likely gaining between 80 and 20% of the time
3. Losing: Reach is likely losing greater than 80% of the time

Results indicate that streams in the northwest of the subbasin have groundwater elevations within 20 feet of extracted surface water elevations, while most of the other stream reaches do not. For visualization of this result - years 2000, 2015, and 2025 were selected as being reflective of the start of the modeled period (2000), two drought years (2015 and 2022), and current conditions (2025) as shown on Figures 4 through 7, respectively. Of these, the modeled low points in groundwater storage (i.e., 2015 and 2022) correlate to the smallest extent of interconnected reaches. By 2025, the extent of interconnected reaches rebounds following several above normal and wet years. It should be noted that there are a limited number of wells available in the southeast with sufficient data to be used in the interpolation. As a result, there may be inaccuracies in this region on Little Dry Creek, Dry Creek, Clear Creek, and Cottonwood Creek. However, this method produces results that align with isotope tracers explained further in the next section.

Expanding the LiDAR analysis to all spring and fall measurements between 2000 and 2025 and applying the BBGM categories as detailed in the methods section, the Sacramento River is identified as gaining, with the lower reaches of Pine Creek, Rock Creek, and Mud Creek considered mixed (Figure 8). The upper reaches of these mixed streams are considered losing along with nearly all other stream reaches. Furthermore, surveyed results indicate that while LiDAR elevations can be up to 5 feet higher at channel bottom, indicating erosive action since LiDAR acquisition, classification into connected and disconnected categories would remain unchanged due to both our use of wide bin intervals and groundwater elevations that remain far below streambeds (Appendix C).

Overall, the categorization of interconnected surface waters and their status as gaining or losing by use of both LiDAR extracted surface water elevations and interpolated groundwater elevations match the general spatial pattern of the BBGM v1.3 results. Due to this, despite Lindo Channel, Sycamore Creek, Comanche Creek, Hamlin Slough, and Cottonwood Creek not being simulated in BBGM, estimates on

these reaches are reasonable. In general, we conclude that aside from the Sacramento River, the likelihood of streams gaining within the Subbasin increases as they traverse westward towards the Sacramento River, with reaches towards the outer margins often disconnected and losing.

Vina Subbasin ISW Identification

Butte County, CA

Spring of 2000

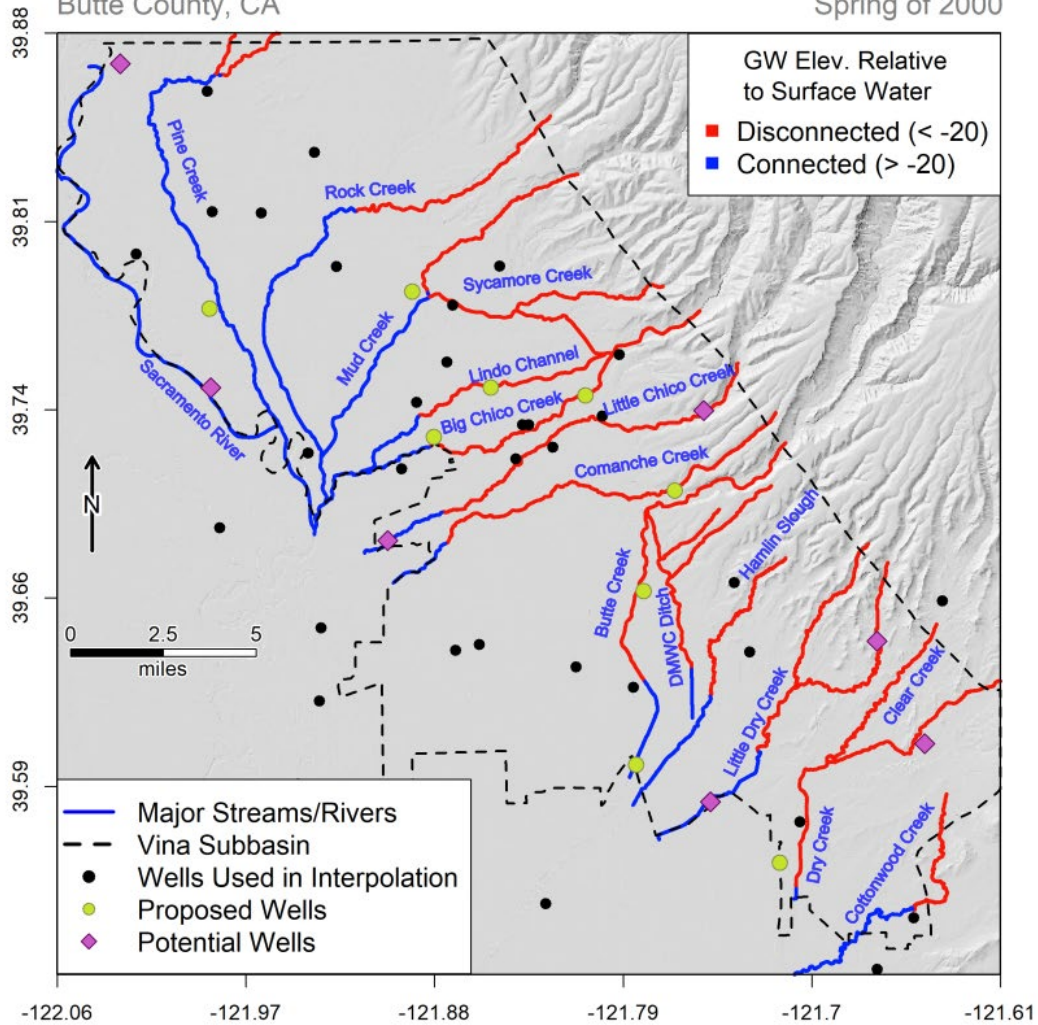


Figure 4: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2000.

Vina Subbasin ISW Identification

Butte County, CA

Spring of 2015

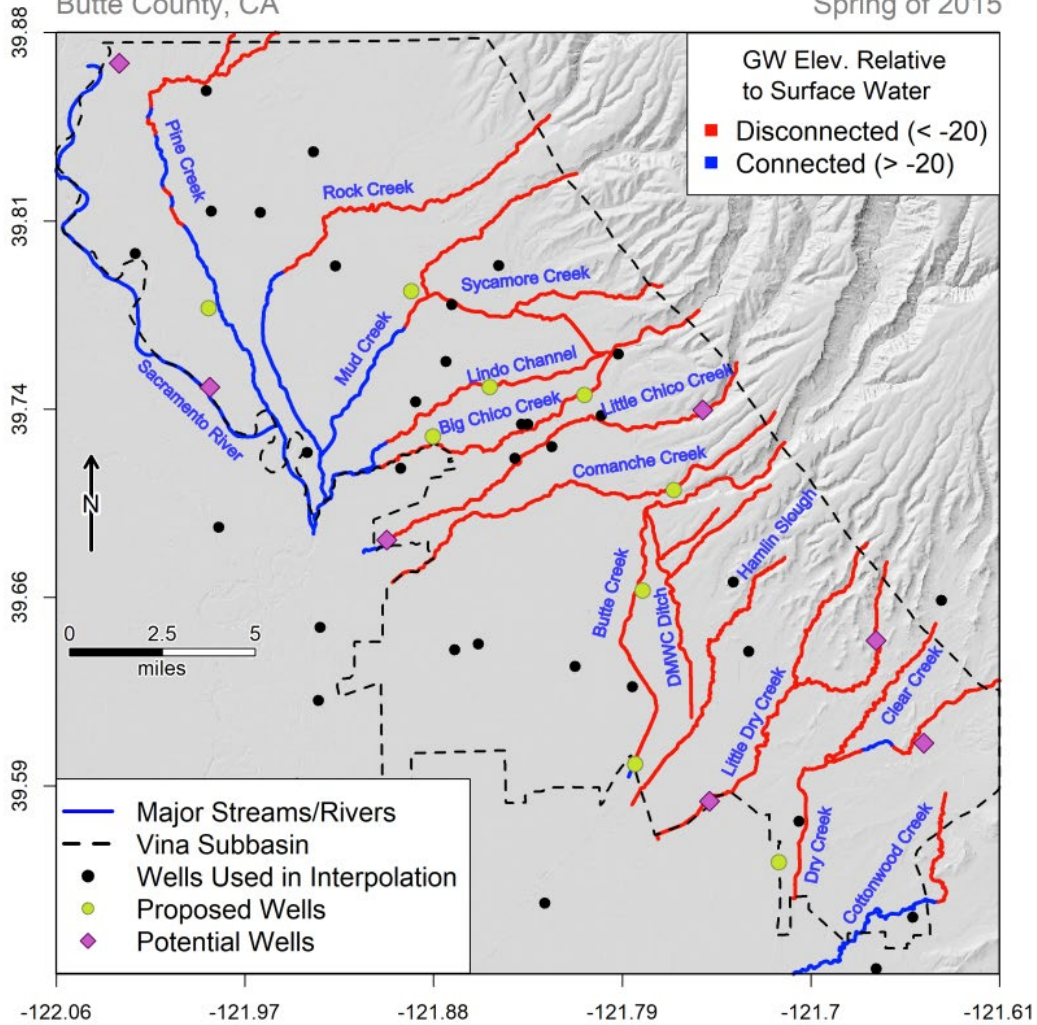


Figure 5: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2015.

Vina Subbasin ISW Identification

Butte County, CA

Spring of 2022

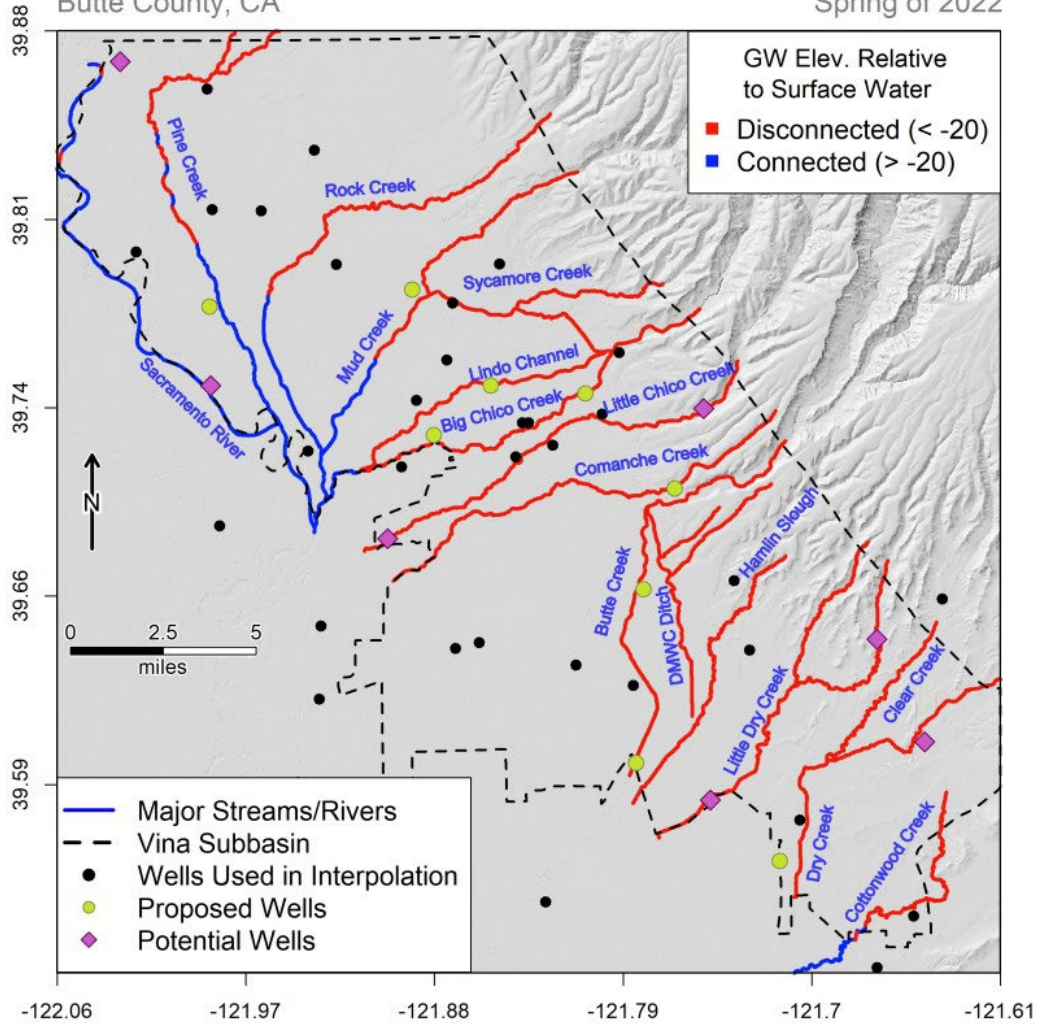


Figure 6: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2022.

Vina Subbasin ISW Identification

Butte County, CA

Spring of 2025

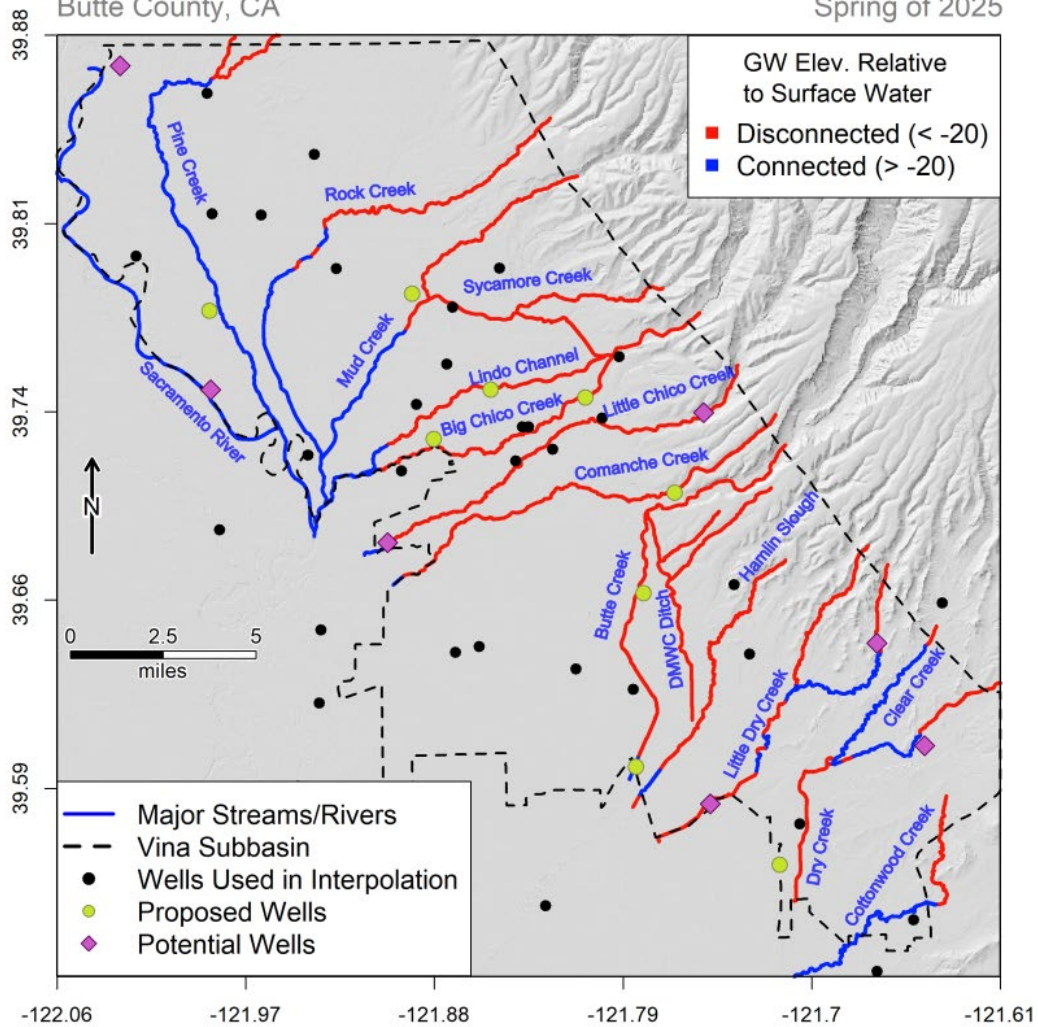


Figure 7: Comparison between shallow interpolated water surface elevations and LiDAR extracted streambed elevations in the spring of 2025.

Gaining and Losing Reaches Within Vina Subbasin

Butte County, CA

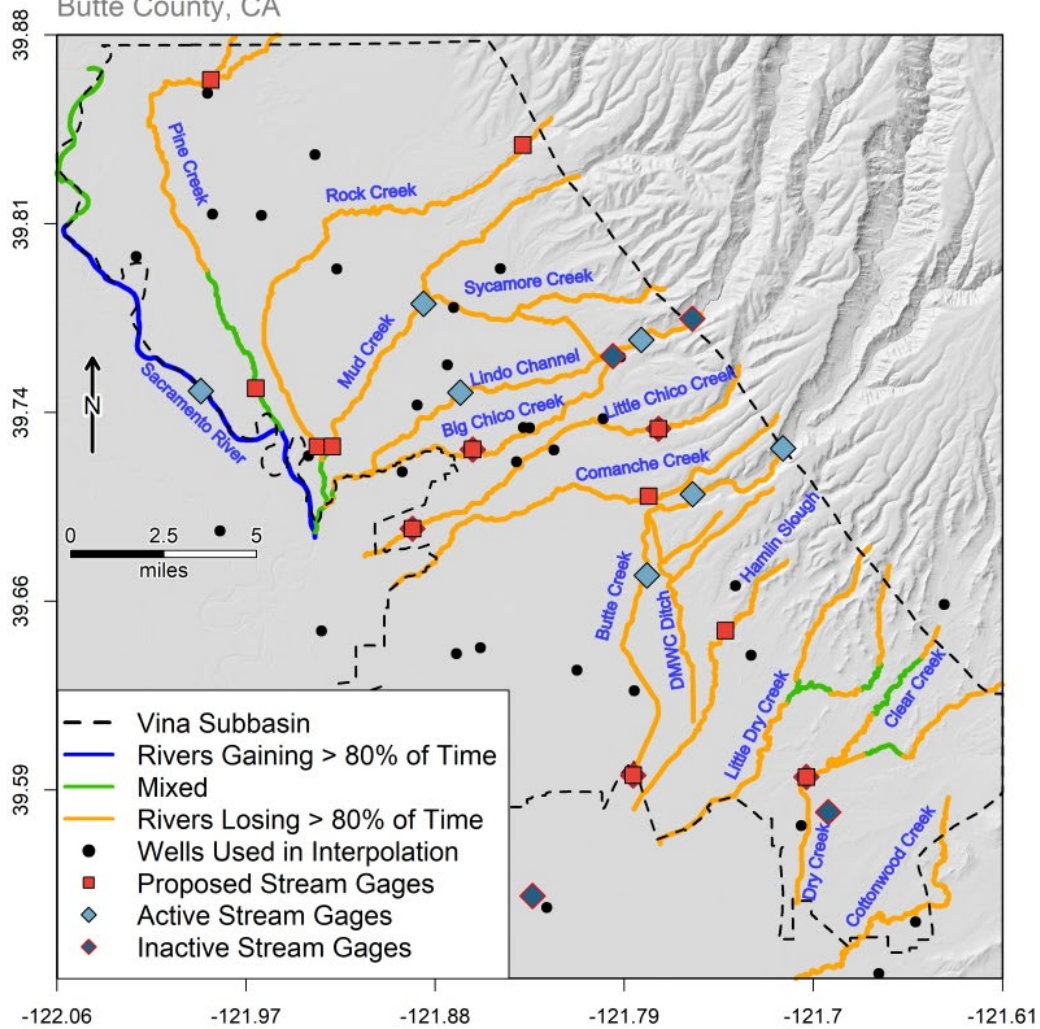


Figure 8: Use of Interpolated water surface elevations and LiDAR extracted water surface elevations over the period from 2000 through 2025 to determine the percentage of time in which a given reach is gaining.

2.1.3 ISW Identification through Isotope Sampling

To understand ISW interactions on a finer timescale than seasonal groundwater interpolations can provide, radon-222 and stable isotopes of the water molecule along Big Chico and Butte Creeks were sampled monthly June through October of 2025. Samples were taken from six locations along Big Chico Creek and four locations along Butte Creek as shown on Figure 9.

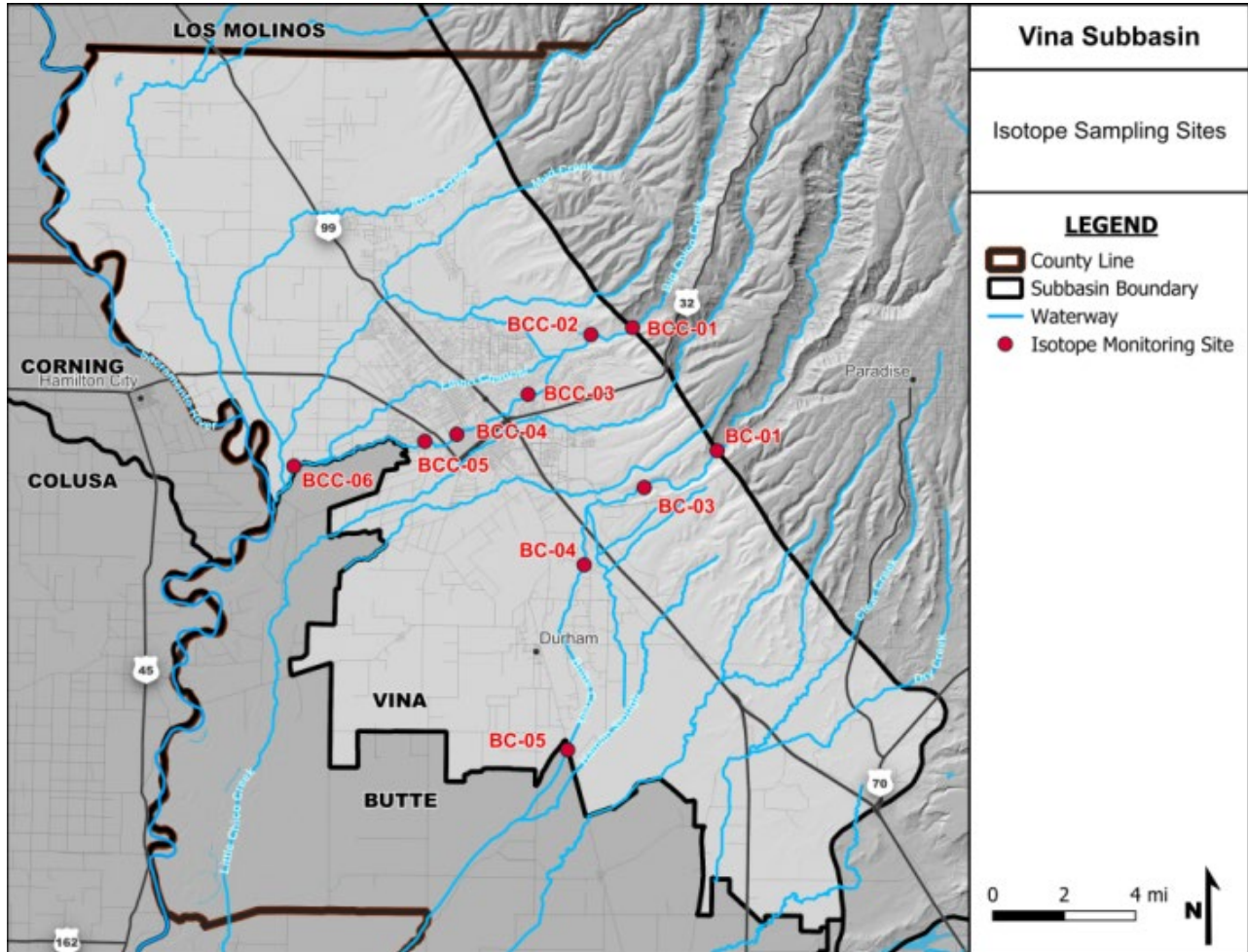


Figure 9: Isotope Sampling Locations along Big Chico and Butte Creeks.

Firstly, radon-222 is a naturally occurring short-lived radioactive noble gas that is produced in geologic material and accumulates in groundwater. As groundwater discharges to the surface, radon-222 quickly degasses, and its presence therefore indicates a localized groundwater contribution to surface water flows. In a 2005 USGS study of the South Sacramento Valley, groundwater radon-222 was measured at between 200-700 pCi/L (USGS, 2005). Therefore, it would be expected that surface water in the Vina Subbasin receiving groundwater inputs (i.e. gaining) should contain elevated levels of radon-222. Secondly, as the ratio of stable isotopes of the water molecule (^{16}O , ^{18}O , ^1H , ^2H) varies due to natural hydrologic processes such as evaporative fractionation and precipitation altitude, sampled water bodies with different source areas should be detected as having distinct isotopic fingerprints (Jameel et al., 2019; Visser et al., 2016). The combination of radon-222 and isotopes of the water molecule allow us to detect seasonal and local groundwater inputs, source area elevation, and evaporative signatures (Castaldo et al., 2021).

In terms of radon-222, low activities (< 4 pCi/L) were observed compared to the 200-700 pCi/L expected from a groundwater signal in all samples (Figures 10 & 11). When combined with the results discussed in the previous section, it is confirmed that the Big Chico and Butte Creeks are losing, which matches BBGM modeled results and groundwater level approach as shown in Figures 3 and 8; respectively. In terms of stable water isotopes, samples taken on Butte Creek from a distinct group and are more depleted in heavy isotopes when compared to those taken on Big Chico Creek, signaling a higher elevation source area for Butte Creek (Figure 12, Castaldo et al., 2021). Samples on both Butte and Big Chico Creek are furthermore close to the Global Meteoric Water Line (GMWL), implying limited impact of evaporative fractionation (Figure 13). This indicates that the streams act as a source of recharge to the local aquifer system without significant water loss through evaporation during transit.

Given the general agreement between the results of groundwater elevations, radon, and stable water isotopes we can conclude that neither Butte Creek nor Big Chico Creek receive groundwater inputs and are disconnected from groundwater a majority of the time. This result has slight disagreement in the far lower reaches of Big Chico Creek when compared to BBGM modeled results. However, it should be noted that the isotope portion of this study represents a snapshot in time and may not capture transitions from gaining to losing or vice versa that occur over time. The isotope study may be continued as funding allows to assess seasonal trends and impacts from groundwater level fluctuations.

