measures targeted to ensure that the applicable basin is operated within its sustainable yield. **(CWC Section 10721)**

Sustainability Indicator*.* The effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code §10721(x). **(23 CCR Section 351)**

Sustainable Groundwater Management*.* The management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results. **(CWC Section 10721)**

Sustainable Yield. The maximum quantity of water calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result. **(CWC Section 10721)**

Technical Study. The geologic or hydrologic report prepared and published by a state or federal agency, or a study published in a peer-reviewed scientific journal, or a report prepared and signed by a Professional Geologist or by a Professional Engineer. **(23 CCR Section 341)**

Uncertainty. The lack of understanding of the basin setting that significantly affects an Agency's ability to develop sustainable management criteria and appropriate projects and management actions in a Plan, or to evaluate the efficacy of Plan implementation, and therefore may limit the ability to assess whether a basin is being sustainably managed. **(23 CCR Section 351)**

Undesirable Result*.* One or more of the following effects caused by groundwater conditions occurring throughout the basin: (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods. (2) Significant and unreasonable reduction of groundwater storage. (3) Significant and unreasonable seawater intrusion. (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies. (5) Significant and unreasonable land subsidence that substantially interferes with surface land uses. (6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. **(CWC Section 10721)**

Urban Water Management Plan. The plan adopted pursuant to the Urban Water Management Planning Act as described in Part 2.6 of Division 6 of the Water Code, commencing with Section 10610 et seq. **(23 CCR Section 351)**

Water Budget. The accounting of the total groundwater and surface water entering and leaving a basin including the changes in the amount of water stored. **(CWC Section 10721)**

Water Source Type*.* The source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, local supplies, and local imported supplies. **(23 CCR Section 351)**

Water Use Sector. The categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation. **(23 CCR Section 351)**

Water Year Type. The classification provided by the Department to assess the amount of annual precipitation in a basin. **(23 CCR Section 351)**

Water Year. The period from October 1 through the following September 30, inclusive. **(CWC Section 10721)**

Water Year. The period from October 1 through the following September 30, inclusive, as defined in the Act. **(23 CCR Section 351)**

Wellhead Protection Area. The surface and subsurface area surrounding a water well or well field that supplies a public water system through which contaminants are reasonably likely to migrate toward the water well or well field. **(CWC Section 10721)**

REFERENCES

California Code of Regulations. Title 23, Section 341.
California Code of Regulations. Title 23, Section 351.
California Department of Water Resources (DWR). 2003. Bulletin 118: California's Groundwater.
California Water Code. Division 6. Part 2.74. Section 10721. Chapter

Appendix 1-D

Elements Guide

Article 5. **Plan Contents for Sample Basin** **GSP Document References**

				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
§ 354.			**Introduction to Plan Contents**					
			This Article describes the required contents of Plans submitted to the Department for evaluation, including administrative information, a description of the basin setting, sustainable management criteria, description of the monitoring network, and projects and management actions.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
SubArticle 1.			**Administrative Information**					
§ 354.2.			**Introduction to Administrative Information**					
			This Subarticle describes information in the Plan relating to administrative and other general information about the Agency that has adopted the Plan and the area covered by the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.4.			**General Information**					
			Each Plan shall include the following general information:					
(a)			An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.	25:39	ES 1:ES 6	ES-1:ES 3	ES-1:ES-3	
(b)			A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.	114, 196:200, 268, 424:430	6			Corresponding references are listed at the end of each chapter of the GSP. A comprehensive list of all references cited in the GSP is in Section 6.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
§ 354.6.			**Agency Information**					
			When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:					
(a)			The name and mailing address of the Agency.	50	1.3.1			
(b)			The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.	49:50	1.3.1			
(c)			The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.	50	1.3.1			
(d)			The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.	50:51	1.3.2			
(e)			An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.	52	1.3.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.8, 10727.2, and 10733.2, Water Code.					
§ 354.8.			**Description of Plan Area**					
			Each Plan shall include a description of the geographic areas covered, including the following information:					
(a)			One or more maps of the basin that depict the following, as applicable:					
	(1)		The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.	63:64	2.1	2-1		
	(2)		Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.	63:64	2.1	2-1		
	(3)		Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.	63:65	2.1.1	2-2		
	(4)		Existing land use designations and the identification of water use sector and water source type.	66:71	2.1.1.2	2-3:2-5	2-1:2-2	
	(5)		The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.	71:83	2.1.1.3	2-6:2-8	2-3	
(b)			A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.	63	2.1			
(c)			Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.	75:86	2.1.2	2-9, 2-10, 2-12, 2-13	2-4	
(d)			A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.	75:86	2.1.2			
(e)			A description of conjunctive use programs in the basin.	87	2.1.2.11			
(f)			A plain language description of the land use elements or topic categories of applicable general plans that includes the following:					
	(1)		A summary of general plans and other land use plans governing the basin.	89:93	2.1.3			
	(2)		A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects	89:93	2.1.3			
	(3)		A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.	89:93	2.1.3			
	(4)		A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.	93:94	2.1.4.1			

