3. Basin Setting

3.1 Hydrogeological Conceptual Model

A hydrogeological conceptual model (HCM) is a description of the physical system within a basin, including (but not limited to) topography, geology and structure, three-dimensional geometry of water-bearing units (aquifers) and aquitards, land and water use, hydrology, and groundwater quality. The HCM provides a framework for understanding the interrelationships among these components and their influence on occurrence and movement of groundwater. The HCM can be used to develop numerical models and water budgets and to help inform decision making with respect to selection of sustainable management criteria, monitoring networks, and potential management actions. An HCM should be periodically reviewed and revised as new data become available. The following sections describe the HCM of the Anderson Subbasin.

The Anderson Subbasin (5-006.03) is one of five groundwater subbasins within the RAGB of Northern California (Figure 2-1). The roughly east-west-oriented subbasin is approximately 5 to 15 miles long and 18 miles wide. The Sacramento River forms the northeastern boundary of the subbasin, the Klamath Mountains form the north/northwestern boundary, the Coast Ranges form the west/southwestern boundary, and Cottonwood Creek forms the southern boundary (DWR, 1968; DWR, 2004).

3.1.1 Topography

Figure 3-1 presents the topography of the Anderson Subbasin. The data presented on Figure 3-1 represent topographic data from a number of sources that were compiled into a single dataset. These data sources include the following:

- USGS 1/3-arcsecond (approximately 30-foot) digital elevation model data (USGS, 2019b)
- Light detection and ranging (Lidar) data collected as part of a Federal Emergency Management Agency study of the Cow Creek drainage area; 2-foot resolution (USGS, 2018)
- High-resolution (3-foot) Lidar data collected as part of a collaborative effort between COR and Shasta County (COR, 2019b)

Ground surface elevations across the Anderson Subbasin vary by as much as 750 feet as the foothills of the Klamath Mountains in the north/northwest and the Coast Ranges to the west/southwest descend to the trough of the Sacramento Valley in the southeast. The maximum ground surface elevation in the Anderson Subbasin, nearly 1,100 feet above the North American Vertical Datum of 1988 (NAVD88), is in the foothills of the Klamath Mountains to the north/northwest. Where the foothills of the Klamath Mountains and Coast Ranges have been deeply incised by Clear Creek, there is local relief in excess of 100 feet at high grades. Topographic relief generally decreases toward the Sacramento River, with a minimum ground surface elevation of approximately 350 feet NAVD88 in the southeasternmost portion of the Anderson Subbasin.

3.1.2 Climate

3.1.2.1 Precipitation

Figure 3-2 presents an isohyetal map of 1981–2010 mean annual precipitation for the Anderson Subbasin (PRISM Climate Group, 2012), showing that precipitation varies along a primarily northwest-southeast trend in the Anderson Subbasin. Based on these 30-year averages from Parameter-elevation Regressions on Independent Slopes Model (PRISM) datasets, the foothills of the Klamath Mountains on the north/northwestern periphery of the subbasin receive a mean annual precipitation of approximately 44 inches, and portions of the valley floor to the south receives approximately 26 inches per year (Figure 3-2). Mean annual precipitation is greater outside the Anderson Subbasin in the mountains to the north and west. The Redding area receives about 84 percent of its precipitation in the autumn and winter, with only about 16 percent falling in the spring and summer (UCC, 2019a; Station USR0000CREA).

Figure 3-3 presents a chart of water year type based on the Sacramento Valley Water Index[1] (an accounting of the volume and timing of unimpaired runoff at specific stream gauges in the Sacramento, Feather, Yuba, and American Rivers) (DWR, 2020a). The water year index is computed as follows:

Sacramento Valley Water Year Index = 0.4 * Current April-July Runoff Forecast (in million-acre feet [MAF]) + 0.3 * Current October-March Runoff (in MAF) + 0.3 * Previous Water Year's Index

If the previous water year's index exceeds 10, then a value of 10 is used for that component of the equation. The computed water year index is used to classify the water year as one of the following:

Year Type	Water Year Index
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8, and less than 9.2
Below Normal	Greater than 6.5, and equal to or less than 7.8
Dry	Greater than 5.4, and equal to or less than 6.5
Critical	Equal to or less than 5.4

The Redding area (included in the Sacramento Valley Water Year Index) had several notable wet years in the early 1980s and in the late 1990s, interspersed by several critical water years in the late 1980s and early 1990s. Prior to 1986, wet years were more frequent, and critical years were scarce. In the decades since 1986, precipitation has become more inconsistent, with periods of drought interrupted by one or a few very wet years. Furthermore, a recent increase in atmospheric river events is bringing more intense storms to California, with total annual precipitation falling in fewer total storms (Swain et al., 2018).

3.1.2.2 Temperature

Within the Anderson Subbasin, summers are hot and arid, and winters are cool and typically wet. Based on data from weather stations at Shasta Dam and Whiskeytown Reservoir, the average annual high temperature is approximately 73 degrees Fahrenheit (°F), ranging from a low of 53°F in January to a high of 96°F in July. The average annual low temperature is approximately 51°F, ranging from a low of 38° in January to a high of 66° in July (UCC, 2019b, 2019c; Stations USC00048135 and USC00049621).

3.1.2.3 Evapotranspiration

Reference evapotranspiration (ET_o) in the Anderson Subbasin has been calculated based on data collected at California Irrigation Management Information System (CIMIS) Station 224 at Shasta College between January 2013 and October 2019. The average annual ET_o measured over the period of record is 55 inches per year, or 4.6 feet per year. The ET_o values calculated from the CIMIS data indicate the amount of water that could be transpired from a reference crop, such as grass or alfalfa, if supplied by irrigation. To calculate a specific crop evapotranspiration (ET_c) rate, the ET_o is multiplied by a crop coefficient that adjusts the water consumption for each specific crop relative to the water consumption of the reference crop. CIMIS Station 224 is located within the neighboring Enterprise Subbasin of the RAGB and it is the closest CIMIS station to the Anderson Subbasin.

According to the State of California Reference Evapotranspiration Map developed by CIMIS, the Anderson Subbasin is located within Zone 14, with an annual average ET_o of 57 inches, or 4.8 feet (CIMIS, 2012). This regional average annual ET_o is similar to the ET_o measured at CIMIS Station 224.

[1] http://cdec.water.ca.gov/reportapp/javareports?name=wsihist

3.1.3 Hydrology

Many streams cross the Anderson Subbasin, generally flowing down from the foothills of the Klamath Mountains in the north/northwest and the Coast Ranges in the west/southwest, eastward to confluences with the Sacramento River. The Sacramento River is the largest and most significant hydrological feature in the subbasin (Figure 3-4). Data referenced in this section were sourced from USGS and the Sacramento River Watershed Program (SRWP, 2010).

The Sacramento River is the largest river and watershed system in California, carrying 31 percent of the state's total surface-water runoff. Around 6,500 square miles of the 27,000-square-mile Sacramento River watershed drain into the RAGB. Sourced from volcanic plateaus approximately 45 miles north of the Anderson Subbasin, its headwaters comprise the Upper Sacramento, McCloud, and Pit Rivers. After flowing through Shasta Lake and Keswick Reservoir, the Sacramento River flows south, making up the northeastern and eastern boundary of the Anderson Subbasin. The Sacramento River is gauged at Keswick Reservoir, where the flow is controlled by releases from Shasta and Keswick Dams. Based on data from this gauge (USGS #11370500, see Figure 2-11, USGS, 2019a) extending back to 1938, the annual average flow in the Sacramento River at this location is approximately 10,000 cfs, with peaks as high as 50,000 to 70,000 cfs in wet years and lows around 5,000 cfs during drought periods.

Water from the Trinity River is imported to the Sacramento River watershed through diversions from Lewiston Lake in Trinity County. Water from Lewiston Lake is conveyed via the Clear Creek Tunnel to the Carr Powerhouse on Whiskeytown Lake in Shasta County. Several purveyors in Shasta County divert water from Whiskeytown Lake through contracts with Reclamation.

The southern boundary of the Anderson Subbasin coincides with Cottonwood Creek. Drainage in this watershed comes from the east slope of the Klamath Mountains and the Coast Ranges, entering the Sacramento River near the town of Cottonwood. Including its three main tributaries (North Fork, Middle Fork, and South Fork) with more than 500,000 AF in annual runoff, this is the third largest watershed on the western side of the Sacramento River Basin at 938 square miles. Typical of westside watersheds, headwaters are from relatively low-elevation, rainfall-dominated areas that produce a flashy hydrology (short-term peak runoff events in winter and low baseflow in summer). Cottonwood Creek is the largest undammed tributary in the Sacramento River Basin and is a major source of sediment and gravel input to the Sacramento River (SRWP, 2010). Cottonwood Creek streamflow is monitored by USGS near the town of Cottonwood with a record extending back to 1940 (USGS #11376000, see Figure 2-11, USGS, 2019a). Average annual flow in Cottonwood Creek at this stream gauge between 1940 and 2019 is approximately 850 cfs, increasing to nearly 3,000 cfs during the wet years (such as 1983) and decreasing to less than 100 cfs during dry/critical years (such as 1977). Cottonwood Creek is known to produce peak flood flows of 20,000 to over 80,000 cfs during heavy storms.

Lower Clear Creek flows west to east though the northern portion of the Anderson Subbasin before reaching a confluence with the Sacramento River between Redding and Anderson. Water in Lower Clear Creek is released from Whiskeytown Dam, and the Whiskeytown Reservoir forms the boundary between Upper Clear Creek and Lower Clear Creek. With the exception of some minor accretion flows from side tributaries, flows in Lower Clear Creek are controlled by the releases through Whiskeytown Dam. The current release schedule is 50 cfs (January through October) and 100 cfs (November and December) (SRWP, 2010). Lower Clear Creek streamflow is monitored by USGS near the town of Igo with a record extending back to 1940 (USGS #11372000, see Figure 2-11, USGS, 2019a). Average annual flow in Clear Creek between 1965 and 2019 is approximately 190 cfs, ranging from nearly 570 cfs during the wet years (such as 1983) to less than 60 cfs during dry/critical years (such as 1977). Peak flows in Clear Creek range from less than 5,000 cfs to as much as nearly 25,000 cfs.

3.1.4 Regional Geologic Setting

The RAGB consists of 510 square miles in the northern Central Valley of California. It is bounded by the foothills of the Cascade Range in the east, the Klamath Mountains in the north/northwest, the Coast

Ranges in the west/southwest, and the Red Bluff Arch in the south (Pierce, 1983). The Red Bluff Arch, a subsurface structural feature, defines the boundary between the RAGB and the Sacramento Groundwater Basin to the south. The area of the RAGB is an interior dissected plain, consisting of a sediment-filled, southward-plunging, symmetrical trough, crossed by the valleys of the Sacramento River and of Churn Creek, Clear Creek, Cottonwood Creek, and Stillwater Creek.

Tertiary deposition of material sourced from the Coast and Cascade Ranges created the principal freshwater-bearing formations in the basin: the Tuscan and Tehama Formations. These formations are up to 2,000 feet thick near the confluence of the Sacramento River and Cottonwood Creek and are interbedded throughout the RAGB, with the Tuscan more prominent to the east and the Tehama more prominent to the west. The Tuscan Formation is generally more permeable and productive than the Tehama Formation (DWR, 2004).

3.1.5 Local Geologic Setting

3.1.5.1 Surface Soils

Figure 3-5 presents the distribution of surface soils within the Anderson Subbasin (USDA, 2019). Soils are derived from the weathering of underlying geological units and are influenced by lithology as well as climate, biological factors (vegetation, biota, human influences), topography, and hydrologic conditions. The United States Department of Agriculture's (USDA) National Resources Conservation Service (NRCS) developed a hierarchical classification system consisting of Order, Suborder, Great Group, Subgroup, Family, and Series. This classification system (or taxonomy) is based on quantitative soil properties such as depth, moisture, temperature, texture, structure, cation exchange capacity, base saturation, clay mineralogy, organic matter content, and salt content. The soil distribution presented on Figure 3-5 categorizes surface soils based on taxonomic order. As shown on Figure 3-5, 5 of the 12 NRCS taxonomic orders are present in the Anderson Subbasin, as follows:

- Alfisols are present across approximately 77 percent of the subbasin. Alfisols are naturally fertile soils, high in aluminum and iron, have clay-rich horizons, and form in semi-arid to humid regions with at least several months of vegetation grown throughout the year (sufficient moisture and warmth).
- Entisols are present over approximately 12 percent of the subbasin, primarily present adjacent to surface streams and within stream floodplains. Entisols are young soils with no profile development (that is, they have not been significantly altered from the parent material).
- Ultisols are present over approximately 2 percent of the subbasin within stream channels. Ultisols are highly weathered, acidic, clay-rich mineral soils with little base nutrients.
- Inceptisols are present over approximately 0.5 percent of the subbasin. Inceptisols are generally young soils with limited soil profile development (more developed than entisols).
- Aridisols are present over approximately 0.02 percent of the subbasin. Aridisols have a very low concentration of organic matter and are often associated with arid climates.

Regions of the subbasin classified as "other" (8.48 percent of the subbasin) on Figure 3-5 are primarily areas that have been mapped as water.

3.1.5.2 Geologic Units

Figure 3-6a,b presents a geologic map of the RAGB, derived from the *Digital Geologic Map of The Redding 1° X 2° Degree Quadrangle, Shasta, Tehama, Humboldt, And Trinity Counties, California* (USGS, 2012). Northwest-southeast and east-west trending cross sections are presented on Figures 3-7 and 3-8, respectively. Geologic cross sections were developed based on available lithologic information with the primary objective of displaying the water-bearing units within the subbasin. Because the level of detail and consistency of historical lithologic logging varied greatly, units are presented on the cross section as dominated by either finer- or coarser-grained materials. Lack of detailed lithologic information precludes differentiating major geologic units in section view. Major geologic units underlying the Anderson Subbasin include (from oldest to youngest) the following:

Basement Complex (Various Units, including Kqd and Dcg, on Figure 3-6a,b)

The pre-Tertiary igneous and metamorphic basement complex is the oldest geologic unit underling the Central Valley. The formations that make up the basement complex formed throughout the Devonian and terminated during the Cretaceous with the inception of the Chico Formation. The basement complex crops out along the steep slopes surrounding the RAGB, forming a nearly impermeable boundary for groundwater. The basement complex is considered non-water bearing, yet scarce water is stored in joints and fractures, permitting small well yields.

Chico Formation (Kc on Figure 3-6a,b)

Unconformably overlying the basement complex is the Cretaceous Chico Formation. The Chico Formation was deposited in a marine and shore zone environment, consisting of a variety of sedimentary rocks—conglomerate, siltstone, sandstone, and shale. This formation is generally of low permeability, with some zones yielding small amounts of saline, connate water. In certain places, this water may be under artesian pressures, especially where shale beds are extensive. The thickness of the Chico Formation ranges from zero feet in the northern RAGB to 6,000 feet to the south, forming the base of the southerly tilt of the Central Valley. Because the Chico Formation contains saline, connate water, the top of the Chico Formation defines the base of fresh water in the RAGB.

Sedimentary Rocks (Ks on Figure-3-6a,b)

Lower Cretaceous marine sedimentary rocks generally outcrop west of the Anderson Subbasin; however, small areas of outcrop are located within the subbasin near the confluence of the North Fork Cottonwood Creek and Cottonwood Creek. This formation consists of "*well indurated, buff-weathering sandstone, mudstone, and conglomerate"* (USGS, 2012). The unit contains ammonites and other marine fossils; rocks are similar to those of equivalent age in the Great Valley sequence.

Tehama Formation (Tte on Figure 3-6a,b)

The Pliocene-age Tehama Formation consists of fluviatile silt, sand, gravel, and clay originating in the Klamath Mountains and Coast Ranges (DWR, 2004). Sourced from the west, the Tehama Formation is most prominent in the western portion of the RAGB and is interbedded with the Tuscan Formation in the central portion of the RAGB. This unit crops out throughout the central portion of the Anderson Subbasin. The thickness of the Tehama Formation is variable, from around 1,000 feet in the northern portion of the Anderson Subbasin to around 4,000 feet at the confluence of Cottonwood Creek and the Sacramento River; however, the formation is generally approximately 500 feet thick over most of the subbasin west of Anderson (DWR, 2004). Permeability is generally moderate to high with yields of 100 to 1,000 gpm, making the Tehama Formation one of the principal water-bearing formations in the RAGB (Pierce, 1983).

Tuscan Formation (Tt on Figure 3-6a,b)

The Pliocene-age Tuscan Formation consists of volcanic breccia, tuff-breccia, volcanic sandstone and conglomerate, coarse- to fine-grained tuff, and tuffaceous silt and clay predominately derived from andesitic and basaltic sources. As shown on Figure 3-6b, the Tuscan Formation generally crops out east and south of the Anderson Subbasin; and much of the formation lies east of the Sacramento Valley under a volcanic plateau of the Cascade Range. The Tuscan Formation dips to the southwest and thins from east to west. The maximum thickness of the Tuscan Formation is 1,600 feet in the Cascade Range, thinning to around 300 feet where it interfingers with the Tehama Formation in the central portion of the RAGB (Pierce, 1983). Fresh water is found throughout the Tuscan Formation, with a thick and low-permeability basalt flow separating it from the underlying and saline Chico Formation. It contains moderately permeable beds at a range of depths, with lenticular clay beds resulting in locally confined conditions. Yields are similar to that of the Tehama Formation—100 to 1,000 gpm (Pierce, 1983).

Red Bluff Formation (Qrb on Figure 3-6a,b)

Unconformably overlying the Tehama and Tuscan Formation is the Pleistocene-age Red Bluff Formation. It is composed of coarse gravels and boulders in a matrix of reddish sand, silt, and clay. This formation is discontinuous, with thicknesses ranging from 1 foot to 100 feet. The Red Bluff Formation typically lies above the zone of saturation, but there are areas of perched water. Permeability generally ranges from poor to moderate, and yields are small to moderate and sufficient for domestic wells (Pierce, 1983).

Riverbank Formation (Qr on Figure 3-6a,b)

The Pleistocene-age Riverbank Formation is present as alluvial fan and terrace deposits along streams in the RAGB. The unit consists of weathered reddish gravel, sand, and silt (USGS, 2012). The Riverbank Formation reaches thicknesses of up to 50 feet in the Anderson Subbasin (DWR, 2004).

Modesto Formation (Qm on Figure 3-6a,b)

The Pleistocene-age alluvial deposits of the Modesto Formation are primarily present along the Sacramento River, Cottonwood Creek, and tributary floodplains in the RAGB. The unit consists of tan and light-gray gravely sand, silt, and clay, except where derived from volcanic rocks of the Tuscan Formation, where it is distinctly red and black with minor brown clasts (USGS, 2012). The Modesto Formation reaches thicknesses of up to 50 feet in the Anderson Subbasin (DWR, 2004).

Alluvium and Overbank Deposits (Qa, Qao, Qo on Figure 3-6a,b)

Alluvium is found in channels and floodplains along the Sacramento River and its tributaries, and has been described by Pierce (1983) as unconsolidated, interbedded, gravel, sand, silt, and clay. Permeability is generally moderate but may be quite high in regions dominated by gravels. Some wells in the alluvium have produced as much as 2,000 gpm, but many others produce only enough for domestic use.

3.1.5.3 Geologic Structures

Red Bluff Arch

A series of northeastward-trending anticlines and synclines located north of Red Bluff, the Red Bluff Arch, distinguishes the RAGB from the Sacramento Groundwater Basin. Data are insufficient to determine the groundwater and surface-water relationship in the vicinity of the Red Bluff Arch; however, the effect of the arch is hypothesized to force groundwater toward the surface to induce gaining streams (Pierce, 1983).

3.1.6 Local Hydrogeology

3.1.6.1 Lateral Basin Boundary

The RAGB is bounded by the foothills of the Cascade Range to the east, the Klamath Mountains to the north/northwest, the Coast Range to the west/southwest, and the Red Bluff Arch to the south (Pierce, 1983). Unlike the RAGB, much of the Anderson Subbasin is bounded by hydrologic features: the Sacramento River to the east and northeast and Cottonwood Creek to the south. Because some of the lateral subbasin boundaries are defined by surface streams, there is likely hydraulic communication between adjacent subbasins. That is, there may be subsurface flow into the Anderson Subbasin from adjacent subbasins and from the Anderson Subbasin into adjacent subbasins.

3.1.6.2 Definable Bottom of Basin

The base of fresh water defines the bottom of the basin. In the RAGB, this is the top of the Chico Formation (Figure 3-9). Although water-bearing formations exist below this depth, the saline nature of the groundwater and the depth to formation prevent the Chico Formation from being a viable aquifer. The top of the Chico Formation in the Anderson Subbasin ranges from a depth of less than 100 feet in the northwest to a depth of greater than 2,000 feet in the southeast (DWR, 1968).

3.1.6.3 Principal Aquifers and Aquitards

Much of the water supply in the Anderson Subbasin, and in the greater RAGB, is stored in surface reservoirs; and as a result, the communities in the region are less dependent on groundwater. This may contribute to the fact that groundwater elevations in the RAGB do not show evidence of continuous decline (as will be discussed further in subsequent sections). In the portions of the Anderson Subbasin near either Sacramento River, Clear Creek, or Cottonwood Creek, depths to groundwater are shallow, within 25 feet of land surface. However, depth to groundwater generally increases to the west, with increasing distance from the streams. In areas outside of large drainages, depths to groundwater can range from 150 to 250 feet below land surface. Alluvial deposits have moderate to high permeabilities in the subbasin, but deposits are not significant sources for groundwater use in the subbasin because of the limited lateral and vertical extents. The Red Bluff Formation is generally present above the regional water table; however, local perched zones may yield small quantities of water to domestic wells (DWR, 1968, Pierce, 1983). The principal water-bearing formations in the Anderson Subbasin, the Tuscan and Tehama Formations, together function as one large, leaky unconfined aquifer with increasing degrees of confinement with depth. Groundwater use of the principal aquifer is for urban, industrial, and agricultural purposes, and is described in greater detail in Chapter 2. Due to the reliability of surface water storage and the readily available groundwater supply within the Tuscan and Tehama aquifers, few resources have been dedicated to describing other aquifers within the RAGB. As shown on Figures 3-7 and 3-8, although laterally discontinuous fine-grained zones are present within the subbasin, there is no evidence of a regional aquitard.

3.1.6.4 Aquifer Properties

Aquifer systems function as a combination of subsurface reservoirs for storage of groundwater and conduits for the transmission of groundwater. The following sections describe the aquifer system properties in the Anderson Subbasin. The magnitude and distribution of hydrogeologic properties of the principal aquifers in the subbasin have not been well characterized or documented. The scarcity of available quantitative estimates of the aquifer properties of the subbasin's principal aquifers results in uncertainties that will be further refined during implementation of this GSP. This will be accomplished through evaluation of hydraulic data collected during development of the new monitoring well and through calibration of the numerical model being developed as part of this GSP.

Transmissivity and Hydraulic Conductivity

There are two general terms that are used to describe the capacity of an aquifer to transmit water: hydraulic conductivity and transmissivity. Hydraulic conductivity is defined as the coefficient of proportionality describing the rate at which a fluid can move through a porous medium and is dependent on the fluid density, fluid viscosity, and the intrinsic permeability. Transmissivity is defined as the capacity of an aquifer to transmit groundwater through a unit width of the aquifer under a unit hydraulic gradient. Transmissivity is equal to the product of the hydraulic conductivity (which is reported in units of feet per day [ft/day]) and saturated thickness, and is generally reported in units of gallons per day per foot or square feet per day (ft^2/day).

Numerous well completion logs filed with DWR include information that can be used to estimate the specific capacity of the associated well, which can then be used to approximate the transmissivity (DWR, 2020b). Additionally, specific capacity estimates are available from short-duration (45- to 176-minute) hydraulic testing performed at the end of development of 13 ACID groundwater monitoring wells

(CH2M HILL, 2004). In general, estimated transmissivity values are lower in the west/southwestern portion of the Anderson Subbasin and increase to the east/northeast, where the thickness of unconsolidated deposits increases. Estimated transmissivities based on reported specific capacity values on well logs by well type are as follows for the Anderson Subbasin:

- Domestic Wells (80 logs): 6 to 9,000 ft^2/day with a geometric mean of 230 ft^2/day
- Public Wells (8 logs): 120 to 13,750 ft^2/day with a geometric mean of 2,400 ft^2/day
- Industrial and Irrigation Wells (11 logs): 600 to 35,000 ft^2/day with a geometric mean of 3,300 ft^2/day
- Monitoring Wells, Test Wells, and Unknown Well Type (15 logs): 80 to 22,000 ft^2/day with a geometric mean of 1,325 ft^2/day

Hydraulic conductivity was estimated from specific capacity data by dividing the estimated transmissivity by the well screen length, where available. Estimated hydraulic conductivity values for the Anderson Subbasin are as follows:

- Domestic Wells (57 logs): 0.2 to 500 ft/day with a geometric mean of 11 ft/day
- Public Wells (4 logs): 42 to 230 ft/day with a geometric mean of 87 ft/day
- Industrial and Irrigation Wells (9 logs): 5.5 to 113 ft/day with a geometric mean of 19 ft/day
- Monitoring Wells, Test Wells, and Unknown Well Type (14 logs): 2.5 to 735 ft/day with a geometric mean of 43 ft/day

Excluding lower-yield wells (those with reported pumping rates less than 50 gpm) and relatively shallow wells (those with depths less than 150 feet bgs), transmissivity ranges from 150 to 35,000 ft^2/day (hydraulic conductivity of 2.5 to 230 ft/day) with a geometric mean of 1,700 ft^2/day (hydraulic conductivity of 20 ft/day).