Radon Activities For Six Sites Along Big Chico Creek

May Through October of 2025, Vina Subbasin, Butte County, CA

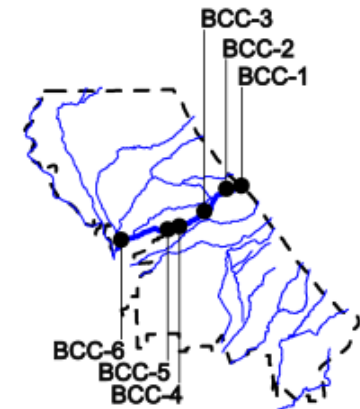
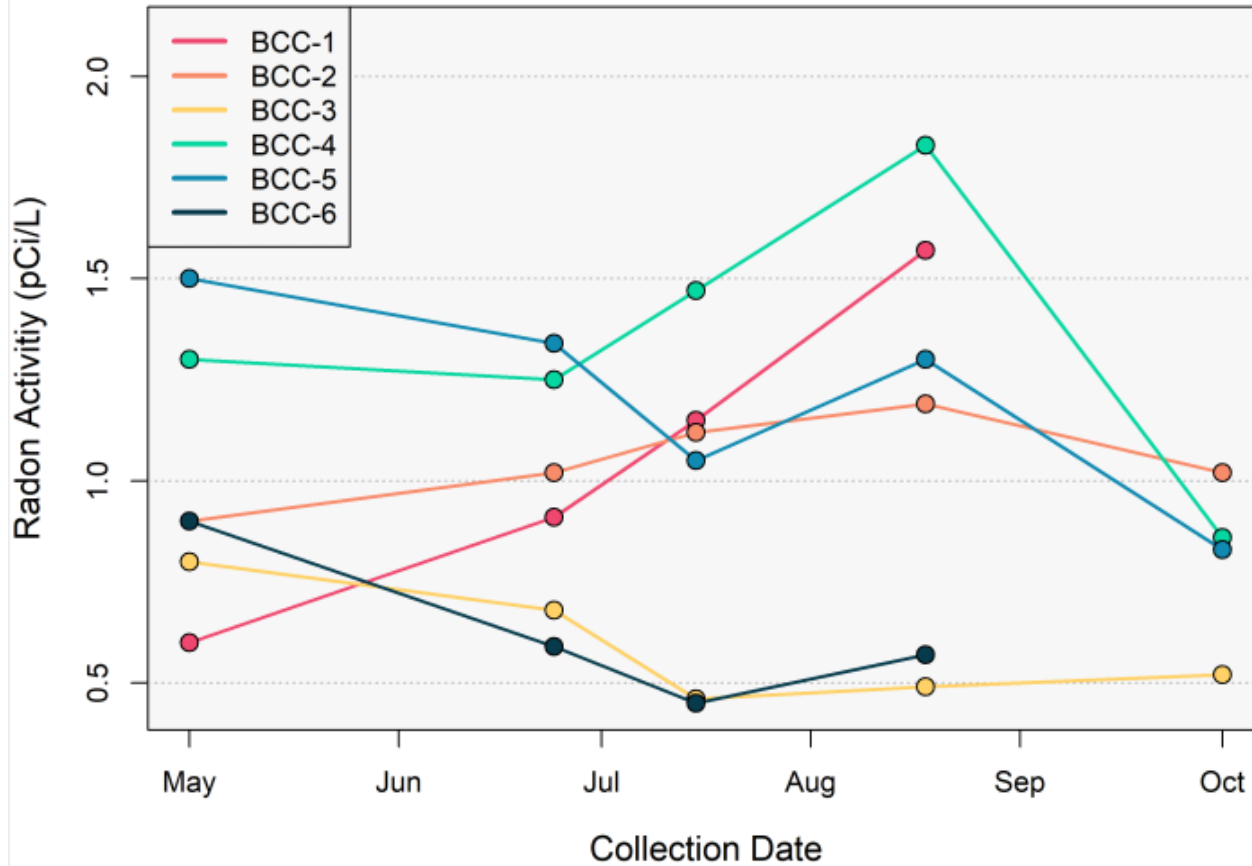


Figure 10: Radon activity for sampled sites along Big Chico Creek in May through October of 2025

Radon Activities For Four Sites Along Butte Creek

May Through October of 2025, Vina Subbasin, Butte County, CA

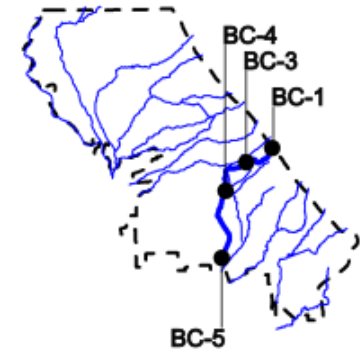
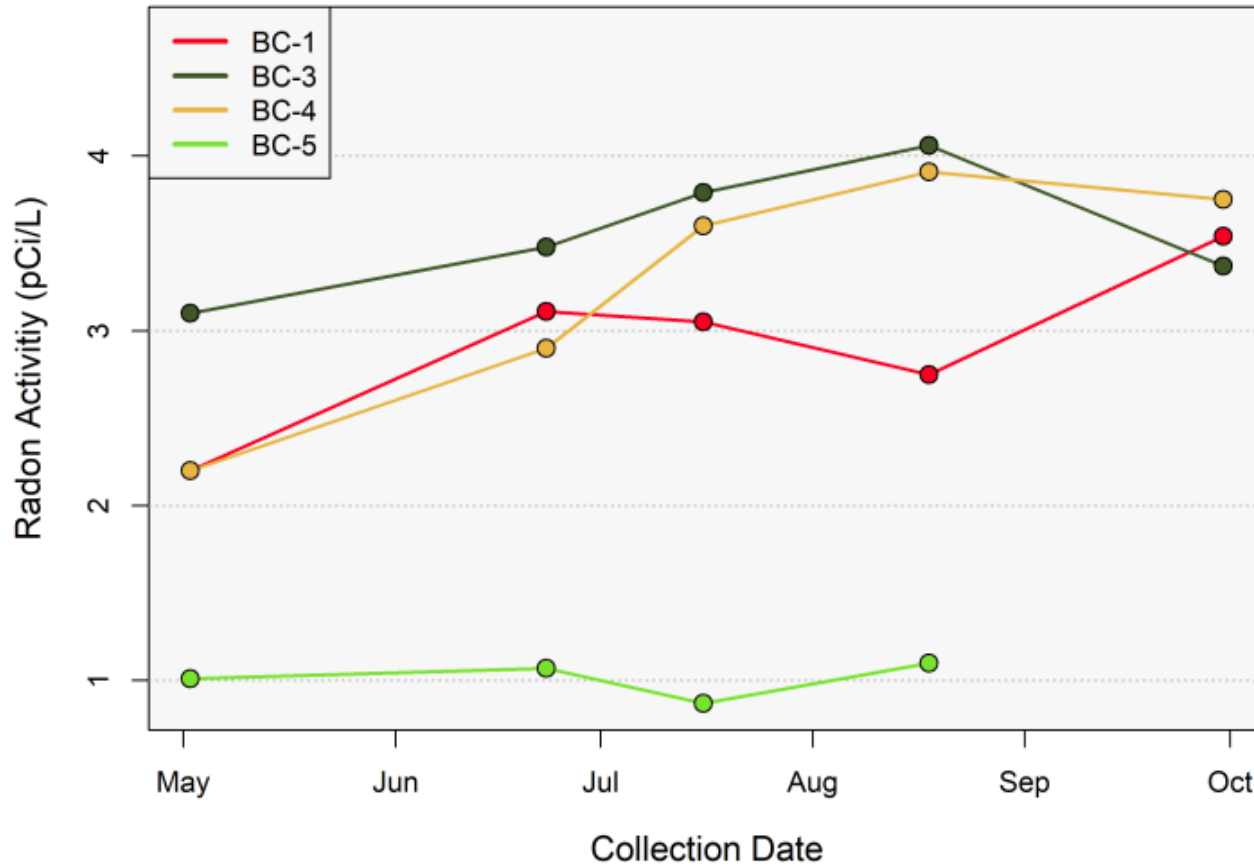


Figure 11: Radon activity for sampled sites along Butte Creek in May through October of 2025

Dual Isotope Plot for Big Chico and Butte Creeks

May Through October of 2025, Vina Subbasin, Butte County, CA

*Uncertainties displayed are 1σ

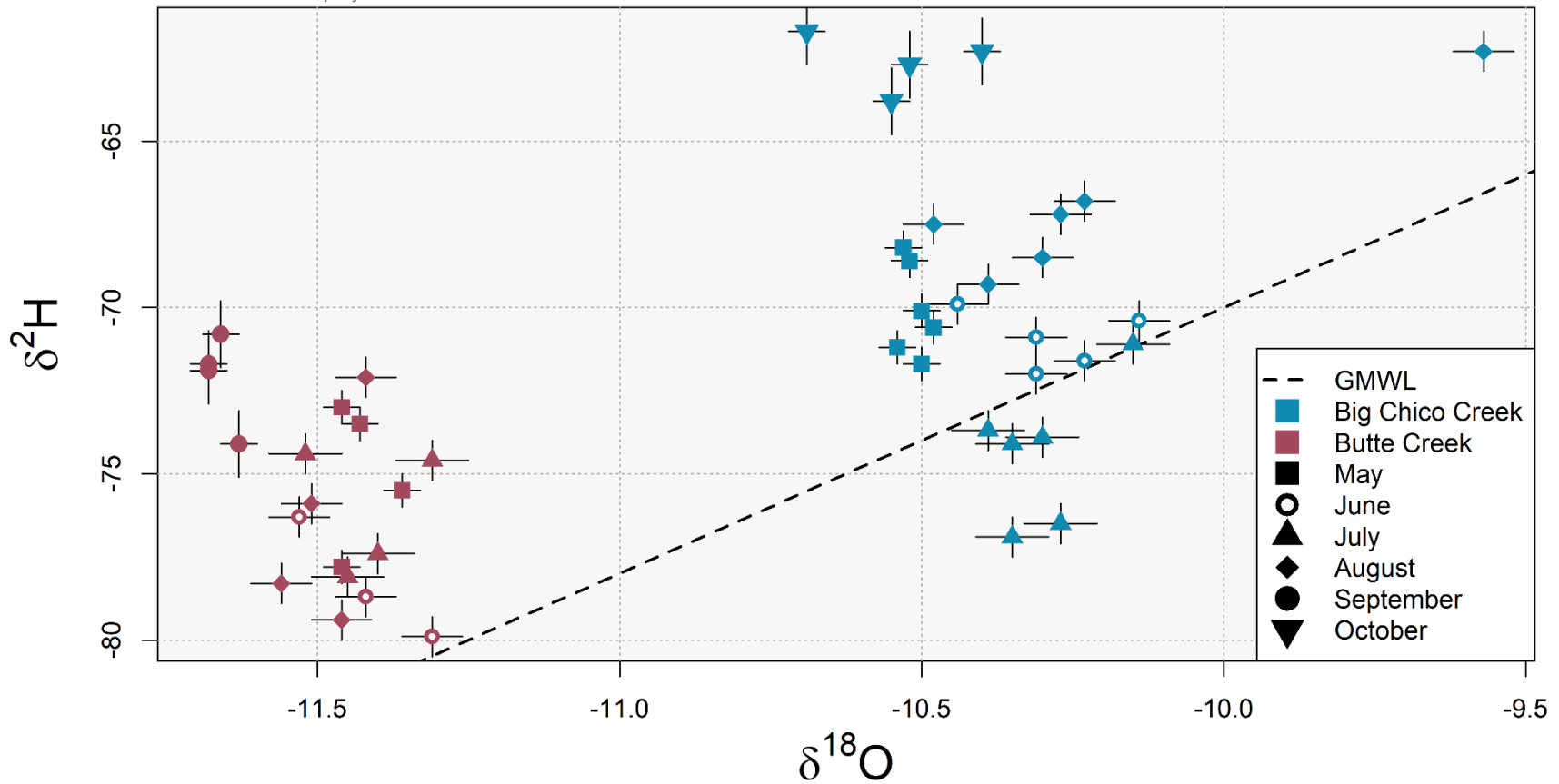


Figure 12: Dual isotope plot for isotopes of the water molecule at sampled sites along Big Chico and Butte Creeks in May through October of 2025. Delta notation is relative to Vienna Standard Mean Ocean Water (VSMOW). Global Meteoric Water Line (GMWL) is defined by the equation $\delta\text{D} = (8 * \delta^{18}\text{O}) + 10 \text{‰}$.

Deuterium Excess of Big Chico and Butte Creek Samples

May Through October of 2025, Vina Subbasin, Butte County, CA

*Uncertainties displayed are 1σ

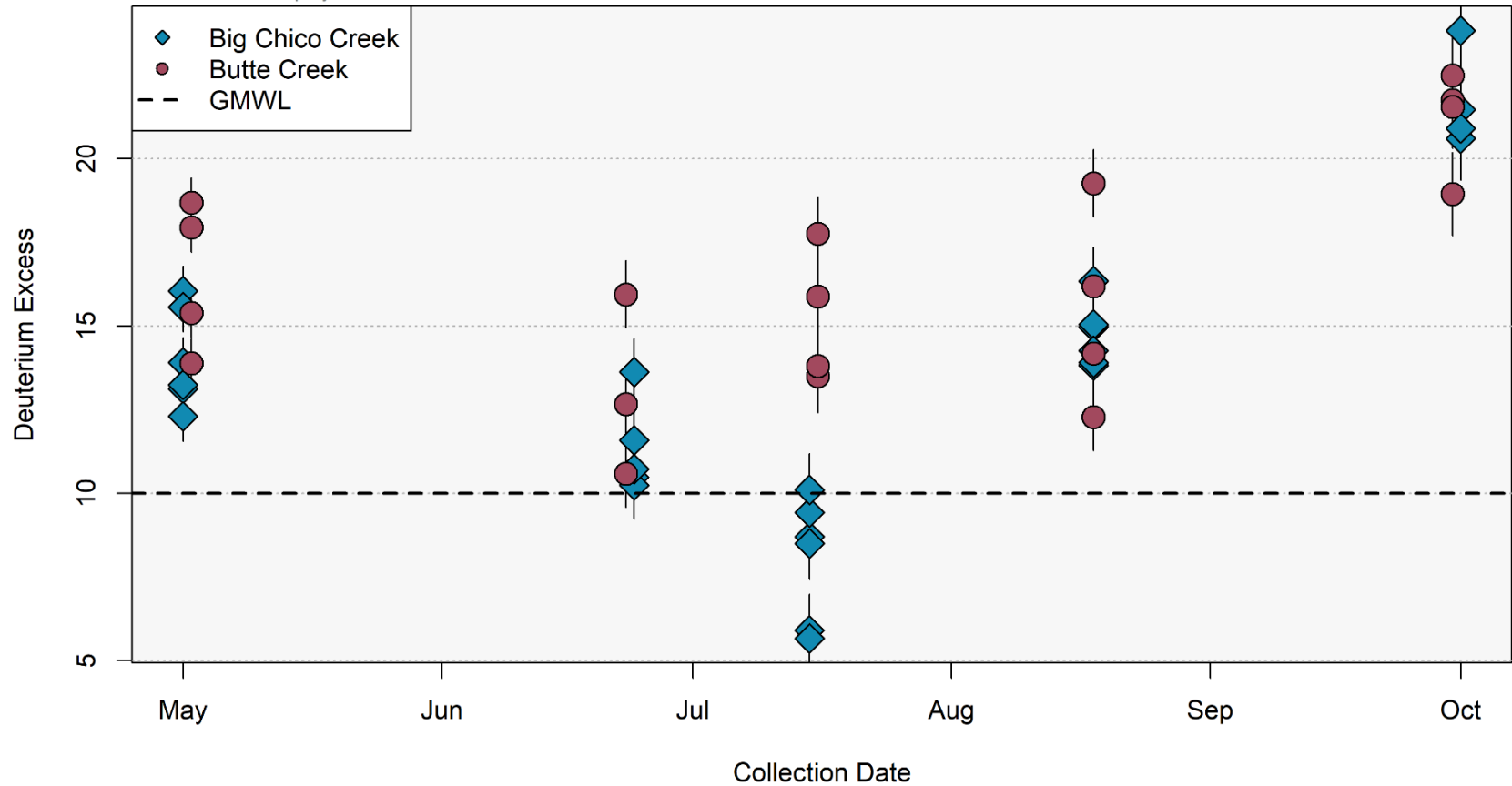


Figure 13: Deuterium excess of Big Chico and Butte Creek samples. Samples taken in June through October of 2025. Deuterium excess defined by the equation $\text{Excess} = \delta D - 8 \cdot \delta^{18}O$.

SECTION 3: SUMMARY AND CONCLUSIONS

This document details efforts in the Vina Subbasin to identify ISW locations using the updated BBGM, LiDAR extracted surface water elevations in conjunction with interpolated groundwater elevations, and stable and radioactive isotope tracers. Based on best available information and data (including multiple lines of evidence), streams are primarily disconnected, except for the Sacramento River and short stream segments in the most western part of the Subbasin as summarized in Table 3. Disconnected streams are not impacted by groundwater pumping; therefore, not subject to SGMA. The new shallow monitoring wells and stream gages (installed in 2026) will help fill remaining data gaps. These conclusions are subject to change as additional information becomes available.

Key preliminary findings include:

- The Sacramento River is primarily a gaining stream and is subject to depletions from groundwater pumping. Depletions from the Sacramento River are not considered to have the potential for significant and unreasonable impacts on beneficial uses and users of the river. It is estimated that the Sacramento River experiences depletions due to groundwater pumping within Vina and adjacent subbasins on the order of 38 CFS (or 16 TAF per year) June through December.
- Perennial streams traversing the Subbasin including Big Chico and Butte Creeks are disconnected from the principal aquifer. Localized perched aquifer layers may influence stream gains / losses. Locations and extent of perched aquifers remain a data gap; however, several studies and site-specific evaluations have confirmed perched layers do exist within the Subbasin. The new shallow wells will help fill data gaps along Big Chico and Butte Creeks.
- Several streams across the Subbasin are ephemeral including Pine, Mud, Rock, Little Chico, Dry, and Little Dry Creeks. Depletions from pumping are limited to when the stream is flowing and the stream is connected to the aquifer. Stream flows typically end by June which leads to a small amount of potential gains / losses in the spring as pumping starts for the irrigation season. These streams are disconnected from the aquifer except for the lower reaches near the Sacramento River such as along Pine and Big Chico Creeks. These segments are likely influenced by the backwater effects from the Sacramento River. Therefore, depletions are not considered to have the potential for significant and unreasonable impacts on beneficial uses and users of surface water in these systems.

Table 3: Preliminary Connected and Disconnected Streams within the Vina Subbasin.

Stream	Type	Preliminary Status (Connected or Disconnected)	Length (miles)
Sacramento River	Perennial (flows controlled by USBR releases at Shasta Lake)	Connected - Gaining	23.4
Pine Creek	Ephemeral	Disconnected (except for lower ~5 miles)	12.6
Rock Creek	Ephemeral	Disconnected (except for lower ~1 miles)	13.4
Mud Creek	Ephemeral	Disconnected (except for lower ~2 miles)	13.2
Big Chico Creek	Perennial	Disconnected (except for lower ~2 miles)	10.7
Little Chico Creek	Ephemeral	Disconnected	11.9
Butte Creek	Perennial	Disconnected	11.8
Little Dry Creek	Ephemeral	Disconnected	10.8
Dry Creek	Ephemeral	Disconnected	10.9
Total:			118.7

SECTION 4: REFERENCES

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Appendices

**APPENDIX A: DISCHARGES FROM STREAM GAGES
WITHIN THE SUBBASIN**

**APPENDIX B: SHALLOW MONITORING WELL
HYDROGRAPHS**

**APPENDIX C: SURVEYED TRANSECTS ACROSS
STREAMS IN THE VINA SUBBASIN**

Appendix A

Discharges from Stream Gages within Vina Subbasin

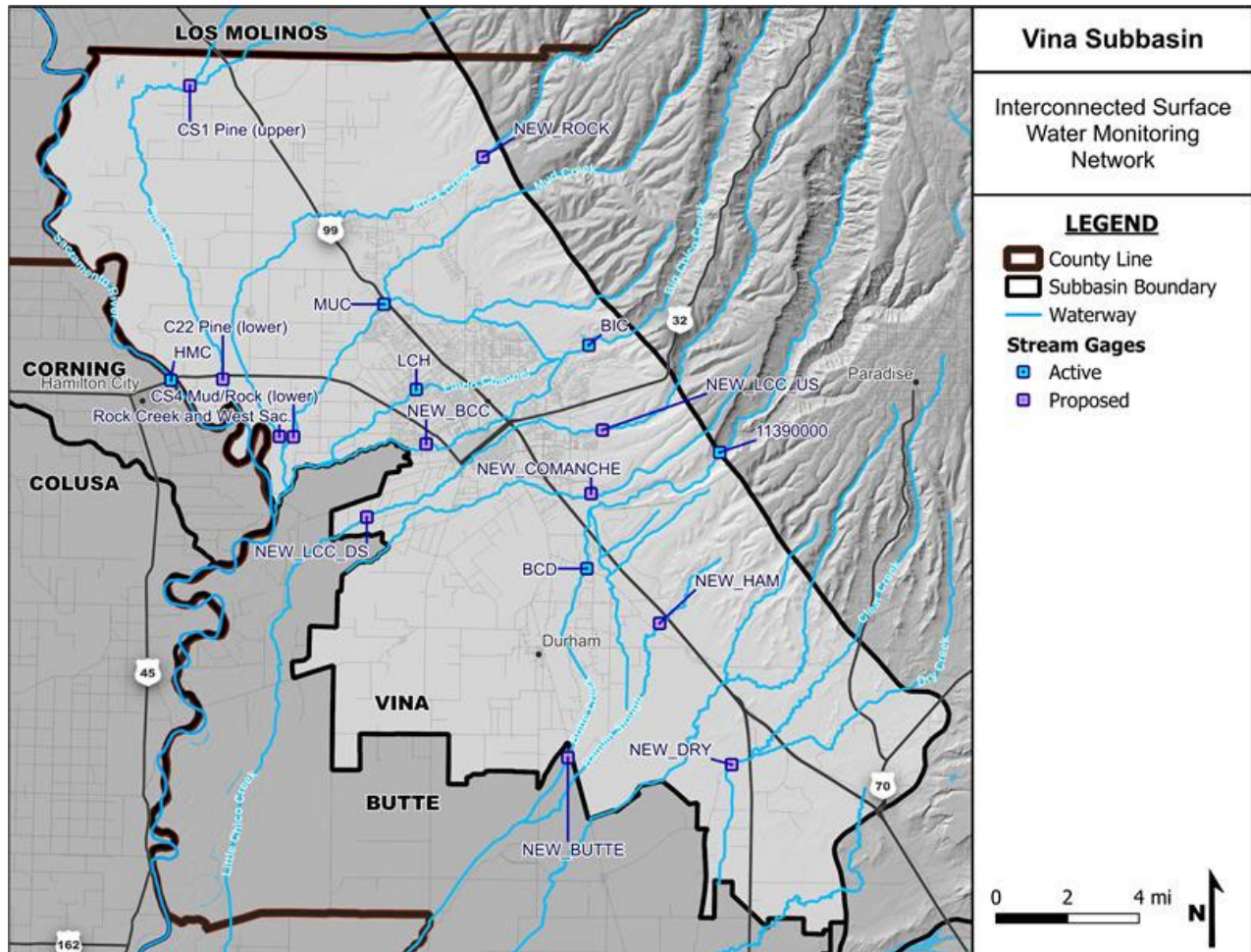


Figure A- 1: Map of active and proposed stream gages. Active gages have historical data. Proposed gages will be installed in 2026.

Discharge At Gage BCD

Butte Creek
2000 - 2025, Vina Subbasin, Butte County, CA

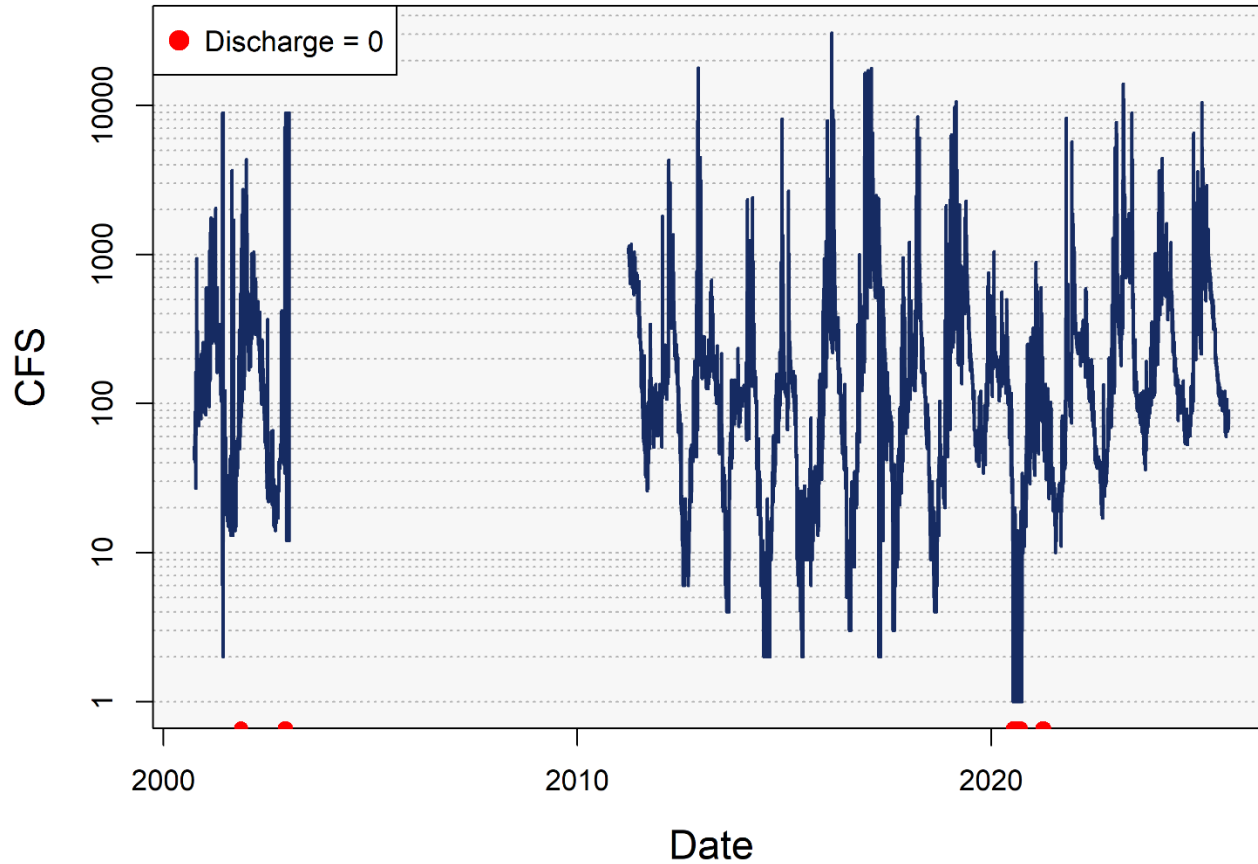


Figure A- 2: Discharge at CDEC gage BCD on Butte Creek between 2000 and 2025. For ease of visualization data has been log transformed.