				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(5)		To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.	96	2.1.4.8			
(g)			A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.	93:96	2.1.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10720.3, 10727.2, 10727.4, 10733, and 10733.2, Water Code.					
§ 354.10.			**Notice and Communication**					
			Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:					
(a)			A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.	98:102	2.1.5.1	2-13, 2-14	2-6	
(b)			A list of public meetings at which the Plan was discussed or considered by the Agency.	103:112	2.1.5.2		2-7	Details in Appendices 2-B and 2-D
(c)			Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.	112	2.1.5.3			Details in Appendix 2-E
(d)			A communication section of the Plan that includes the following:					
	(1)		An explanation of the Agency's decision-making process.	113	2.1.5.4			
	(2)		Identification of opportunities for public engagement and a discussion of how public input and response will be used.	103	2.1.5.2			
	(3)		A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.	102	2.1.5.2			
	(4)		The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.	98, 103	2.1.5			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.8, 10728.4, and 10733.2, Water Code					
SubArticle 2.			**Basin Setting**					
§ 354.12.			**Introduction to Basin Setting**					
			This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.14.			**Hydrogeologic Conceptual Model**					
(a)			Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.	123:165	2.2.1			
(b)			The hydrogeologic conceptual model shall be summarized in a written description that includes the following:					
	(1)		The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.	127:148	2.2.1.3	2-15:2-25		
	(2)		Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.	123:124, 127:141	2.2.1.1, 2.2.1.3	2-1, 2-21:2-25		
	(3)		The definable bottom of the basin.	158:159, 124:126	2.2.1.6	2-15:2-17		
	(4)		Principal aquifers and aquitards, including the following information:					
		(A)	Formation names, if defined.	133:145	2.2.1.3.2	2-21:2-25	2-8	
		(B)	Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.	133:145, 157:158	2.2.1.3:2.2.1.5			
		(C)	Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.	133:147, 157:159	2.2.1.3:2.2.1.5	2-21:2-25	2-8	
		(D)	General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.	178:180	2.2.2.3	2-46:2-48		
		(E)	Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.	157:159	2.2.1.5			
	(5)		Identification of data gaps and uncertainty within the hydrogeologic conceptual model	162:165	2.2.1.8			
(c)			The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.	136:142	2.2.1.3.2	2-22:2-25	2-8	
(d)			Physical characteristics of the basin shall be represented on one or more maps that depict the following:					
	(1)		Topographic information derived from the U.S. Geological Survey or another reliable source.	127:129	2.2.1.2	2-18, 2-19		
	(2)		Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.	134:141	2.2.1.3	2-21:2-25		
	(3)		Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.	147:156	2.2.1.4	2-26: 2-31		
	(4)		Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.	159, 162:164	2.2.1.7	2-33, 2-34		
	(5)		Surface water bodies that are significant to the management of the basin.	159, 161	2.2.1.7	2-32		
	(6)		The source and point of delivery for imported water supplies.	84	2.1.2.8	2-10		
			Note: Authority cited: Section 10733.2, Water Code.					