In addition to estimating transmissivity based on specific capacity measurements, aquifer properties have been estimated through the process of numerical model calibration, which is a process of adjusting model inputs (such as transmissivity) to achieve a reasonable match to field observations of interest. The most recent version of the Redding Basin Finite Element Model (REDFEM) included transmissivity estimates of less than 1,000 ft^2/day (hydraulic conductivity of 5 ft/day) in the northern portion of the subbasin to more than 200,000 ft^2/day (hydraulic conductivity of 300 ft/day) in the southern portion of the subbasin (CH2M HILL, 2011). These values represent the estimated transmissivity for the entire thickness of unconsolidated materials of the principal aquifers overlying the Chico Formation (Figure 3-9) as opposed to aquifer thickness associated with a well screen (as is the case for specific capacity estimates). Estimates of transmissivity and hydraulic conductivity will be further refined in the numerical groundwater flow model development effort being performed to support this GSP.

Storativity

Storativity (or storage coefficient) is the volume of water released from (or taken into) storage in the aquifer system per unit area per unit change in head (i.e., groundwater elevation). In general, unconfined aquifer systems have relatively higher storativity values (typically known as specific yield), whereas confined aquifer systems have lower storativity values. Point estimates of aquifer storage from hydraulic testing within the Anderson Subbasin are currently unavailable. Values incorporated into REDFEM include a specific yield of 10 percent for shallow portions of the basin aquifer and a specific storage of 2×10^{-6} per foot for the deeper portions of the aquifer. Storativity values are computed by multiplying the specific storage value by the aquifer thickness. The assumed resulting storativity values for the deeper model layers in REDFEM range from 1×10^{-4} to 4×10^{-3} (CH2M HILL, 2011). Similar to transmissivity, storage properties will be further refined in the numerical groundwater flow model that is being developed as part of this GSP.

3.1.6.5 Natural Recharge Areas

Recharge to the principal aquifers (i.e., Tuscan and Tehama Formations) in the Anderson Subbasin and the shallower, overlying water-bearing units occurs through a combination of the following (DWR, 1968; Pierce, 1983):

- Groundwater recharge from precipitation
- Groundwater recharge from applied water
- Groundwater recharge from streams and irrigation canals
- Subsurface inflow from adjacent subbasins

Recharge to aquifer systems is influenced by a number of parameters including (but not limited to) the following: surface soil infiltration capacity; land use/vegetative cover; topography; lithology; and the frequency, intensity, duration, and volume of precipitation. Figure 3-10 presents the distribution of the Soil Agricultural Groundwater Banking Index (SAGBI) for the Anderson Subbasin. The SAGBI was developed by the University of California–Davis as part of a study of the potential to bank groundwater, while maintaining healthy crops as a drought management strategy (O'Geen et al., 2015). The SAGBI data presented on Figure 3-10 are based on the following factors: infiltration capacity of soils, the duration that the root zone would be anticipated to remain saturated, topography, potential for leaching of high-salinity soils to degrade groundwater quality, and the susceptibility of soils to compact and erode. As shown on Figure 3-10, the SAGBI indicates that much of the western (foothills of the Klamath Mountains and Coast Ranges) and central portions of the subbasin overlie areas with a moderately poor to very poor potential for groundwater recharge. Areas within and along stream channels, especially those of the Sacramento River and Cottonwood Creek, represent areas of good to excellent potential for groundwater recharge; however, groundwater levels in these areas are often shallow, limiting the quantity of recharge that can enter the shallow aquifer. This distribution provides one source of information on where natural recharge to the groundwater system likely occurs. Quantitative estimates of natural and anthropogenic recharge are discussed further in Chapter 4, Water Budgets.

3.1.6.6 Natural Discharge Areas

Natural groundwater discharge areas within the Anderson Subbasin include groundwater discharge to surface-water bodies (streams, ponds, wetlands), subsurface outflow to adjacent subbasins, and shallow groundwater ET by phreatophytes. Although groundwater discharge to streams has not been mapped, previous numerical modeling efforts indicate that the Sacramento River and at least the lower portions of primary tributaries are gaining streams. REDFEM output indicates that the Sacramento River gains approximately 700,000 AF/yr (on average) from groundwater as it flows through the RAGB. Updated estimates of the location and magnitude of natural groundwater discharge are discussed further in Chapter 4, Water Budgets.

Figure 3-11 presents the distribution of potential groundwater-dependent ecosystems (GDEs) within the Anderson Subbasin contained in the DWR Natural Communities (NC) dataset (DWR, 2020c). The NC dataset is the product of a collaborative effort among DWR, California Department of Fish and Wildlife, and The Nature Conservancy. These agencies compiled and screened information from 48 datasets (such as the National Hydrography Dataset, National Wetlands Inventory, Vegetation Classification and Mapping Program, and Classification and Assessment with Landsat Of Visible Ecological Groupings) to produce the NC dataset. As defined in the NC dataset, the two classifications of GDEs are (1) wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions (NC wetland) and (2) vegetation types commonly associated with the subsurface presence of groundwater (NC vegetation or phreatophytes). Within the Anderson Subbasin, NC wetlands typically occur within and immediately adjacent to stream channels (primarily the Sacramento River and Cottonwood Creek), whereas NC vegetation areas are typically present in floodplain areas associated with streams. However, there has been no independent verification that the locations shown on this map constitute actual GDEs; therefore, Figure 3-11 shows only potential GDEs. Additional field reconnaissance may be necessary to further inform the potential existence of these GDEs.

3.2 Groundwater Conditions

This section describes current and historical groundwater conditions in the Anderson Subbasin. Unless otherwise specified, current conditions will refer to conditions occurring after January 1, 2015, and historical conditions will refer to those occurring prior to January 1, 2015. The groundwater conditions described in the following sections present the current and historical variability of groundwater levels and groundwater quality.

3.2.1 Groundwater Elevations

The assessment of groundwater elevation conditions in the Anderson Subbasin is largely based on data collected by DWR from March 16, 1954 to April 11, 2019. The groundwater-level monitoring network in the Anderson Subbasin comprises 47 groundwater wells gauged by DWR, Clear Creek CSD, Shasta County, and USGS (DWR; 2019a; DWR, 2019b; USGS, 2019a). Groundwater wells in the monitoring network have various uses including residential, irrigation, industrial, and observation, as well as two groundwater wells with the designation of other, one groundwater well with a designation of unknown, and five groundwater wells without a designation for well usage. The location and type of monitoring program are shown on Figure 2-9 and listed in Table 3-1. Data collected by Clear Creek CSD and Shasta County are maintained under the DWR groundwater elevation dataset.

Groundwater elevation data have been routinely collected in the subbasin to provide data to better understand seasonal changes and to monitor longer-term trends in groundwater levels. A general summary of the historical groundwater-level monitoring activities conducted within the Anderson Subbasin since 1954 is described below:

- Between 1954 and 1969, DWR gauged up to 11 groundwater wells monthly to triennially
- Between 1970 and 1999, DWR gauged up to 16 groundwater wells monthly to semiannually
- Between 2000 and 2009, DWR gauged up to 25 groundwater wells triennially to semiannually
- Between 2010 and 2019, DWR gauged up to 27 groundwater wells weekly to semiannually
- Between 2004 and 2018, DWR used transducers to gauge up to 20 groundwater wells monthly
- Between 2016 and 2019, Shasta County gauged 1 groundwater well semiannually
- Between 2016 and 2017, CCCSD gauged 1 groundwater well three times
- Between January 2018 and April 2019, USGS gauged 6 groundwater wells one time

The amount of available groundwater-level data for a given well varies from 1 measurement at the USGS-monitored wells to over 400 data points at a DWR-monitored location. The period of record for wells included in the DWR dataset ranges from 1 year at Well 1, to 63 years of groundwater-level monitoring at 30N/04W-05K01 and 30N/04W-23G01, with an average period of record of nearly 22 years.

Due to the various regional and local influences on groundwater elevations, characterization of subbasin groundwater elevation conditions was completed using three methodologies: groundwater elevation contour maps, hydrographs, and vertical hydraulic gradients, as follows:

- Groundwater elevation contour maps show the geographic distribution of groundwater elevations at a specific time. Contours and posted groundwater elevations represent the elevation of the water table in elevation units of feet NAVD88.
- Hydrographs show variations in groundwater elevations at an individual well over time. A review of hydrographs can provide insight to both seasonal and longer-term temporal trends in groundwater elevations.
- Vertical hydraulic gradients provide information on the potential for vertical groundwater flow at a given location.

A summary of current and historical groundwater elevations and evaluations of vertical and horizontal flow directions are included herein.

3.2.1.1 Groundwater Elevation Contours and Horizontal Groundwater Gradients

Because the Anderson Subbasin comprises a portion of the larger RAGB and groundwater flow is not affected by jurisdictional boundaries (such as subbasin boundaries), a regional review of groundwater-level data is important for understanding groundwater flow on a basinwide scale. Consistent with GSP requirements, groundwater-level data for two recent timeframes, March 19 through April 3, 2018 (spring) and October 16 through October 26, 2018 (fall), were used to create groundwater elevation contour maps for the RAGB. Groundwater levels in wells within the Anderson Subbasin were measured between March 19 and March 30, 2018 (spring) and October 16 and October 26, 2018 (fall). These groundwater measurements represent the most recent groundwater-level data as of the time of this evaluation.

The first step in the process of groundwater elevation contouring was to identify wells representative of groundwater conditions across the RAGB (that is, completed at consistent depths within the primary aquifer units). With some exceptions, wells included in the contouring were generally completed between depths of 50 and 150 feet below ground surface (bgs). A limited number of wells completed shallower (between 30 and 60 feet bgs) and deeper (between 150 to 880 feet bgs) were considered outlier data and were not included in the contouring.

As mentioned in Section 2.2.1.3, Sacramento River serves as a northern and eastern boundary, and Cottonwood Creek serves as a southern boundary for the Anderson Subbasin. These surface-water bodies are inferred to be gaining streams, or streams in which the stream stage is at a lower elevation than the underlying water table. Thus, groundwater moves from the aquifer into the stream channel. A gaining stream is hydraulically connected to the water table; and as a result, surface-water elevations in perennial streams that are coupled with the underlying aquifer must be considered when generating water table elevation contours. Because the Sacramento River is perennial and coupled with the groundwater system, the river surface elevation was included in groundwater contouring. The river gauge below Keswick Reservoir (11370500) and the river gauge at Bend Bridge in Red Bluff (11377100) served as upper and lower extents for consideration of Sacramento River stages in groundwater elevation contouring (USGS, 2019a). The topographic data (discussed in Section 3.1.1) were used to help inform Sacramento River stage between Keswick Reservoir and Bend Bridge. The average surface-water elevations between March 19 through April 3, 2018 (spring) and October 16 through October 26, 2018 (fall) at the Keswick Reservoir and Bend Bridge river gauges were computed. The average surface-water elevations at the two river gauges during the dates above were compared to the surface-water elevations in the digital elevation model near these two locations. The average spring surface-water elevation was more similar to the topographic elevation measured in the digital elevation model; thus, the topographic elevations along the Sacramento River were extracted from the digital elevation model to represent spring 2018 surface-water elevations. The fall 2018 Sacramento River surface-water elevations were interpolated from the previously extracted elevations from the digital elevation model and the difference between the spring 2018 and fall 2018 surface-water elevations at the river gauges. Because there is a lack of measured groundwater-level data in the northern and western portions of the Anderson Subbasin, groundwater elevation output from REDFEM (CH2M HILL, 2011) were used to augment the dataset used in the contouring in these sections of the Anderson Subbasin. Groundwater elevation contours for the Anderson Subbasin for spring and fall 2018 are shown on Figures 3-12 and 3-13, respectively.

During spring and fall 2018, groundwater flow in the Anderson Subbasin was generally east toward the Sacramento River. Groundwater flow directions and variations in groundwater elevation generally mimic a muted version of ground surface topography. Horizontal hydraulic gradients are estimated to be steeper in the western portion of the Anderson Subbasin, where transmissivity is lower, and flatter in the eastern portion of the subbasin, near the Sacramento River, where transmissivity is higher. The steepest horizontal hydraulic gradient is near 30N/06W-03M01, with both a spring and fall 2018 hydraulic gradient of approximately 0.027 foot per foot (ft/ft). The shallower horizontal gradients in the east near 30N/03W-32P03 are approximately 0.0016 ft/ft in spring 2018 and 0.0014 ft/ft in fall 2018. Measured spring and fall 2018 groundwater elevations considered in the contouring ranged from a high of approximately 990 feet NAVD88 at 30N/06W-03M01 in the western portion of the subbasin to a low of approximately 387 feet NAVD88 at 30N/03W-32P03 in the farthest eastern portion.

A comparison of Figures 3-12 and 3-13 shows that wells with groundwater levels measured in both spring and fall 2018 generally exhibit a decrease in groundwater levels between spring and fall. Generally, most groundwater recharge occurs from increased precipitation and less groundwater pumping in winter and spring. Conversely, groundwater recharge decreases during summer and fall when there is less precipitation and more groundwater pumping. Twenty-one of the twenty-eight wells with measurements in both spring and fall demonstrated declining groundwater levels, ranging from a decline of 0.29 foot at well 30N/06W-03M01 to a maximum decline of 4.1 feet at well 29N/05W-11A2. Groundwater levels in seven wells have increasing groundwater levels between spring and fall 2018, ranging from a rise of 1.45 foot at well 30N/03W-18B02 to a maximum rise of 8.6 feet at well 29N/04W-03R06.

3.2.1.2 Hydrographs

As mentioned above, the Anderson Subbasin groundwater monitoring network consists of groundwater wells monitored by multiple agencies, with data maintained by either USGS or DWR. Each of the six USGS-monitored groundwater wells has only one groundwater-level measurement, whereas the DWR dataset is more robust, with an average of approximately 145 datapoints per groundwater well. With the USGS and DWR datasets combined, temporal groundwater-level data for the Anderson Subbasin date as far back as March 16, 1954, with some locations continuing to be updated annually.

Temporal trends in groundwater elevations can be assessed with hydrographs that plot changes in groundwater elevations over time. Figure 3-14 depicts locations and hydrographs of representative wells in the Anderson Subbasin. The points on the plots represent groundwater elevation measurements, whereas the color-coded bars on the hydrographs represent the Sacramento Valley Water Year Index (as discussed in Section 3.1.2.1). Representative wells were chosen based on their distribution across the subbasin, and the timeframe and continuity of their monitoring record. A complete set of hydrographs is included in Appendix C.

Historical groundwater-level records for the Anderson Subbasin indicate groundwater levels have been relatively consistent, generally without long-term trends of increasing or decreasing groundwater levels, as indicated by the hydrographs for wells 29N/04W-02P01 and 30N/05W-02Q01 (Figure 3-14). However, some well locations in the Anderson Subbasin exhibit spatial and temporal variability with groundwater levels generally increasing at location 30N/04W-23G01 and decreasing groundwater levels at 29N/04W-04R03. Groundwater levels in 30N/04W-23G01 have generally increased from approximately 385 feet elevation during the 1976-1977 drought to nearly 400 feet elevation in 2011. Recent groundwater levels (since 2013) show declines during the recent dry and critical water years. Conversely, groundwater levels at location 29N/04W-04R03 indicate longer-term declining groundwater levels. Groundwater levels at 29N/04W-04R03 have generally decreased from approximately 450 feet elevation in 1970 to approximately 440 feet elevation in 2004. Groundwater levels in 29N/05W-11A02 have been more variable over time, increasing from approximately 450 feet elevation in the early 1970s to approximately 465 feet elevation in 1985, at which point groundwater levels remained relatively consistent until the two droughts between 2007 and 2015, when groundwater levels decreased to approximately 455 feet elevation.

Although there have been relatively few long-term changes in groundwater levels, there are seasonal variations in groundwater levels that are evident in hydrographs. Figure 3-14 shows that groundwater levels in many wells can fluctuate between 0 and 10 feet within a year. In general, groundwater levels increase during the rainy season only to decrease during the dry season. As discussed in Section 3.1.2.1, precipitation has been variable in the RAGB, with multi-year droughts (critical and dry water years) occurring between 1976 and 1977, 1987 to 1992, 2007 to 2009, and 2013 to 2015, and wet years occurring between 1970 to 1975, 1982 to 1984, and 1995 to 2000.

Groundwater levels in most of the wells shown on Figure 3-14 depict some influence from droughts and wet periods. Groundwater levels in groundwater wells 29N/04W-02P01, 29N/05W-11A02, 30N/04W-23G01, and 30N/05W-02Q01 are responsive to multi-year wet and dry periods. The intermittent droughts between 2007 and 2015 had a large impact on groundwater levels in 29N/05W-11A02, 30N/04W-23G01, and 30N/05W-02Q01, with groundwater levels decreasing by approximately 10 to 20 feet during droughts. Conversely, even brief wet periods have resulted in increasing groundwater levels at these locations. Wet and dry climatic periods are similarly pronounced in the groundwater-level records of many other wells in the Anderson Subbasin.

3.2.1.3 Vertical Hydraulic Gradients

The potential for groundwater to move vertically within an aquifer system is evaluated by comparing groundwater elevations in wells screened at different depths. Because groundwater elevations change spatially, the potential for vertical movement is computed between wells of differing depths that are in proximity to each other (that is, a well cluster or a multiple completion well). For the purposes of this analysis, the vertical hydraulic gradient is computed as the groundwater elevation at the shallower well minus the groundwater elevation at the deeper well divided by the vertical distance between the well screen midpoints. Based on this calculation method, a positive vertical hydraulic gradient represents the potential for downward groundwater flow, and a negative vertical hydraulic gradient represents the potential for upward groundwater flow. The larger the value of the vertical hydraulic gradient (either positive or negative), the stronger the potential for upward or downward groundwater flow. When comparing groundwater elevations over time (hydrographs) measured in well clusters (such as presented on Figures 3-15a through 3-15f), there is the potential for some groundwater from the well completion with higher groundwater elevation to flow vertically toward the well completion with the lower groundwater elevation. If the well with the higher groundwater elevation is shallower than the well with the lower groundwater elevation, then the potential for downward vertical groundwater flow exists. If the well with the higher groundwater elevation is deeper than the well with the lower groundwater elevation, the potential for upward vertical groundwater flow exists.

There are six clusters of wells in the Anderson Subbasin, wherein each well in the cluster is within 80 feet of the other (Figures 3-15a through 3-15f). These well pairs/clusters include the 29N/04W-03R, 30N/03W-18B, 30N/04W-10H, 30N/04W-22F, 30N/04W-23M, and 30N/04W-25D wells. Because it appears that well pair 30N/04W-10H04 and 30N/04W-10H05 is a replacement for well pair 30N/04W-10H02 and 30N/04W-10H03 (based on the similarity in well construction and the periods of measurements), data for these locations are plotted on the same figure. General observations with respect to potential vertical groundwater flow is as follows:

- Well clusters/pairs 29N/04W-03R, 30N/04W-22F, 30N/04W-23M, and 30N/04W-25D are located along the ACID canal and show generally downward vertical gradients (Figures 3-15a, and Figures 3-15d through 3-15f).
  - The potential for vertical groundwater flow is small at the 30N/04W-22F and 30N/04W-25D clusters (Figures 3-15d and 3-15f) as indicated by the very small to no difference in groundwater elevations between the well completions.
  - Although there is generally the potential for downward vertical flow near the 29N/04W-03R well cluster, the second shallowest completion (29N/04W-03R05) has the lowest groundwater elevation in the well cluster. This suggests that groundwater is converging on this depth interval (the potential for upward flow from the deeper three completions and downward flow from the shallower completion exists).
  - The drawdown in groundwater levels at deeper well 30N/04W-23M02 during 2013 through 2015 is likely related to pumping at the ACID Barney Road well, approximately 400 feet away (Figure 3-15e).
- Vertical groundwater flow directions in well pairs near the Sacramento River vary spatially. The 30N/03W-18B well pair indicate generally upward groundwater flow over the period of record (Figure 3-15b). Upward vertical groundwater flow near the Sacramento River is consistent with the river being a regional groundwater discharge area. The 30N/04W-10H well pairs, located nearly 3 miles upstream of the 30N/03W-18B well pair, show more seasonal variability in vertical groundwater flow directions (Figure 3-15c). During the wet months, vertical flow directions are generally upward, and during the dry months when groundwater usage is generally greater, vertical hydraulic gradients are generally downward.

Vertical hydraulic gradients calculated from groundwater well data measured in spring, summer, and fall 2018 are summarized in Table 3-2. As described above, vertical hydraulic gradients vary spatially, with depth and with the seasons. As previously discussed, vertical hydraulic gradients are generally downward, but can be upward near the Sacramento River and at greater depths near the ACID canal. Vertical hydraulic gradients range between -0.06 ft/ft to 0.38 ft/ft.

3.2.2 Interconnected Surface Water and Groundwater

Surface water that is in hydraulic communication with the groundwater flow systems is referred to as interconnected surface water. If the groundwater elevation beneath a stream is higher than the stream stage (i.e., surface-water elevation), the stream is considered to be a gaining stream, because it gains water from the underlying aquifer. If the groundwater elevation is lower than the stream stage, the stream is considered to be a losing stream, because it loses water to the underlying aquifer. If the water table is a sufficient distance below the streambed elevation, the stream and groundwater are considered to be disconnected (or decoupled), and the leakage rate of water from the stream to the underlying aquifer is independent of the water table elevation.

As previously discussed, the RAGB is bounded on the east by the Cascade Range, on the north/northwest by the Klamath Mountains, and on the west/southwest by the Coast Range. Following rain and snowmelt events, the resulting discharge to surface-water channels and infiltration to the aquifer system produces flow within the tributaries to the perennial Sacramento River and recharges the aquifer within the RAGB. To identify areas where interconnected surface water and groundwater may be present, an analysis was performed based on reviewing depth-to-groundwater data. The underlying assumption of this analysis is that the shallower the depth to groundwater, the more likely that area is in hydraulic connection with nearby stream channels.

To document this relationship, the groundwater elevation contours for spring of 2018 were compared to ground surface elevations presented in Section 3.1.1 to estimate the depth to groundwater across the Anderson Subbasin. Spring 2018 was selected because it represents a period of seasonal high groundwater levels that would be anticipated to result in greater connection between groundwater and surface-water features in the Anderson Subbasin. Figure 3-16 presents the results of that analysis and shows that groundwater in the Anderson Subbasin is generally greater than 20 feet bgs in most of the subbasin.

Most areas of interconnected surface water and groundwater are located along the Sacramento River and Cottonwood Creek where surface water flows perennially. Additional areas of potentially interconnected surface water and groundwater are located along the lower reaches of Anderson, Clear, and Olney Creeks.

This analysis of locations of interconnected surface water is based on available data but contains significant uncertainty. Additional data are needed to reduce uncertainty and refine the map of interconnected surface water and groundwater. The main source of these data will be the numerical model being developed as part of this GSP.

3.2.3 Groundwater Storage

To be included in a future draft of this chapter.

3.2.4 Seawater Intrusion

The RAGB is not vulnerable to seawater intrusion, given its distance from the Pacific Ocean.

3.2.5 Groundwater Quality

This section presents a summary of current groundwater quality conditions within the Anderson Subbasin. The EAGSA does not have regulatory authority over groundwater quality and is not charged with improving groundwater quality in the Anderson Subbasin under SGMA. Although there may be localized areas of impairment, the overall quality of groundwater in the Anderson Subbasin is good and suitable for the designated beneficial uses of the subbasin. Although projects and actions implemented by the EAGSA are not required to improve groundwater quality under SGMA, the management actions and projects recommended must not further degrade groundwater quality, as compared with baseline (i.e., January 2015) conditions.

SWRCB monitors and regulates activities and discharges that can contribute to constituents that are released to groundwater over large areas. The SWRCB's GAMA program compiles groundwater quality data from a variety of sources and makes these data available to the public for download by county (SWRCB, 2020b). Groundwater quality monitoring programs incorporated into the dataset include the following:

- Data from a GAMA domestic well sampling program
- USGS GAMA program
- Lawrence Livermore National Laboratory GAMA program
- Data from the Department of Pesticides Regulation groundwater sampling program
- Data from groundwater sampling programs conducted by DWR
- Data from the California Department of Public Health's sampling of public water supply wells
- Data from sampling of environmental monitoring wells at regulated sites

The Shasta County dataset was downloaded, and a compiled dataset of publicly available groundwater quality results from the Anderson Subbasin was used for establishing baseline groundwater quality in the subbasin. Groundwater quality data were then compared to an applicable regulatory standard including the following:

- Primary MCLs established by either EPA or the California EPA (Cal/EPA), whichever was more strict
- Secondary maximum contaminant levels (SMCLs) established by either EPA or Cal/EPA, whichever was more strict
- Federal Action Level established by EPA
- Cancer or non-cancer Health Based Screening Level established by USGS
- Chronic non-cancer Human Health Benchmark for Pesticides established by EPA
- Federal Health Advisory Level established by EPA
- Reference Dose as a drinking water level
- National Academy of Science Health Advisory Level
- California Cancer Potency Factor
- California Proposition 65 Safe Harbor Levels as a drinking water level
- SWRCB notification levels

The following analyses used analytical data collected between 2000 and 2019 to compare to State or federal groundwater limits. Detected concentrations of constituents based on groundwater analytical data were compared to the associated regulatory limit to evaluate whether the concentration was higher (an exceedance) or lower (a non-exceedance) than the limit. Most tested constituents were either nondetect or detected at concentrations below regulatory limits. Constituents with low detection frequencies do not represent pervasive groundwater quality issues throughout the Anderson Subbasin; these constituents will not be considered further in this GSP.

Figures 3-18 and 3-19 present the distribution of sampled locations and locations of exceedances for each constituent that exceeded the applicable regulatory limit at 10 percent or more of the sampled locations. The locations are symbolized as either non-exceedance (indicating that the constituent has not exceeded the applicable limit in any of the samples at a given well) or symbolized by the number of exceedances over time at a given location. Groundwater quality data included in the analysis of recent subbasin groundwater quality are presented in Appendix D.

In the Anderson Subbasin, the following water quality constituents were identified to have exceedances in 10 percent or more of tested groundwater wells: chromium, iron, manganese, benzene, gasoline, kerosene, tert-butyl alcohol (TBA), and methyl-tert-butyl ether (MTBE). Naturally occurring water quality constituents may include the metals chromium, iron, and manganese; whereas groundwater quality constituents related to human activity include the fuel-related compounds, such as benzene, gasoline, and kerosene, and the non-hydrocarbon solvents TBA and MTBE. Table 3-3 summarizes the analytical results for each of the above water quality constituents. Although available data show localized areas of potential groundwater impairments, the overall quality of groundwater in the Anderson Subbasin is good and suitable for the designated beneficial uses of the subbasin.