Discharge At Gage BCK

Butte Creek
2000 - 2025, Vina Subbasin, Butte County, CA

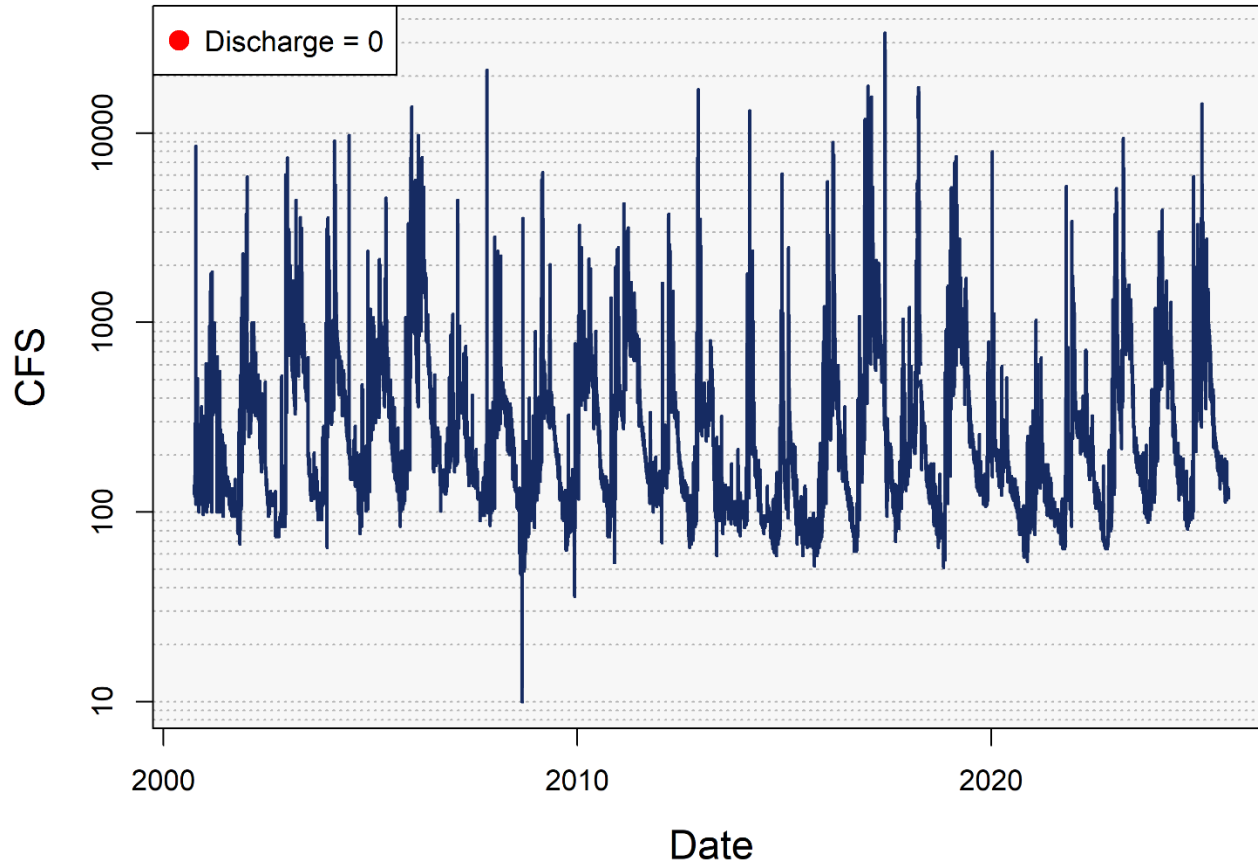


Figure A- 3: Discharge at CDEC gage BCK on Butte Creek between 2000 and 2025. For ease of visualization data has been log transformed.

Discharge At Gage HMC

Sacramento River
2000 - 2025, Vina Subbasin, Butte County, CA

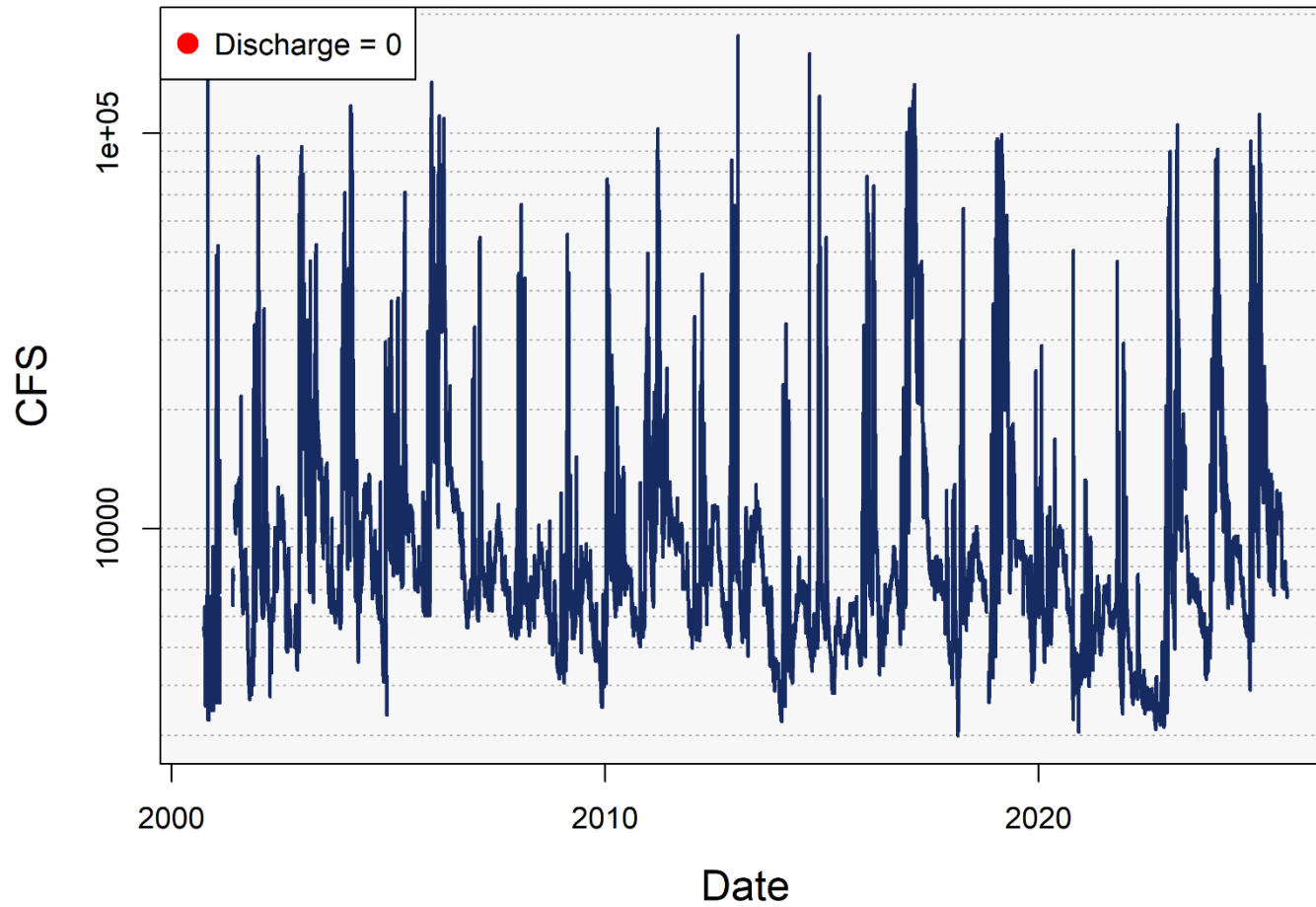


Figure A- 4: Discharge at CDEC gage HMC on the Sacramento River between 2000 and 2025. For ease of visualization data has been log transformed.

Discharge At Gage MUC

Mud Creek
2000 - 2025, Vina Subbasin, Butte County, CA

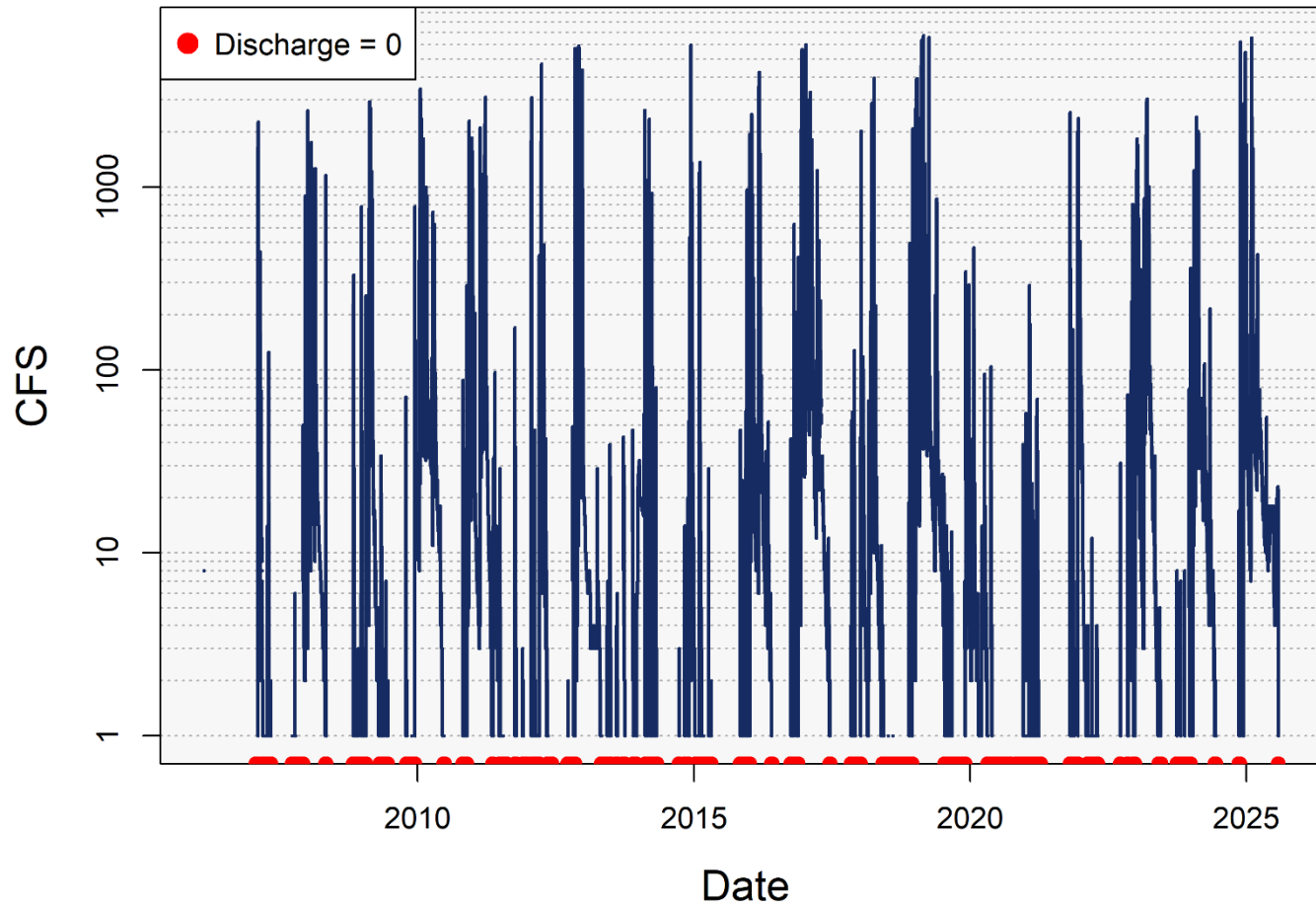


Figure A- 5: Discharge at CDEC gage MUC on Mud Creek between 2000 and 2025. For ease of visualization data has been log transformed.

Discharge At Gage LCH

Lindo Channel
2000 - 2025, Vina Subbasin, Butte County, CA

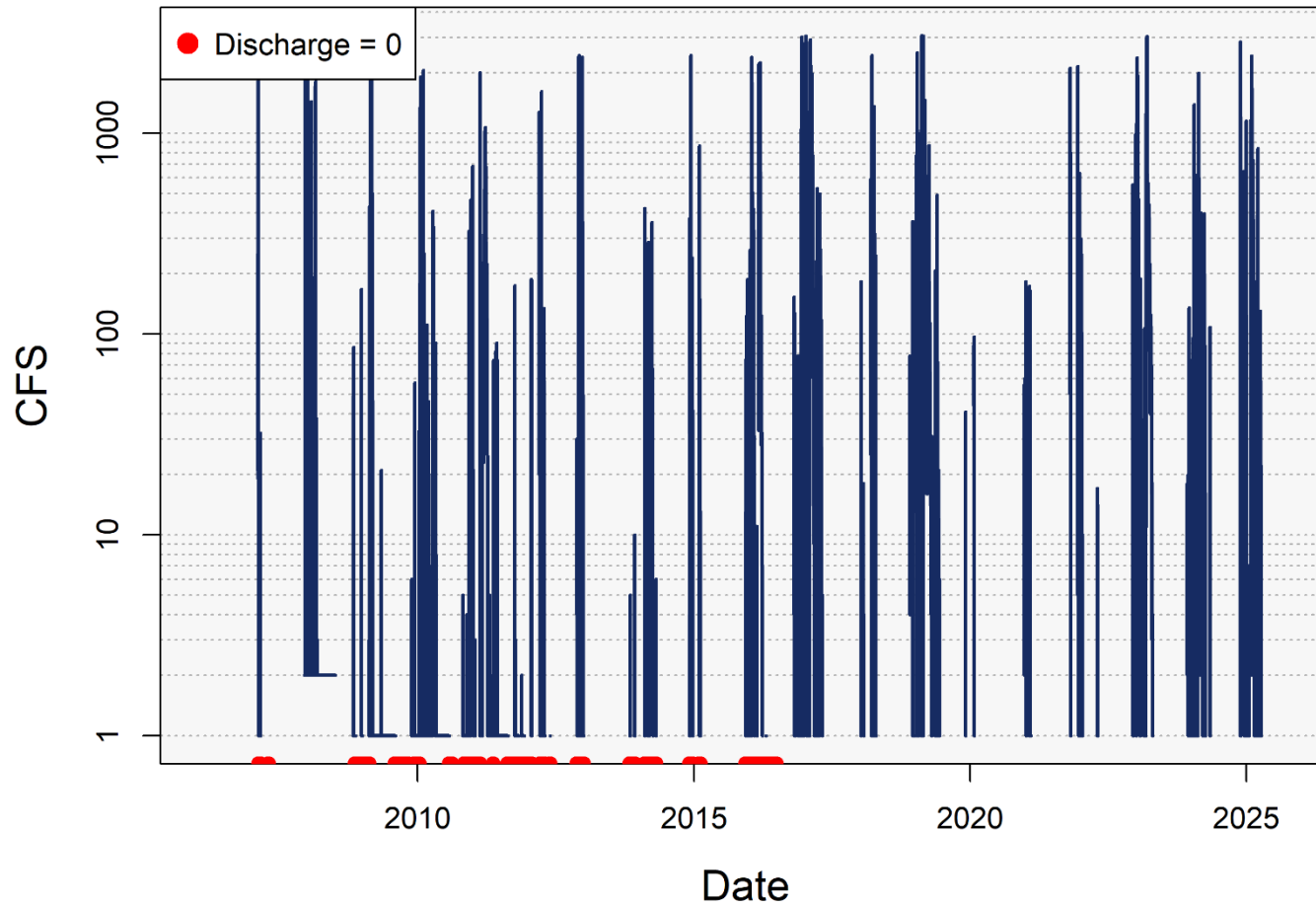


Figure A- 6: Discharge at CDEC gage LCH on Lindo Channel between 2000 and 2025. For ease of visualization data has been log transformed.

Discharge At Gage BIC

Big Chico Creek
2000 - 2025, Vina Subbasin, Butte County, CA

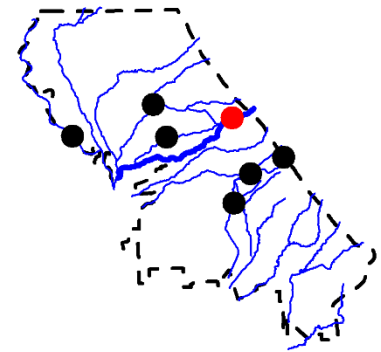
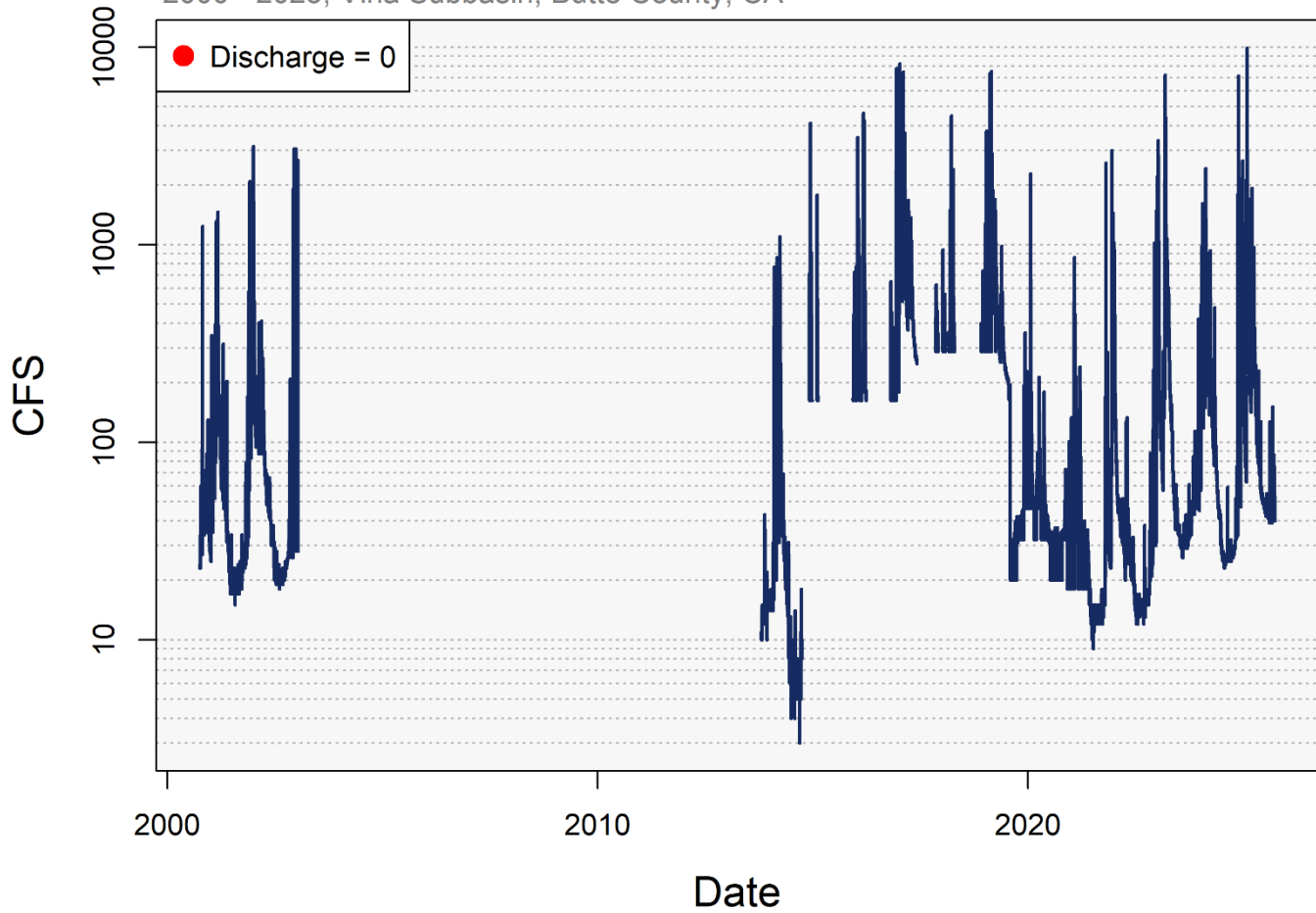


Figure A- 7: Discharge at CDEC gage BIC Big Chico Creek between 2000 and 2025. For ease of visualization data has been log transformed.

Appendix B

Shallow Monitoring Well Hydrographs

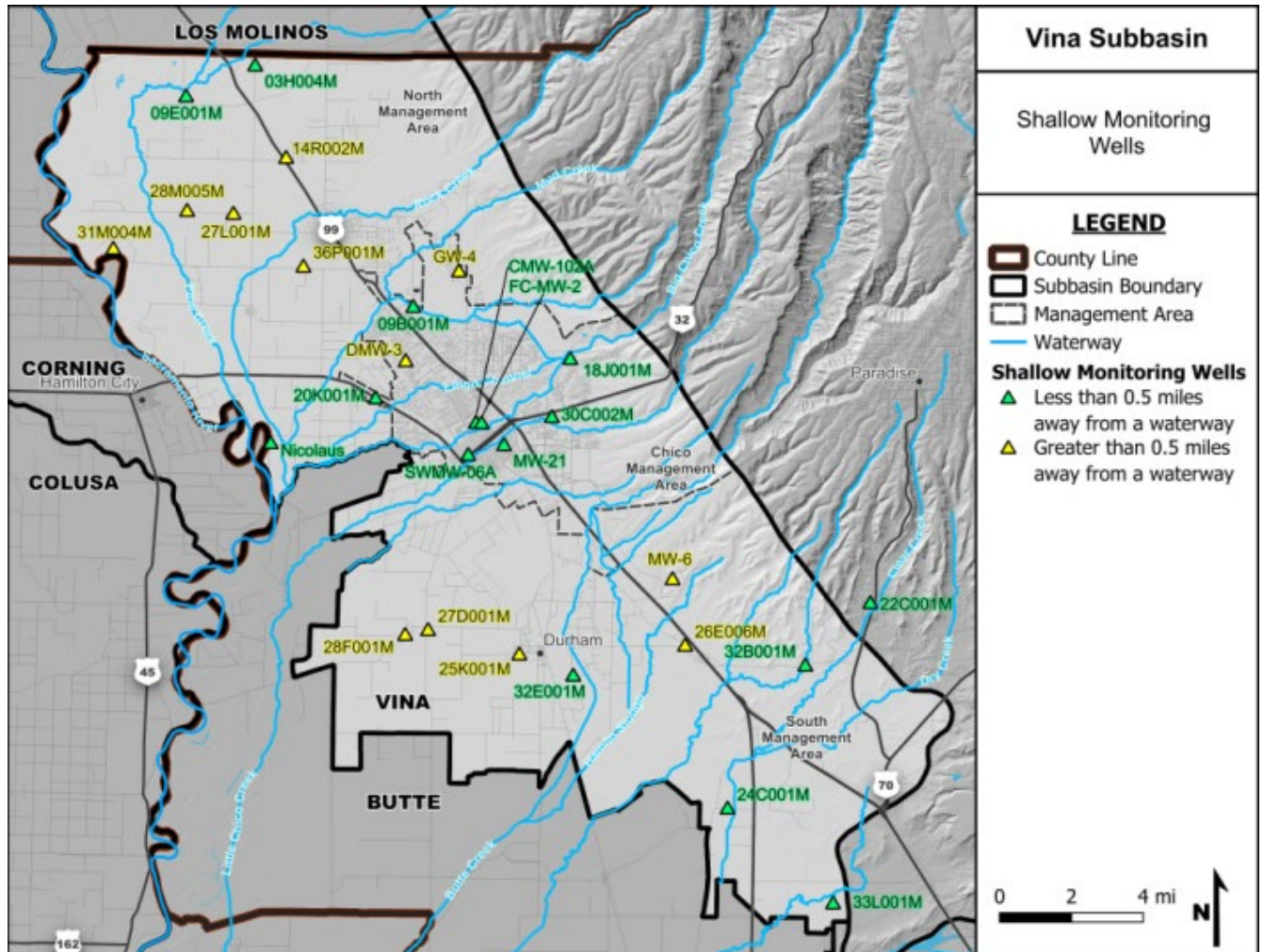
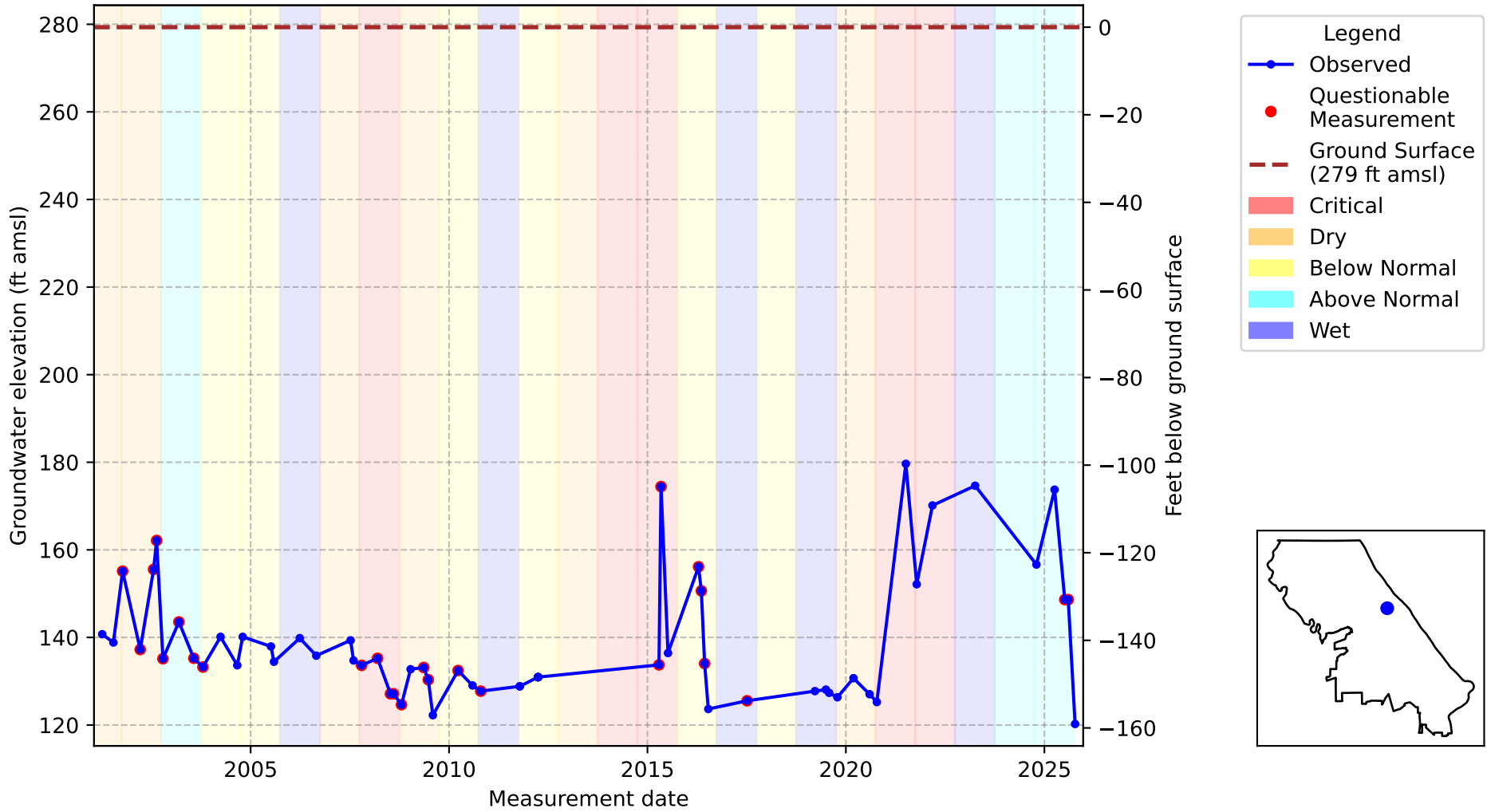
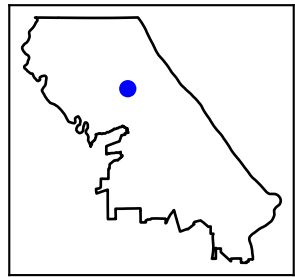
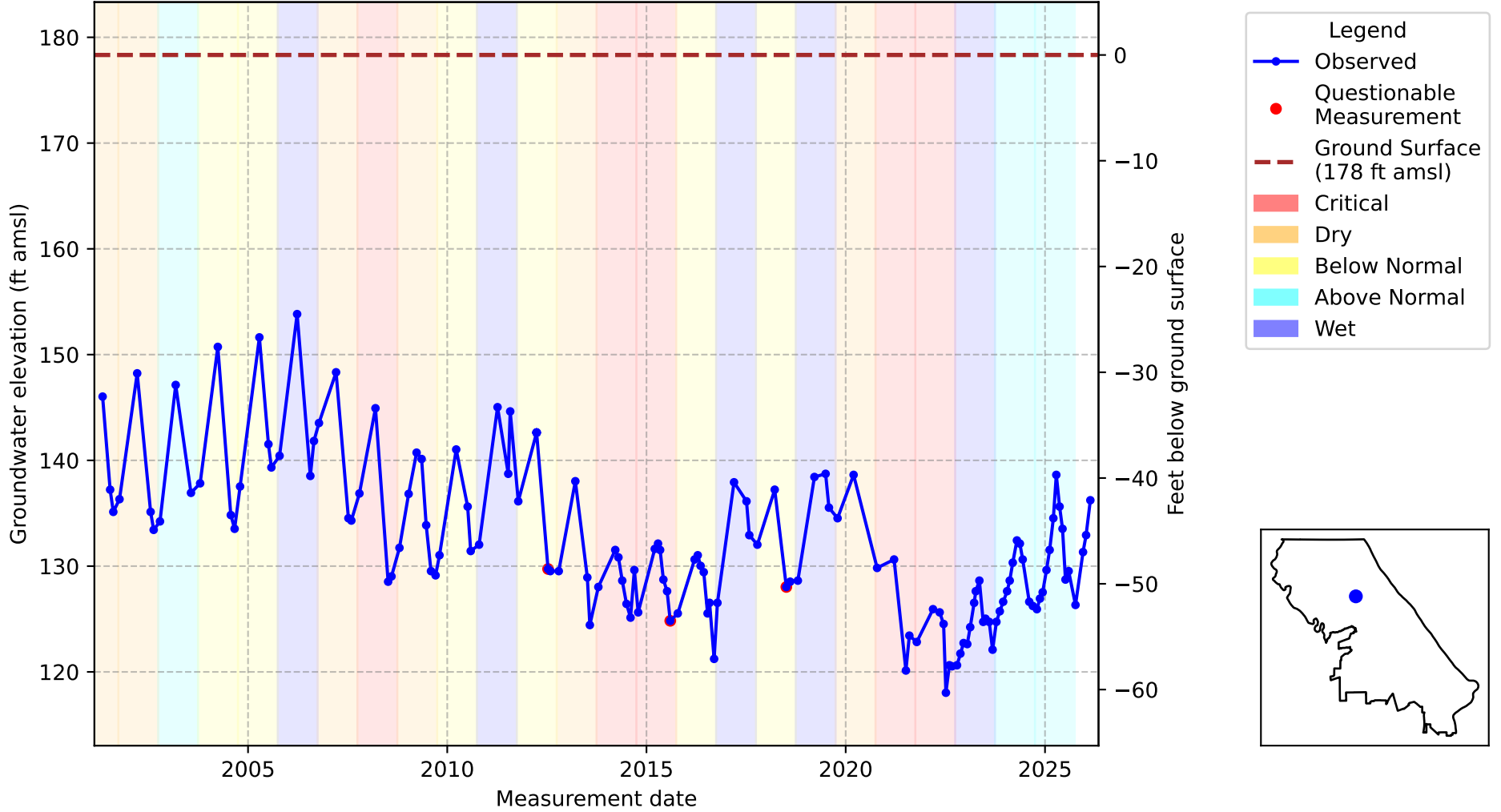


Figure B- 1: Shallow Monitoring Well Locations.