				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Reference: Sections 10727.2, 10733, and 10733.2, Water Code.					
§ 354.16.			**Groundwater Conditions**					
			Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:					
(a)			Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:					
	(1)		Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.	171:178	2.2.2.1.2	2-37:2-44		
	(2)		Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.	169	2.2.2.1.1	2-35		Additional hydrographs in Appendix 2-F
(b)			A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.	234	2.2.2.2	2-62		Annual storage changes are given in Table 2-22. Water budget details are in Appendix 2-K
(c)			Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.	N/A				Seawater intrusion is not an applicable sustainability indicator for the Subbasin
(d)			Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.	95, 97, 179, 181, 182:184	2.1.4.6, 2.2.2.3	2-12, 2-46:2-48		Groundwater quality timeseries graphs in Appendix 2-G
(e)			The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	181, 186, 187, 188	2.2.2.5	2-49:2-51		
(f)			Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	189, 192	2.2.2.6.1	2-52	2-10	
(g)			Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	190:194	2.2.2.7	2-52:2-54		Details in Appendix 2-I
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, and 10733.2, Water Code.					
§ 354.18.			**Water Budget**					
(a)			Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.	207:267	2.3			
(b)			The water budget shall quantify the following, either through direct measurements or estimates based on data:					
	(1)		Total surface water entering and leaving a basin by water source type.	216:217, 228:231	2.3.3.2, 2.3.5.2	2-60	2-21	
	(2)		Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.	221:222, 232:235	2.3.4.1, 2.3.5.3	2-61, 2-62	2-22	
	(3)		Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.	221:222, 232:235	2.3.4.1, 2.3.5.3	2-61, 2-62	2-22	
	(4)		The change in the annual volume of groundwater in storage between seasonal high conditions.	232:235, 238	2.3.5.3, 2.3.6.2	2-61, 2-62	2-22, 2-24	Storage change values given in the GSP are total changes within a water year (October 01 to September 30). Flow model calculates storage change during each month. Annual storage change is equal to the sum of monthly changes. Additional details are in Appendices 2-J and 2-K
	(5)		If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.	N/A				Overdraft conditions did not occur during the historical baseperiod
	(6)		The water year type associated with the annual supply, demand, and change in groundwater stored.	235	2.3.5.3		2-22	
	(7)		An estimate of sustainable yield for the basin.	267-268	2.3.12			
(c)			Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:					
	(1)		Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.	236:237	2.3.6		2-23:2-24	
	(2)		Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:					
		(A)	A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.	228:231	2.3.5.2	2-60	2-21	Details in Appendix 2-K
		(B)	A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.	228:235	2.3.5.2,2.3.5.3	2-60:2-62	2-21, 2-22	Details in Appendix 2-K
		(C)	A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.	228, 232	2.3.5.2, 2.3.5.3			

				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:					
		(A)	Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.	239:264	2.3.7:2.3.10	2-63:2-65	2-25:2-33	Details in Appendix 2-K
		(B)	Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.	239:264	2.3.7:2.3.10	2-63:2-65	2-25:2-33	Details in Appendix 2-K
		(C)	Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.	239:243, 251:255, 261	2.3.7:2.3.9	2-63, 2-68	2-25, 2.-29	Details in Appendix 2-K
(d)			The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:					
	(1)		Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.	224:235	2.3.5	2-58:2-62	2-19:2-22	Details in Appendix 2-K
	(2)		Current water budget information for temperature, water year type, evapotranspiration, and land use.	236:237	2.3.6		2-23	
	(3)		Projected water budget information for population, population growth, climate change, and sea level rise.	239:	2.3.7:2.3.10	2-63:2-70	2-25:2-34	Details in Appendix 2-K
(e)			Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.	208:210	2.3.1			Details in Appendices 2-J and 2-K
(f)			The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.	207	2.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10727.6, 10729, and 10733.2, Water Code.					
§ 354.20.			**Management Areas**					
(a)			Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.	N/A				Management areas are not defined
(b)			A basin that includes one or more management areas shall describe the following in the Plan:					
	(1)		The reason for the creation of each management area.	N/A				Management areas are not defined
	(2)		The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.	N/A				Management areas are not defined
	(3)		The level of monitoring and analysis appropriate for each management area.	N/A				Management areas are not defined
	(4)		An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.	N/A				Management areas are not defined
(c)			If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.	N/A				Management areas are not defined
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
SubArticle 3.			**Sustainable Management Criteria**					
§ 354.22.			**Introduction to Sustainable Management Criteria**					
			This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.24.			**Sustainability Goal**					