3.2.5.1 Point-source Contamination

Point-source contamination data collection activities take place in the Anderson Subbasin in response to known or potential sources of groundwater contamination. These sources include leaking underground storage tank (LUST) sites and various other state cleanup sites.

SWRCB and DTSC have the responsibility for cleanup and monitoring of point-source pollutants. Both entities make all related materials available to the public through two public portals: GeoTracker managed by SWRCB (SWRCB, 2020c) and EnviroStor managed by DTSC (DTSC, 2020). Figure 3-20 presents a map with locations of active remediation sites within the Anderson Subbasin, and Table 3-4 summarizes the active remediation sites.

The SWRCB’s GeoTracker database identifies five open LUST remediation sites, five other sites linked to fuel storage areas or spills at a gas station, a former dry cleaner location, the Winemucca Trading Co/former Shasta Paper Treatment Lagoons, the former Branstetter Mill, Redding Lumber Transport, Northstate Recycling, and a Pacific Gas & Electric (PG&E) manufactured gas plant (MGP) as sites with potential or actual groundwater contamination within the Anderson Subbasin. DTSC’s EnviroStor database also identifies the former Branstetter Mill (but with differing constituents of concern than the GeoTracker listing) and the Winemucca Trading Co/former Shasta Paper Treatment Lagoons, but lists the former Shasta Paper site as two separate open sites under different site names (Simpson Paper Company and Plainwell Paper). The EnviroStor database redirects the user to the GeoTracker database for more information on the former Shasta Paper sites. The DTSC EnviroStor database identifies the PG&E MGP site (formerly the Redding Gas Company) as a location with potential or actual groundwater contamination. The GeoTracker database also has a listing for the PG&E MGP, but the site is recognized as completed, the case is closed, and the site only has continued operation and maintenance. DTSC’s EnviroStor database identifies the J H Baxter & Company site and the Roseburg Lumber Company site as locations that may be open with potential or actual groundwater contamination within the Anderson Subbasin. The EnviroStor database redirects the user to “Other Agency” for more information on the J H Baxter & Company site and redirects the user to the GeoTracker database for more information on the Roseburg Lumber Company site; however, attempts to locate these sites have been unsuccessful as the GeoTracker database does not contain an entry for either remediation site. Resolution of the status of these potentially open remediation sites remains a data gap that will be filled via additional communication with DTSC and/or SWRCB.

As indicated in Table 3-4, point-source contaminants include gasoline, metals, petroleum and petroleum based constituents, dioxins, insecticides and pesticides and other pest related chemicals, solvents or non-petroleum hydrocarbons, and halogenated organic compounds or organic compounds with halogen. Although these constituents are of concern, only fuel-related compounds and metals were detected in more than 10 percent of sampled wells within the Anderson Subbasin to warrant inclusion in the GSP monitoring program.

3.2.5.2 Connate Water

In addition to the above potential constituents of concern, there exists a potential source of saline water intrusion from the Chico Formation. The Chico Formation, which underlies the primary aquifer units of the RAGB, contains saline, connate water under artesian pressure (Pierce, 1983). The Chico Formation is composed of marine deposits of sandstone, conglomerates, and shale, most of which are of low permeability with a few exceptions. Pumping at depths near the top of the Chico Formation could potentially induce upward migration of the saline water into the principal aquifers. No historical evidence indicates widespread migration of saline water from the Chico Formation into the principal aquifers as a result of groundwater use.

3.2.6 Land Subsidence

Land subsidence was recently measured across the Sacramento Valley by DWR, and results were published in the report *2017 GPS Survey of the Sacramento Valley Subsidence Network* (DWR, 2018). The DWR document provides no indication of inelastic subsidence to have occurred in the entire RAGB. Furthermore, the distribution of unconsolidated deposits without extensive low-permeability aquitards in the RAGB indicates that the RAGB is also not particularly vulnerable to pumping-induced land subsidence. As such, land subsidence from groundwater extraction in the Anderson Subbasin is not considered an issue of concern.

Table 3-1. Anderson Subbasin Groundwater Monitoring Network

Location ID	Easting	Northing	Well Type	Monitoring Agency	Ground Surface Elevation (feet NAVD88)	Reference Point Elevation (feet NAVD88)	Total Well Depth (feet bgs)	Top of Well Screen (feet bgs)	Bottom of Well Screen (feet bgs)
29N/03W-03L01	6508501.448	2027822.572	--	USGS	366	--	80	--	--
29N/03W-06P01	6492811.675	2025599.187	Residential well	DWR	412.24	412.54	69	--	--
29N/04W-01Q01	6488356.696	2026158.589	Residential well	DWR	418.52	419.52	100	--	--
29N/04W-02F01	6481719.452	2028411.688	--	USGS	479	--	492	--	--
29N/04W-02M02	6480411.608	2026950.932	Irrigation well	DWR	462	464.2	270	160	255
29N/04W-02P01	6481522.479	2025796.118	Other	DWR	447.49	447.99	425	165	425
29N/04W-03R02	6479654.939	2026562.585	Observation well	DWR	457.84	460.49	917	740	880
29N/04W-03R03	6479654.939	2026562.585	Observation well	DWR	457.84	460.33	696	515	660
29N/04W-03R04	6479654.939	2026562.585	Observation well	DWR	457.84	460.15	438	380	390
29N/04W-03R05	6479654.939	2026562.585	Observation well	DWR	457.84	460.03	254	128	188
29N/04W-03R06	6479651.04	2026562.598	Observation well	DWR	457.84	459.81	76	40	60
29N/04W-04R03	6474653.559	2026385.74	Residential well	DWR	507.48	507.48	96	--	--
29N/04W-05Q01	6468328.704	2025826.251	Residential well	DWR	512.5	513	152	--	--
29N/05W-03K01	6445973.827	2027704.965	--	USGS	574	--	157	--	--
29N/05W-07B01	6430582.47	2025125.502	Irrigation well	DWR	551.56	555.66	450	--	--
29N/05W-09L01	6439772.048	2021251.763	Residential well	DWR	517.55	517.55	140	100	140
29N/05W-11A02	6452974.047	2025057.407	Irrigation well	DWR	514.54	514.54	360	110	356
30N/03W-18B01	6493690.642	2051435.115	Observation well	DWR	400.12	399.49	55	30	55
30N/03W-18B02	6493701.217	2051435.814	Observation well	DWR	400.1	399.47	164	110	164
30N/03W-18F02	6492322.353	2049424.831	Residential well	DWR	397.56	398.56	52	--	--
30N/03W-29K01	6499390.17	2038440.766	Residential well	DWR	422.14	422.54	72	--	--
30N/03W-30N01	6491866.91	2036129.707	Unknown	DWR	452.44	453.54	150	--	--
30N/03W-30Q02	6493079.327	2036191.111	Observation well	DWR	445.09	444.37	103	70	103
30N/03W-32P03	6497602.699	2031267.524	Observation well	DWR	434.07	433.74	101	60	101
30N/04W-05K01	6465919.666	2058882.962	Industrial well	DWR	457.59	459.09	300	45	300
30N/04W-06B03	6463349.279	2061946.658	Residential well	DWR	452.6	455.6	312	--	--
30N/04W-10H02	6479484.728	2054892.592	Observation well	DWR	410.47	409.88	40	20	40
30N/04W-10H03	6479484.728	2054892.592	Observation well	DWR	410.57	410.02	150	100	150
30N/04W-10H04	6479557.953	2054826.774	Observation well	DWR	418.8	421.3	62	35	62
30N/04W-10H05	6479552.615	2054811.492	Observation well	DWR	418.7	421.2	161	110	161
30N/04W-22F02	6477735.921	2044142.988	Observation well	DWR	447.86	447.36	113	70	113
30N/04W-22F03	6477740.031	2044124.031	Observation well	DWR	447.64	447.09	202	170	202

Table 3-1. Anderson Subbasin Groundwater Monitoring Network

Location ID	Easting	Northing	Well Type	Monitoring Agency	Ground Surface Elevation (feet NAVD88)	Reference Point Elevation (feet NAVD88)	Total Well Depth (feet bgs)	Top of Well Screen (feet bgs)	Bottom of Well Screen (feet bgs)
30N/04W-22F04	6477673.925	2044163.966	Observation well	DWR	447.8	449.96	540	480	540
30N/04W-23A01	6485186.031	2045896.406	--	USGS	404	--	80	--	--
30N/04W-23G01	6482927.12	2043989.068	Industrial well	DWR	452.55	452.35	345	324	345
30N/04W-23M01	6481410.172	2042877.84	Observation well	DWR	472.33	471.72	114	80	114
30N/04W-23M02	6481425.501	2042883.983	Observation well	DWR	472.67	472.11	201	140	201
30N/04W-23M03	6481421.746	2043265.403	Irrigation well	DWR	467	469.3	465	150	455
30N/04W-25D03	6485633.332	2040414.851	Observation well	DWR	472.47	471.19	122	100	122
30N/04W-25D04	6485625.589	2040431.633	Observation well	DWR	472.07	471.16	201	150	201
30N/05W-02Q01	6451349.47	2057661.165	Residential well	DWR	712.61	713.11	180	116	176
30N/05W-05Q01	6435537.424	2056792.526	Irrigation well	DWR	822.62	823.12	264	224	244
30N/05W-18A01	6431397.446	2050799.469	--	USGS	865	--	255	--	--
30N/05W-23D01	6448502.646	2045144.513	Residential well	DWR	757.58	757.58	234	--	--
30N/06W-03M01	6411766.217	2058602.862	Observation well	Shasta County	1062.5	1062.5	130	--	--
30N/06W-35L01	6419356.268	2032439.926	Residential well	DWR USGS	678 661	679 --	180 --	178 --	180 --
Well 1	6448299.647	2025348.972	Other	CCCSD	519	509	450	216	444

Notes:

-- = information not available
bgs = below ground surface
CCCSD = Clear Creek Community Services District
DWR = California Department of Water Resources
NAVD88 = North American Vertical Datum of 1988
USGS - U.S. Geological Survey

The horizontal datum for well coordinates is North American Datum 1983, State Plane California Zone I in feet.

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Table 3-2. Anderson Subbasin Vertical Head Differences During Spring, Summer, and Fall 2018

Location ID of Shallow Well	Location ID of Deep Well	Distance Between Wells (feet)	Measured Groundwater Elevation in Shallow Well (feet NAVD88)	Measured Groundwater Elevation in Deep Well (feet NAVD88)	Difference in Groundwater Elevation (feet)	Measurement Date of Groundwater Levels	Screen Elevation of Shallow Well (feet NAVD88)	Screen Elevation of Deep Well (feet NAVD88)	Calculated Vertical Hydraulic Gradient (foot/foot)
29N/04W-03R06	29N/04W-03R05	3.90	418.31	387.83	30.48	3/19/2018	417.84-397.84	329.84-269.84	0.282
29N/04W-03R06	29N/04W-03R05	3.90	425.91	384.53	41.38	8/7/2018	417.84-397.84	329.84-269.84	0.383
29N/04W-03R06	29N/04W-03R05	3.90	426.91	385.68	41.23	10/17/2018	417.84-397.84	329.84-269.84	0.382
29N/04W-03R06	29N/04W-03R04	3.90	418.31	394.15	24.16	3/19/2018	417.84-397.84	77.84-67.84	0.072
29N/04W-03R06	29N/04W-03R04	3.90	425.91	391.65	34.26	8/7/2018	417.84-397.84	77.84-67.84	0.102
29N/04W-03R06	29N/04W-03R04	3.90	426.91	391.75	35.16	10/17/2018	417.84-397.84	77.84-67.84	0.105
29N/04W-03R06	29N/04W-03R03	3.90	418.31	392.95	25.36	3/19/2018	417.84-397.84	-57.16--202.16	0.047
29N/04W-03R06	29N/04W-03R03	3.90	425.91	390.03	35.88	8/7/2018	417.84-397.84	-57.16--202.16	0.067
29N/04W-03R06	29N/04W-03R03	3.90	426.91	390.03	36.88	10/17/2018	417.84-397.84	-57.16--202.16	0.069
29N/04W-03R06	29N/04W-03R02	3.90	418.31	392.09	26.22	3/19/2018	417.84-397.84	-282.16--422.16	0.035
29N/04W-03R06	29N/04W-03R02	3.90	425.91	389.09	36.82	8/7/2018	417.84-397.84	-282.16--422.16	0.048
29N/04W-03R06	29N/04W-03R02	3.90	426.91	389.07	37.84	10/17/2018	417.84-397.84	-282.16--422.16	0.050
29N/04W-03R05	29N/04W-03R04	0	387.83	394.15	-6.32	3/19/2018	329.84-269.84	77.84-67.84	-0.028
29N/04W-03R05	29N/04W-03R04	0	384.53	391.65	-7.12	8/7/2018	329.84-269.84	77.84-67.84	-0.031
29N/04W-03R05	29N/04W-03R04	0	385.68	391.75	-6.07	10/17/2018	329.84-269.84	77.84-67.84	-0.027
29N/04W-03R05	29N/04W-03R03	0	387.83	392.95	-5.12	3/19/2018	329.84-269.84	-57.16--202.16	-0.012
29N/04W-03R05	29N/04W-03R03	0	384.53	390.03	-5.5	8/7/2018	329.84-269.84	-57.16--202.16	-0.013
29N/04W-03R05	29N/04W-03R03	0	385.68	390.03	-4.35	10/17/2018	329.84-269.84	-57.16--202.16	-0.010
29N/04W-03R05	29N/04W-03R02	0	387.83	392.09	-4.26	3/19/2018	329.84-269.84	-282.16--422.16	-0.0065
29N/04W-03R05	29N/04W-03R02	0	384.53	389.09	-4.56	8/7/2018	329.84-269.84	-282.16--422.16	-0.007
29N/04W-03R05	29N/04W-03R02	0	385.68	389.07	-3.39	10/17/2018	329.84-269.84	-282.16--422.16	-0.005
29N/04W-03R04	29N/04W-03R03	0	394.15	392.95	1.2	3/19/2018	77.84-67.84	-57.16--202.16	0.006
29N/04W-03R04	29N/04W-03R03	0	391.65	390.03	1.62	8/7/2018	77.84-67.84	-57.16--202.16	0.008
29N/04W-03R04	29N/04W-03R03	0	391.75	390.03	1.72	10/17/2018	77.84-67.84	-57.16--202.16	0.008
29N/04W-03R04	29N/04W-03R02	0	394.15	392.09	2.06	3/19/2018	77.84-67.84	-282.16--422.16	0.005
29N/04W-03R04	29N/04W-03R02	0	391.65	389.09	2.56	8/7/2018	77.84-67.84	-282.16--422.16	0.006
29N/04W-03R04	29N/04W-03R02	0	391.75	389.07	2.68	10/17/2018	77.84-67.84	-282.16--422.16	0.006
29N/04W-03R03	29N/04W-03R02	0	392.95	392.09	0.86	3/19/2018	-57.16--202.16	-282.16--422.16	0.004
29N/04W-03R03	29N/04W-03R02	0	390.03	389.09	0.94	8/7/2018	-57.16--202.16	-282.16--422.16	0.004
29N/04W-03R03	29N/04W-03R02	0	390.03	389.07	0.96	10/17/2018	-57.16--202.16	-282.16--422.16	0.004
30N/03W-18B01	30N/03W-18B02	10.60	381.39	384.67	-3.28	3/19/2018	370.12-345.12	290.1-236.1	-0.035
30N/03W-18B01	30N/03W-18B02	10.60	384.19	386.87	-2.68	8/6/2018	370.12-345.12	290.1-236.1	-0.028
30N/03W-18B01	30N/03W-18B02	10.60	383.09	386.12	-3.03	10/16/2018	370.12-345.12	290.1-236.1	-0.032

Table 3-2. Anderson Subbasin Vertical Head Differences During Spring, Summer, and Fall 2018

Location ID of Shallow Well	Location ID of Deep Well	Distance Between Wells (feet)	Measured Groundwater Elevation in Shallow Well (feet NAVD88)	Measured Groundwater Elevation in Deep Well (feet NAVD88)	Difference in Groundwater Elevation (feet)	Measurement Date of Groundwater Levels	Screen Elevation of Shallow Well (feet NAVD88)	Screen Elevation of Deep Well (feet NAVD88)	Calculated Vertical Hydraulic Gradient (foot/foot)
30N/04W-10H04	30N/04W-10H05	16.19	395.5	400.4	-4.9	3/19/2018	383.8-356.8	308.7-257.7	-0.056
30N/04W-10H04	30N/04W-10H05	16.19	397.2	396.6	0.6	8/6/2018	383.8-356.8	308.7-257.7	0.007
30N/04W-10H04	30N/04W-10H05	16.19	395.8	398.7	-2.9	10/16/2018	383.8-356.8	308.7-257.7	-0.033
30N/04W-22F02	30N/04W-22F03	19.40	402.76	402.29	0.47	3/19/2018	377.86-334.86	277.64-245.64	0.005
30N/04W-22F02	30N/04W-22F03	19.40	399.51	398.69	0.82	8/6/2018	377.86-334.86	277.64-245.64	0.009
30N/04W-22F02	30N/04W-22F03	19.40	400.36	399.79	0.57	10/17/2018	377.86-334.86	277.64-245.64	0.006
30N/04W-22F02	30N/04W-22F04	65.45	402.76	401.96	0.8	3/19/2018	377.86-334.86	-32.2--92.2	0.002
30N/04W-22F02	30N/04W-22F04	65.45	399.51	398.86	0.65	8/6/2018	377.86-334.86	-32.2--92.2	0.0015
30N/04W-22F02	30N/04W-22F04	65.45	400.36	399.26	1.1	10/17/2018	377.86-334.86	-32.2--92.2	0.0026
30N/04W-22F03	30N/04W-22F04	77.23	402.29	401.96	0.33	3/19/2018	277.64-245.64	-32.2--92.2	0.001
30N/04W-22F03	30N/04W-22F04	77.23	398.69	398.86	-0.17	8/6/2018	277.64-245.64	-32.2--92.2	-0.0005
30N/04W-22F03	30N/04W-22F04	77.23	399.79	399.26	0.53	10/17/2018	277.64-245.64	-32.2--92.2	0.0016
30N/04W-23M01	30N/04W-23M02	16.51	402.72	400.01	2.71	3/19/2018	392.33-358.33	332.67-271.67	0.037
30N/04W-23M01	30N/04W-23M02	16.51	401.32	397.91	3.41	8/6/2018	392.33-358.33	332.67-271.67	0.047
30N/04W-23M01	30N/04W-23M02	16.51	400.92	397.81	3.11	10/17/2018	392.33-358.33	332.67-271.67	0.043
30N/04W-25D03	30N/04W-25D04	18.48	398.29	398.26	0.03	3/19/2018	372.47-350.47	322.07-271.07	0.000
30N/04W-25D03	30N/04W-25D04	18.48	396.19	396.26	-0.07	8/6/2018	372.47-350.47	322.07-271.07	-0.001
30N/04W-25D03	30N/04W-25D04	18.48	395.99	395.96	0.03	10/17/2018	372.47-350.47	322.07-271.07	0.000

Notes:

NAVD88 = North American Vertical Datum of 1988

Positive vertical hydraulic gradient indicates downward flow.

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Table 3-3. Summary of Anderson Subbasin Analytical Chemistry for Potential Analytes of Concern, 2000–2019

Analyte	Limit Type	Regulatory Limit (µg/L)	Number of Wells Sampled	Number of Samples Collected	Number of Wells with Exceedances
Chromium	Federal EPA MCL	50	147	565	17
Iron	EPA SMCL	300	184	966	74
Manganese	Federal Health Advisory Level	50	205	776	84
Benzene	Cal/EPA MCL	1	392	6,191	89
Gasoline	Federal Health Advisory Level	5	130	721	79
Kerosene	Federal Health Advisory Level	100	27	249	13
Methyl-Tert-Butyl Ether	Cal/EPA MCL	13	394	6,413	140
Tert-Butyl Alcohol	Federal Notification Level	12	343	5,988	81

Notes:

µg/L = micrograms per liter
Cal/EPA California Environmental Protection Agency
EPA = U.S. Environmental Protection Agency
MCL = Maximum Contaminant Limit
SMCL = Secondary Maximum Contaminant Limit

750

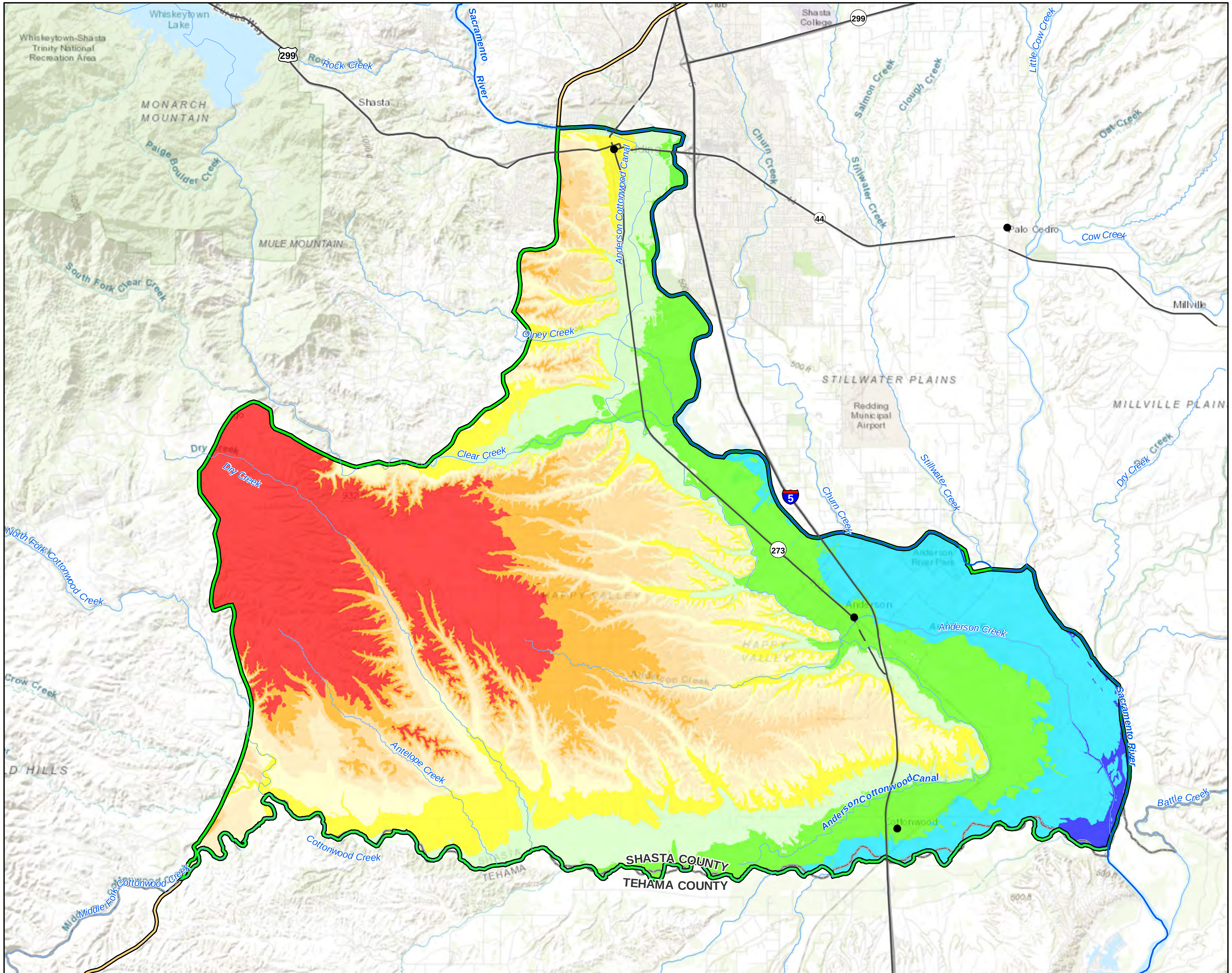
Table 3-4. Anderson Subbasin Active Remediation Sites