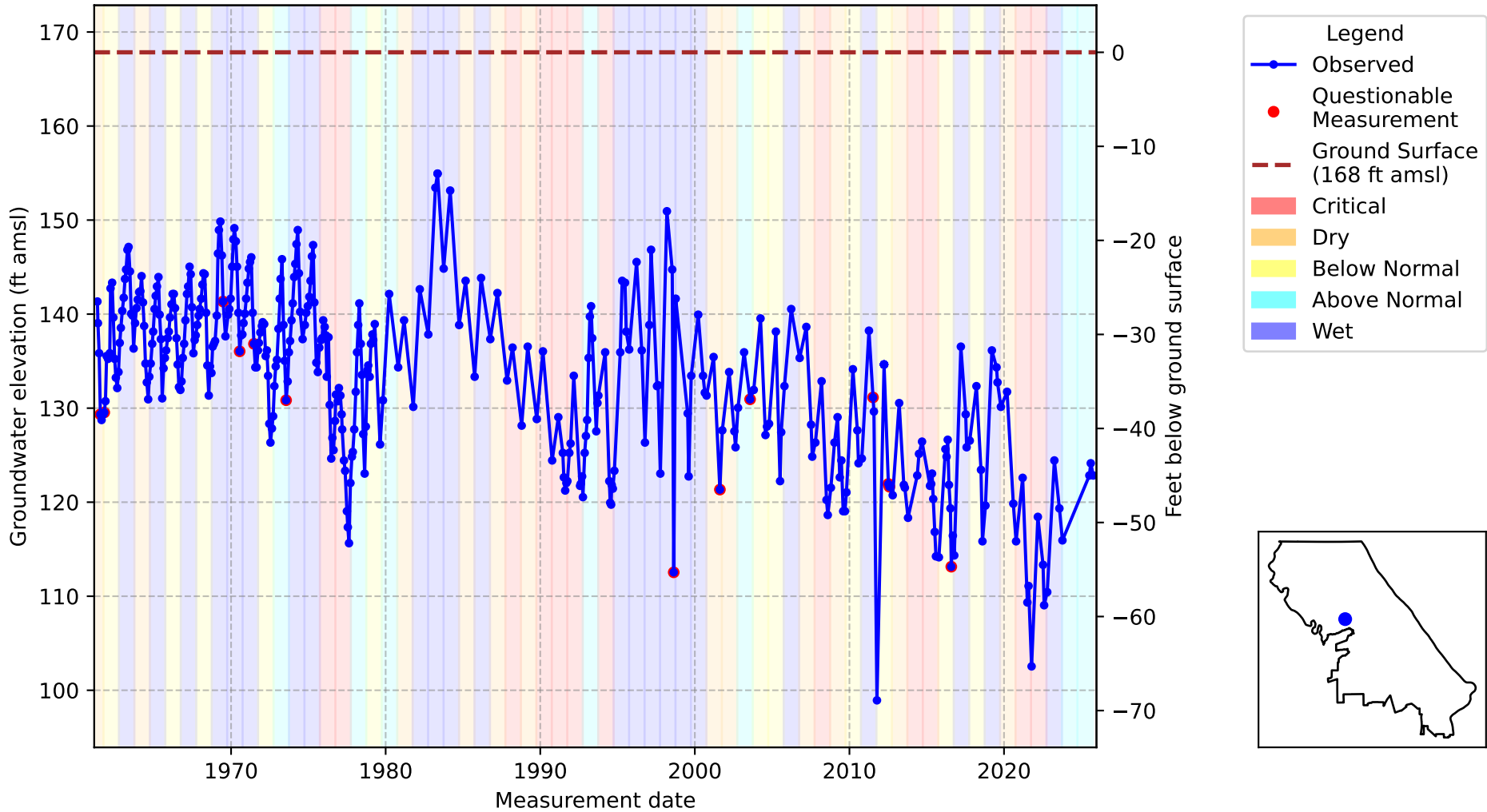
Vina Subbasin - Chico
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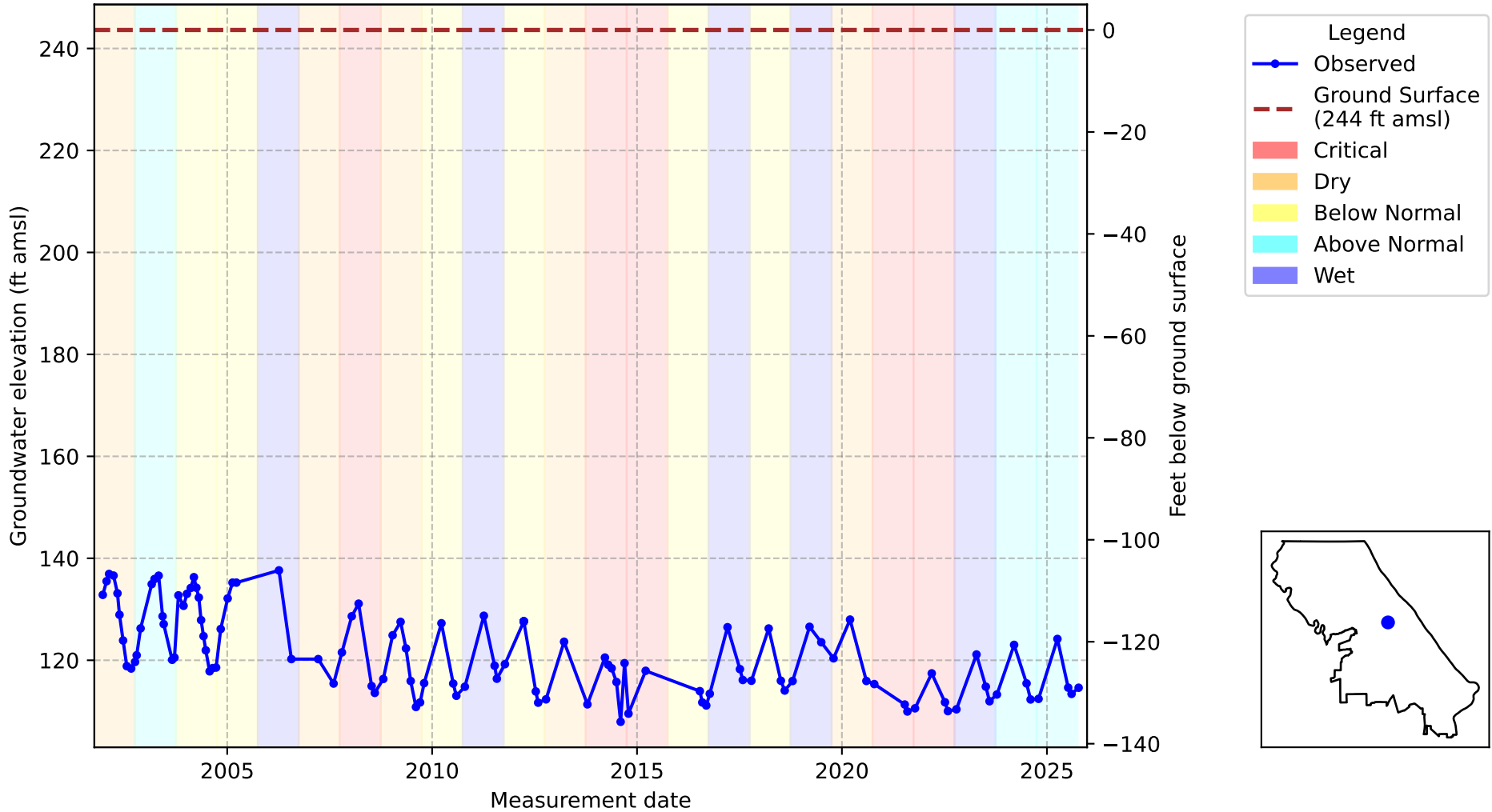
Vina Subbasin - Chico
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Vina Subbasin - Chico
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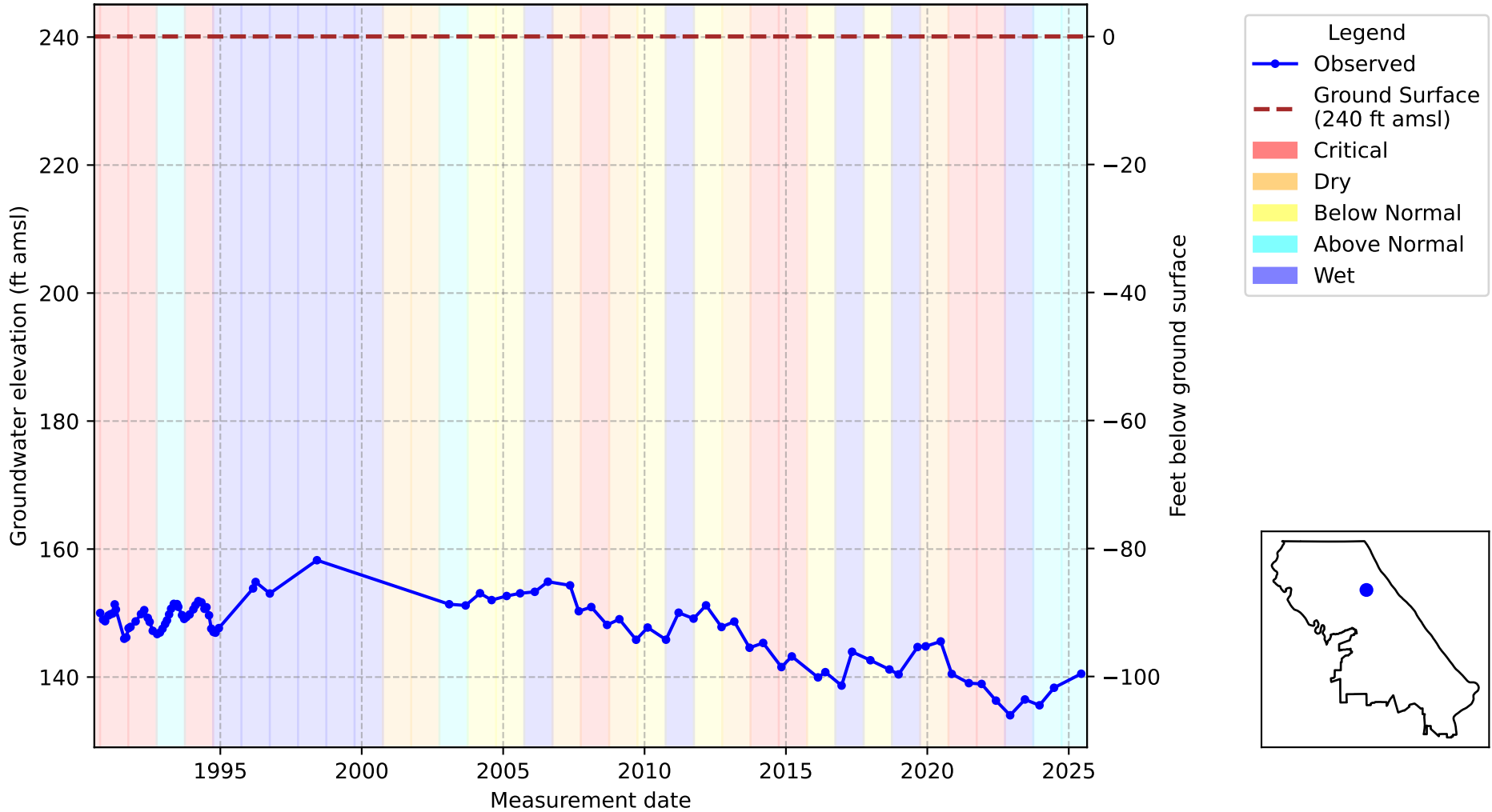


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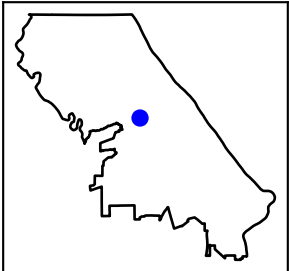
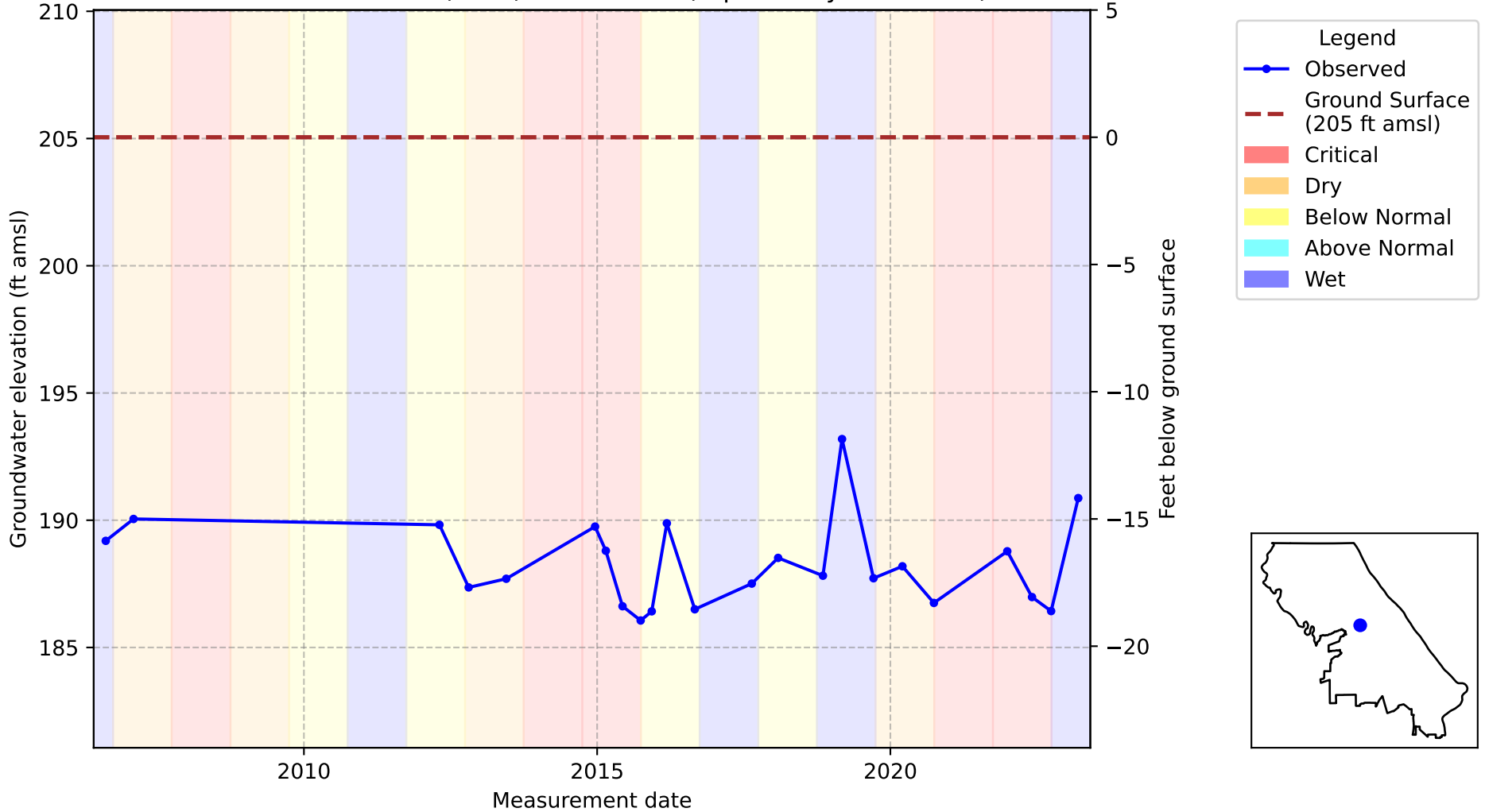
Vina Subbasin - Chico

State Well Number (SWN): Chico Airport GW-4 (Aquifer Layer: shallow)



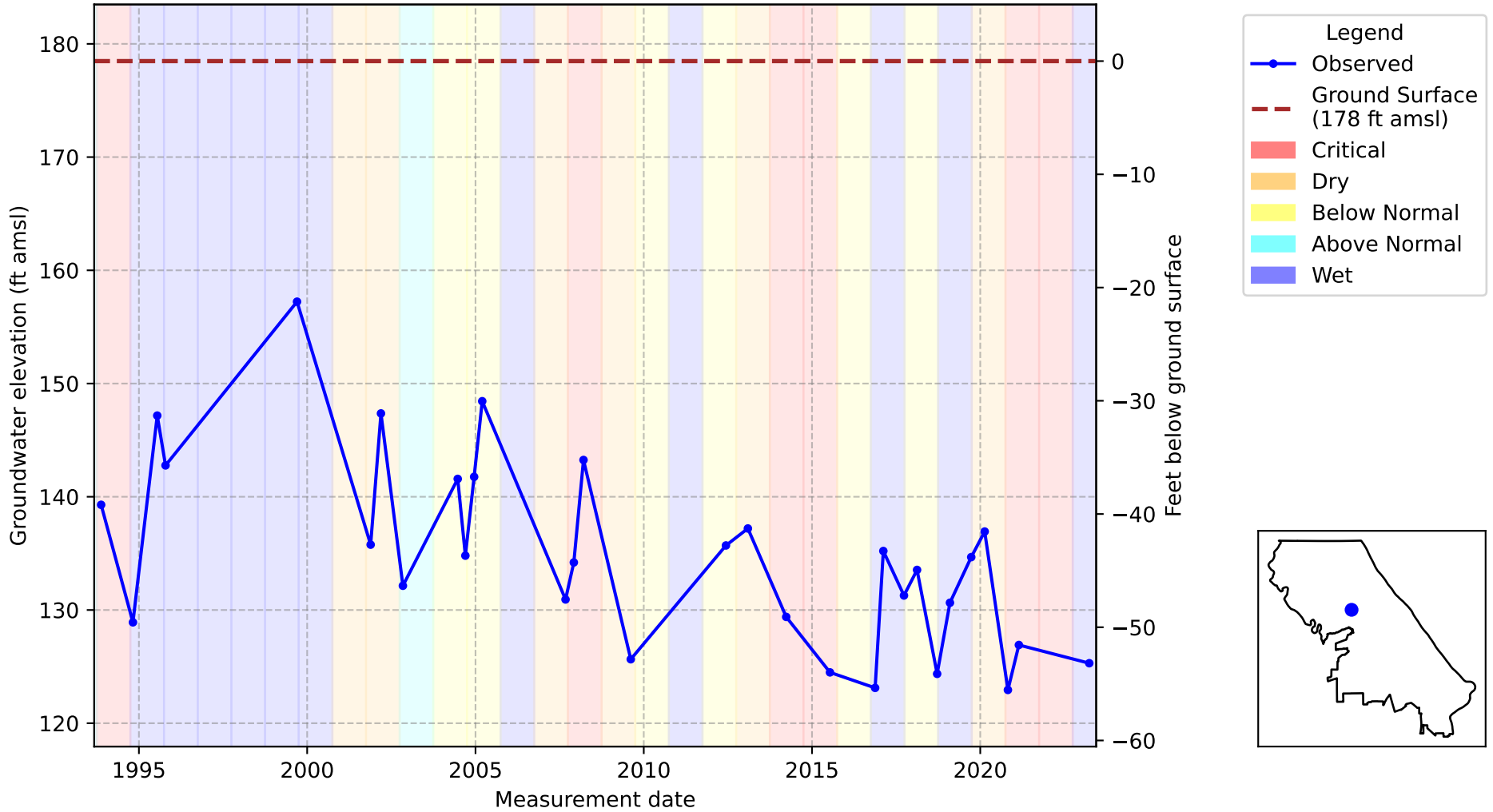
Vina Subbasin - Chico

State Well Number (SWN): CMW-102A (Aquifer Layer: shallow)