				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.	277:291	3.1, 3.2	3-1:3-6	3-1:3-6	
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10727, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.26.			**Undesirable Results**					
(a)			Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.	301:304	3.4		3-12	Undesirable results are also discussed in sections 3.3.1.4, 3.3.2.4, 3.3.3.4, 3.3.4.4 and 3.3.5.4 under each sustainability indicator.
(b)			The description of undesirable results shall include the following:					
	(1)		The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.	275:276, 300, 301:304	3, 3.3.6, 3.4		3-1	
	(2)		The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.	292:299, 301:304	3.3.1: 3.3.5, 3.4		3-7, 3-12	
	(3)		Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.	294, 295, 297, 298:299	3.3.1.5, 3.3.2.5, 3.3.3.5, 3.3.4.5, 3.3.5.5			
(c)			The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.	291:304	3.3, 3.4	3.3	3-7, 3-12	
(d)			An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.	276, 278, 302	3, 3.4		3-1, 3-12	Sustainability indicator for seawater intrusion is not applicable to the Subbasin
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.28.			**Minimum Thresholds**					
(a)			Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.	291:301	3.3		3-7:3-12	
(b)			The description of minimum thresholds shall include the following:					
	(1)		The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.	292:299	3.3.1:3.3.5			
	(2)		The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.	300	3.3.6			
	(3)		How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.	300:301	3.3.7			
	(4)		How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.	294, 295, 297, 298:299, 301	3.3.1.5, 3.3.2.5, 3.3.3.5, 3.3.4.5, 3.3.5.5, 3.3.8			
	(5)		How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.	294, 295, 297, 298, 299	3.3.1.3, 3.3.2.3, 3.3.3.3, 3.3.4.3, 3.3.5.3			
	(6)		How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.	294, 295, 297, 298, 299	3.3.1.2, 3.3.2.2, 3.3.3.2, 3.3.4.2, 3.3.5.2,			
(c)			Minimum thresholds for each sustainability indicator shall be defined as follows:					
	(1)		Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:					
		(A)	The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.	292	3.3.1.1			Water level hydrographs with MOs and MTs are in Appendix 3-B
		(B)	Potential effects on other sustainability indicators.	300	3.3.6			

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	(2)		Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.	294:295	3.3.2			
	(3)		Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:					
		(A)	Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.	N/A				Seawater intrusion is not applicable to the Subbasin
		(B)	A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.	N/A				Seawater intrusion is not applicable to the Subbasin
	(4)		Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.	297:299	3.3.4			
	(5)		Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:					
		(A)	Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.	296:297	3.3.3			
		(B)	Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.	181, 186, 187, 188, 296:297	2.2.2.5, 3.3.3			
	(6)		Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:					
		(A)	The location, quantity, and timing of depletions of interconnected surface water.	299	3.3.5			
		(B)	A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.	289:291	3.2.5			Reason to use MOs of the chronic lowering of groundwater elevations as a proxy for interconnected surface water is given in Section 3.2.5
(d)			An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.	299	3.3.5			Minimum thresholds of the chronic lowering of groundwater elevations is used as a proxy for interconnected surface water
(e)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.	276, 278	3		3-1	Sustainability indicator for seawater intrusion is not applicable to the Subbasin
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10733, 10733.2, and 10733.8, Water Code.					
§ 354.30.			**Measurable Objectives**					
(a)			Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.	280:291	3.2.1: 3.2.5	3-2:3-6	3-2:3-11	
(b)			Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.	280:291	3.2.1: 3.2.5	3-2:3-6	3-2:3-11	
(c)			Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.	280:291	3.2.1: 3.2.5			
(d)			An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.	289	3.2.5.1			Measurable objectives of chronic lowering of groundwater elevations were used to establish interim MOs for interconnected surface water
(e)			Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.	280:291	3.1.3, 3.2.1: 3.2.5			
(f)			Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.	N/A				Additional plan elements are not included
(g)			An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.	N/A				Measurable objectives do not exceed the reasonable margin of operational flexibility