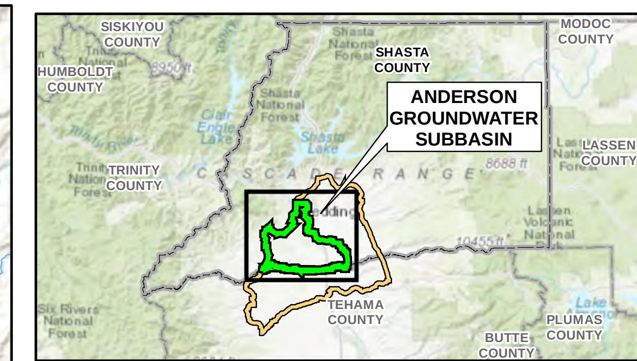
Site Name	Site Type	Status	Constituents of Concern	Address	City	Source Database (Site ID)
Anderson Chevron	LUST Cleanup Site	Open - Verification Monitoring	Gasoline	2298 North Street	Anderson	GeoTracker (T0608900318)
Branstetter Mill	Voluntary Cleanup	Active	Arsenic, Dioxin (as 2,3,7,8-TCDD TEQ), Furan, Pentachlorophenol	1535 Branstetter Lane	Redding	EnviroStor (60000855)
Branstetter Mill Site (Former)	Cleanup Program Site	Open - Site Assessment	Gasoline, Metals, Other Insecticides/Pesticide/Fumigants/Herbicides	1535 Branstetter Lane	Redding	GeoTracker (SL0608916110)
ConocoPhillips Bulk Plant #0629 - Redding	Cleanup Program Site	Open - Remediation	Gasoline, MTBE/TBA/Other Fuel Oxygenates, Petroleum/Fuels/Oils	2340 Wyndham Lane	Redding	GeoTracker (SL375322881)
Dotzenrod Shell Anderson	Cleanup Program Site	Open - Remediation	None Specified	2030 North Street	Anderson	GeoTracker (T10000009265)
Flyers Energy (Former Valero #266)	Cleanup Program Site	Open - Site Assessment	Benzene, Ethylbenzene, Gasoline, Naphthalene, Toluene, Xylene	2470 Balls Ferry Road	Anderson	GeoTracker (T10000013643)
Former Attainable Auto	LUST Cleanup Site	Open - Remediation	Diesel, Waste Oil/Motor/Hydraulic/Lubricating	1893 Eureka Way	Redding	GeoTracker (T0608993531)
J H Baxter & Company	Evaluation	Refer: Other Agency	None Specified	1115 Court Street	Redding	EnviroStor (45240010)
McGee's Corner Saloon	LUST Cleanup Site	Open - Assessment & Interim Remedial Action	Diesel, Gasoline, Lead	5533 Deschutes Road	Anderson	GeoTracker (T10000004977)
Northstate Recycling	Cleanup Program Site	Open - Remediation	Copper, Diesel, Lead, other Metal, Waste Oil/Motor/Hydraulic/Lubricating	2041 Girvan Road	Redding	GeoTracker (T10000003519)
Payless Gas & Food Mart	LUST Cleanup Site	Open - Verification Monitoring	Gasoline	3440 South Market Street	Redding	GeoTracker (T0608900234)
PG&E MGP, Redding	State Response ERAP	Certified O&M - Land Use Restrictions Only	Arsenic, Contaminated Soil, Polynuclear Aromatic Hydrocarbons, TPH-Diesel, TPH-Gas	California, Gold, Oregon, & South Streets	Redding	EnviroStor (45490001)
PG&E Former Manufactured Gas Plant	Cleanup Program Site	Completed - Case Closed - Land Use Restrictions	Crude Oil, Other Solvent or Non-Petroleum Hydrocarbon, Petroleum	Bounded by South Street, Center Street, California Street, Gold Street	Redding	GeoTracker (SL0606723378)
RAM Auto Sales	LUST Cleanup Site	Open - Site Assessment	Gasoline	3270 South Market Street	Redding	GeoTracker (T10000003476)
Redding Lumber Transport	Cleanup Program Site	Open - Assessment & Interim Remedial Action	Diesel	4301 Eastside Road	Redding	GeoTracker (T10000010253)
Roseburg Lumber Company	Evaluation	Refer: RWQCB	Halogenated Organic Compounds, Organic Liquids (Nonsolvents) with Halogens, Unspecified Sludge Waste, Waste Potentially Containing Dioxins	Locust & Deschutes Road	Anderson	EnviroStor (45240002)
San Francisco Deli (previously a gas station and automotive service center)	Cleanup Program Site	Open - Assessment & Interim Remedial Action	None Specified	2395 Athens Avenue	Redding	GeoTracker (T10000011100)
SST Oil Inc.	Cleanup Program Site	Open - Verification Monitoring	Diesel, Gasoline, MTBE/TBA/Other Fuel Oxygenates, Petroleum/Fuels/Oils	2341 Wyndham Lane	Redding	GeoTracker (SL375312880)
Village Plaza Cleaners	Cleanup Program Site	Open - Site Assessment	Tetrachloroethylene	2325 Athens Avenue	Redding	GeoTracker (SL0608997819)
Winemucca Trading Co/Former Shasta Paper Treatment Lagoons	Cleanup Program Site	Open - Assessment & Interim Remedial Action	Dioxin/Furans, Dioxins, Other Inorganic/Salt	21091 Hawes Road	Anderson	GeoTracker (SL0608923324)
Plainwell Paper	Tiered Permit	Refer: RWQCB	None Specified	21091 Hawes Road	Anderson	EnviroStor (71002477)
Simpson Paper Company	Evaluation	Refer: RWQCB	None Specified	21091 Hawes Road	Anderson	EnviroStor (45260001)

Notes:

2,3,7,8-TCDD TEQ = 2,3,7,8-Tetrachlorodibenzo-P-dioxin
ERAP = Expedited Remedial Action Program
LUST = Leaking Underground Storage Tank
MTBE = methyl-tert-butyl ether
O&M = operations and maintenance
RWQCB = Regional Water Quality Control Board
TBA = tert-butyl alcohol

TEQ = toxic equivalency
TPH = total petroleum hydrocarbons





LEGEND

- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

GROUND SURFACE ELEVATION (feet NAVD88)

- 772 to 819.21
- 722 to 772
- 672 to 722
- 622 to 672
- 572 to 622
- 522 to 572
- 472 to 522
- 422 to 472
- 372.48 to 422
- 372.48

NOTES:

DATA SOURCE: SURFACE DATA REPRESENTS TOPOGRAPIC DATA FROM MULTIPLE SOURCES THAT WERE COMPILED INTO A SINGLE SURFACE (USGS, 2018; USGS, 2019b; AND COR, 2019)

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-1
TOPOGRAPHIC SETTING
Anderson Subbasin Groundwater Sustainability Plan

JACOBS

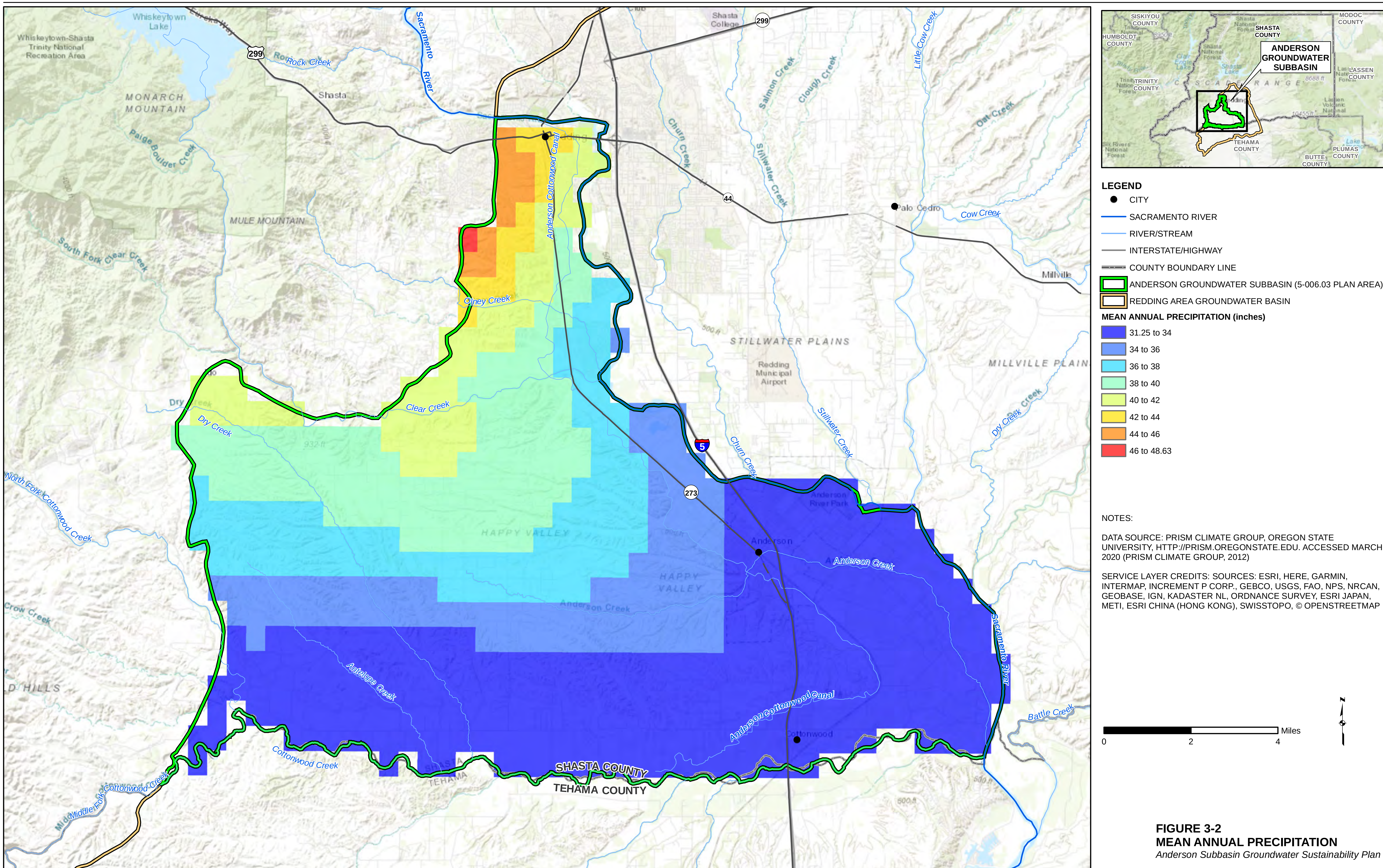
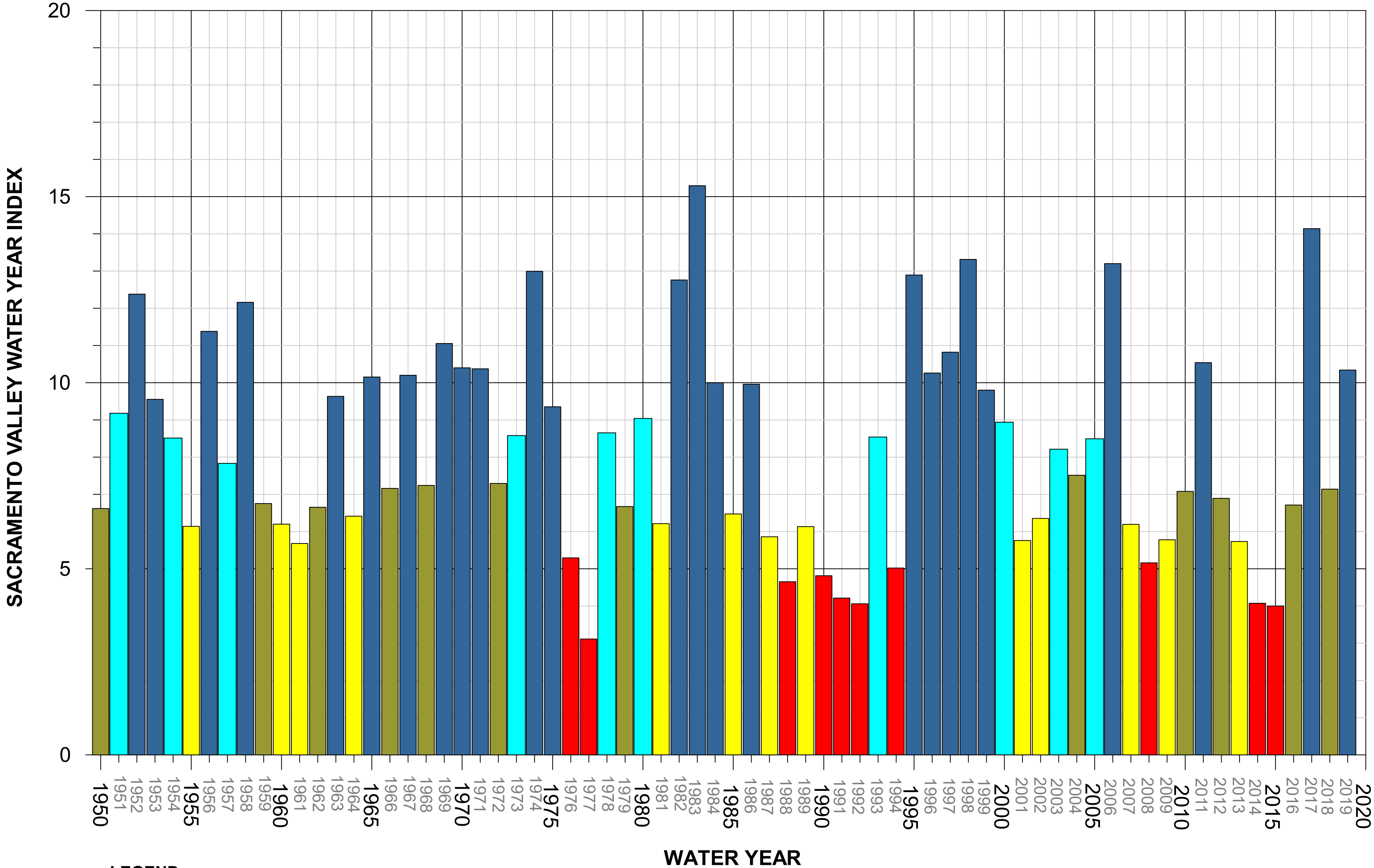


FIGURE 3-2
MEAN ANNUAL PRECIPITATION
Anderson Subbasin Groundwater Sustainability Plan

JACOBS



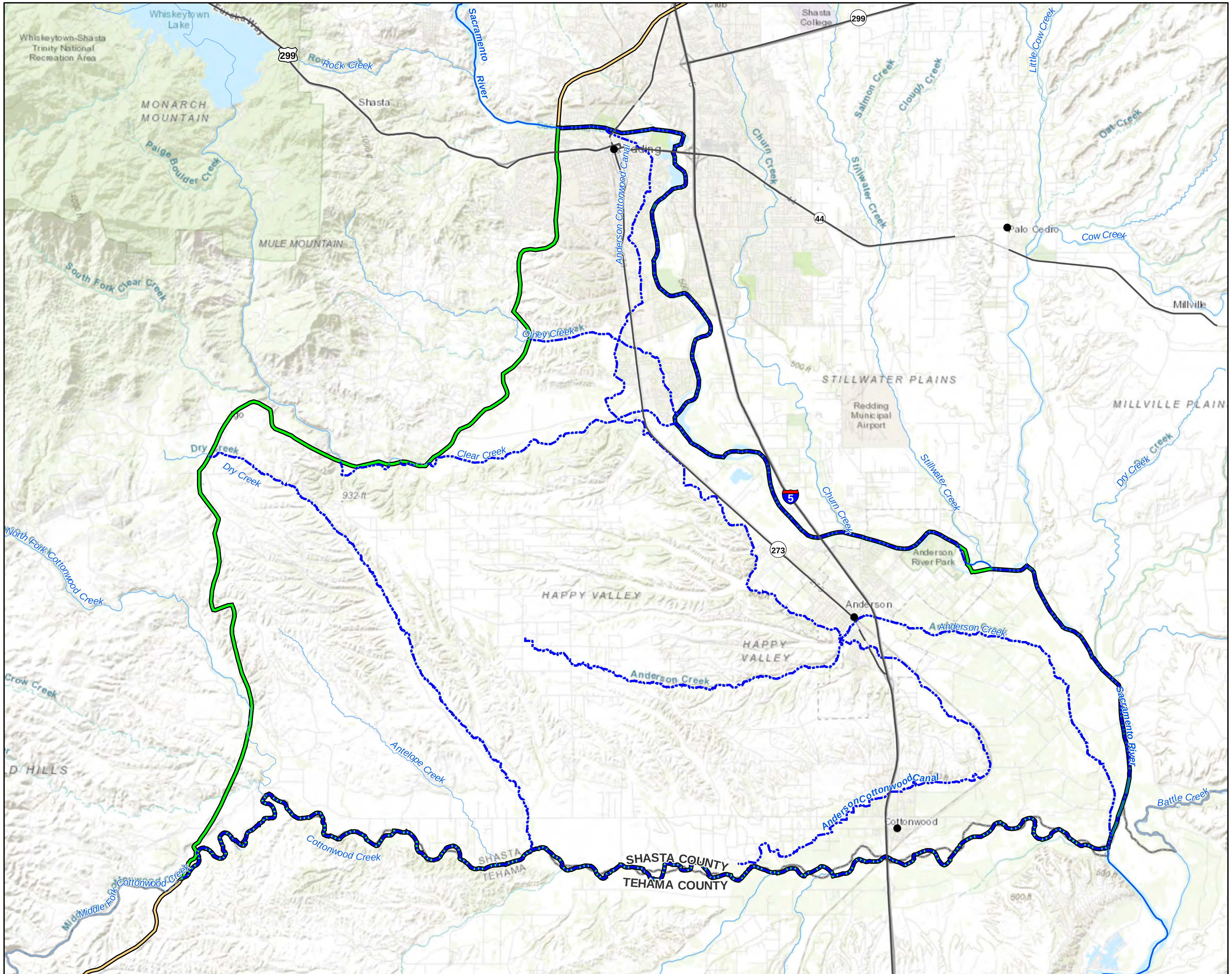
LEGEND

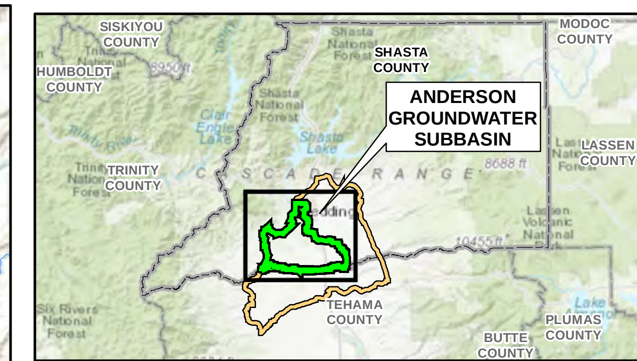
- WET YEAR
- ABOVE NORMAL YEAR
- BELOW NORMAL YEAR
- DRY YEAR
- CRITICAL YEAR

NOTE:

HTTP://CDEC.WATER.CA.GOV/REPORTAPP/JAVAREPORTS?NAME=WSIHIST

FIGURE 3-3
WATER YEAR TYPE
Anderson Subbasin Groundwater Sustainability Plan





LEGEND

- CITY
- MAJOR HYDROLOGIC FEATURE
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTES:

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-4
MAJOR HYDROLOGIC FEATURES
Anderson Subbasin Groundwater Sustainability Plan

JACOBS

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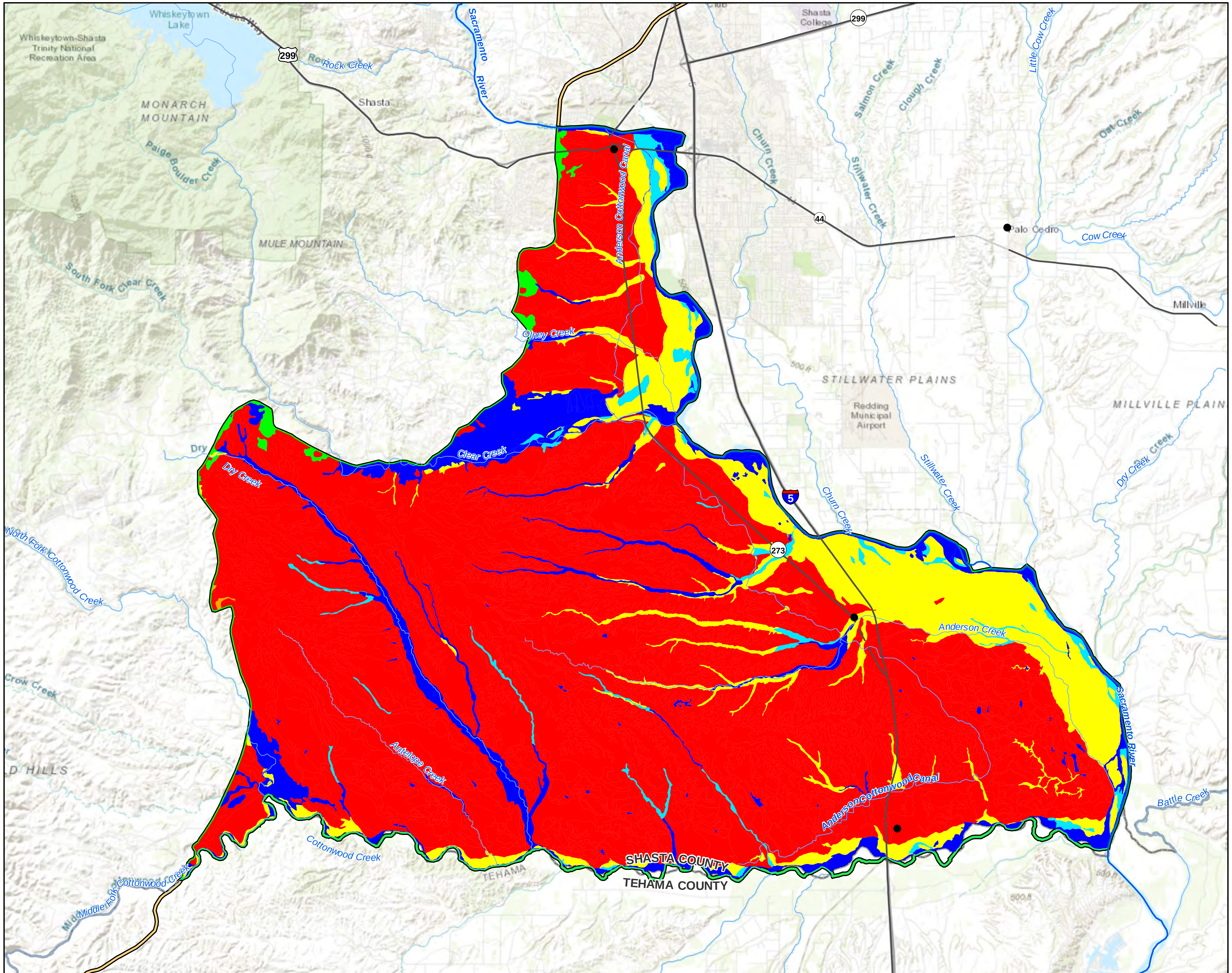

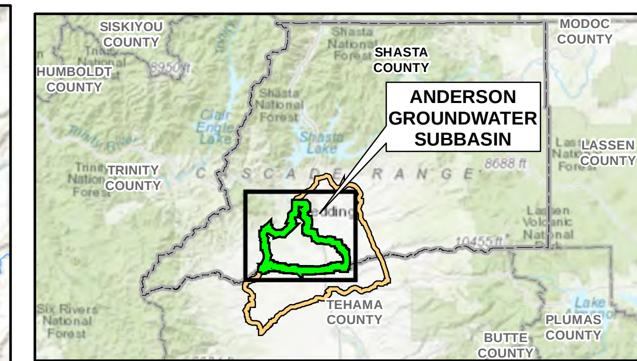

LEGEND

- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

ANDERSON SUBBASIN SURFACE SOIL

- Alfisols
- Aridisols
- Entisols
- Inceptisols
- Ultisols
- Other

NOTES:

DATA SOURCE: SURFACE SOILS ARE BASED ON TAXONOMIC ORDER, DEVELOPED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE'S (USDA) NATIONAL RESOURCES CONSERVATION SERVICE (USDA, 2019)

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-5
ANDERSON SUBBASIN SURFACE SOILS
Anderson Subbasin Groundwater Sustainability Plan

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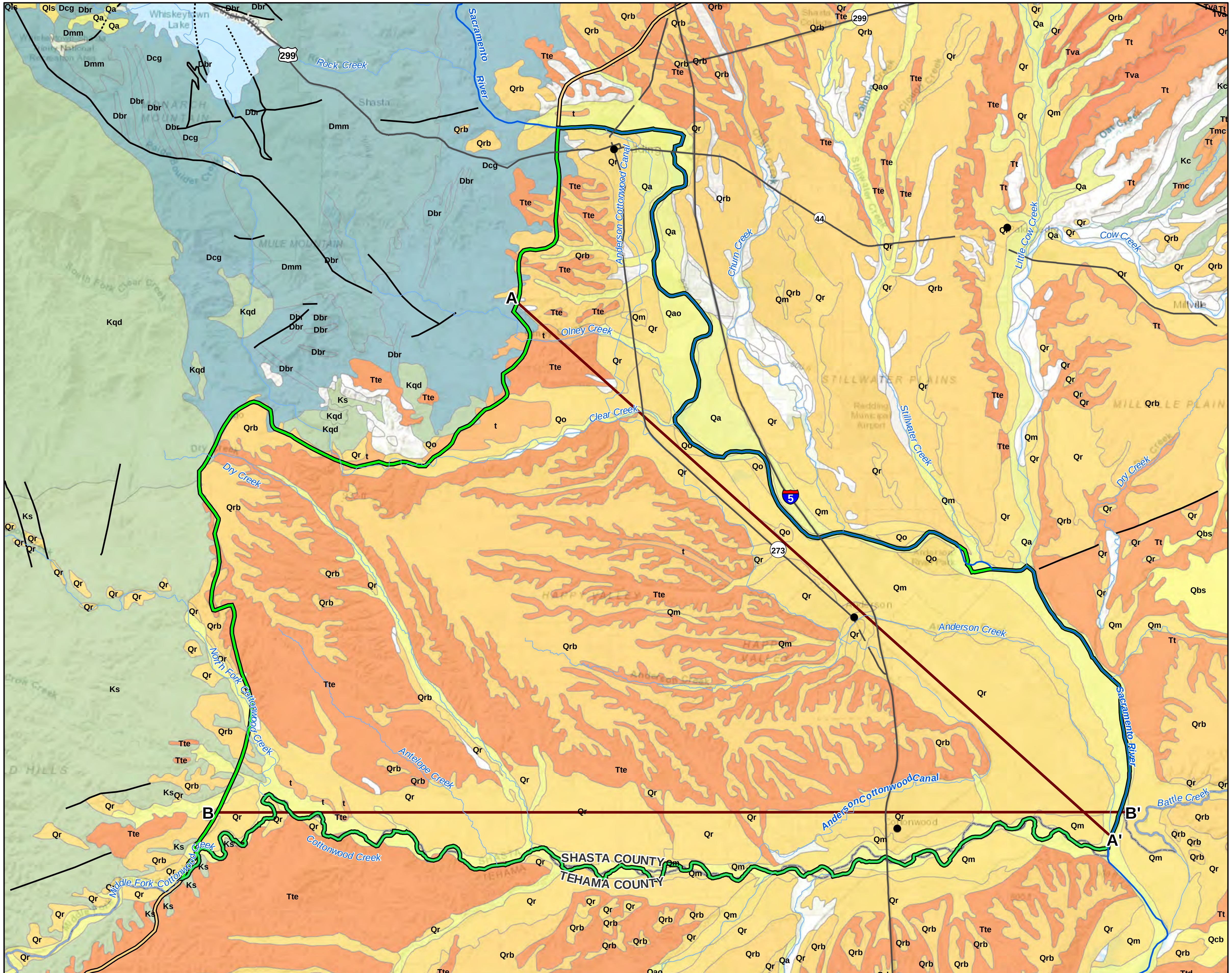

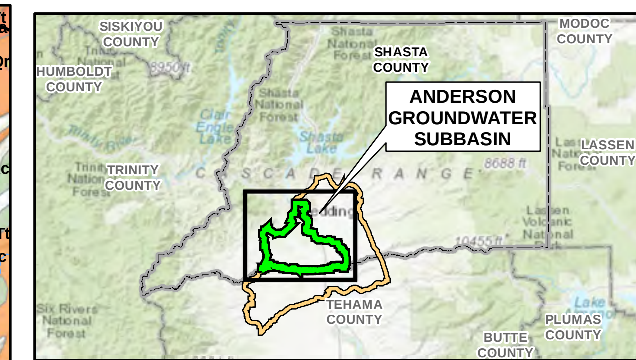

LEGEND

- CITY
- LOCATION OF CROSS SECTION
- FAULT LINE
- FAULT LINE (CONCEALED)
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTES:

GEOLOGY DERIVED FROM THE DIGITAL GEOLOGIC MAP OF THE REDDING 1° X 2° DEGREE QUADRANGLE, SHASTA, TEHAMA, HUMBOLDT, AND TRINITY COUNTIES, CALIFORNIA (USGS, 2012). FIGURE 3-6b PRESENTS EXPLANATION OF MAP UNITS.