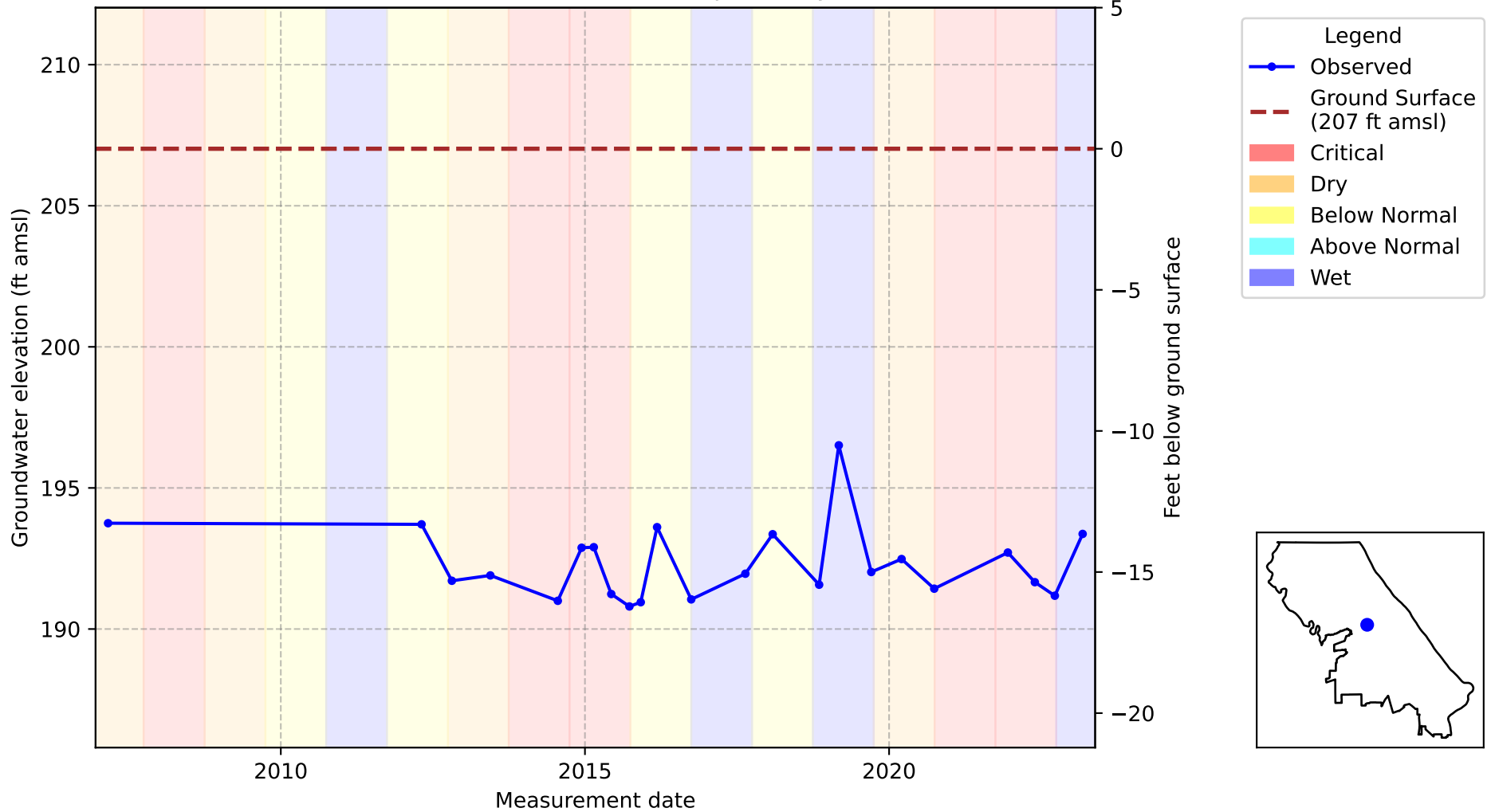


Vina Subbasin - Chico

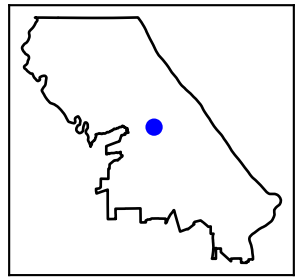
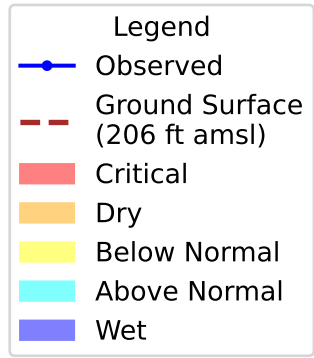
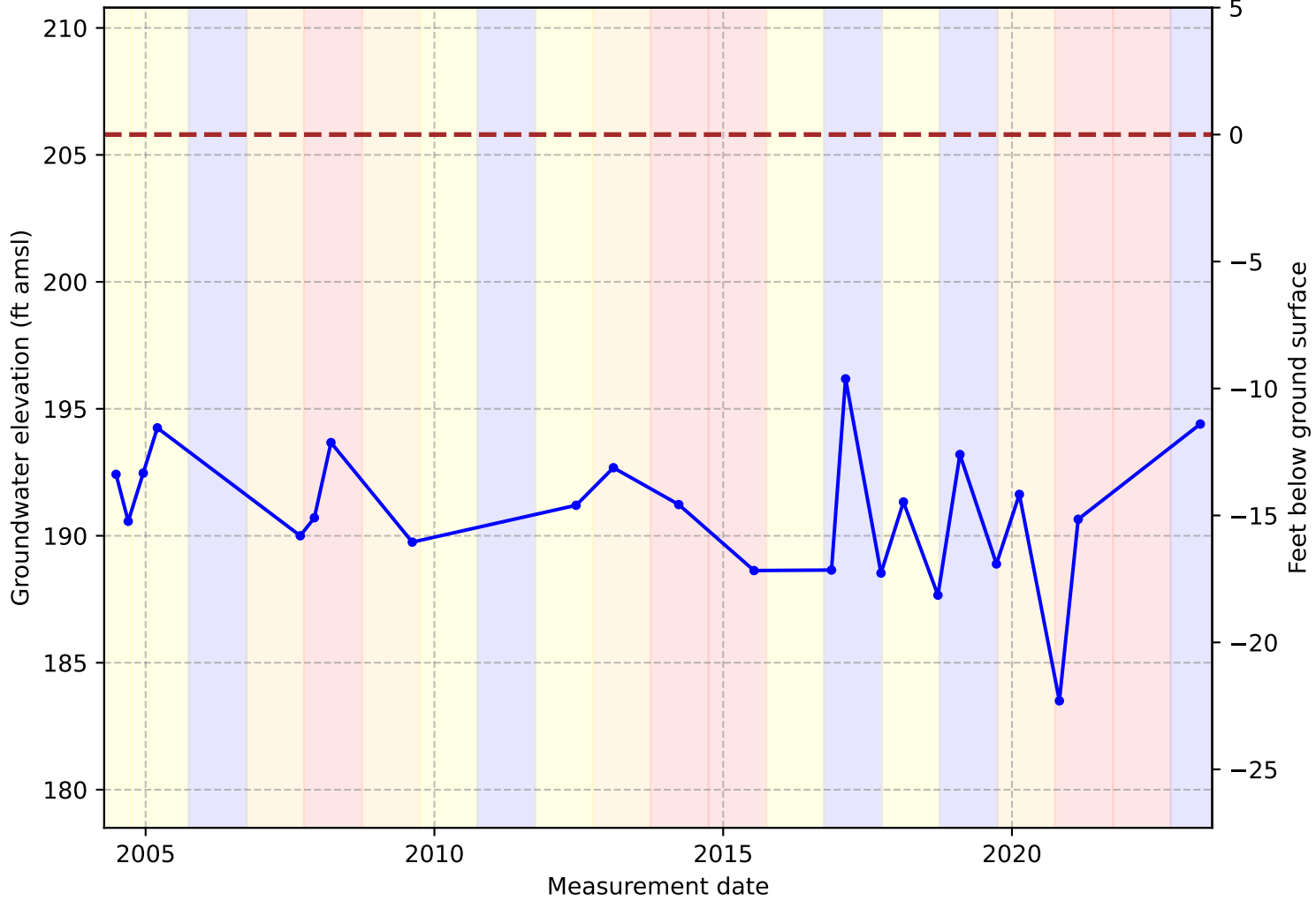
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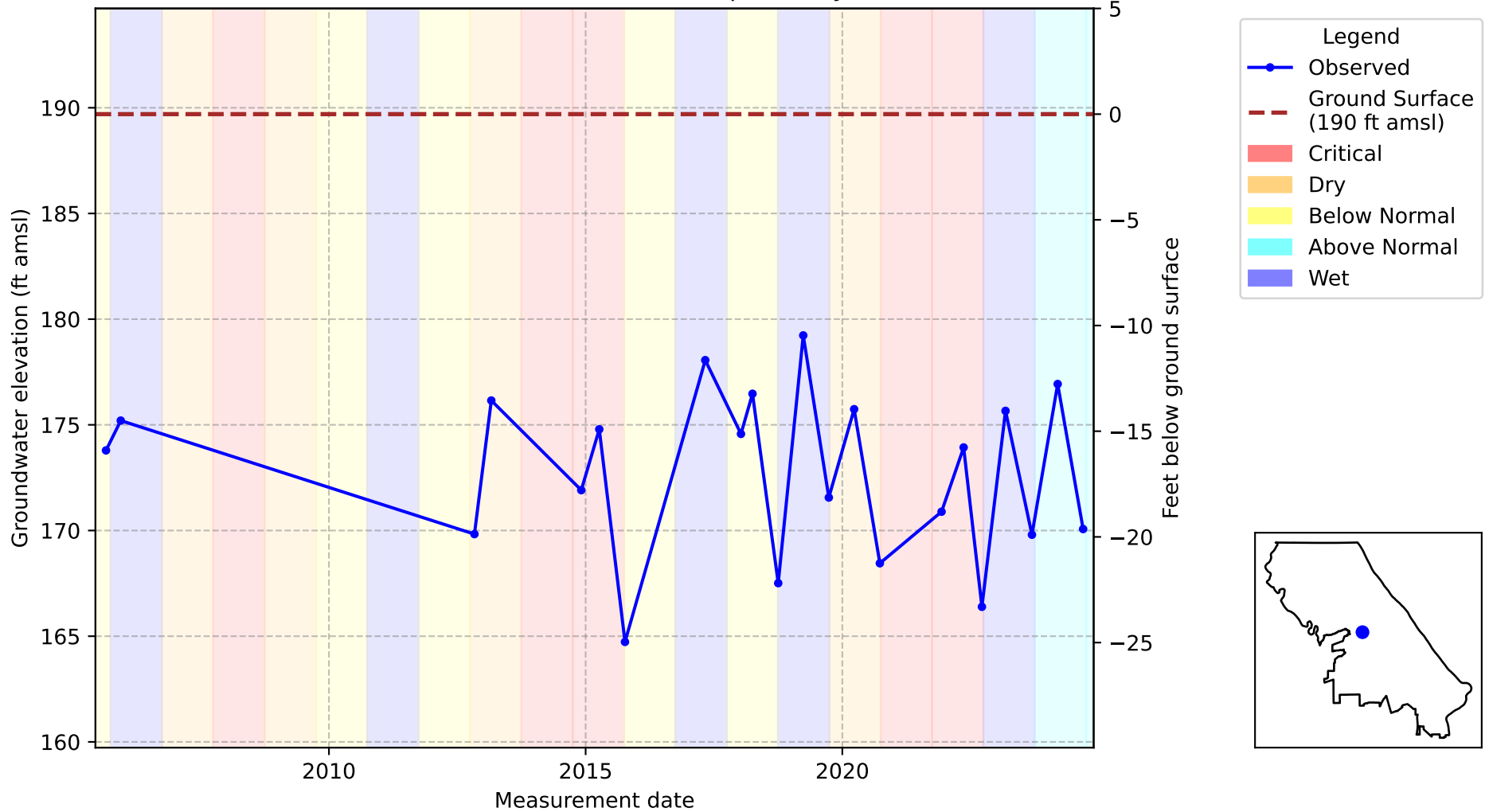
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State Well Number (SWN): FC-MW-2 (Aquifer Layer: shallow)



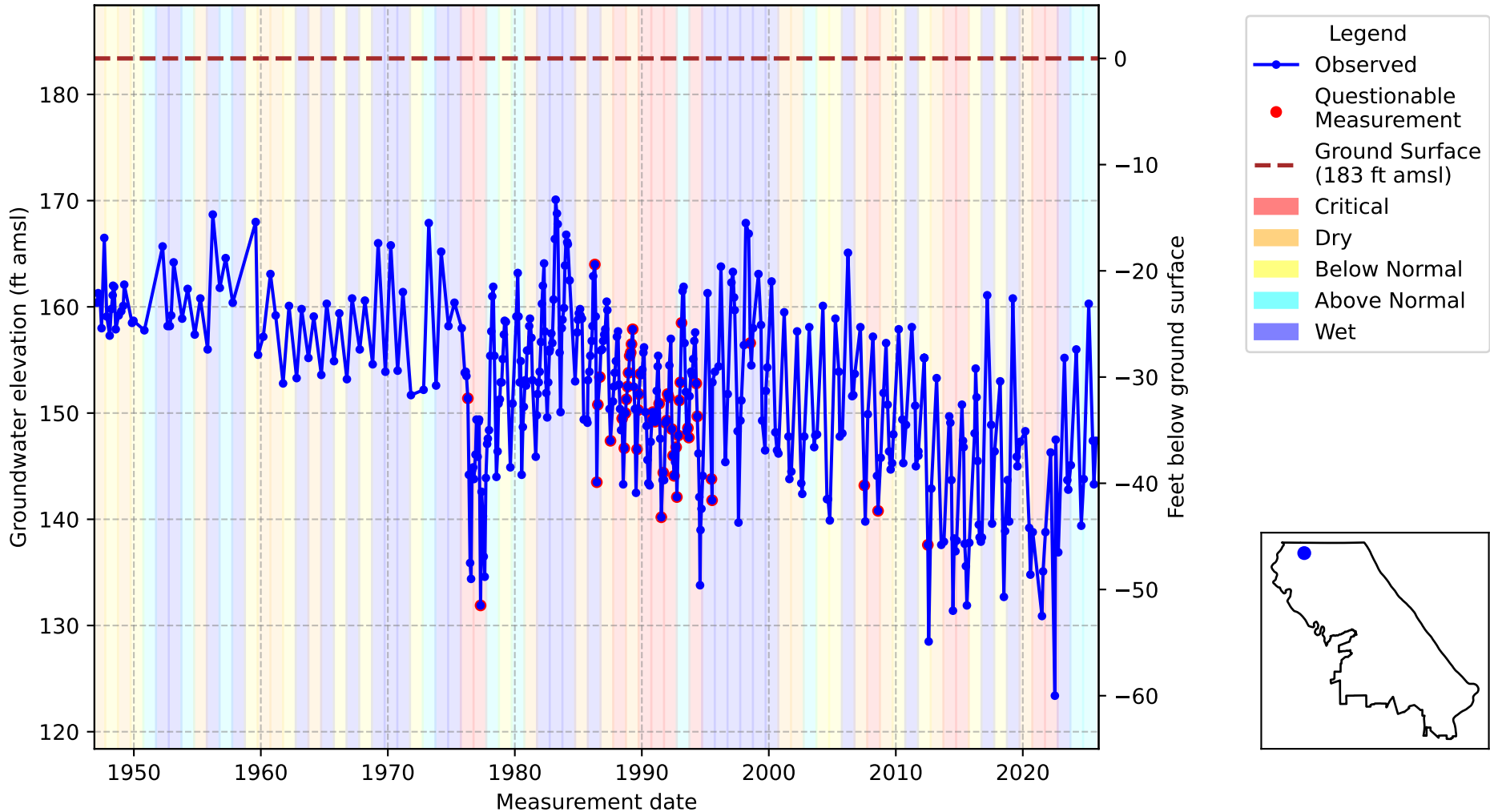
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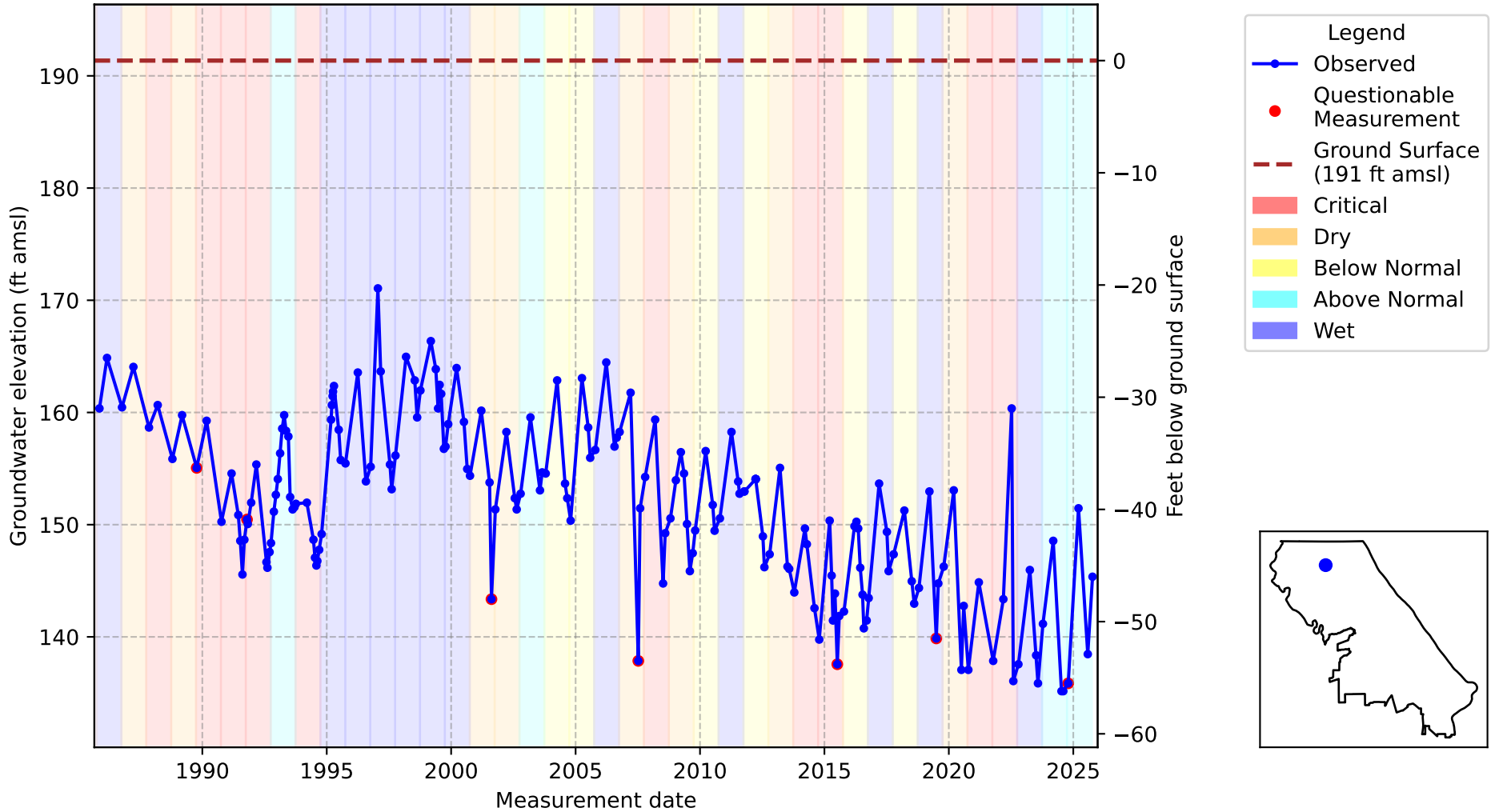
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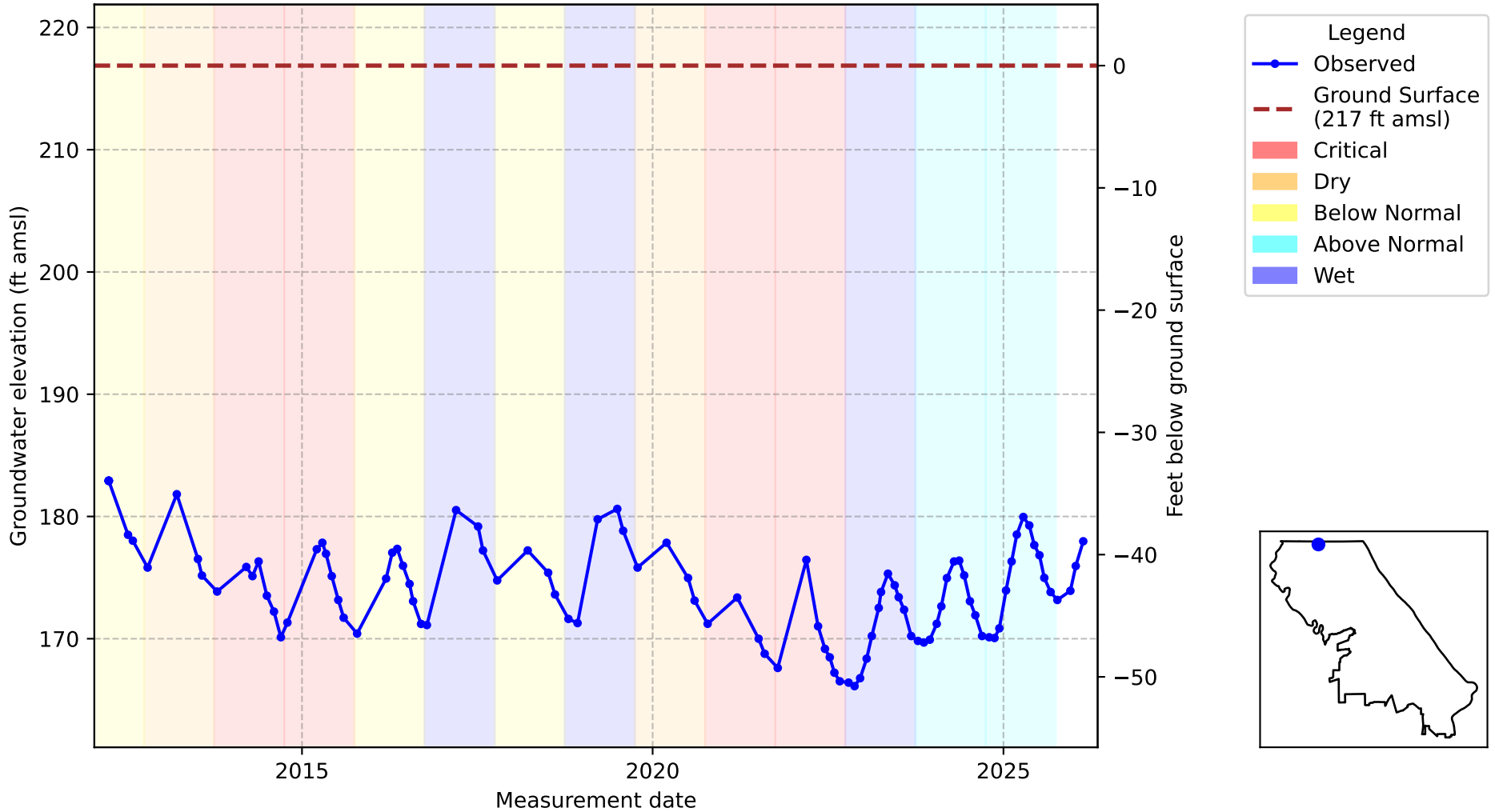
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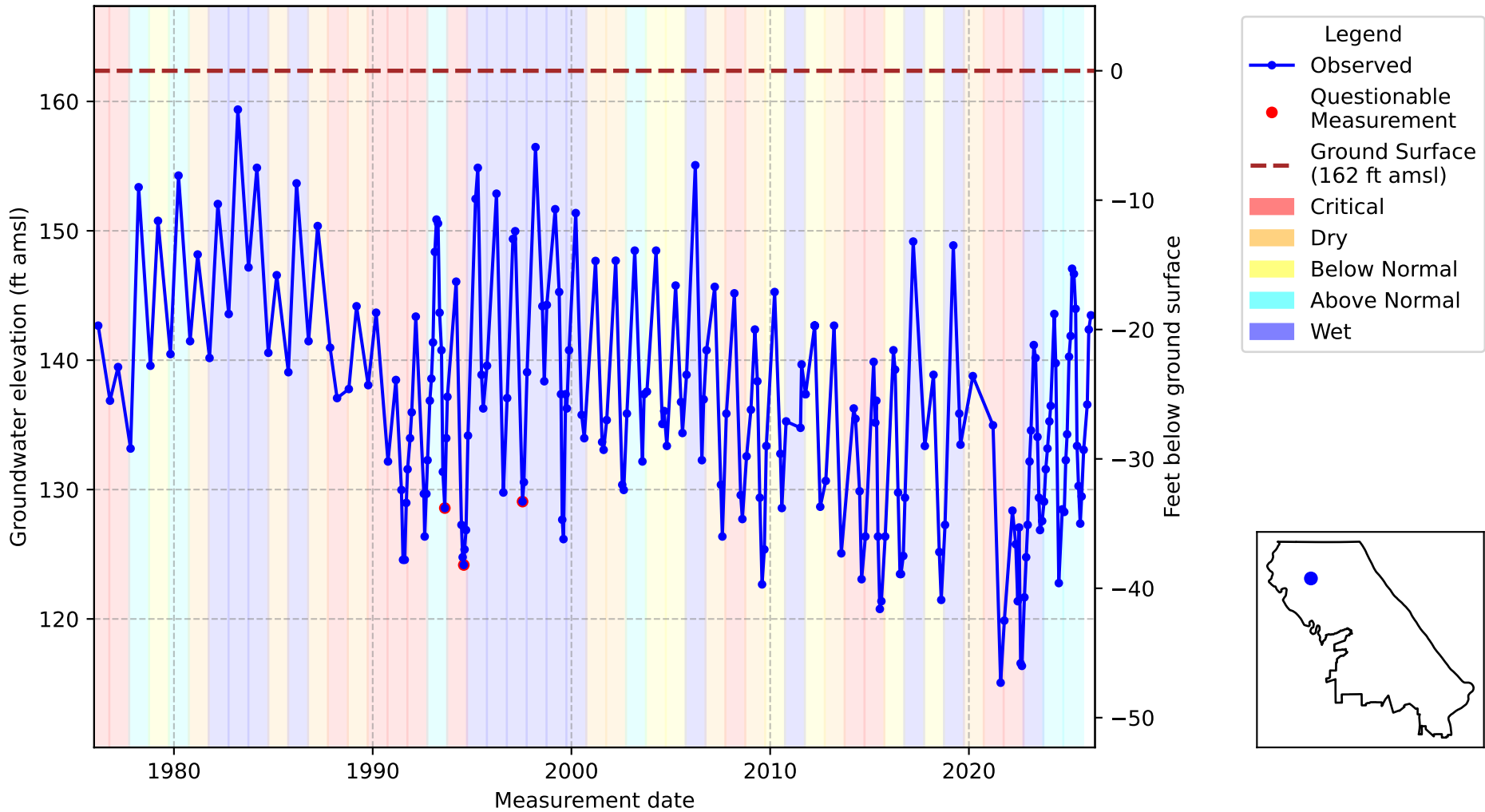
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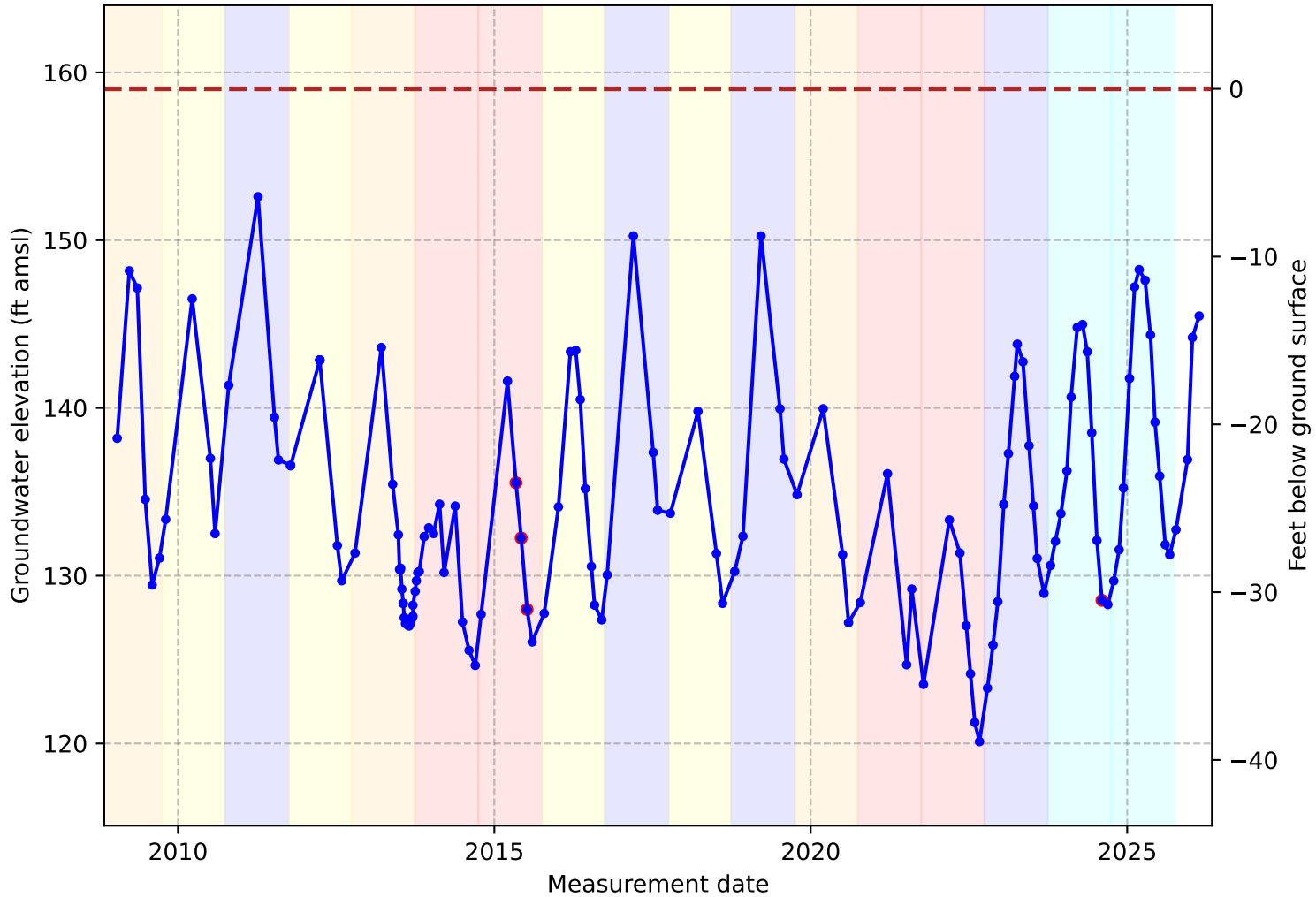
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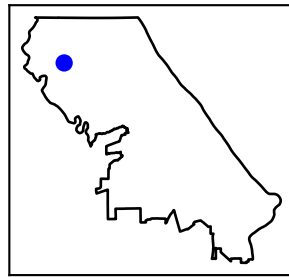