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			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					
SubArticle 4.			**Monitoring Networks**					
§ 354.32.			**Introduction to Monitoring Networks**					
			This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.34.			**Monitoring Network**					
(a)			Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.	304:317	3.6.1:3.6.6		3-13:3-25	
(b)			Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:					
	(1)		Demonstrate progress toward achieving measurable objectives described in the Plan.	304	3.6			
	(2)		Monitor impacts to the beneficial uses or users of groundwater.	304	3.6			
	(3)		Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.	307:308, 310, 314, 316,	3.6.2: 3.6.6			
	(4)		Quantify annual changes in water budget components.	307:308, 310	3.6.2: 3.6.6			Additional data required to develop water budget will be collected from other sources
(c)			Each monitoring network shall be designed to accomplish the following for each sustainability indicator:					
	(1)		Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:	307:309, 318:320	3.6.2, 3.7.2	3-2, 3-3	3-14:3-16	Maps of representative monitoring sites are in Sections 3.1 and 3.2 (pages 277, 282, 283)
		(A)	A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.	307:309, 318:320	3.6.2, 3.7.2	3-2, 3-3	3-14:3-16	Maps of representative monitoring sites are in Sections 3.1 and 3.2 (pages 277, 282, 283)
		(B)	Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.	307:309	3.6.2		3-14, 3-15	
	(2)		Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.	310:311, 320	3.6.3, 3.7.3	3-2, 3-3	3-17, 3-18	
	(3)		Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.	N/A				Seawater intrusion is not applicable to the Subbasin
	(4)		Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.	314:315, 320:321	3.6.5, 3.7.4	3-5	3-22, 3-26	
	(5)		Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.	312:313, 321	3.6.4, 3.7.5		3-20, 3-21	
	(6)		Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:					
		(A)	Flow conditions including surface water discharge, surface water head, and baseflow contribution.	316:317,	3.6.6, 3.7.6, 3.7.8.7		3-24	
		(B)	Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.	323:324	3.7.8.7, 3.7.8.8			
		(C)	Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.	316:317, 322, 323:324	3.6.6, 3.7.6, 3.7.8.7		3-24	
		(D)	Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.	316:317, 322, 323:324	3.6.6, 3.7.6, 3.7.8.7		3-24	
(d)			The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.	304:306	3.6.1		3-13	Maps of representative monitoring sites are in Sections 3.1 and 3.2 (pages 277, 282, 283)
(e)			A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.	304:317	3.6.1:3.6.6		3-13:3-25	
(f)			The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:					
	(1)		Amount of current and projected groundwater use.	307:308	3.6.2			
	(2)		Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.	307:308	3.6.2			
	(3)		Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.	304:305	3.6			Impacts to beneficial uses and users of groundwater are also discussed in Sections 3.2 and 3.3