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-6a
ANDERSON SUBBASIN GEOLOGY
Anderson Subbasin Groundwater Sustainability Plan

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FIGURE 3-6a MAP UNIT EXPLANATION

SURFICIAL DEPOSITS

t	Man-made materials (Holocene)
Qa	Alluvium and colluvium (Holocene)
Qo	Overbank deposits (Holocene)
Qao	Alluvial and overbank deposits, undivided (Holocene)
Qls	Landslide deposits (Holocene)
Qm	Modesto formation of Davis and Hall (1959) (Pleistocene)
Qr	Riverbank Formation (Pleistocene)
Qrb	Red Bluff formation of Diller (1894) (Pleistocene)

VOLCANIC ROCKS

Qbs	Basalt of Shingletown Ridge (Pleistocene)
Qcb	Basalt of Coleman Forebay (Pleistocene)
Tva	Andesitic breccia (Pliocene)

SEDIMENTARY ROCKS

Tte	Tehama Formation (Pliocene)
Tt	Tuscan Formation, undivided (Pliocene)
Ttd	Fragmental Deposits
Tmc	Montgomery Creek Formation (Eocene)
Kc	Chico Formation (Upper Cretaceous)
Ks	Sedimentary Rocks (Lower Cretaceous)

EASTERN KLAMATH TERRANE

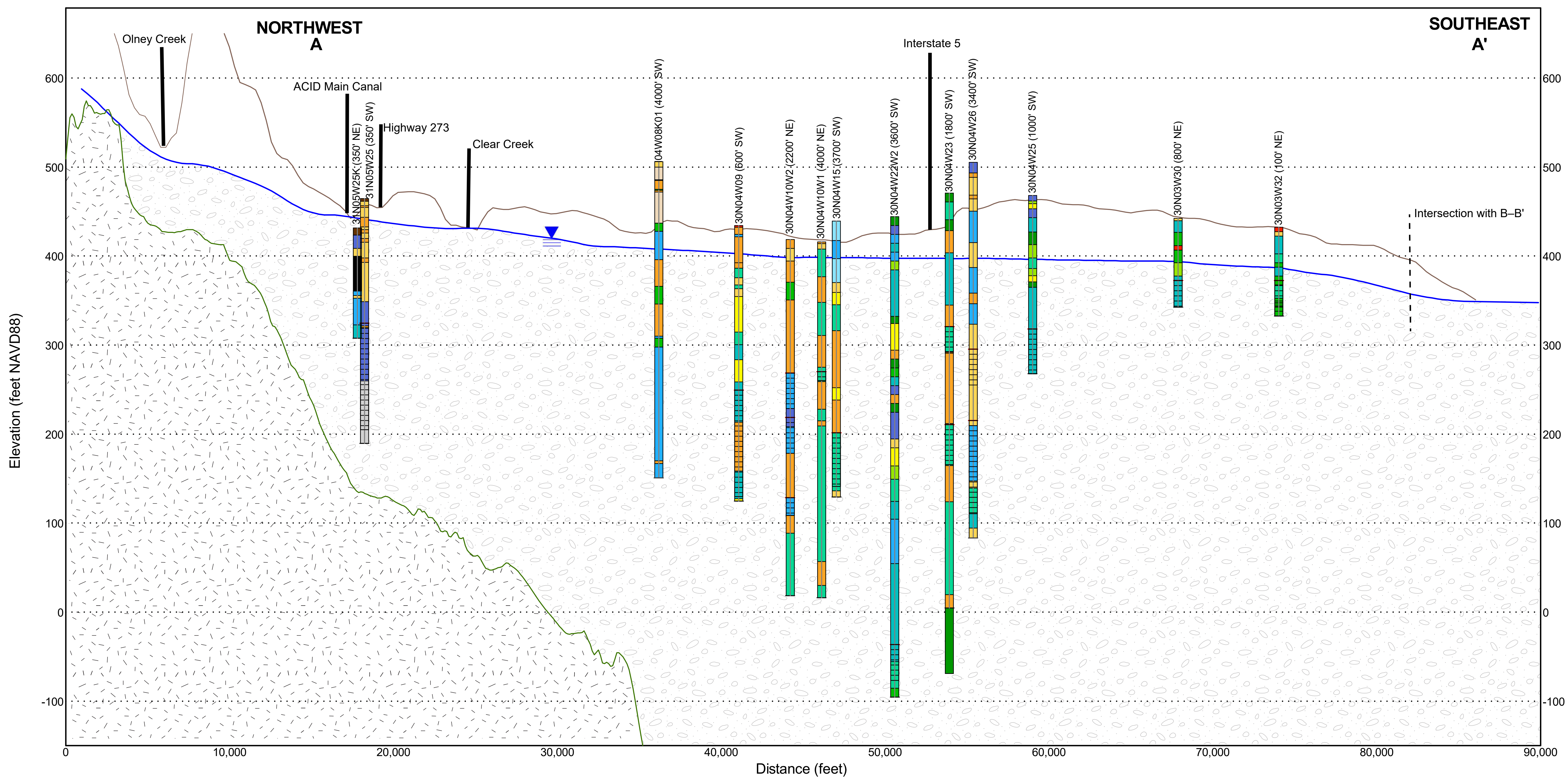
Dmm	Mule Mountain stock (Devonian)
Dbr	Balaklala Rhyolite (Devonian(?))
Dcg	Copley Greenstone (Devonian(?))

NOTES:

GEOLOGY DERIVED FROM THE DIGITAL GEOLOGIC MAP OF THE REDDING 1° X 2° DEGREE QUADRANGLE, SHASTA, TEHAMA, HUMBOLDT, AND TRINITY COUNTIES, CALIFORNIA (USGS, 2012).

MAP UNIT (Ttm) LABELED ON THE MAP IS OF UNKNOWN IDENTITY AND AGE; UNLABELED AREAS ARE OF UNKNOWN IDENTITY AND AGE. BOTH ARE UNFILLED ON THIS MAP.

FIGURE 3-6b
LIST OF MAP UNITS
Anderson Subbasin Groundwater Sustainability Plan



GROUND SURFACE ELEVATION (feet NAVD88)

TOP OF CHICO FORMATION

GROUNDWATER ELEVATION (feet NAVD88)

SCREEN INTERVAL

SCALE EXAGGERATION – 54:1 (H:V)

SOIL AND LITHOLOGY

SAND	GRAVEL	CLAY	BASALT	PRINCIPAL AQUIFER
CLAYEY SAND	CLAYEY GRAVEL	SANDY CLAY	HARD PAN	BEDROCK
GRAVELLEY SAND	SANDY GRAVEL	GRAVELLEY CLAY	SHALE	
SILTY SAND	SILTY GRAVEL	SILT	UNDIFFERENTIATED ROCK	
SANDSTONE	TUFF	SILTSTONE	UNDIFFERENTIATED SOIL	

NOTES:

LOCATION OF CROSS SECTION SHOWN ON FIGURE 3-6a.

30N04W08K01 (4000' SW) = LOCATION (DISTANCE/DIRECTION) FROM SECTION LINE (SEE FIGURE 3-6a).

GROUNDWATER ELEVATION IS ESTIMATED FROM GROUNDWATER LEVELS MEASURED BETWEEN OCTOBER 16 AND OCTOBER 26, 2018 (DWR, 2019b) (SEE FIGURE 3-13).

TOP OF CASING ELEVATION OF SOME WELLS DIFFER FROM THE ELEVATION OF THE PROFILE BECAUSE THOSE WELLS ARE NOT COLLINEAR WITH THE SECTION LINE.

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988.

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FIGURE 3-7
GEOLOGIC CROSS SECTION A-A'
Anderson Subbasin Groundwater Sustainability Plan

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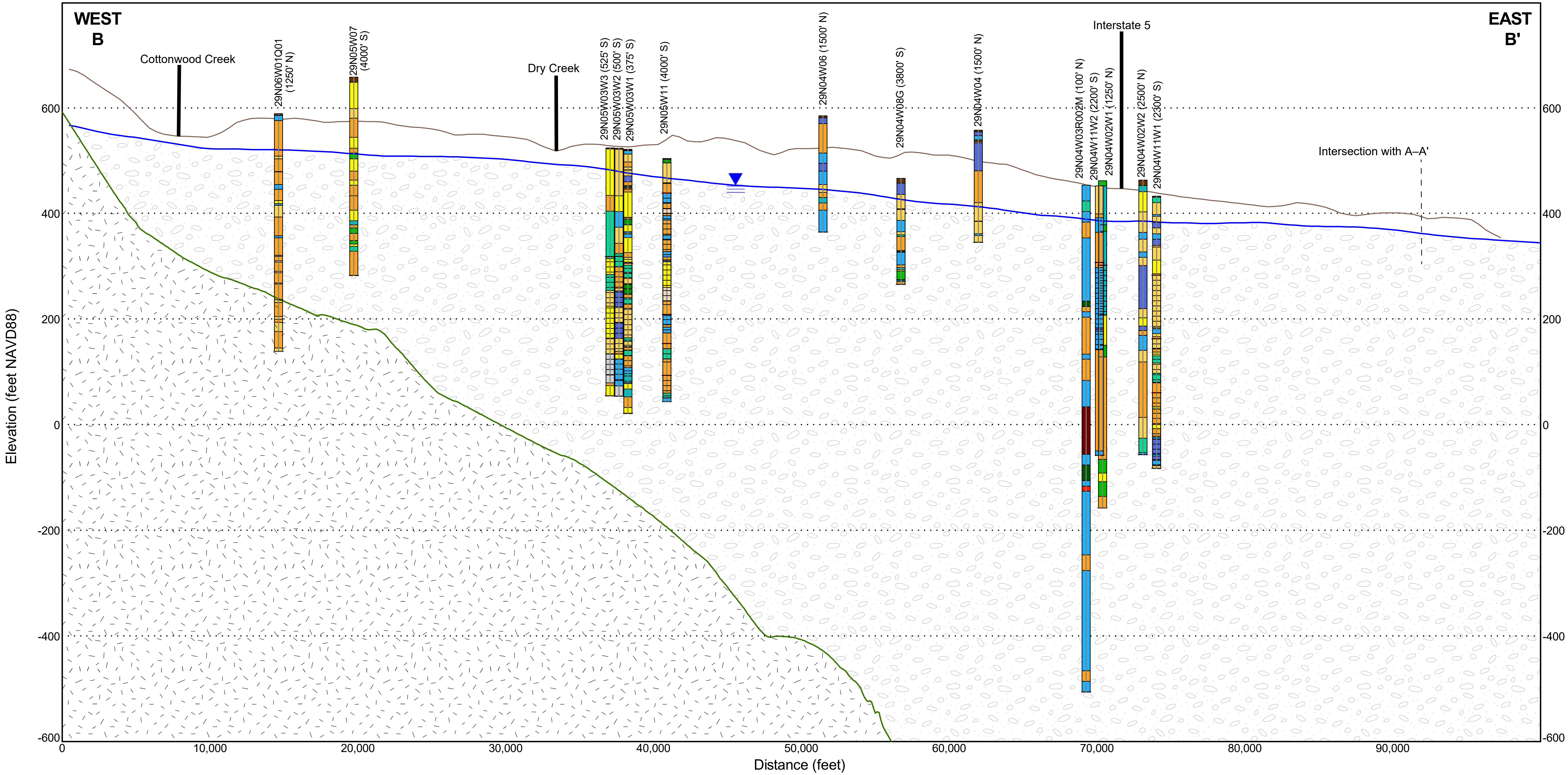

GROUND SURFACE ELEVATION (feet NAVD88)

TOP OF CHICO FORMATION (DASHED WHERE UNCERTAIN)

GROUNDWATER ELEVATION (feet NAVD88)

SCREEN INTERVAL

SCALE EXAGGERATION – 36:1 (H:V)

SOIL AND LITHOLOGY

SAND	GRAVEL	CLAY	BASALT
CLAYEY SAND	CLAYEY GRAVEL	SANDY CLAY	HARD PAN
GRAVELLEY SAND	SANDY GRAVEL	GRAVELLEY CLAY	SHALE
SILTY SAND	SILTY GRAVEL	SILT	UNDIFFERENTIATED ROCK
SANDSTONE	TUFF	SILTSTONE	UNDIFFERENTIATED SOIL

PRINCIPAL AQUIFER

BEDROCK

NOTES:

LOCATION OF CROSS SECTION SHOWN ON FIGURE 3-6a.

30N04W08K01 (4000' SW) = LOCATION (DISTANCE/DIRECTION) FROM SECTION LINE (SEE FIGURE 3-6a).

GROUNDWATER ELEVATION IS ESTIMATED FROM GROUNDWATER LEVELS MEASURED BETWEEN OCTOBER 16 AND OCTOBER 26, 2018 (DWR, 2019b) (SEE FIGURE 3-13).

TOP OF CASING ELEVATION OF SOME WELLS DIFFER FROM THE ELEVATION OF THE PROFILE BECAUSE THOSE WELLS ARE NOT COLLINEAR WITH THE SECTION LINE.

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988.

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FIGURE 3-8
GEOLOGIC CROSS SECTION B-B'
Anderson Subbasin Groundwater Sustainability Plan

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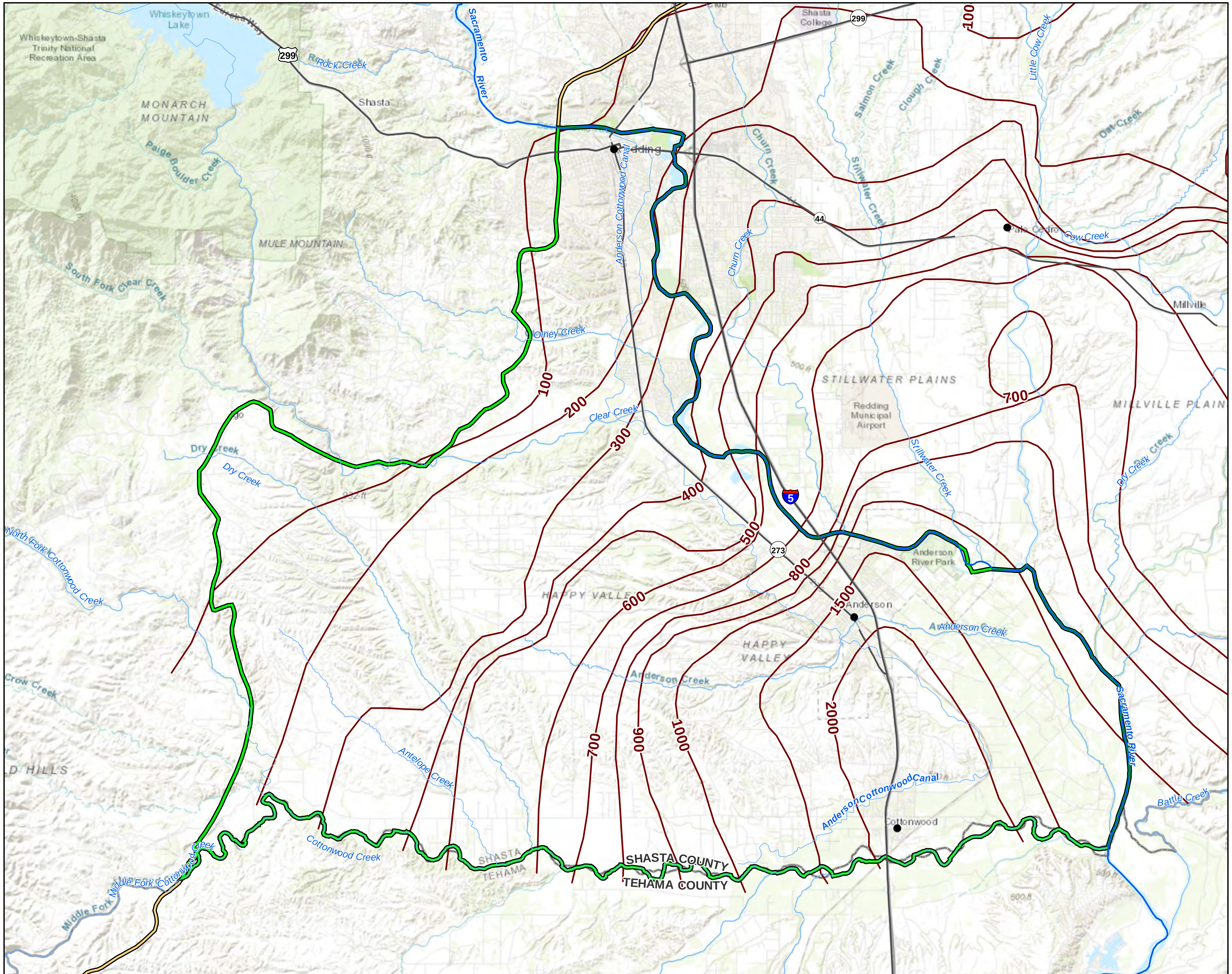

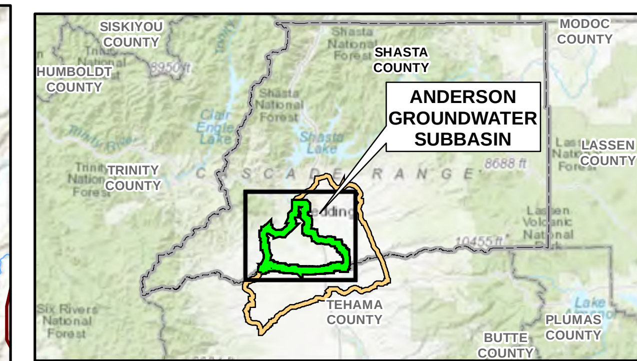

LEGEND

- CITY
- DEPTH TO CHICO FORMATION (feet BGS)
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTE:

DATA SOURCE: DIGITIZED FROM DWR, 1968

BGS = BELOW GROUND SURFACE

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-9
DEPTH TO THE TOP OF THE CHICO FORMATION
Anderson Subbasin Groundwater Sustainability Plan

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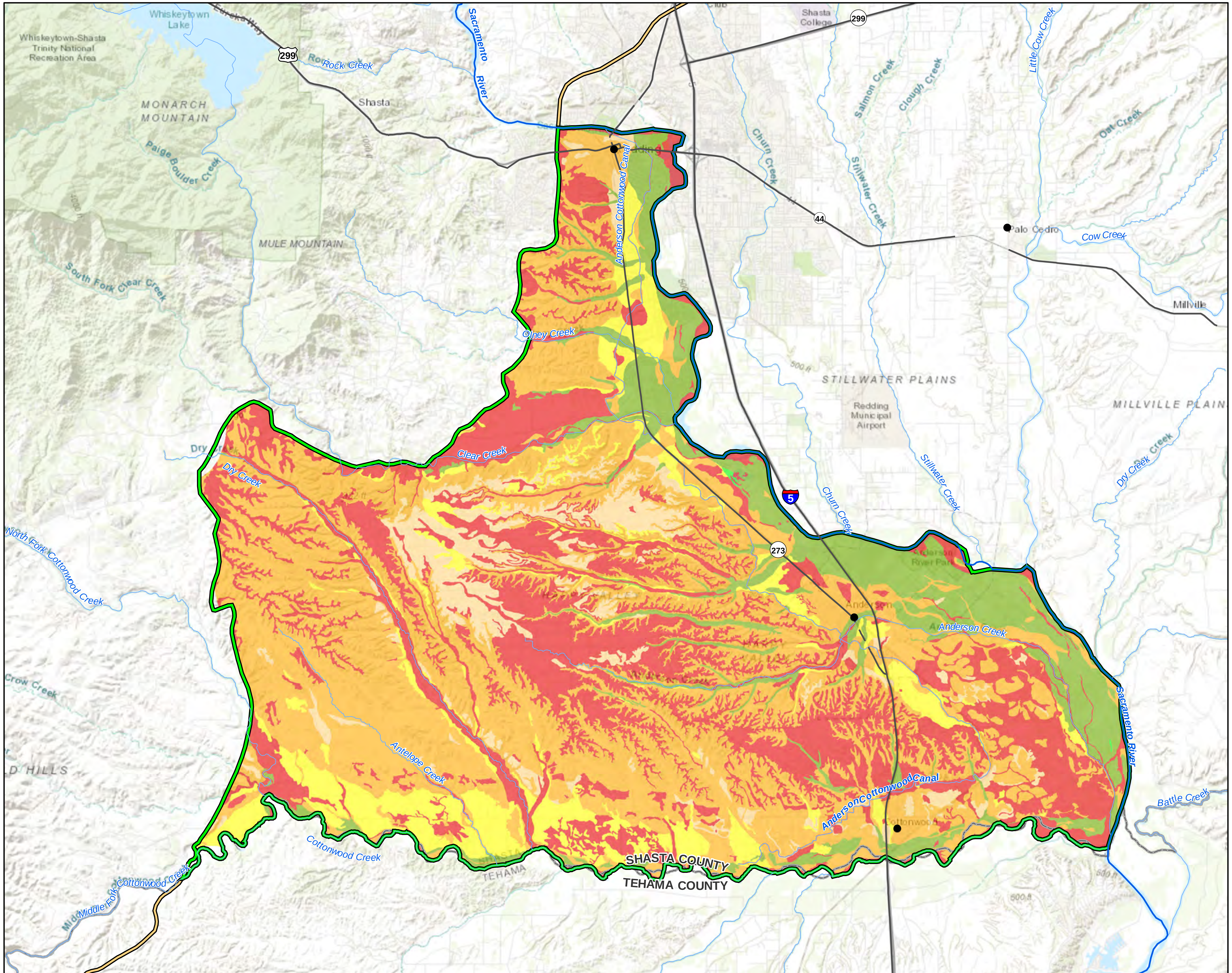

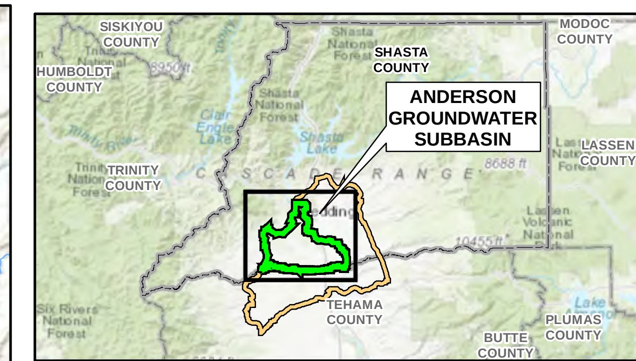

LEGEND

- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

SAGBI RATING (RATING CLASS)

- 85 to 100 (EXCELLENT)
- 69 to 85 (GOOD)
- 49 to 69 (MODERATELY GOOD)
- 29 to 49 (MODERATELY POOR)
- 15 to 29 (POOR)
- 0 to 15 (VERY POOR)

NOTES:

DATA SOURCE: SOIL AGRICULTURAL GROUNDWATER BANKING INDEX (SAGBI) (O'GEEN ET AL., 2015)

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

Miles 0 2 4

FIGURE 3-10
SOIL AGRICULTURAL GROUNDWATER BANKING INDEX MAP
Anderson Subbasin Groundwater Sustainability Plan