Vina Subbasin - North
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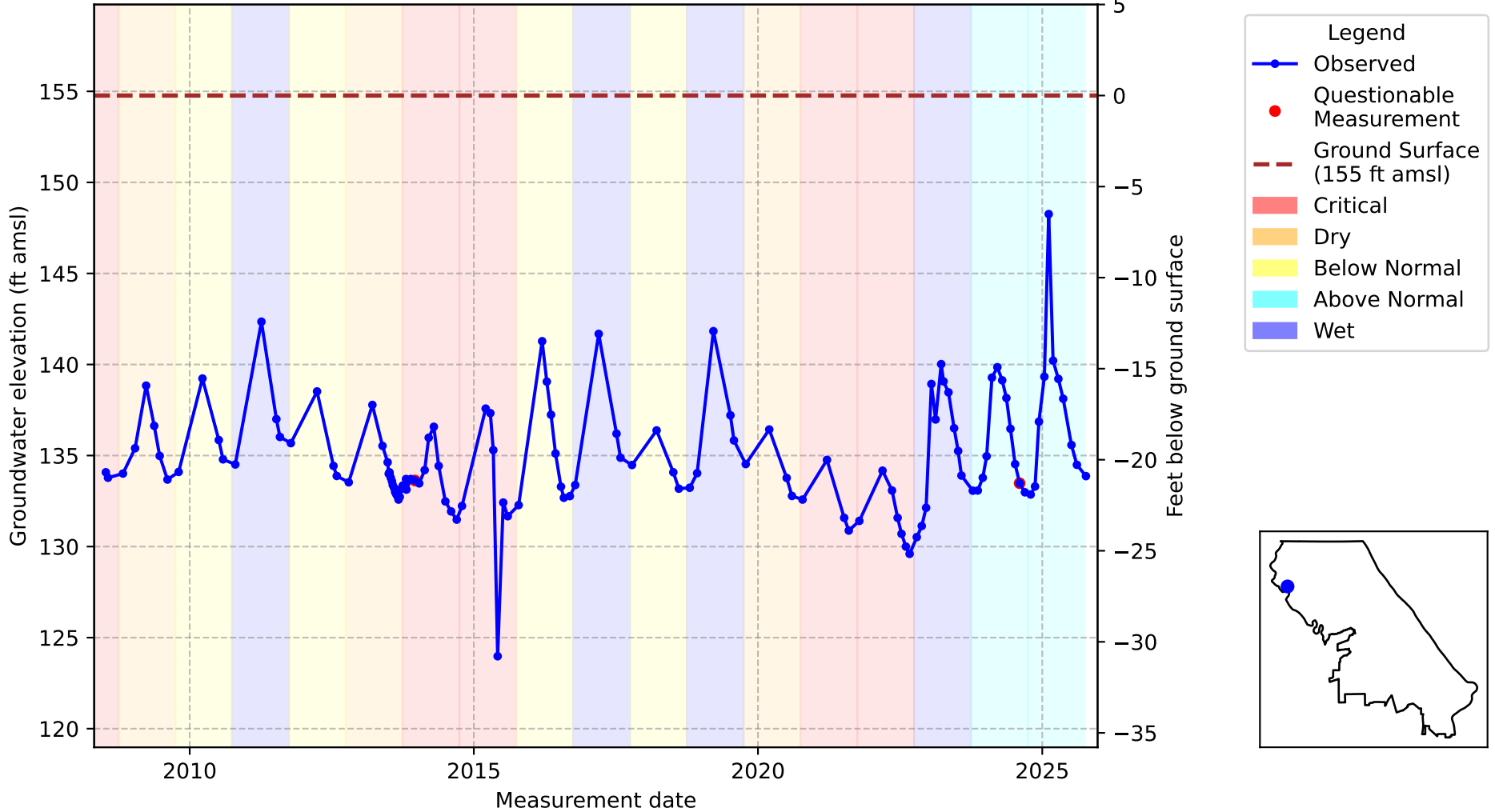


Legend

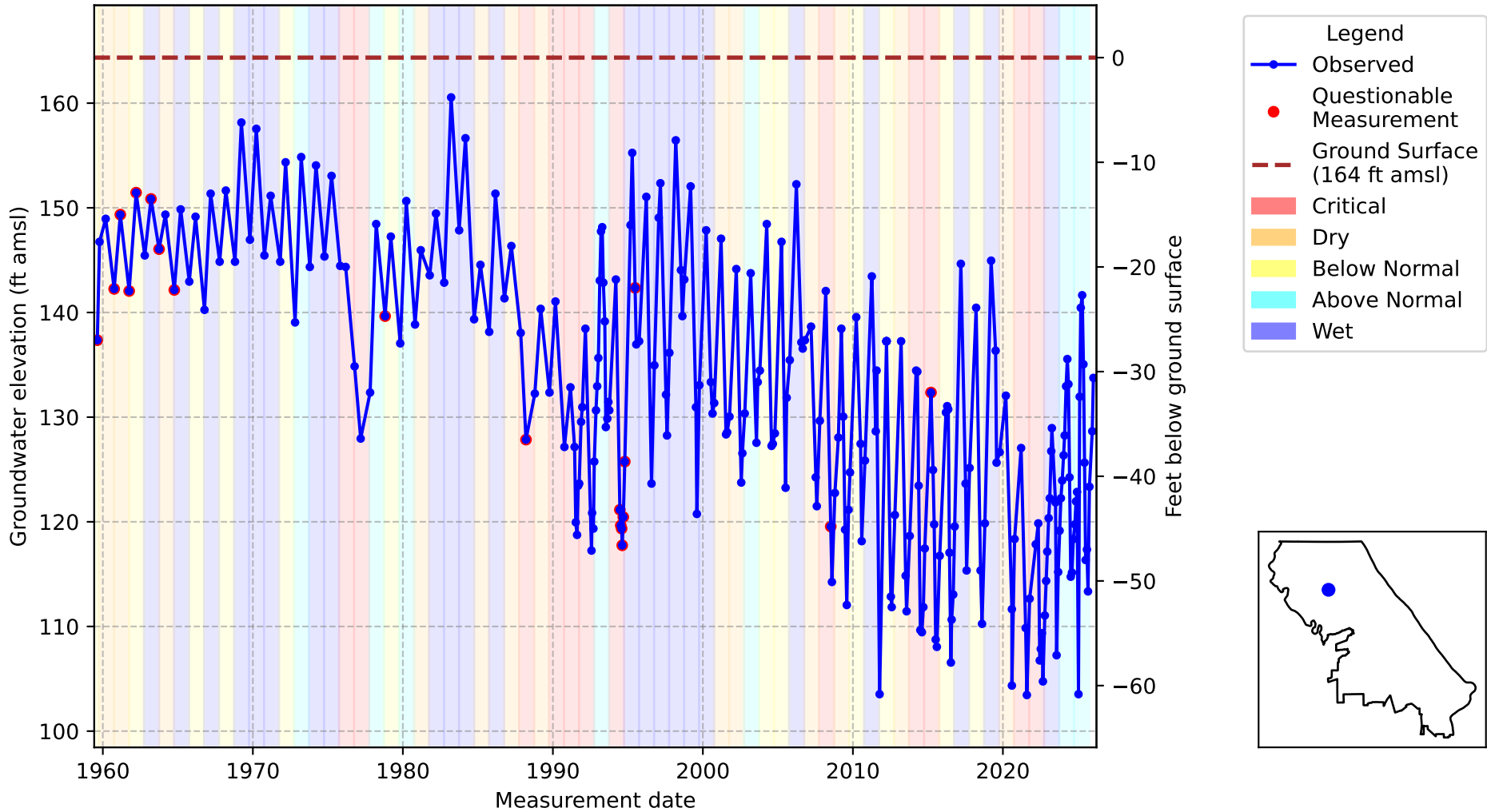
- Observed
- Questionable Measurement
- Ground Surface (159 ft amsl)
- Critical
- Dry
- Below Normal
- Above Normal
- Wet



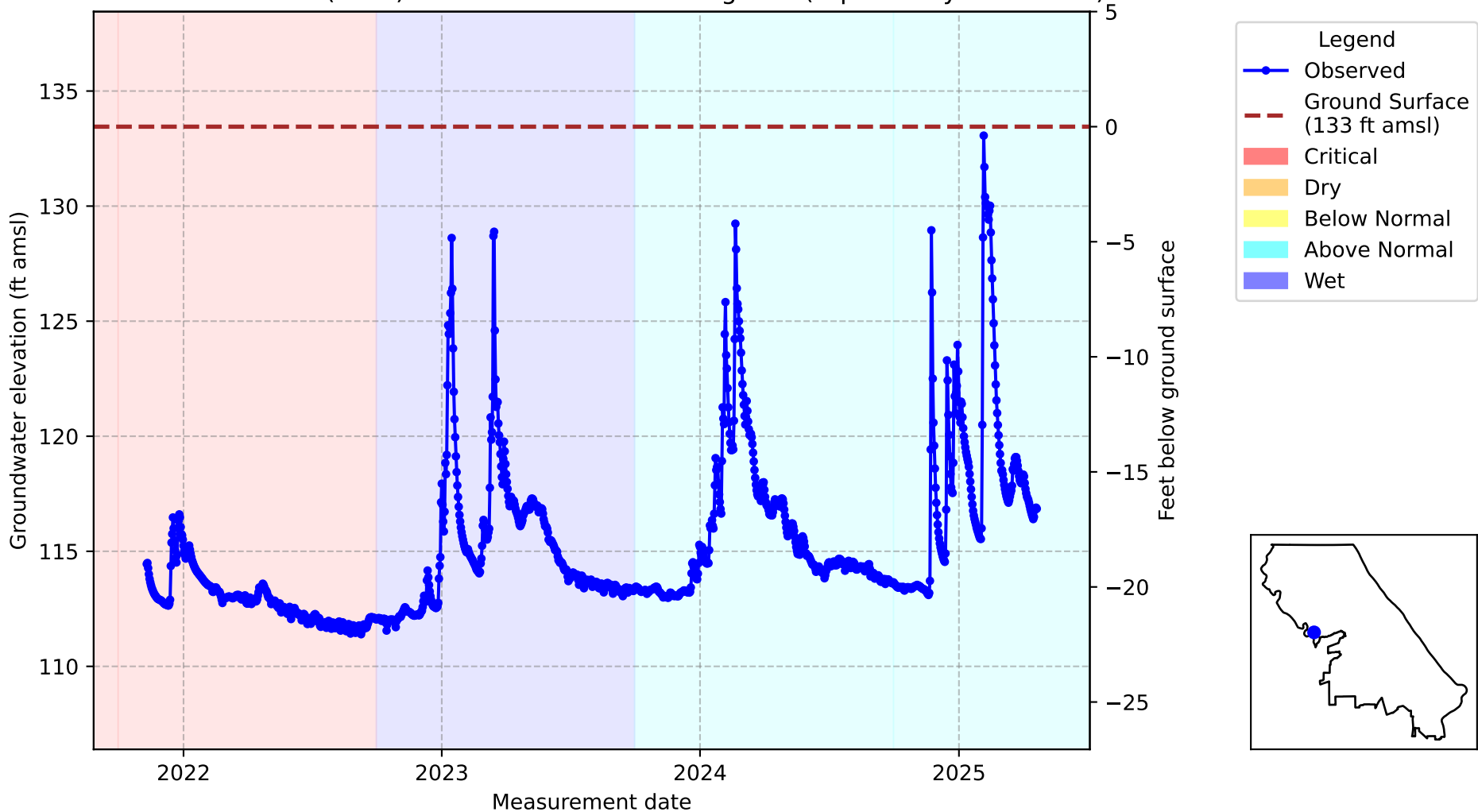
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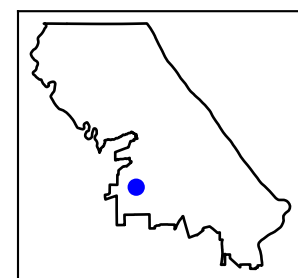
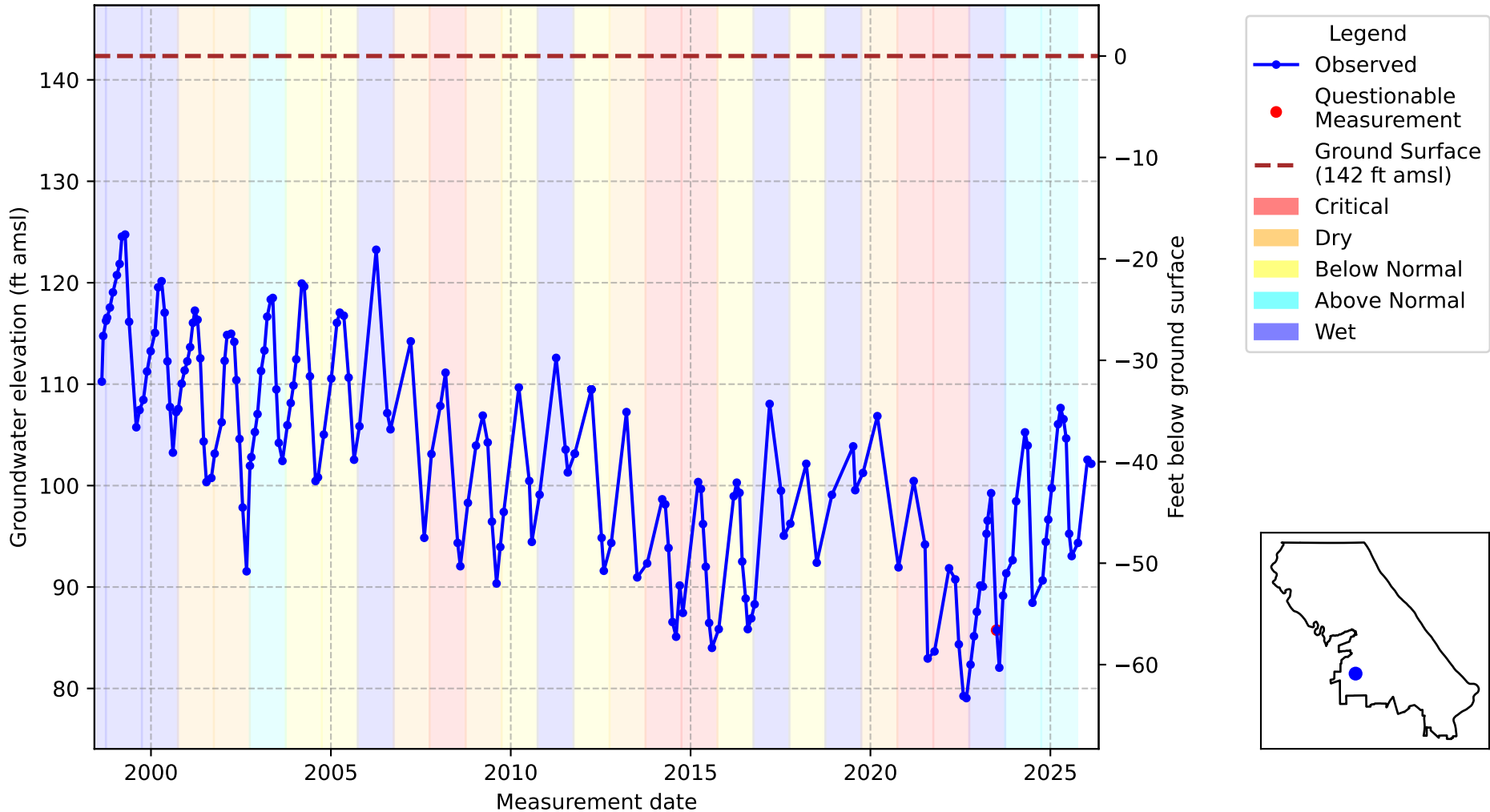
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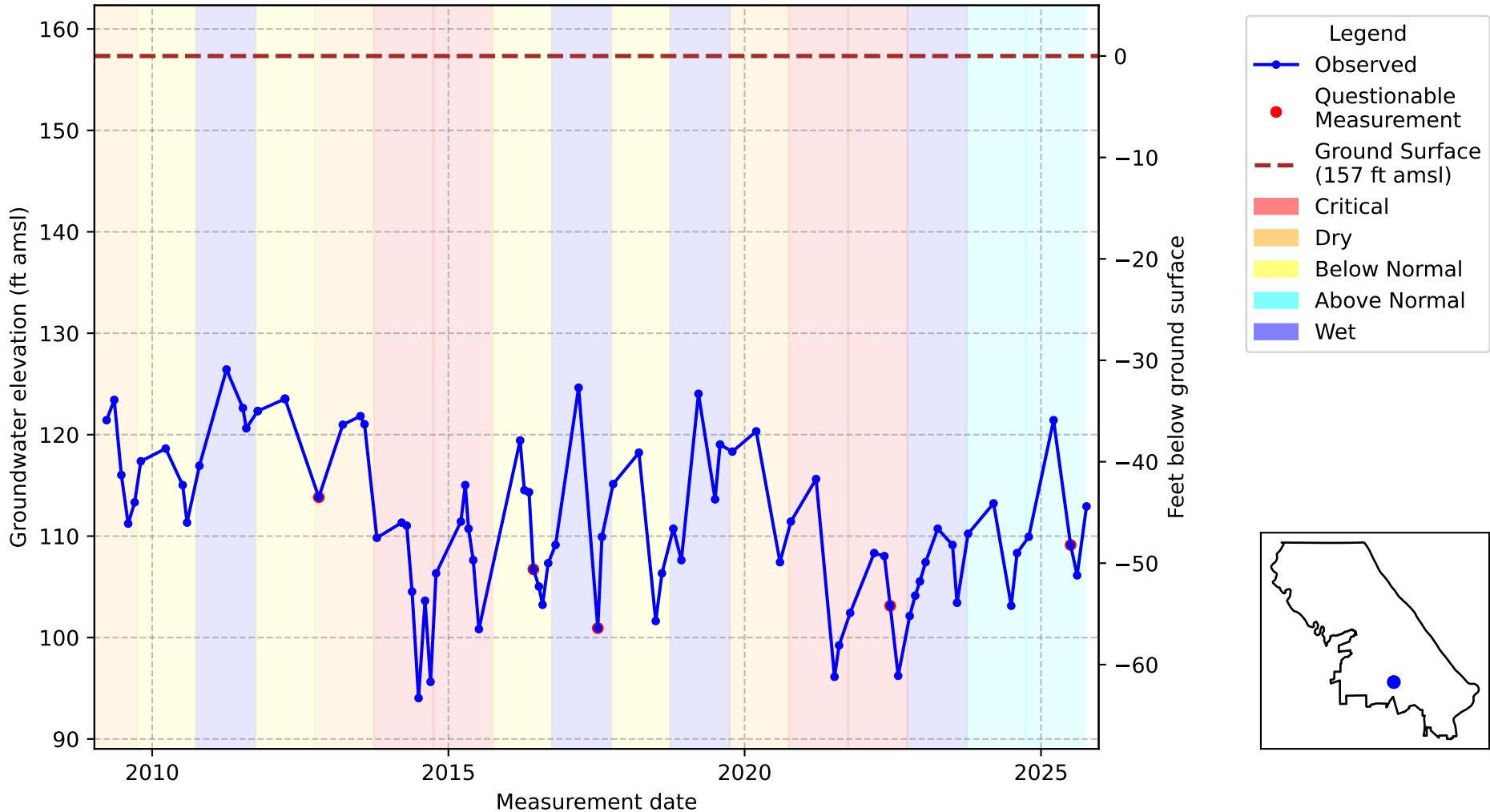
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State Well Number (SWN): TNC Nicolaus monitoring well (Aquifer Layer: shallow)



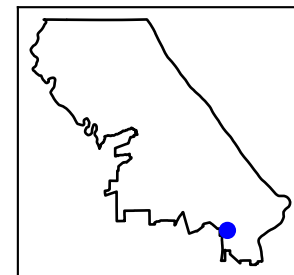
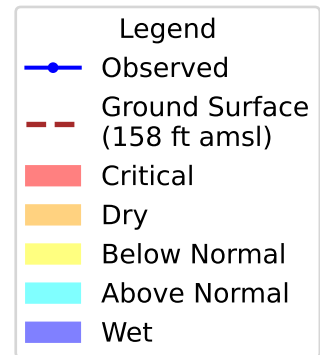
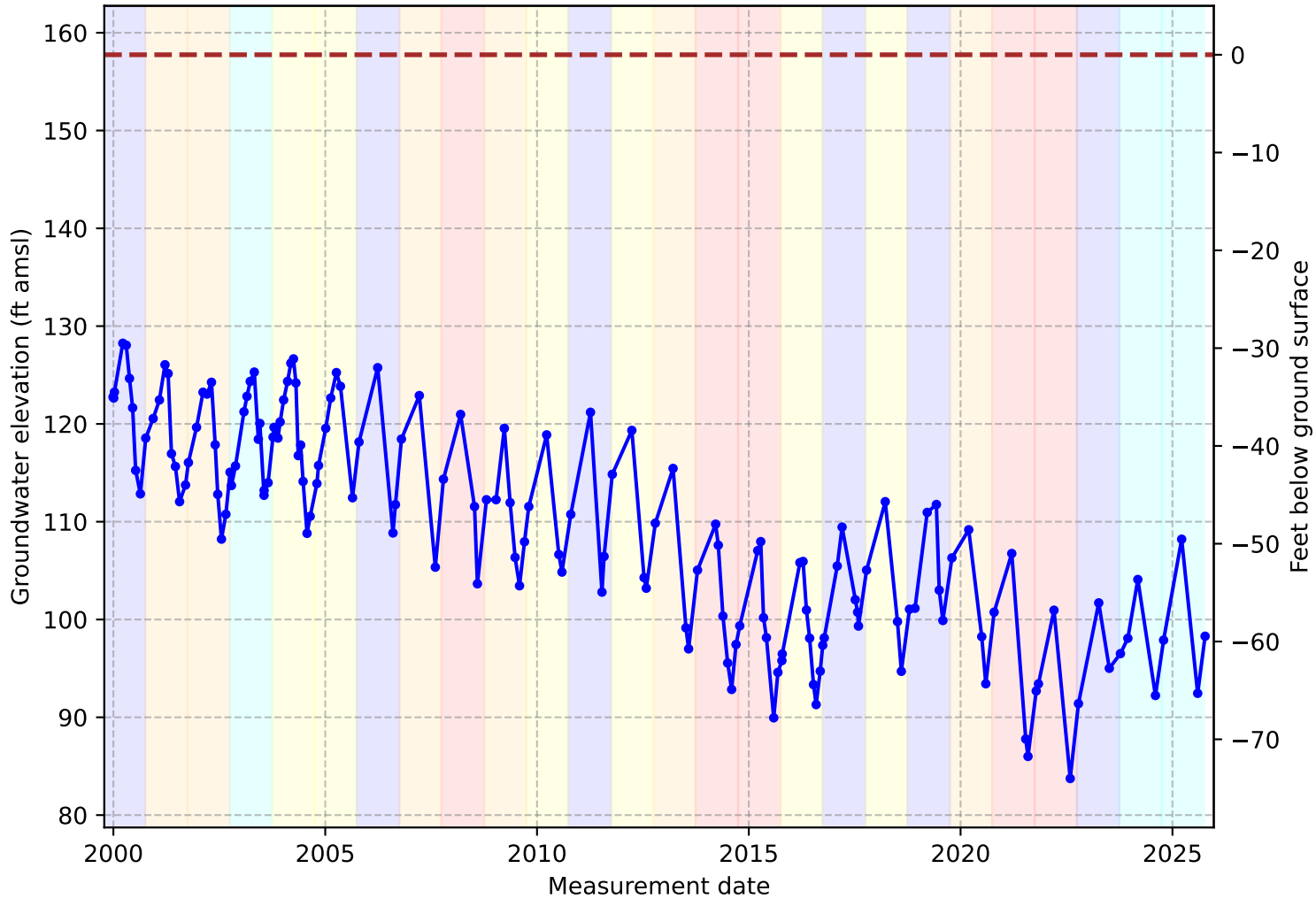
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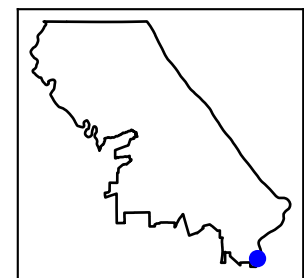
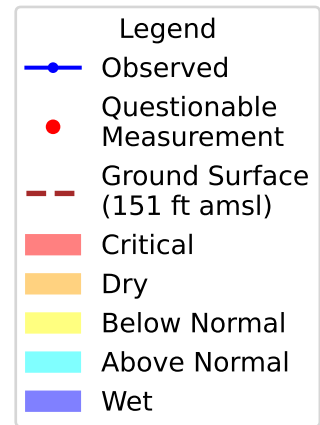
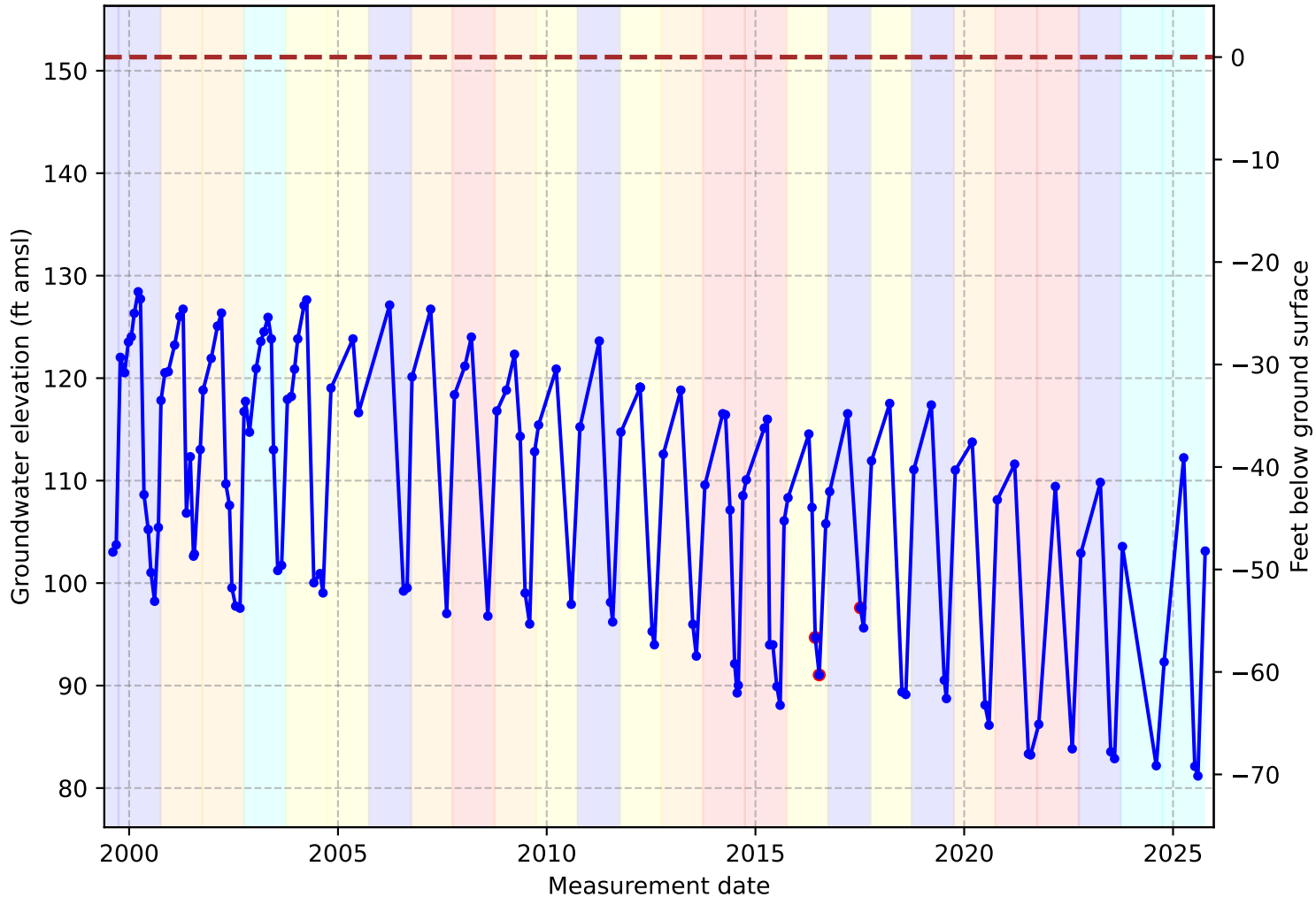
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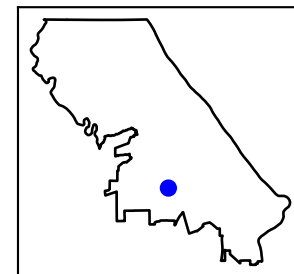
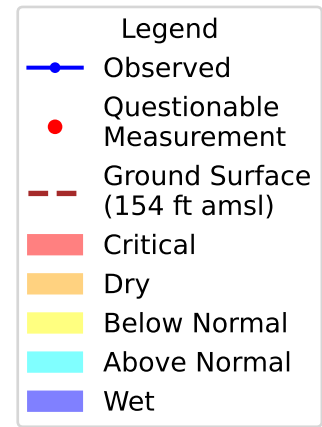
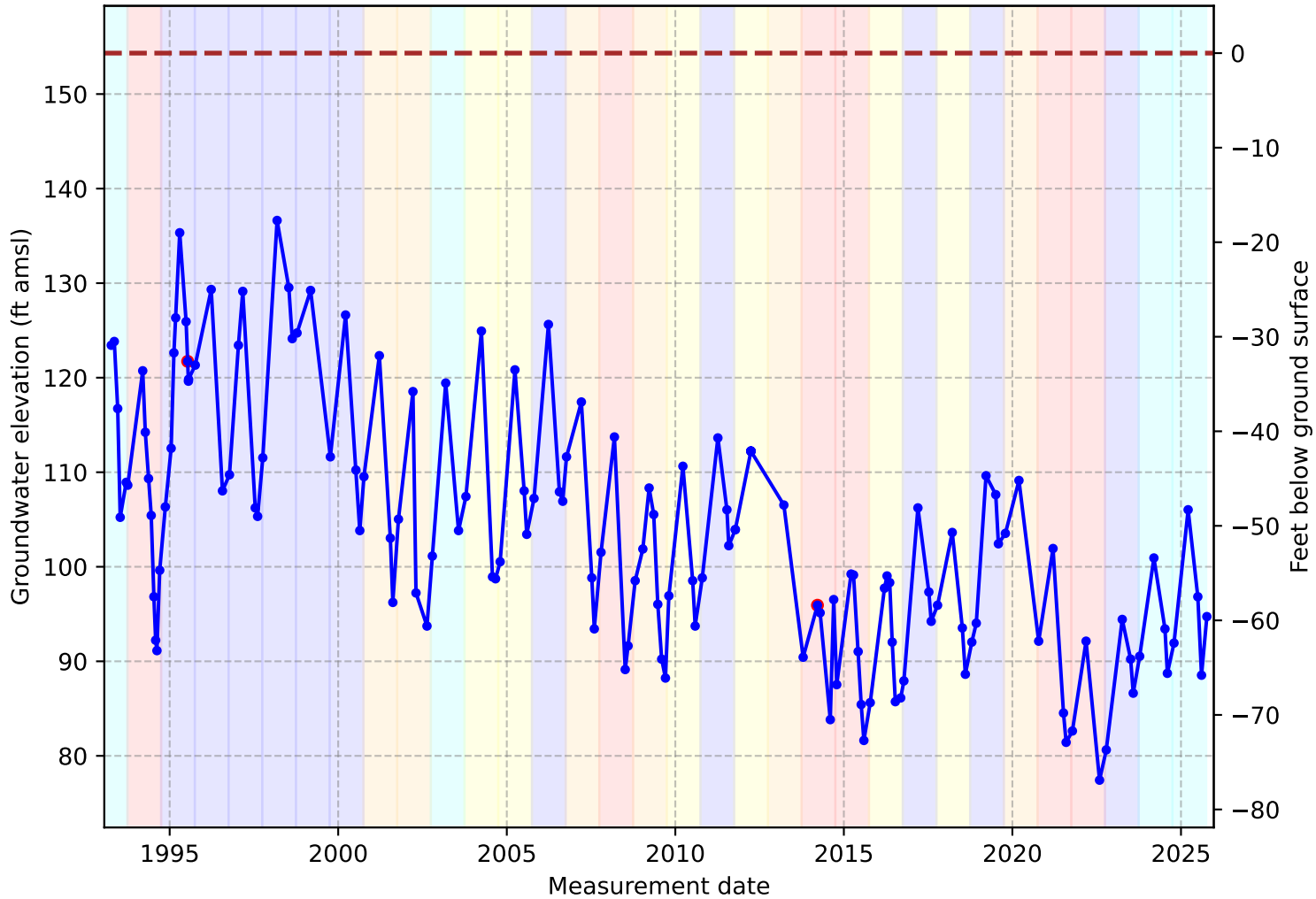
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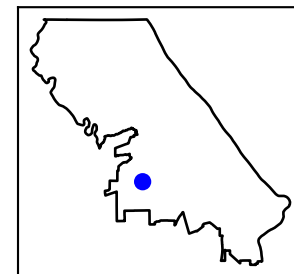
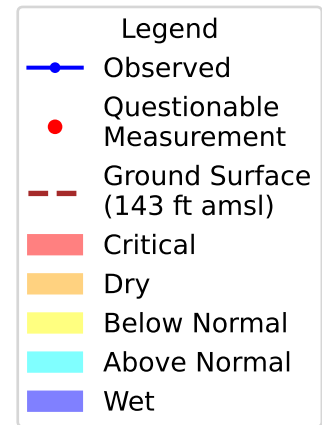
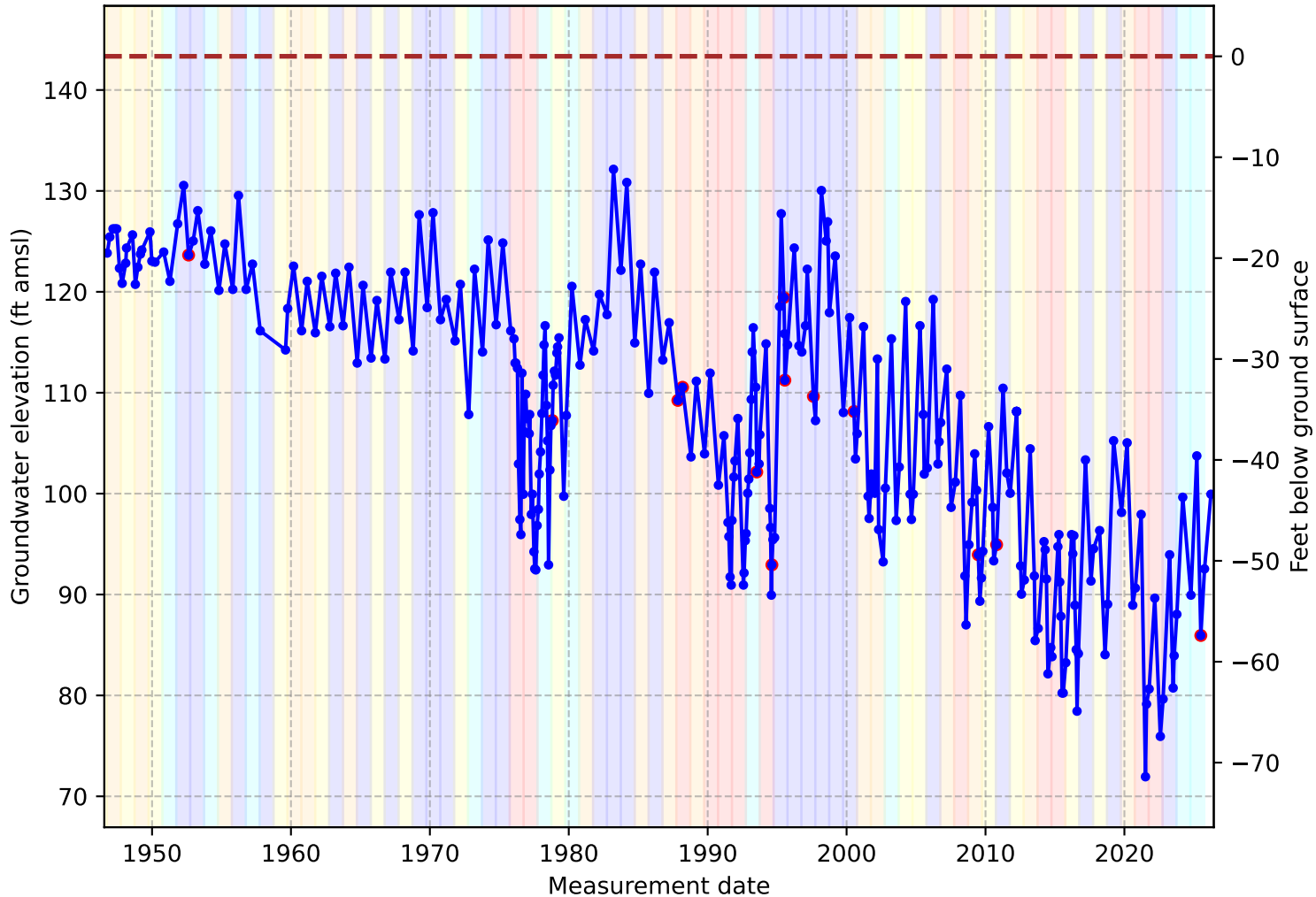
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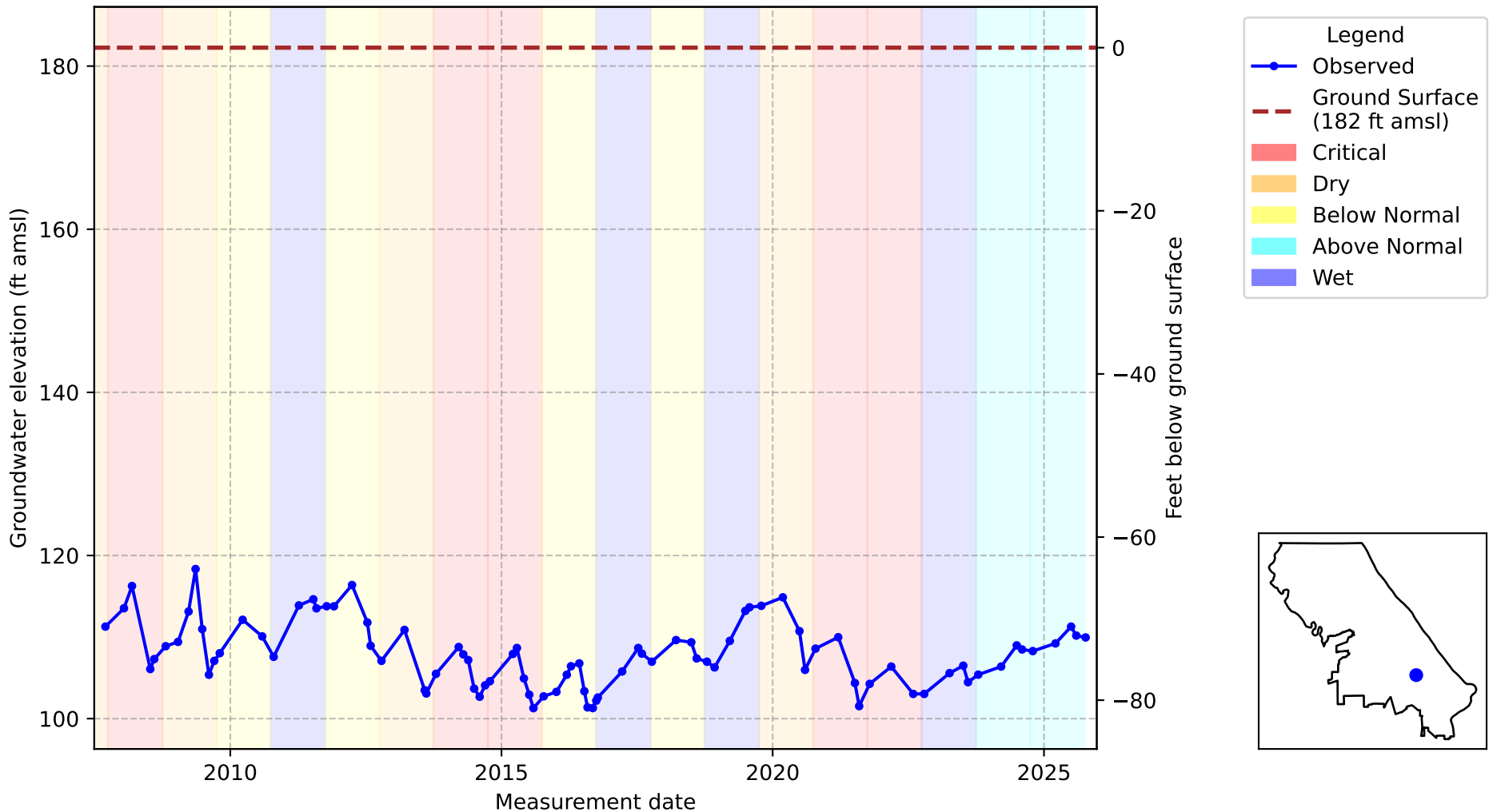
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State Well Number (SWN): 21N01E25K001M (Aquifer Layer: shallow)



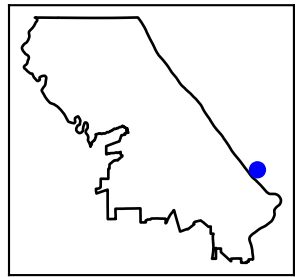
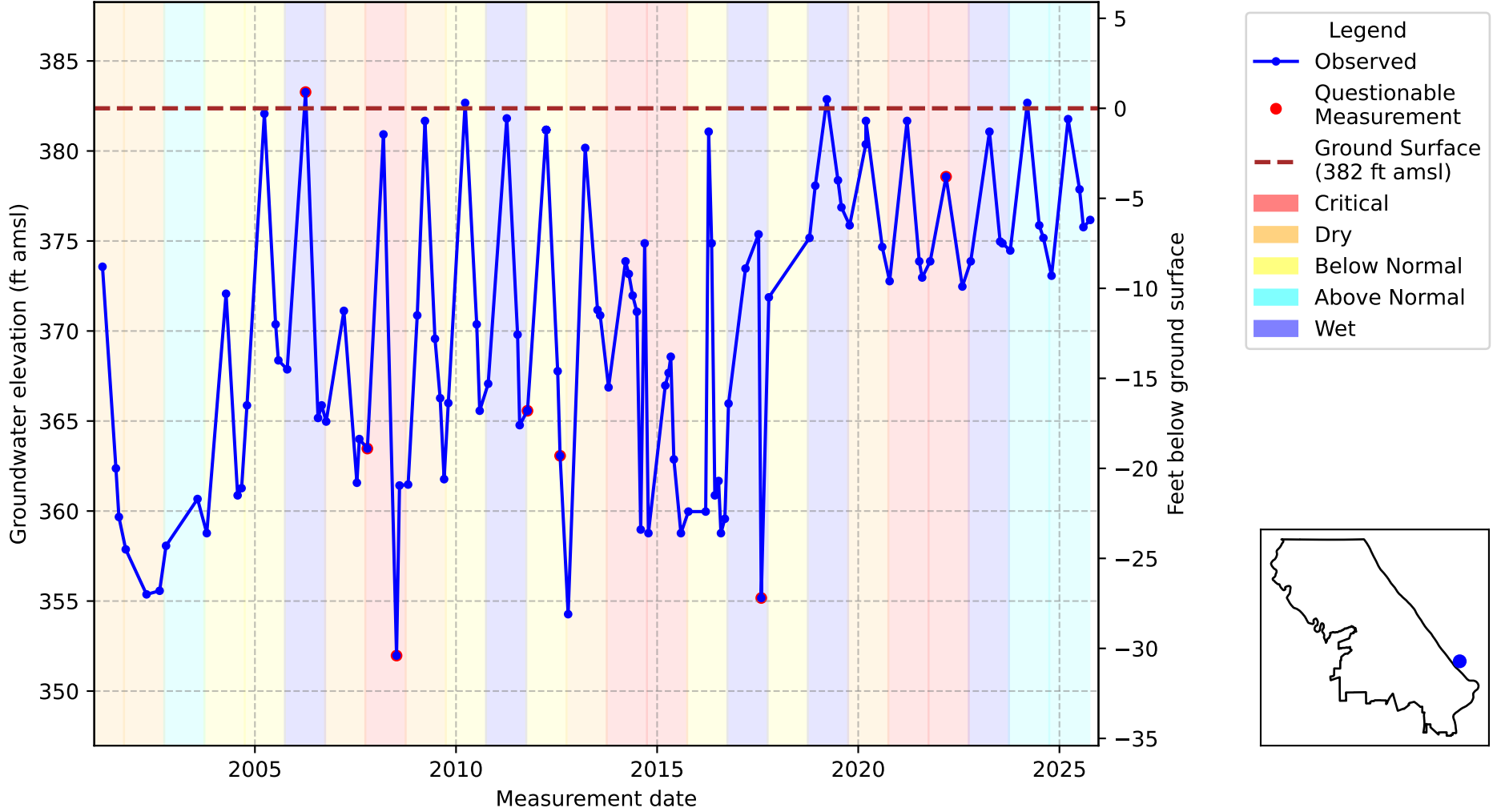
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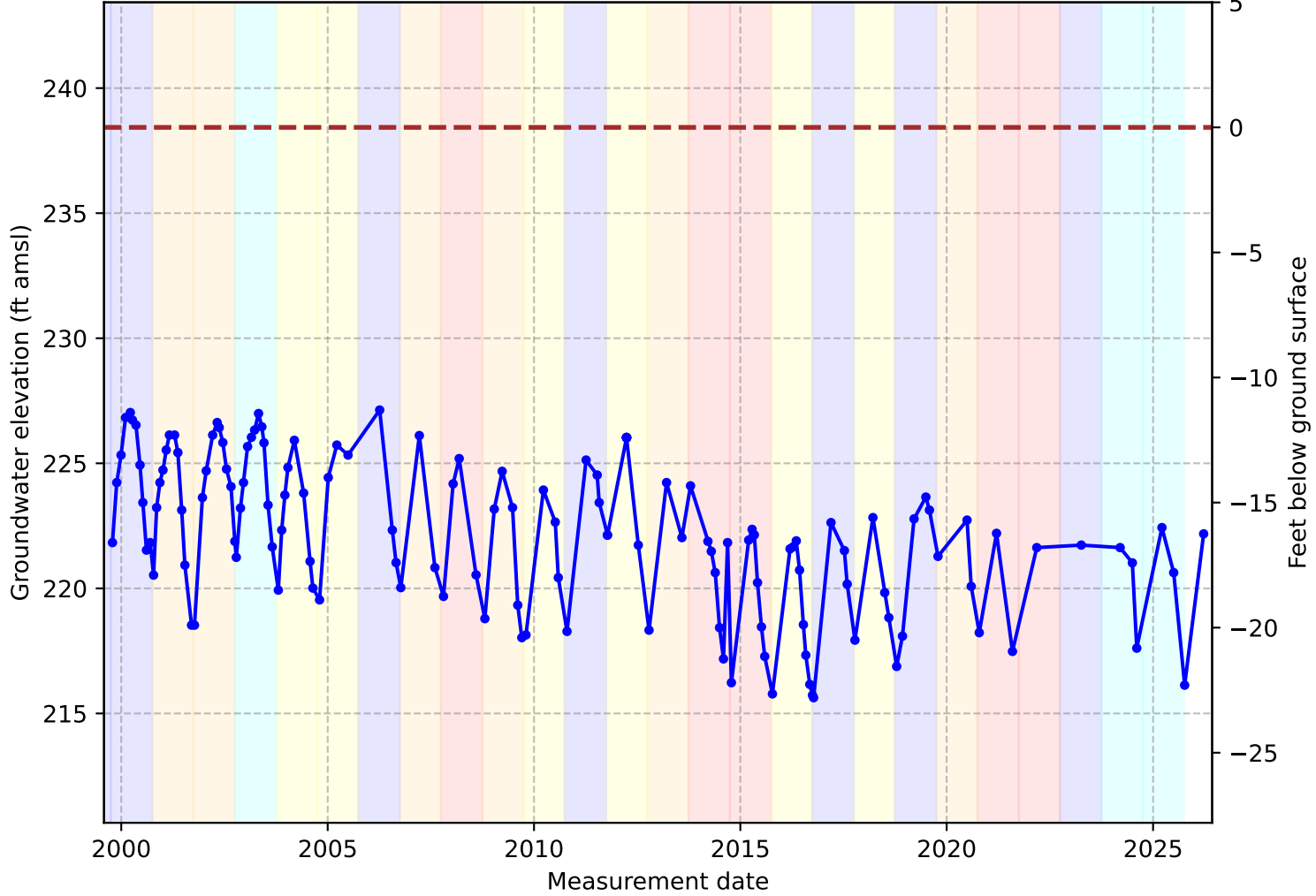
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Vina Subbasin - South
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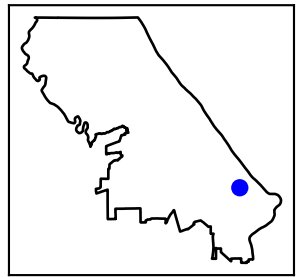


Vina Subbasin - South
State Well Number (SWN): 21N03E32B001M (Aquifer Layer: shallow)



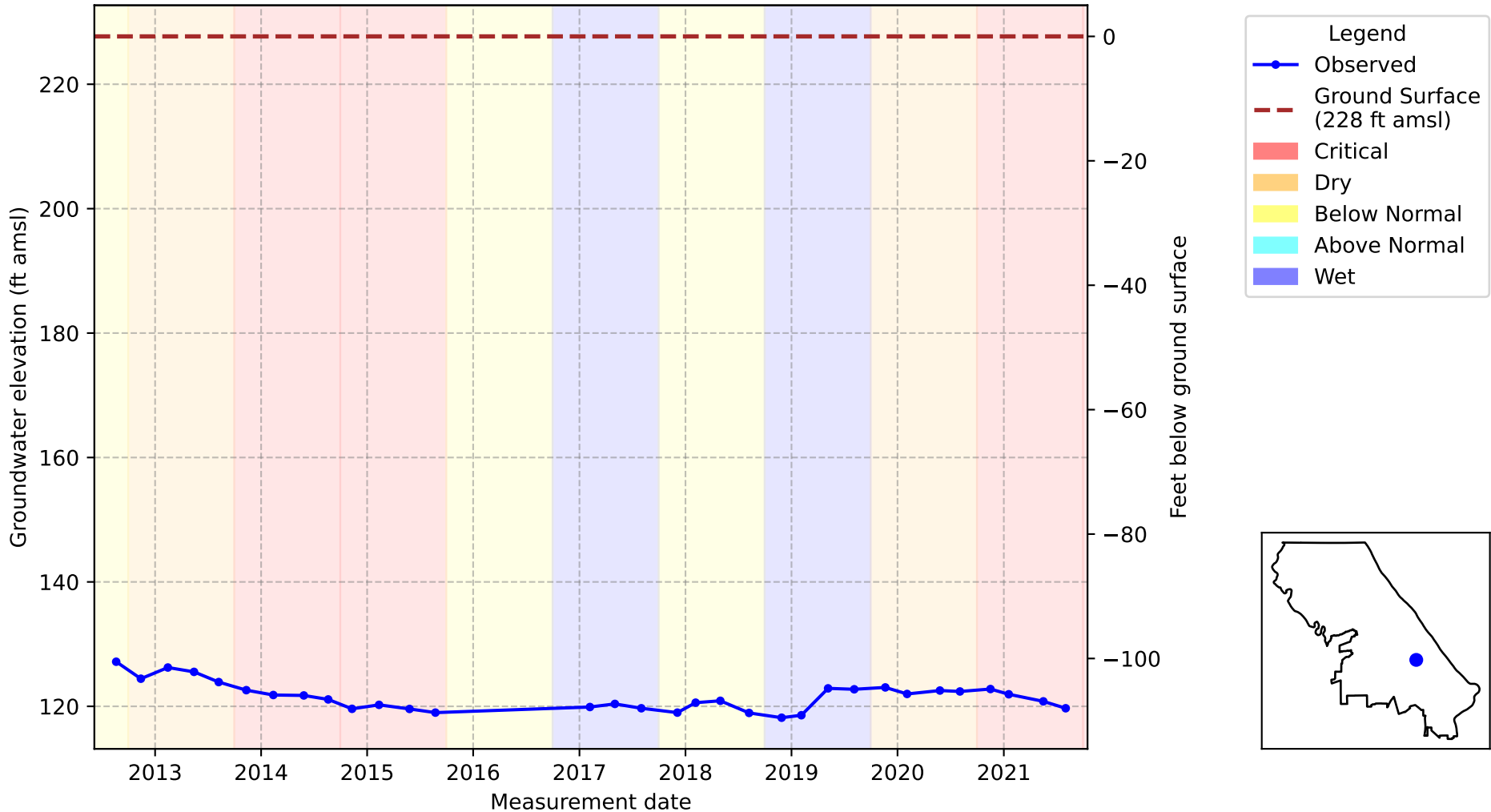
Legend

- Observed
- Ground Surface (238 ft amsl)
- Critical
- Dry
- Below Normal
- Above Normal
- Wet



Vina Subbasin - South

State Well Number (SWN): Neal Rd Landfill MW-6 (Aquifer Layer: shallow)



Appendix C

Surveyed Transects Across Streams in the Wyandotte Creek Subbasin

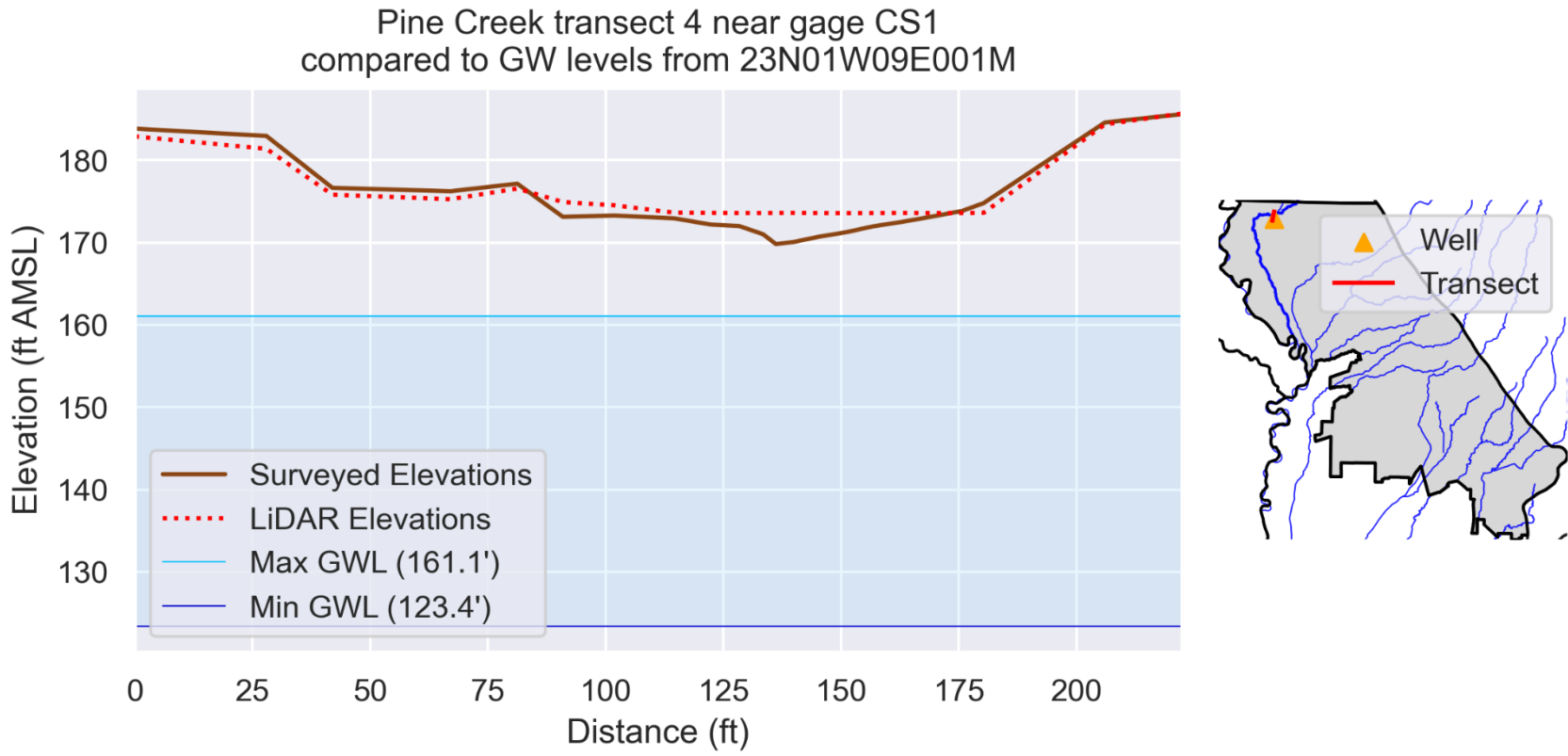


Figure C- 1: Transect Comparing Surveyed and LiDAR Extracted Elevations on Upper Reach of Pine Creek (distance from well to transect: 0.2 miles).