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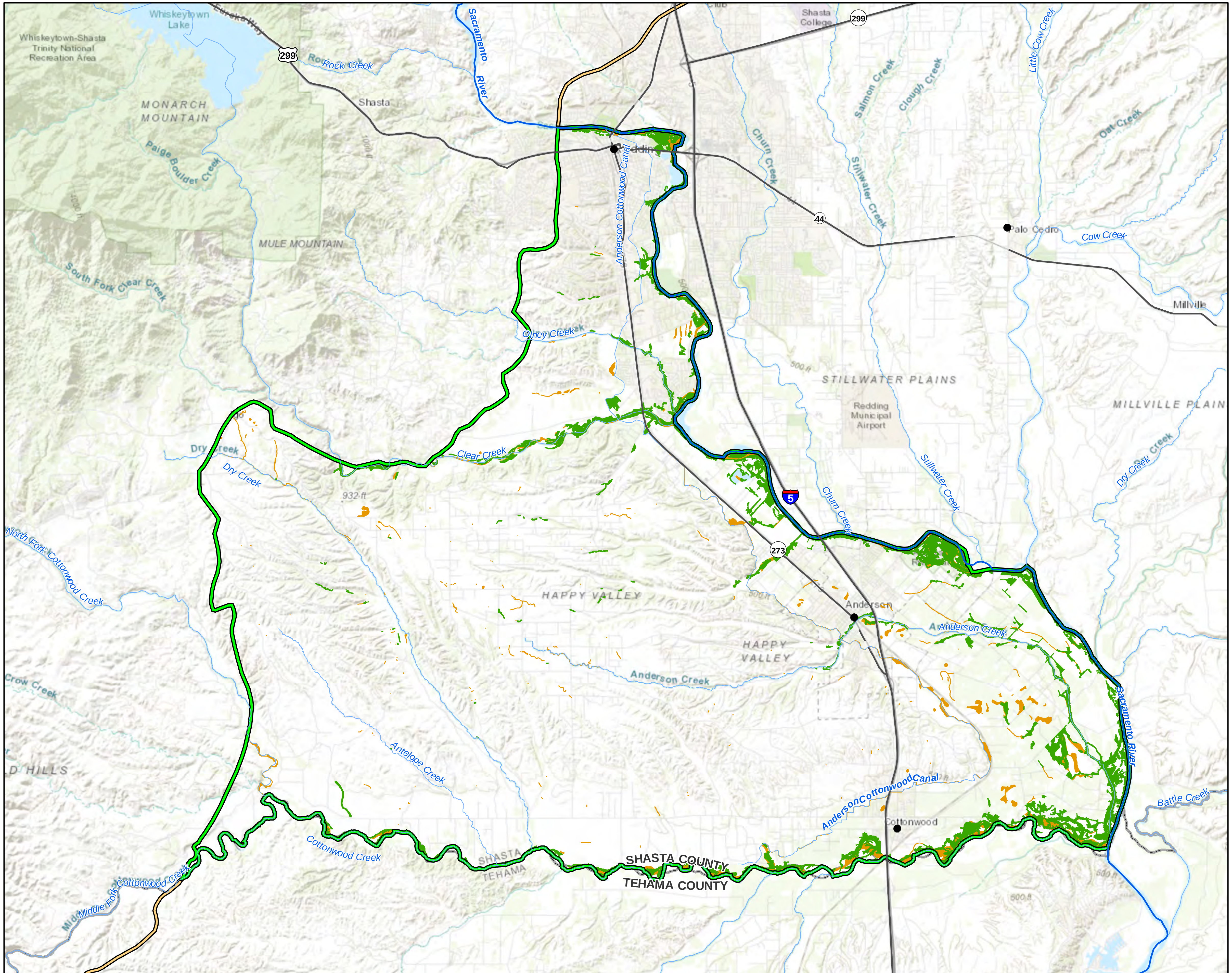

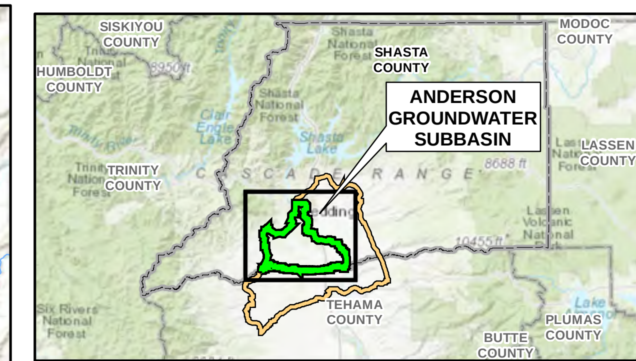

LEGEND

- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN
- NATURAL COMMUNITIES COMMONLY ASSOCIATED WITH GROUNDWATER VEGETATION
- NATURAL COMMUNITIES COMMONLY ASSOCIATED WITH GROUNDWATER WETLANDS

NOTES:

DATA SOURCE:
HTTPS://GIS.WATER.CA.GOV/APP/NCDATASETVIEWER/#. ACCESSED MARCH 2020 (DWR, 2020c)

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

N

FIGURE 3-11
POTENTIAL GROUNDWATER-DEPENDENT ECOSYSTEMS
Anderson Subbasin Groundwater Sustainability Plan

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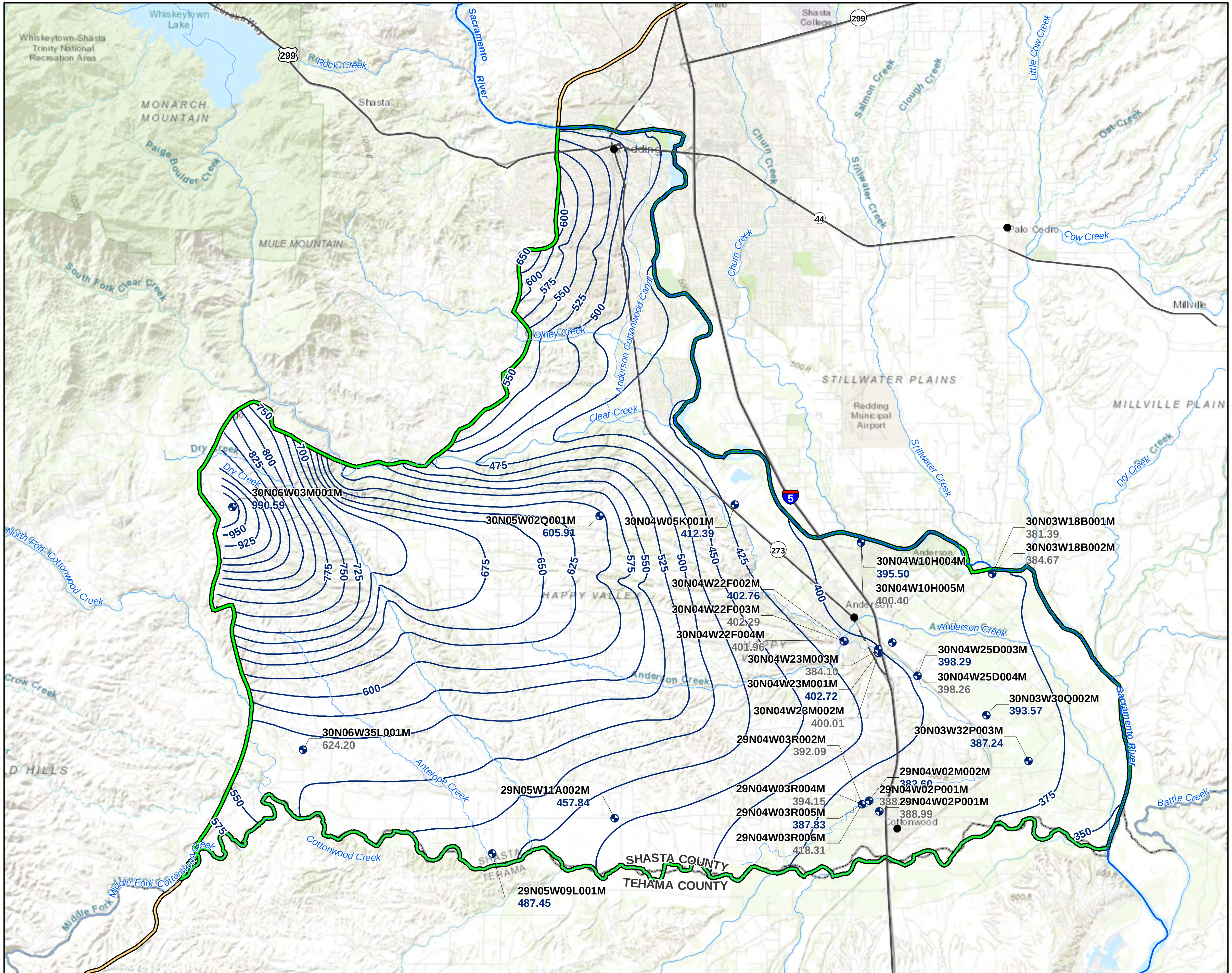

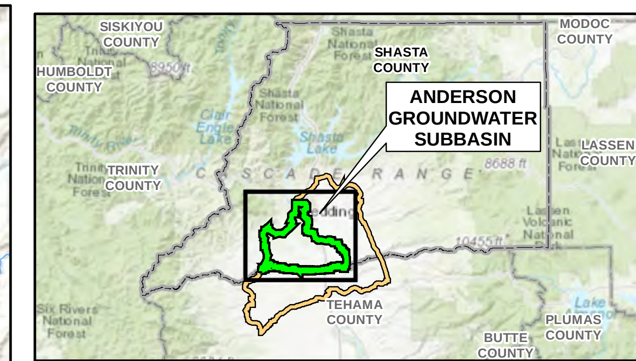

LEGEND

- GROUNDWATER ELEVATION LOCATION
- 395.50 MEASURED GROUNDWATER ELEVATION (feet NAVD88) (GRAY TEXT INDICATES ELEVATION NOT USED IN CONTOURING)
- CITY
- SPRING 2018 GROUNDWATER ELEVATION CONTOUR (feet NAVD88)
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTES:

GROUNDWATER LEVELS WERE MEASURED BETWEEN MARCH 19 AND APRIL 3, 2018 (DWR, 2019b).

WELLS SCREENED IN SHALLOW GROUNDWATER, POINT LOCATIONS ALONG SACRAMENTO RIVER WITH INTERPOLATED SURFACE WATER ELEVATIONS, AND RIVER GAGES BELOW KESWICK RESERVOIR (11370500) AND AT BEND BRIDGE IN RED BLUFF (11377100) WERE USED IN CONTOURING SHALLOW GROUNDWATER. REDFEM OUTPUTS WERE USED TO SUPPLEMENT AREAS WITHOUT CURRENT GROUNDWATER ELEVATION DATA (CH2M HILL, 2011 AND USGS, 2019a).

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-12
SPRING 2018 GROUNDWATER ELEVATION CONTOURS
Anderson Subbasin Groundwater Sustainability Plan

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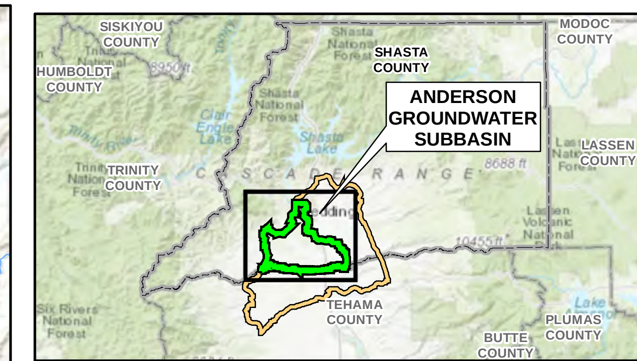

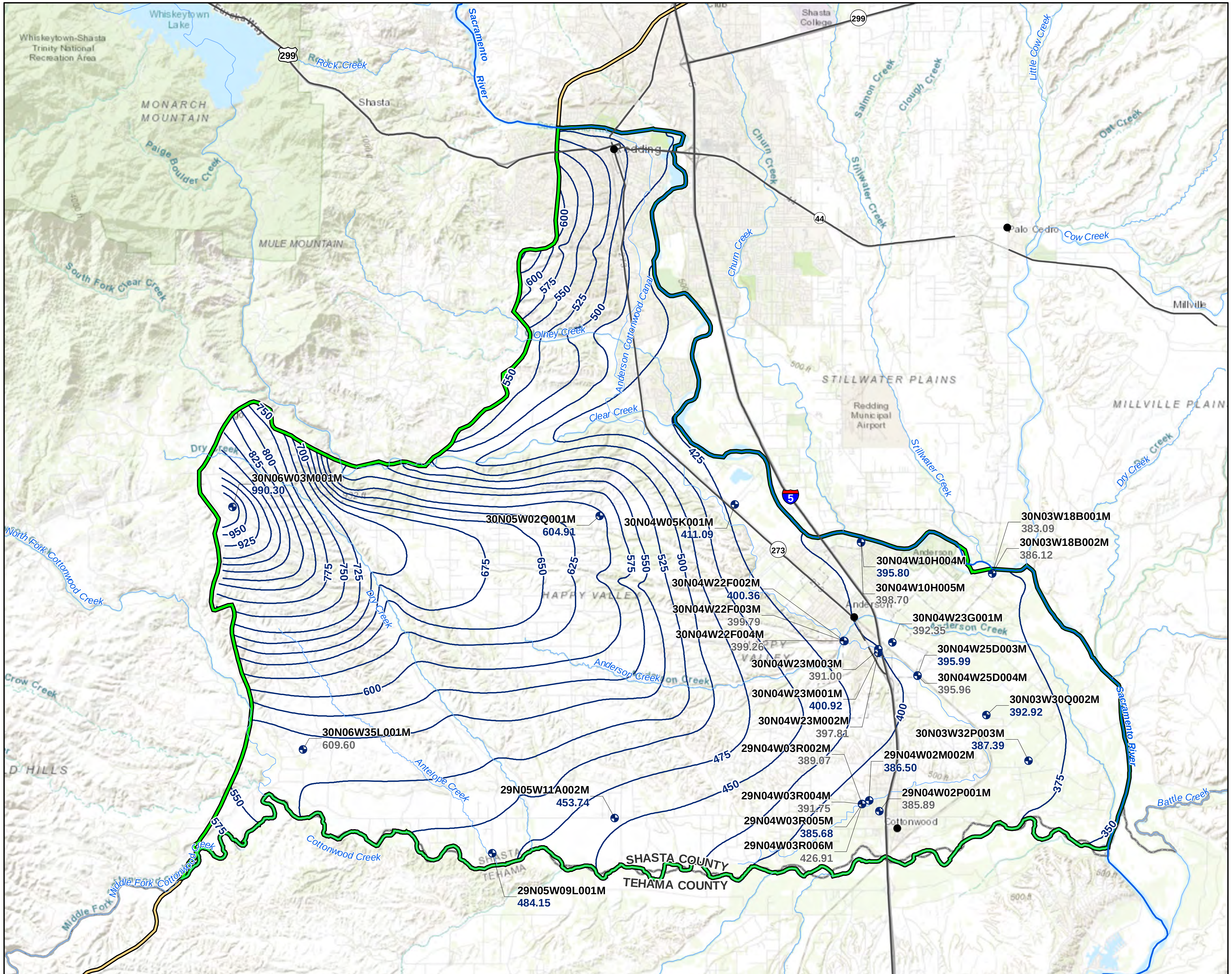

LEGEND

- GROUNDWATER ELEVATION LOCATION
- 395.50 MEASURED GROUNDWATER ELEVATION (feet NAVD88) (GRAY TEXT INDICATES ELEVATION NOT USED IN CONTOURING)
- CITY
- FALL 2018 GROUNDWATER ELEVATION CONTOUR (feet NAVD88)
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTES:

GROUNDWATER LEVELS WERE MEASURED BETWEEN OCTOBER 16 AND 26, 2018 (DWR, 2019b).

WELLS SCREENED IN SHALLOW GROUNDWATER, POINT LOCATIONS ALONG SACRAMENTO RIVER WITH INTERPOLATED SURFACE WATER ELEVATIONS, AND RIVER GAGES BELOW KESWICK RESERVOIR (11370500) AND AT BEND BRIDGE IN RED BLUFF (11377100) WERE USED IN CONTOURING SHALLOW GROUNDWATER. REDFEM OUTPUTS WERE USED TO SUPPLEMENT AREAS WITHOUT CURRENT GROUNDWATER ELEVATION DATA (CH2M HILL, 2011 AND USGS, 2019a).

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

FIGURE 3-13
FALL 2018 GROUNDWATER ELEVATION CONTOURS
Anderson Subbasin Groundwater Sustainability Plan

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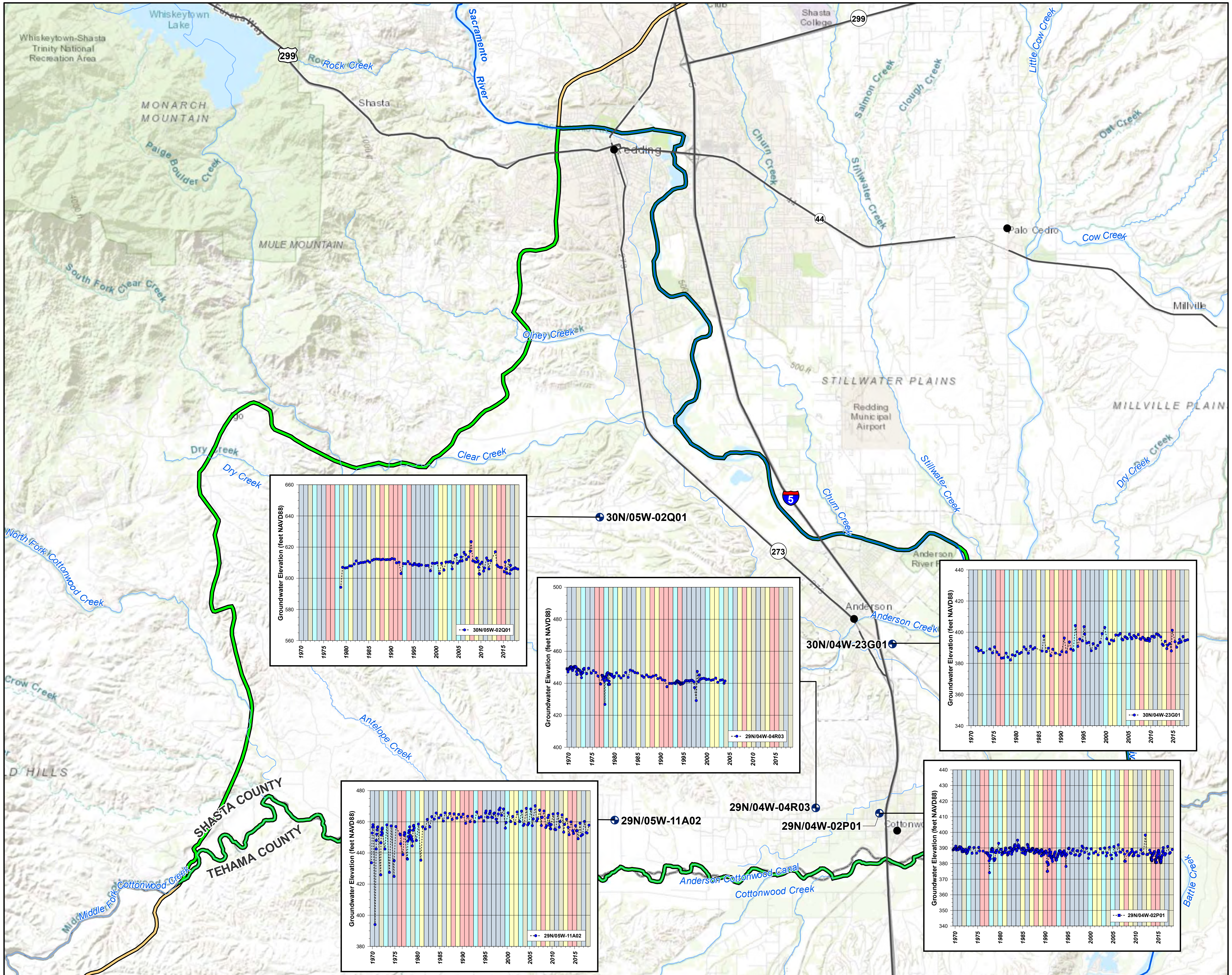

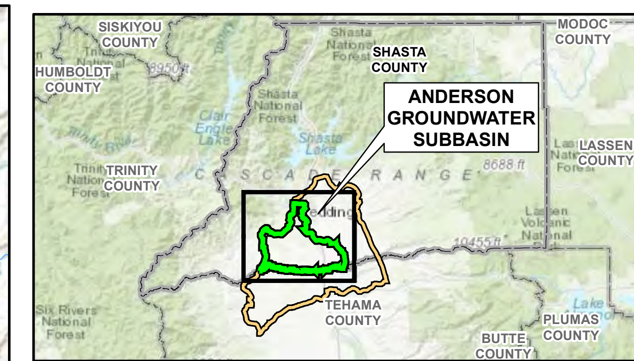

MAP LEGEND

- GROUNDWATER ELEVATION LOCATION
- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

GRAPH LEGEND

- GROUNDWATER ELEVATION (feet NAVD88)

SACRAMENTO VALLEY HYDROLOGIC REGION UNIMPAIRED RUNOFF (5 MILLION ACRE-FEET)

- WET YEAR
- ABOVE NORMAL YEAR
- BELOW NORMAL YEAR
- DRY YEAR
- CRITICAL YEAR

NOTES:

DATA SOURCES: DWR, 2019b

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-14
SELECT HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan

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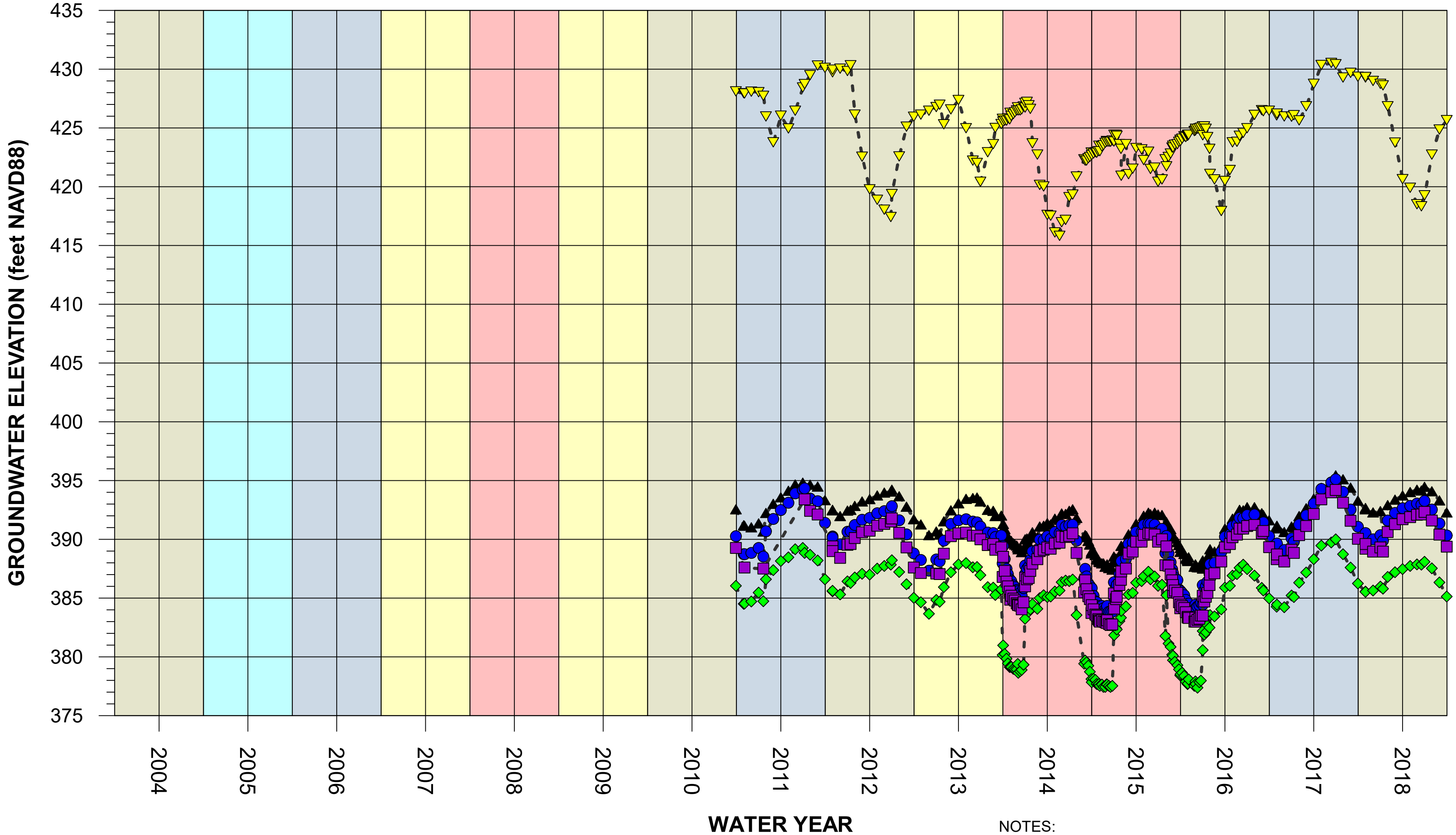

NOTES:

(200.6 to 119.6) = WELL SCREEN ELEVATION (feet NAVD88)

DATA SOURCES: DWR, 2019a and 2020a

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

LEGEND

- 29N/04W-03R06 (417.84 to 397.84)
- 29N/04W-03R05 (329.84 to 269.84)
- 29N/04W-03R04 (77.84 to 67.84)
- 29N/04W-03R03 (-57.16 to -202.16)
- 29N/04W-03R02 (-282.16 to -422.16)

- WET YEAR
- ABOVE NORMAL YEAR
- BELOW NORMAL YEAR
- DRY YEAR
- CRITICAL YEAR

FIGURE 3-15a
ANDERSON SUBBASIN WELL CLUSTER HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan

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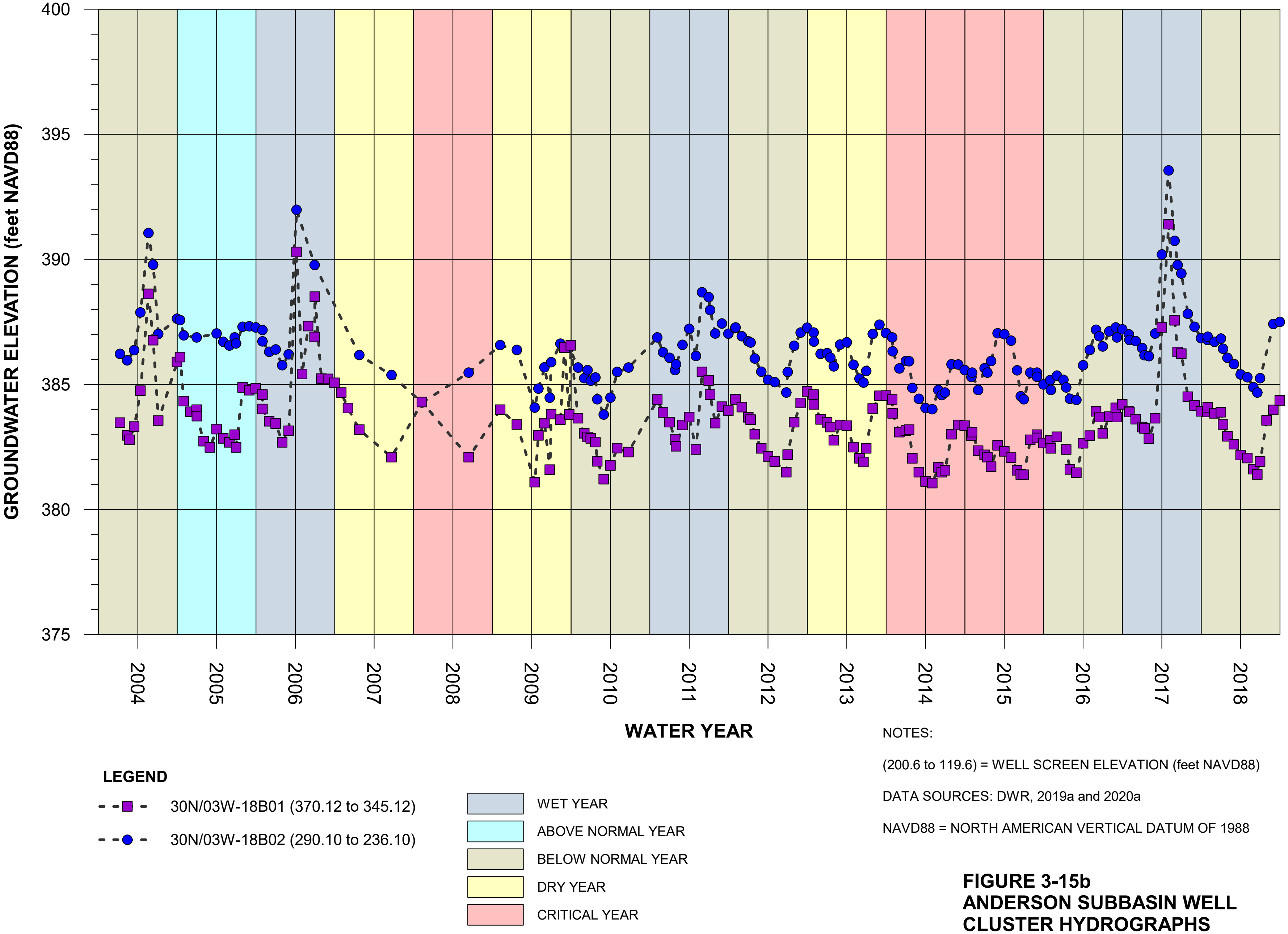


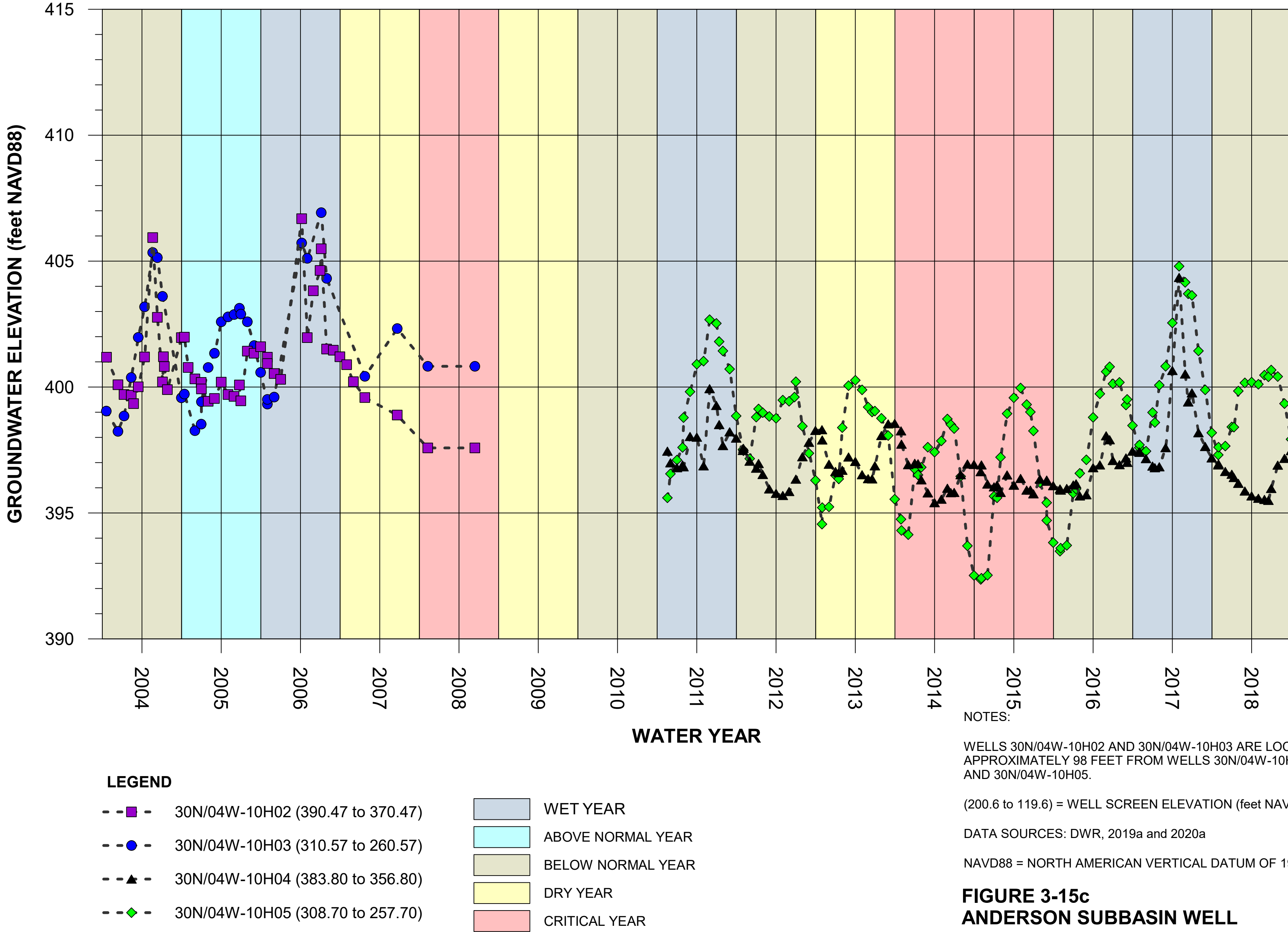
NOTES:

(200.6 to 119.6) = WELL SCREEN ELEVATION (feet NAVD88)

DATA SOURCES: DWR, 2019a and 2020a

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

FIGURE 3-15b
ANDERSON SUBBASIN WELL CLUSTER HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan



NOTES:

WELLS 30N/04W-10H02 AND 30N/04W-10H03 ARE LOCATED APPROXIMATELY 98 FEET FROM WELLS 30N/04W-10H04 AND 30N/04W-10H05.

(200.6 to 119.6) = WELL SCREEN ELEVATION (feet NAVD88)

DATA SOURCES: DWR, 2019a and 2020a

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

FIGURE 3-15c
ANDERSON SUBBASIN WELL CLUSTER HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan

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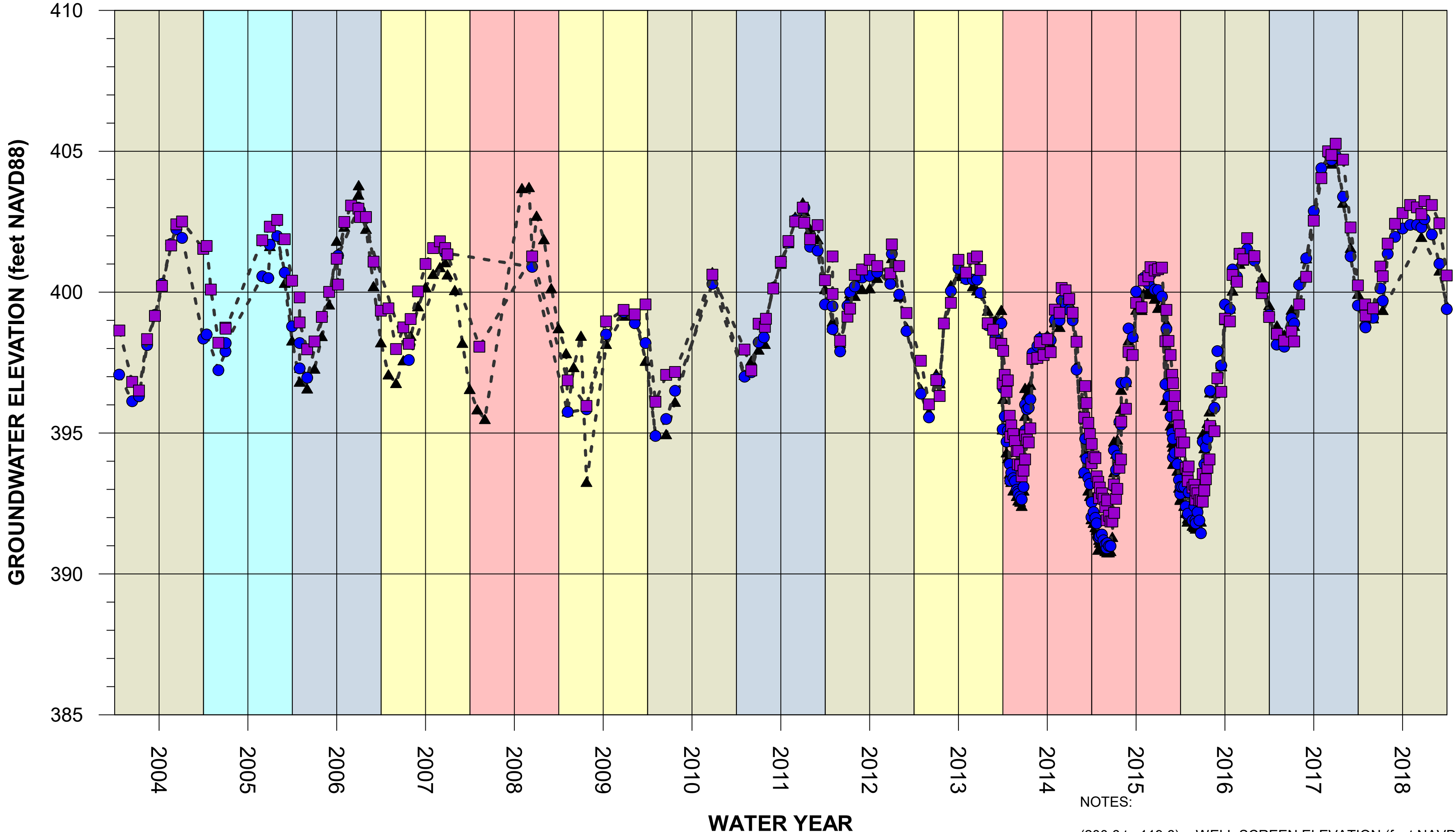

NOTES:

(200.6 to 119.6) = WELL SCREEN ELEVATION (feet NAVD88)

DATA SOURCES: DWR, 2019a and 2020a

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

LEGEND

30N/04W-22F02 (377.86 to 334.86)

30N/04W-22F03 (277.64 to 245.64)

30N/04W-22F04 (-32.20 to -92.20)

WET YEAR

ABOVE NORMAL YEAR

BELOW NORMAL YEAR

DRY YEAR

CRITICAL YEAR

FIGURE 3-15d
ANDERSON SUBBASIN WELL CLUSTER HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan

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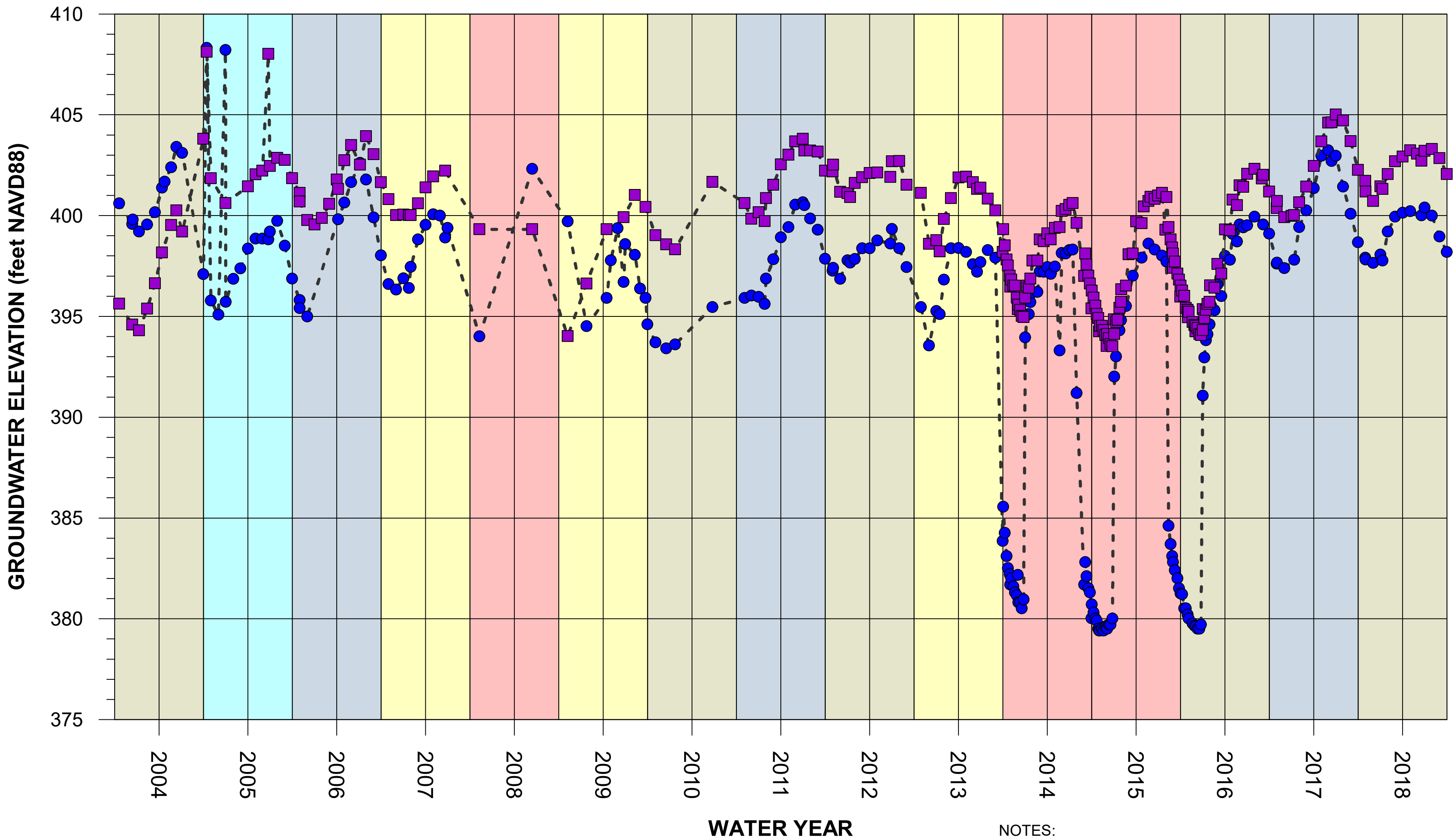

LEGEND

30N/04W-23M01 (392.33 to 358.33)

30N/04W-23M02 (332.67 to 271.67)

WET YEAR

ABOVE NORMAL YEAR

BELOW NORMAL YEAR

DRY YEAR

CRITICAL YEAR

NOTES:

(200.6 to 119.6) = WELL SCREEN ELEVATION (feet NAVD88)

DATA SOURCES: DWR, 2019a and 2020a

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

FIGURE 3-15e
ANDERSON SUBBASIN WELL CLUSTER HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan

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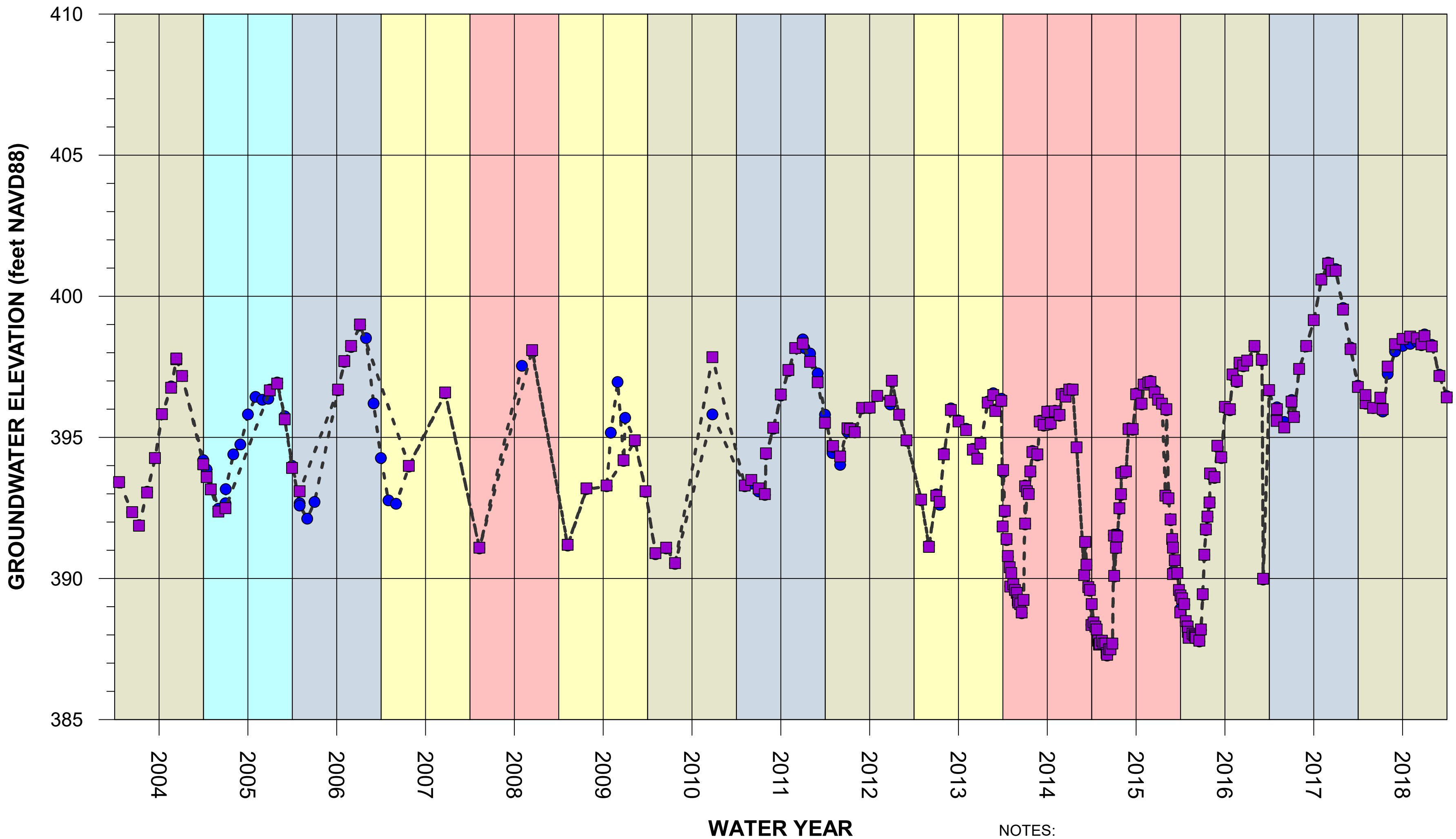

NOTES:

(200.6 to 119.6) = WELL SCREEN ELEVATION (feet NAVD88)

DATA SOURCES: DWR, 2019a and 2020a

NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988

LEGEND

30N/04W-25D03 (372.47 to 350.47)

30N/04W-25D04 (322.07 to 271.07)

WET YEAR

ABOVE NORMAL YEAR

BELOW NORMAL YEAR

DRY YEAR

CRITICAL YEAR

FIGURE 3-15f
ANDERSON SUBBASIN WELL CLUSTER HYDROGRAPHS
Anderson Subbasin Groundwater Sustainability Plan

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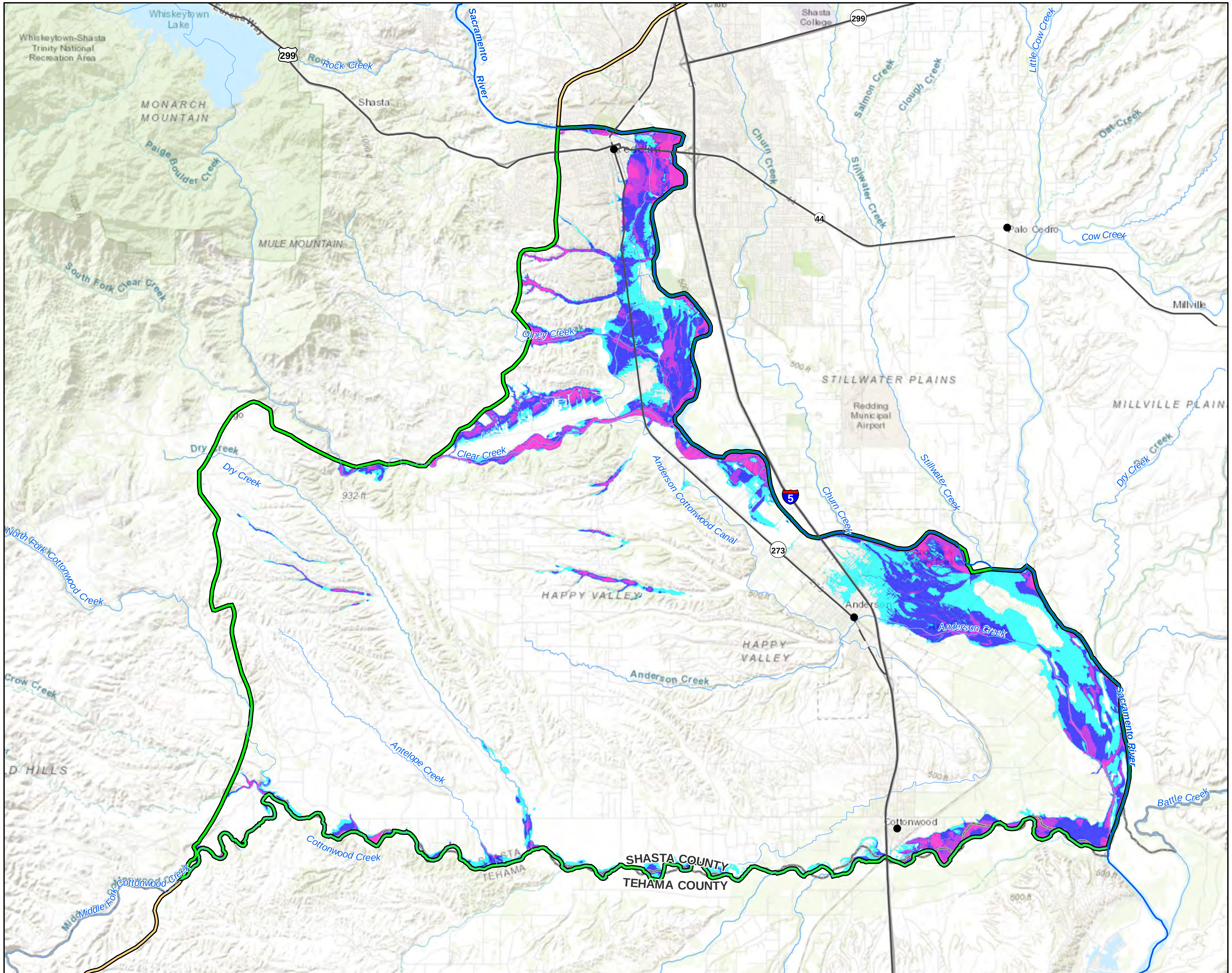

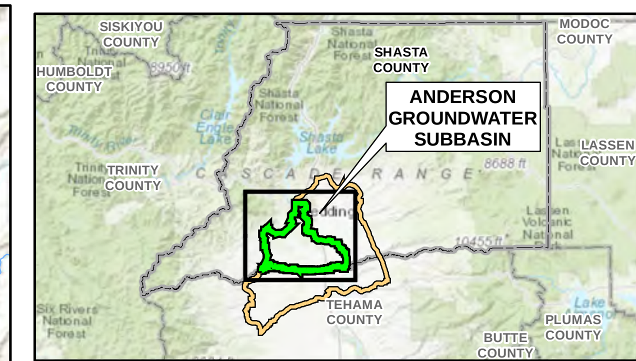

LEGEND

395.50 MEASURED GROUNDWATER ELEVATION (feet NAVD88) (GRAY TEXT INDICATES ELEVATION NOT USED IN CONTOURING)

- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

GROUNDWATER LEVELS WITHIN 20 FEET OF GROUND SURFACE (feet BGS)

- ABOVE GROUND SURFACE TO 5 FEET
- 5 to 10
- 10 to 15
- 15 to 20

NOTES:

BGS = BELOW GROUND SURFACE

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-16
GROUNDWATER WITHIN 20 FEET OF LAND SURFACE; SPRING 2018
Anderson Subbasin Groundwater Sustainability Plan