Butte Creek transect 4 near gage SG4
 compared to GW levels from 21N02E32E001M

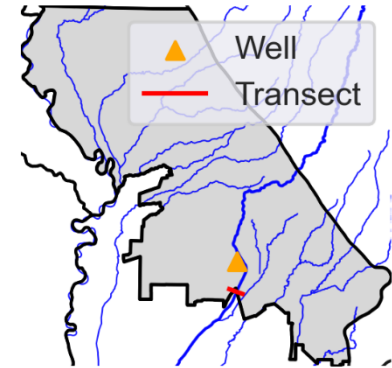
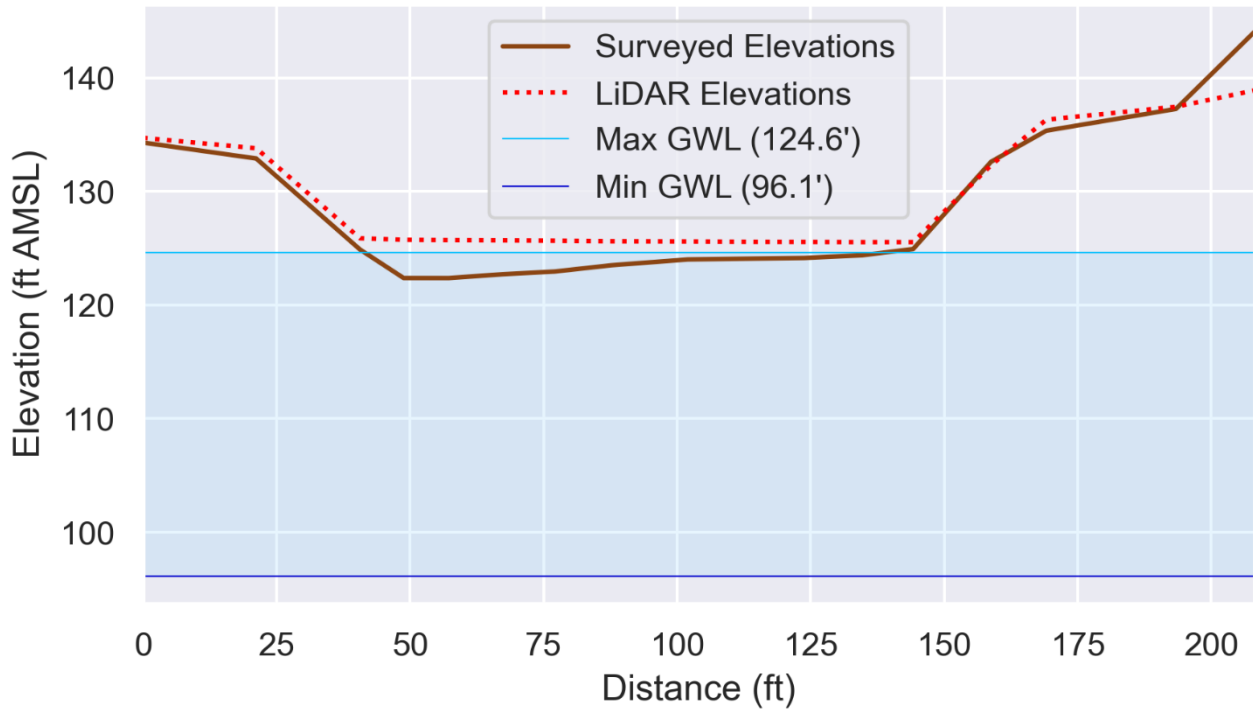


Figure C- 2: Transect Comparing Surveyed and LiDAR Extracted Elevations on Lower Reach of Butte Creek (distance from well to transect: 2.0 miles).

Mud Creek transect 1B near gage CS4 compared to GW levels from TNC Well

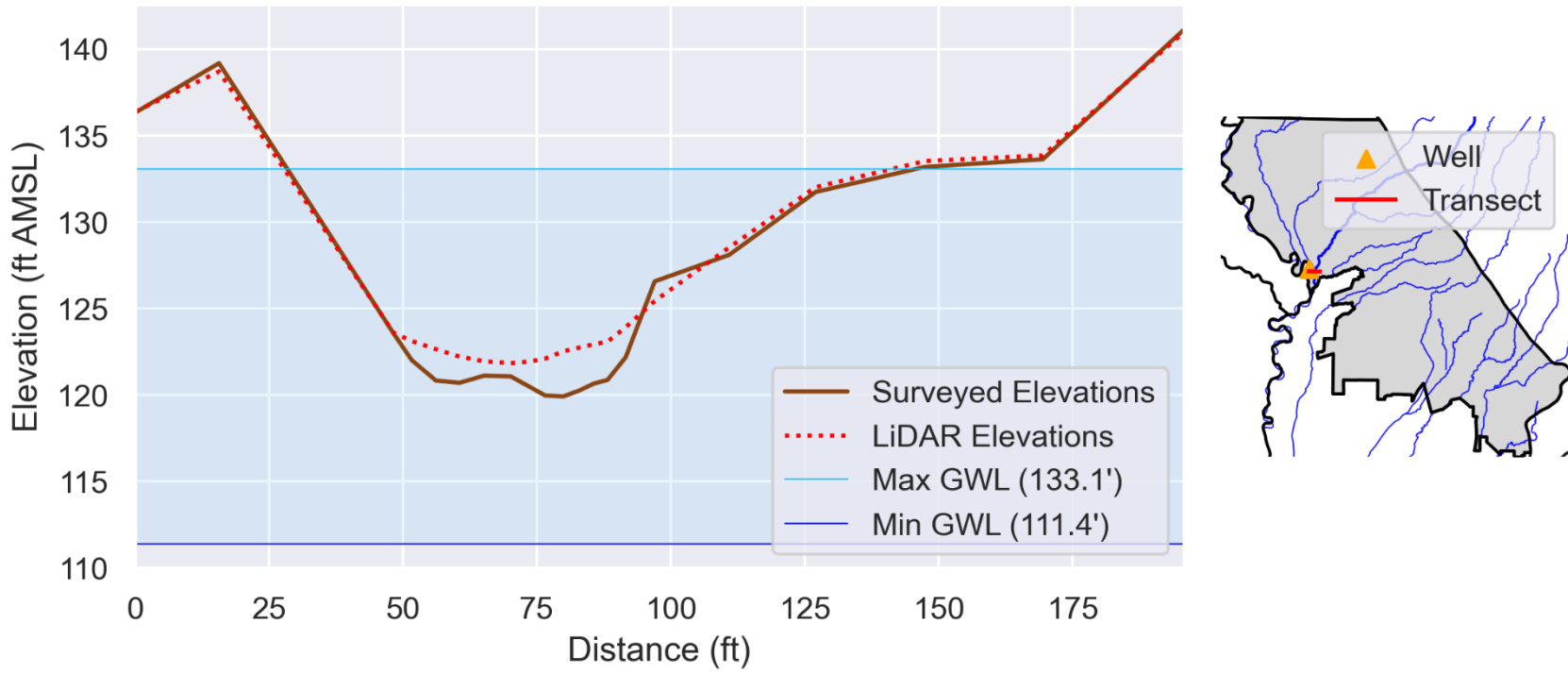


Figure C- 3: Transect Comparing Surveyed and LiDAR Extracted Elevations on Lower Reach of Mud Creek (distance from well to transect: 0.38 miles).

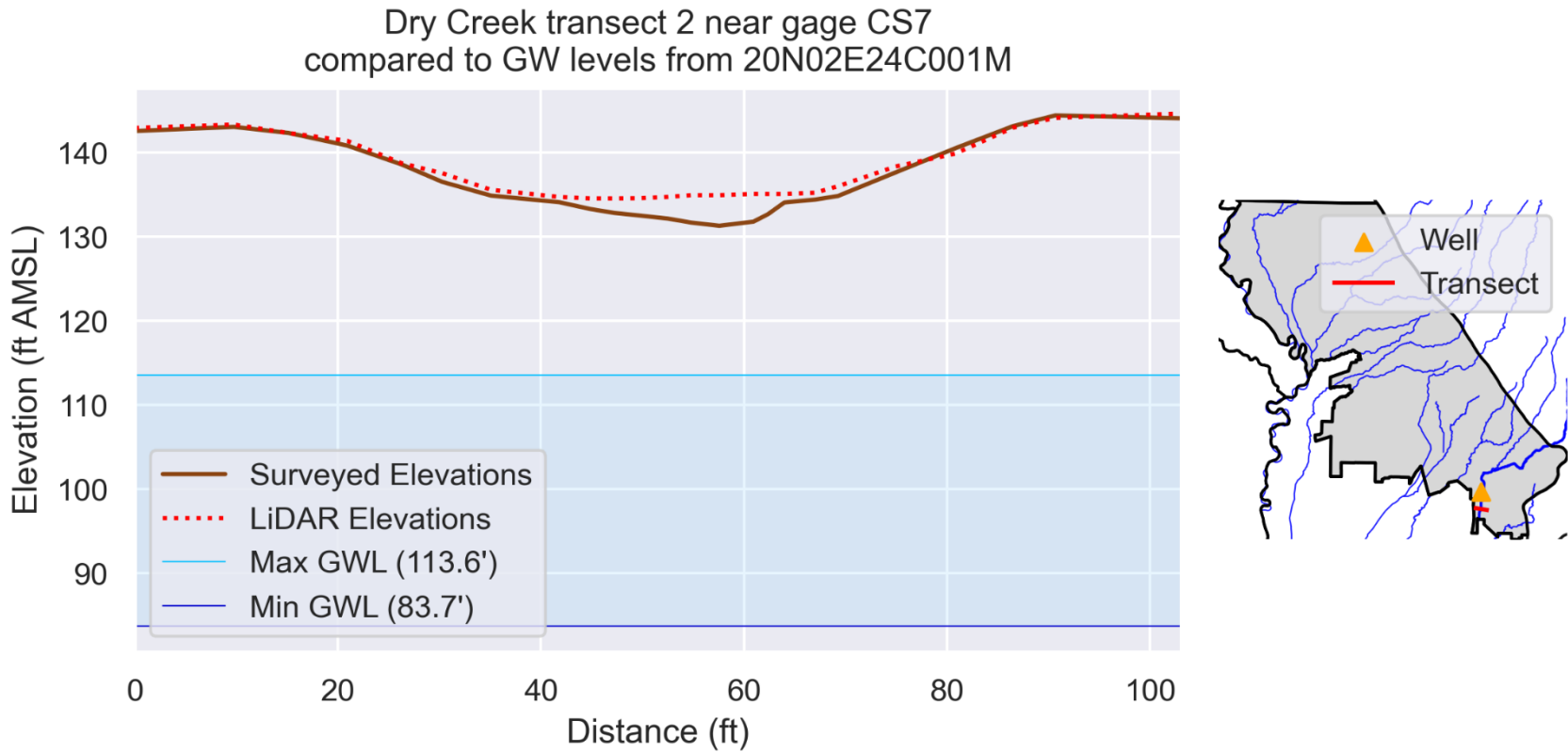


Figure C- 4: Transect Comparing Surveyed and LiDAR Extracted Elevations on Dry Creek (distance from well to transect: 1.3 miles).

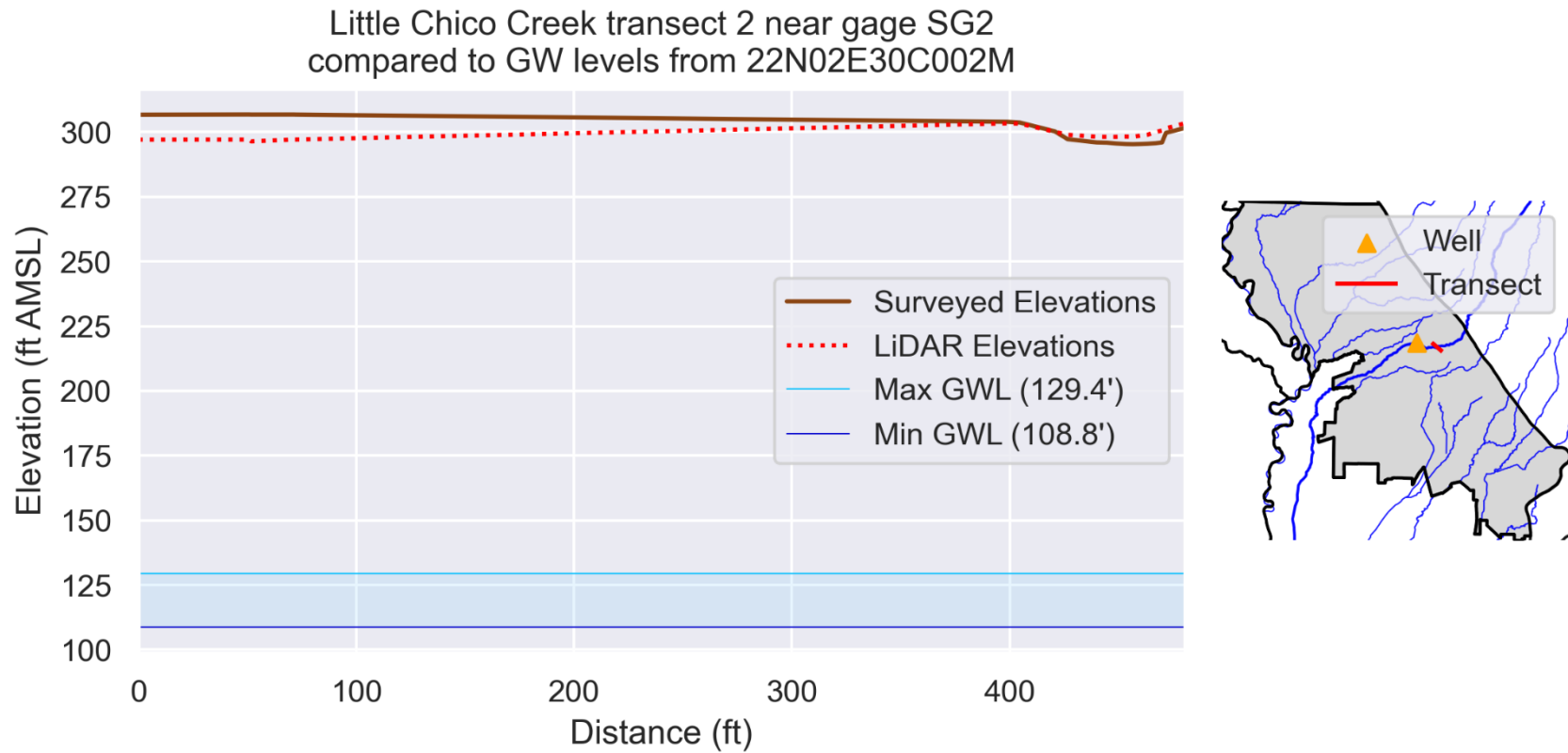


Figure C- 5: Transect Comparing Surveyed and LiDAR Extracted Elevations on Little Chico Creek (distance from well to transect: 1.8 miles).

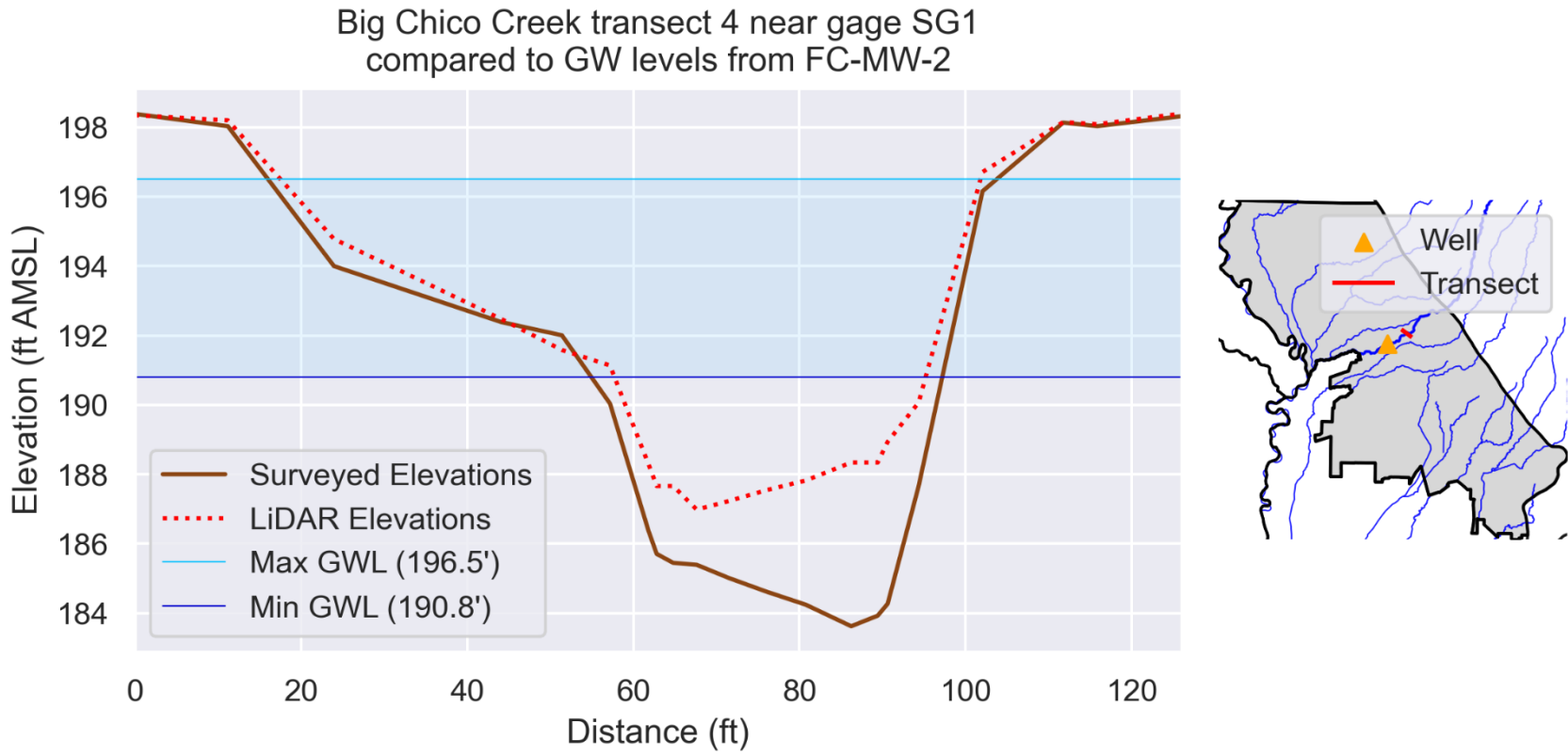


Figure C- 6: Transect Comparing Surveyed and LiDAR Extracted Elevations on Big Chico Creek (distance from well to transect: 1.8 miles).

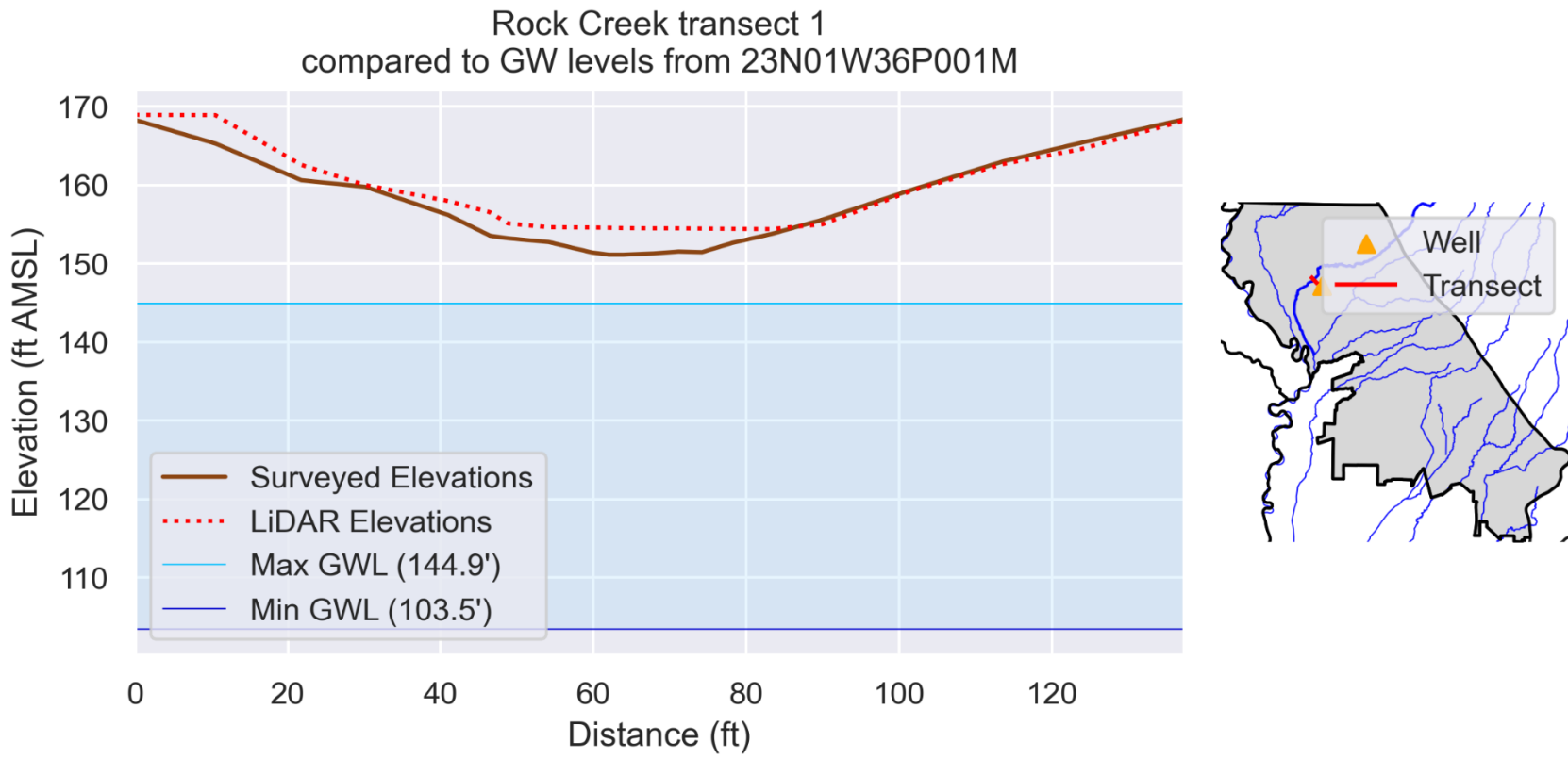


Figure C- 7: Transect Comparing Surveyed and LiDAR Extracted Elevations on Rock Creek (distance from well to transect: 0.7 miles).

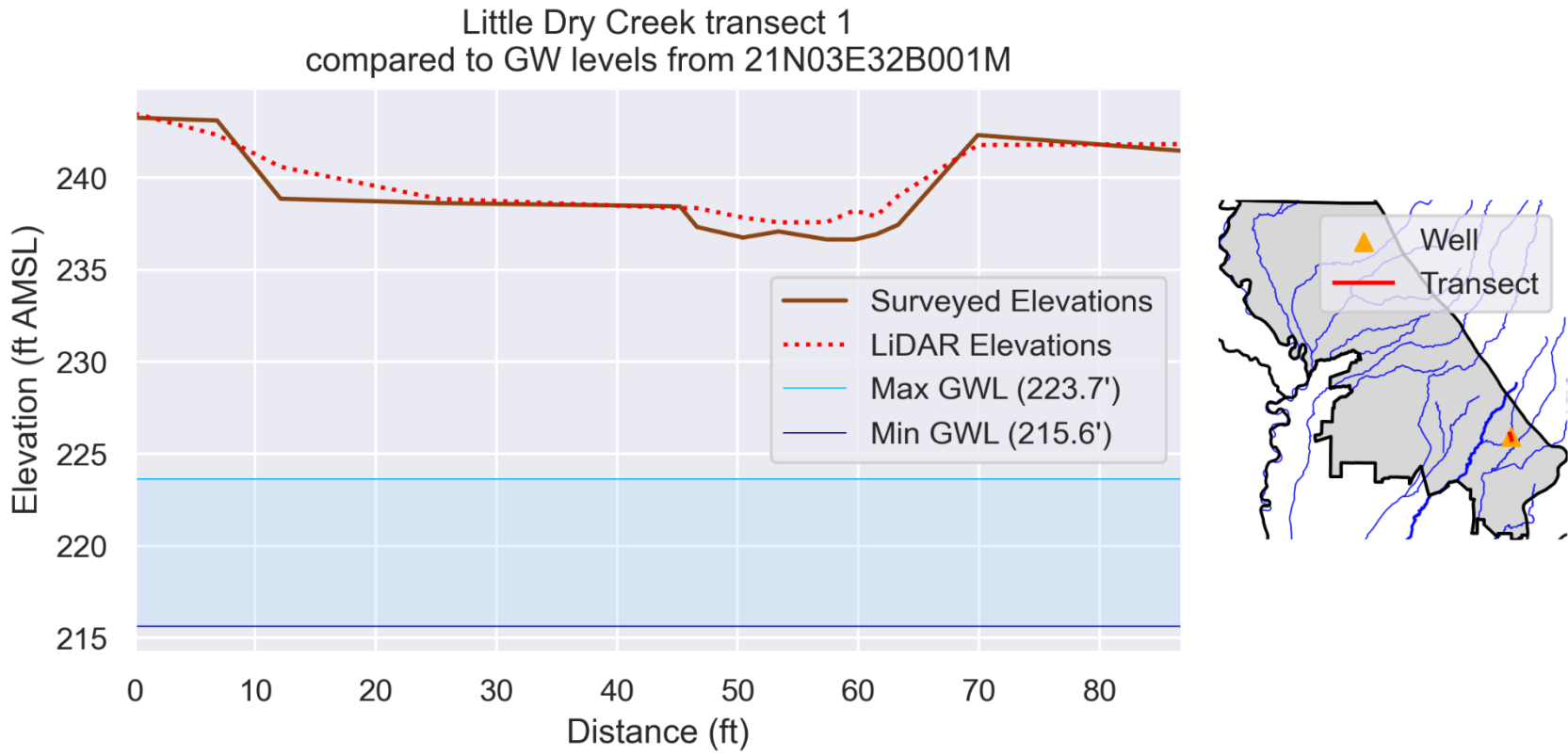


Figure C- 8: Transect Comparing Surveyed and LiDAR Extracted Elevations on Little Dry Creek (distance from well to transect: 0.01 miles).