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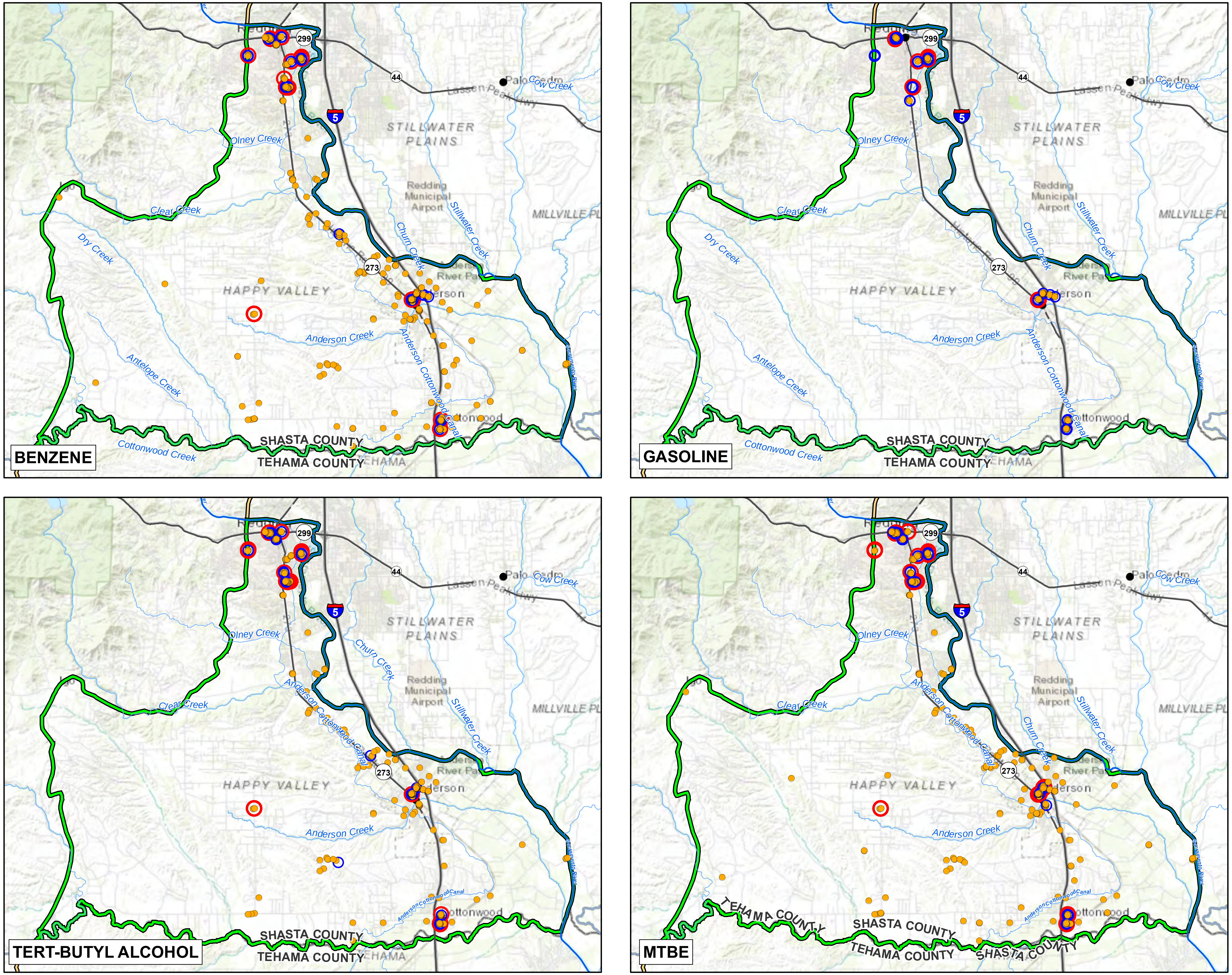
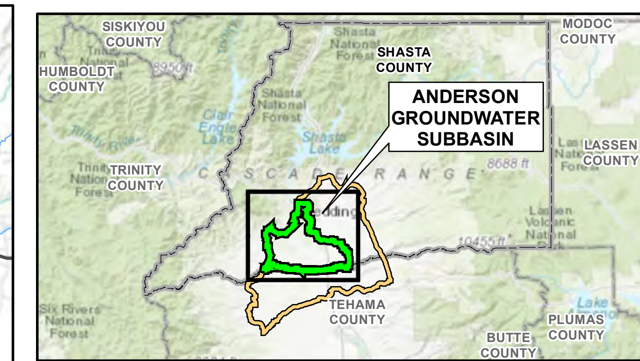
Figure 3-17





LEGEND

- SAMPLING LOCATION (NO EXCEEDANCES)
- SAMPLING LOCATION (1 to 5 EXCEEDANCES)
- SAMPLING LOCATION (> 5 EXCEEDANCES)
- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTES:

DATA USED TO ASSESS AREAS OF AFFECTED GROUNDWATER ARE FROM 2000 THROUGH 2019 (SWRCB, 2020b).

BENZENE CalEPA MAXIMUM CONTAMINANT LEVEL = 1 µg/L

GASOLINE US FEDERAL HEALTH ADVISORY LEVEL = 5 µg/L

TERT-BUTYL ALCOHOL FEDERAL NOTIFICATION LEVEL = 12 µg/L

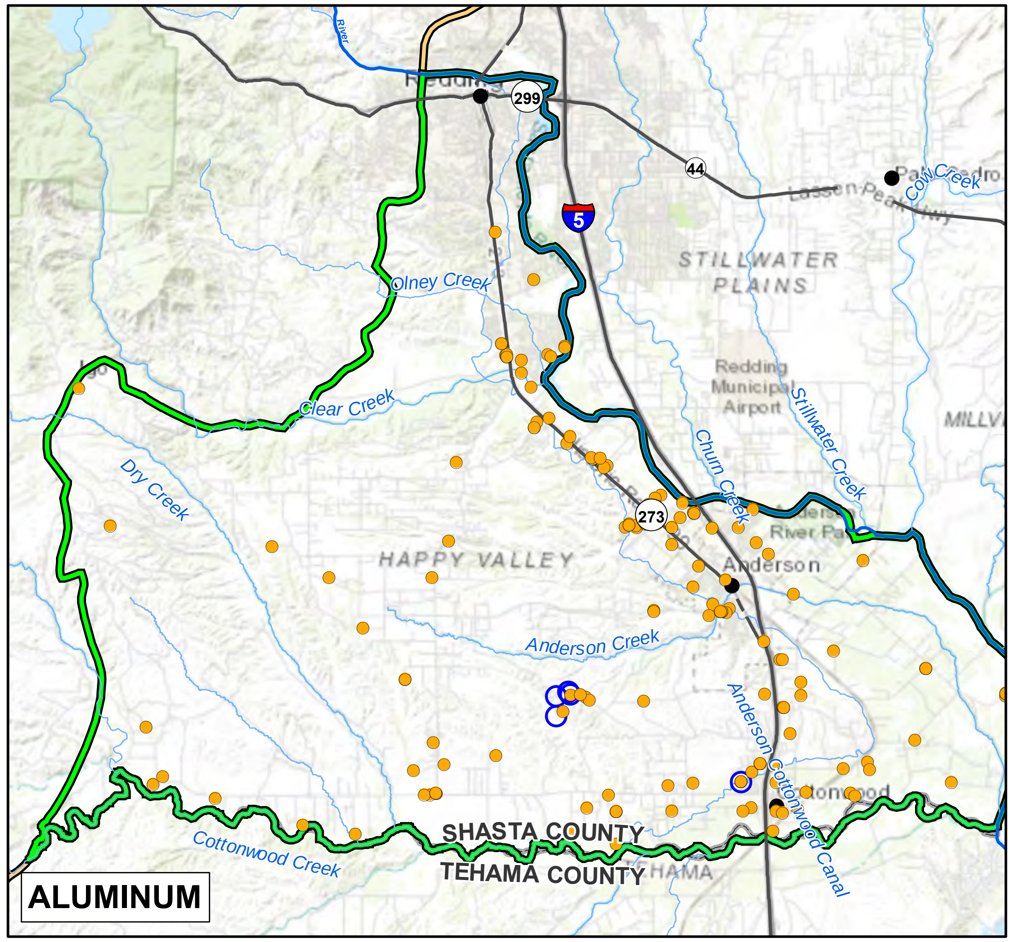
METHYL-TERT-BUTYL ETHER (MTBE) CA EPA MAXIMUM CONTAMINANT LEVEL = 13 µg/L

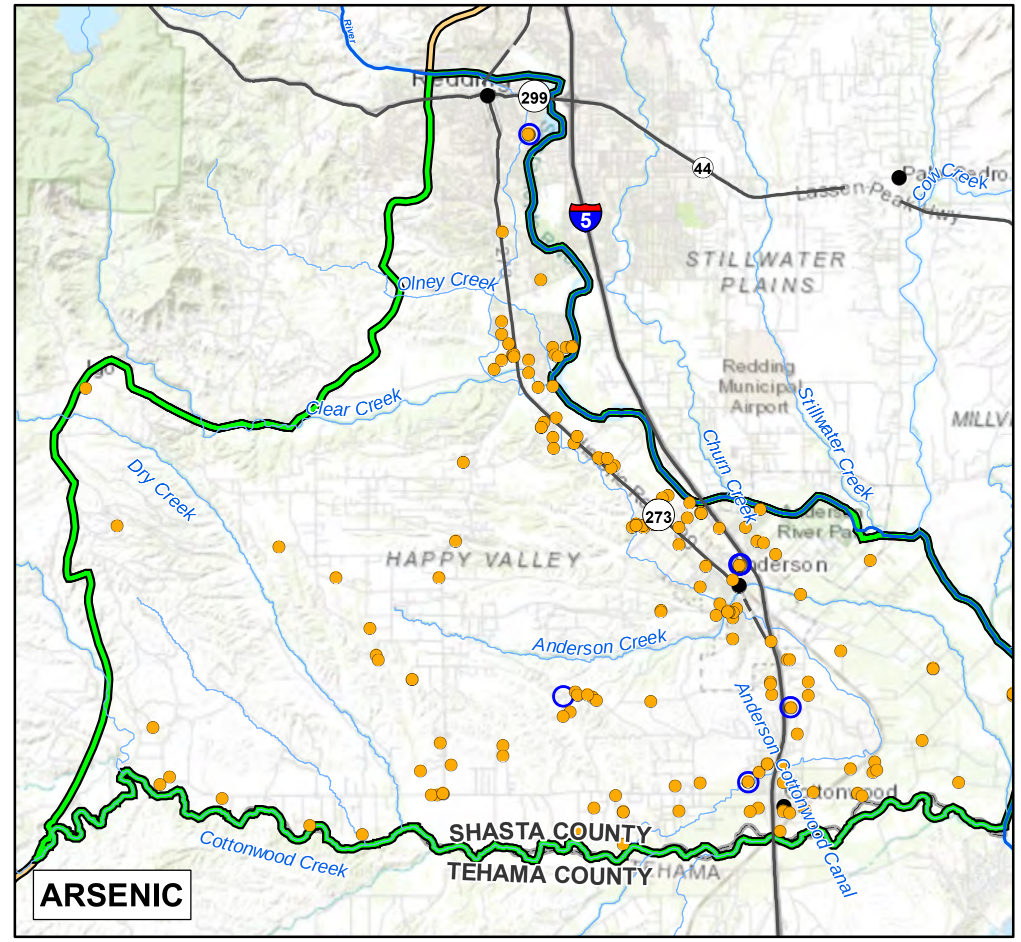
µg/L = MICROGRAMS PER LITER

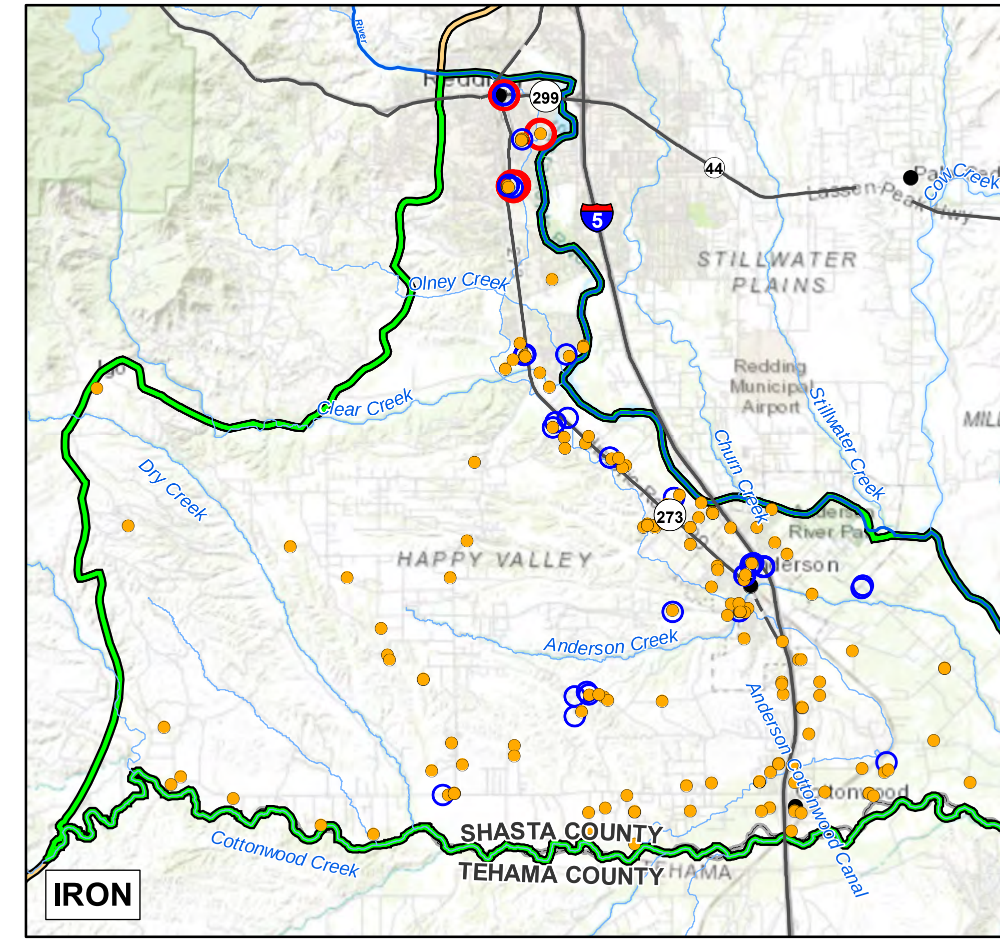
SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

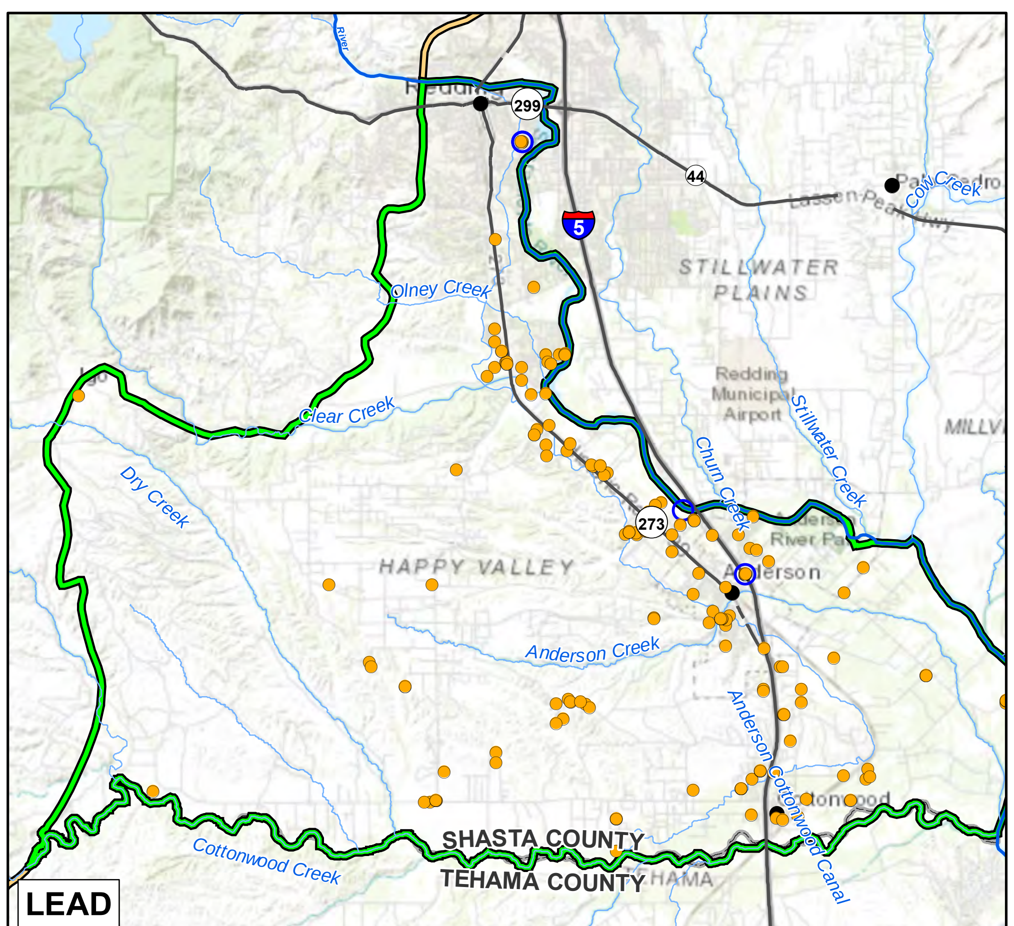
0 3.5 7 Miles

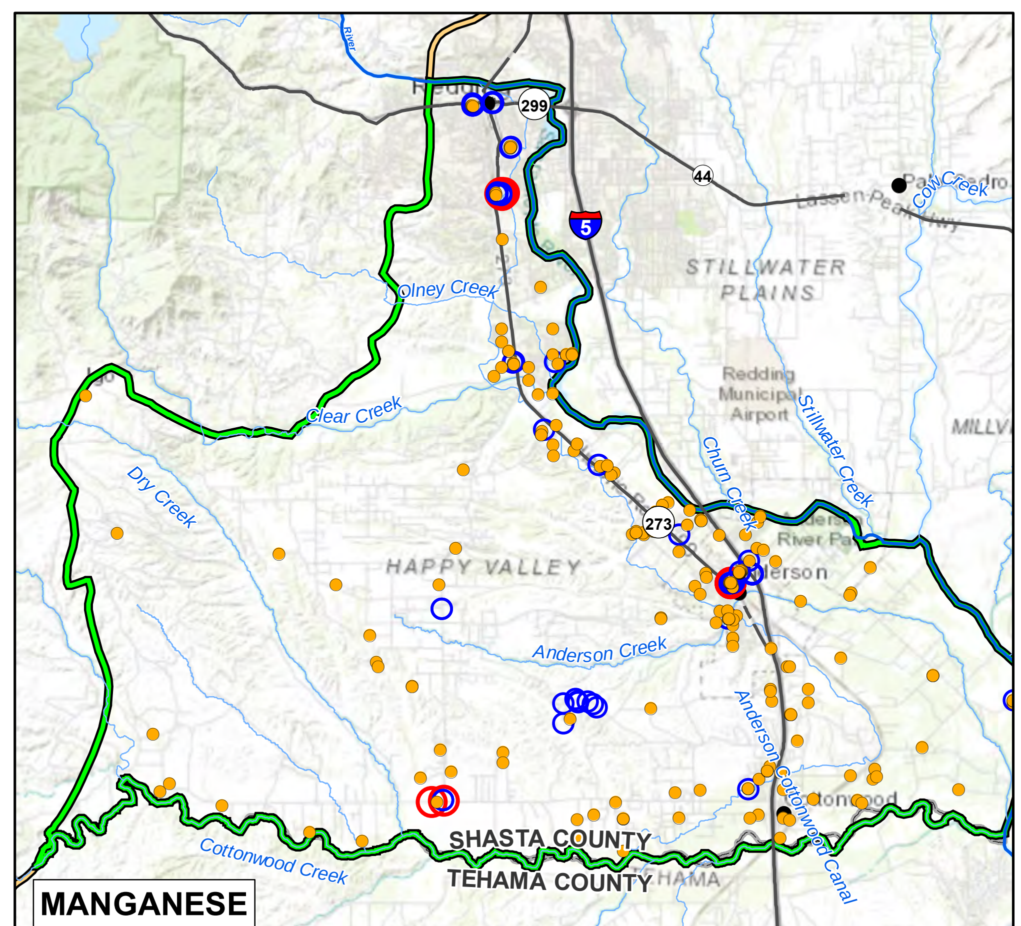
FIGURE 3-18
GROUNDWATER SAMPLING LOCATIONS – ORGANICS
Anderson Subbasin Groundwater Sustainability Plan











NOTES:

DATA USED TO ASSESS AREAS OF AFFECTED GROUNDWATER ARE FROM 2000 THROUGH 2019 (SWRCB, 2020b).

ALUMINUM CalEPA MCL = 1,000 µg/L

ARSENIC CalEPA MCL = 10 µg/L

IRON SECONDARY MCL = 300 µg/L

LEAD US FEDERAL ACTION LEVEL= 15 µg/L

MANGANESE US HEALTH ADVISORY LEVEL = 50 µg/L

µg/L = MICROGRAMS PER LITER

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

LEGEND

- SAMPLING LOCATION (NO EXEEDANCES)
- SAMPLING LOCATION (1 to 5 EXCEEDANCES)
- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

0 4 8 Miles

FIGURE 3-19
GROUNDWATER SAMPLING LOCATIONS – INORGANICS
Anderson Subbasin Groundwater Sustainability Plan

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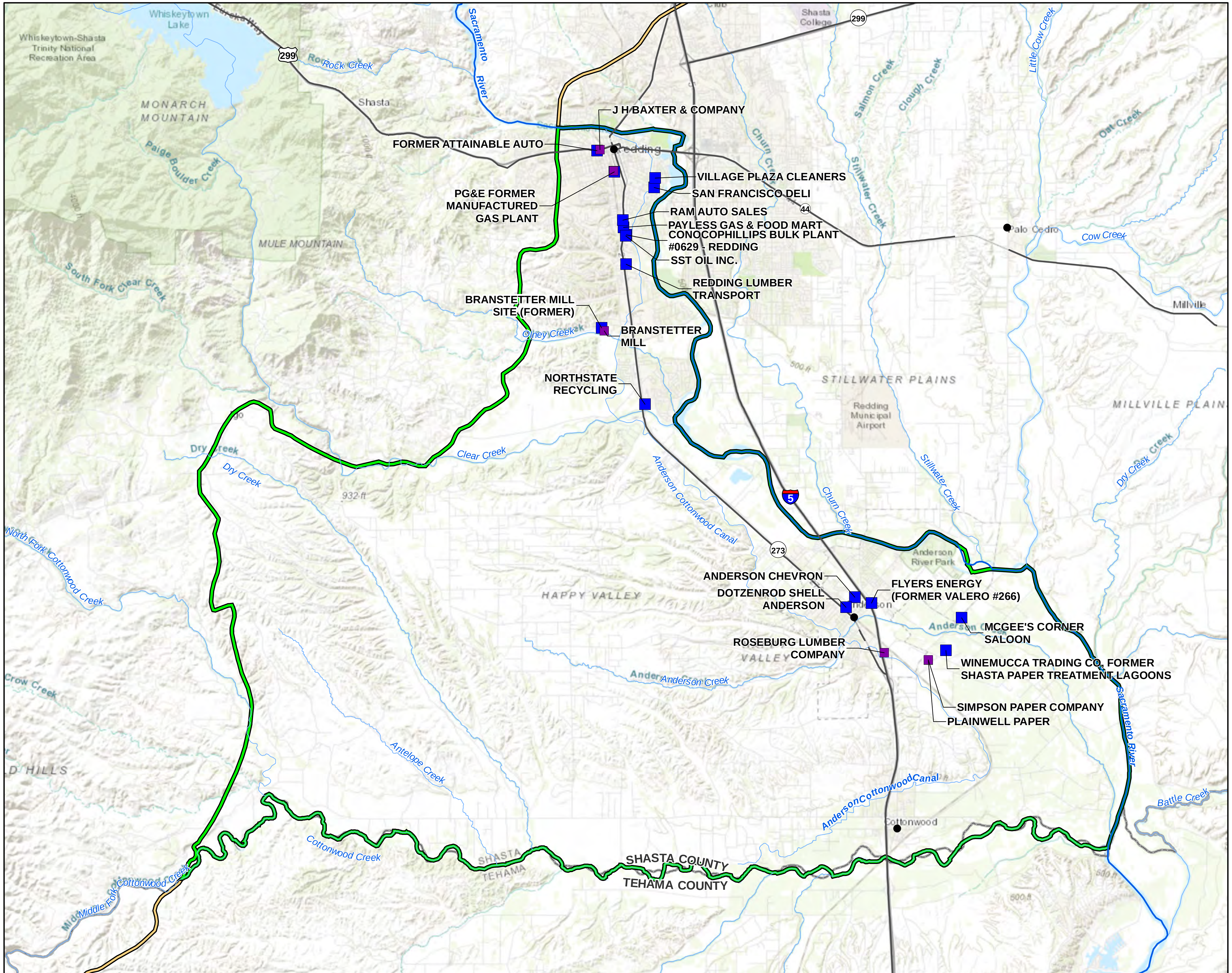

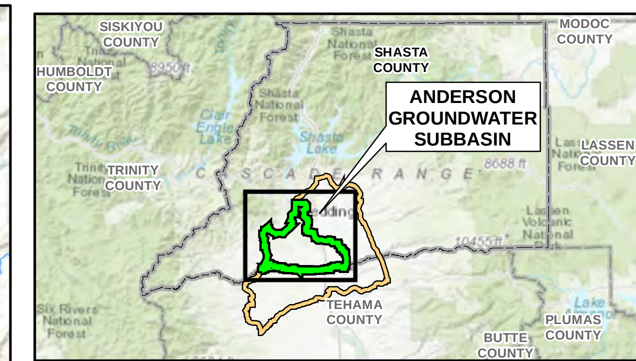

LEGEND

ACTIVE REMEDIATION SITE

- CALIFORNIA STATE DEPARTMENT OF TOXIC SUBSTANCES CONTROL
- STATE WATER RESOURCES CONTROL BOARD
- CITY
- SACRAMENTO RIVER
- RIVER/STREAM
- INTERSTATE/HIGHWAY
- COUNTY BOUNDARY LINE
- ANDERSON GROUNDWATER SUBBASIN (5-006.03 PLAN AREA)
- REDDING AREA GROUNDWATER BASIN

NOTES:

DATA SOURCES: DTSC, 2020 AND SWRCB, 2020b

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

0 2 4 Miles

FIGURE 3-20
ACTIVE REMEDIATION SITES
Anderson Subbasin Groundwater Sustainability Plan

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