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	(4)		Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.	307:317	3.6.2:3.6.6		3-14:3-24	
(g)			Each Plan shall describe the following information about the monitoring network:					
	(1)		Scientific rationale for the monitoring site selection process.	307:317	3.6.2:3.6.6		3-14:3-24	
	(2)		Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.	318:322	3.7.1: 3.7.6		3-26	
	(3)		For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.	280:299, 318:322	3.2.1: 3.2.5, 3.3.1: 3.3.5, 3.7.1:3.7.6		3-2:3-12	Established MOs, MTs and IMs are in Sections 3.2.1:3.2.5. and 3.3.1:3.3.5. Measurement protocols are in Sections 3.7.1:3.7.6
(h)			The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.	277, 282, 283, 286, 288, 290,		3-1:3-6	3-13:3-25	
(i)			The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.	318:322	3.7.1:3.7.6			
(j)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.	304:305	3.6.1			No monitoring for seawater intrusion sustainability indicator
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, 10728, 10733, 10733.2, and 10733.8, Water Code					
§ 354.36.			**Representative Monitoring**					
			Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:					
(a)			Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.	322	3.7.7			
(b)			(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:					
	(1)		Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.	289	3.2.5.1			Measurable objectives of chronic lowering of groundwater elevations were used to establish interim MOs for interconnected surface water
	(2)		Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.	280:281	3.2.1			
(c)			The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.	275:276, 322	3, 3.7.7			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2 and 10733.2, Water Code					
§ 354.38.			**Assessment and Improvement of Monitoring Network**					
(a)			Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.	322:324	3.7.8			
(b)			Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.	324:326	3.7.8.8	3-7,3-8		
(c)			If the monitoring network contains data gaps, the Plan shall include a description of the following:					
	(1)		The location and reason for data gaps in the monitoring network.	323:326	3.7.8.2:3.7.8.7	3-7:3-8		
	(2)		Local issues and circumstances that limit or prevent monitoring.	N/A				No known issues or circumstances at present
(d)			Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.	324	3.7.8.8			
(e)			Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:					
	(1)		Minimum threshold exceedances.	322:324	3.7.8			
	(2)		Highly variable spatial or temporal conditions.	322:324	3.7.8			
	(3)		Adverse impacts to beneficial uses and users of groundwater.	322:324	3.7.8			
	(4)		The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.	322:324	3.7.8			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10728.2, 10733, 10733.2, and 10733.8, Water Code					
§ 354.40.			**Reporting Monitoring Data to the Department**					
			Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.					

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SubArticle 5.			**Projects and Management Actions**					
§ 354.42.			**Introduction to Projects and Management Actions**					
			This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.44.			**Projects and Management Actions**					
(a)			Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.	335:344, 365:366	4.2.1, 4.5		4-2, 4-3, 4-10	Details in Appendix 4-A
(b)			Each Plan shall include a description of the projects and management actions that include the following:					
	(1)		A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:					
		(A)	A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3		4-10:4-37	
		(B)	The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3		4-11:4-20, 4-22:4-29, 4-31:4-37	"Notice to Public and Other Agencies" is described under each Project/ Management Action
	(2)		If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.	N/A				Overdraft conditions were not identified. Section 4.2.1 provides an overview of all proposed Projects and Management Actions
	(3)		A summary of the permitting and regulatory process required for each project and management action.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3		4-11:4-20, 4-22:4-29, 4-31:4-37	"Legal Authority, Permitting Processes, and Regulatory Control" is described under each Project/ Management Action
	(4)		The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3			Status, timeline and expected benefits are described under each Project/ Management Action
	(5)		An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3			Benefits and benefit evaluation methodology are described under each Project/ Management Action
	(6)		An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3			Implementation and reliability of water source if applicable are described under each Project/ Management Action
	(7)		A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3			"Legal Authority, Permitting Processes, and Regulatory Control" is described under each Project/ Management Action
	(8)		A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.	350:365, 366:403	4.4.1: 4.4.3, 4.5.1:4.5.3			Estimated costs and funding sources are described under each Project/ Management Action
	(9)		A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.	331:332	4.1.1		4-1	
(c)			Projects and management actions shall be supported by best available information and best available science.	331:332	4.1.1			
(d)			An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.	331:332	4.1.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					

Appendix 2-A

Domestic Well Inventory

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Figure 4b Summary by Section of Domestic Wells from Well Completion Reports 2013-2020.

Figure 5a Total Annual Number of Well Completion Reports and Permits 2013-2020 in Antelope Subbasin

Figure 5b Total Annual Number of Well Completion Reports and Permits 2013-2020 in Bowman Subbasin

Figure 5c Total Annual Number of Well Completion Reports and Permits 2013-2020 in Los Molinos Subbasin

Figure 5d Total Annual Number of Well Completion Reports and Permits 2013-2020 in Red Bluff Subbasin

Figure 6 Parcels with Domestic Wells Inferred from Land Use Codes

Figure 7 Summary by Section of Inferred Domestic Wells

Figure 8 Summary of Known and Inferred Domestic Well Locations

Figure 9a Community Water Systems and Public Water Supply Well Locations

Figure 9b Domestic Wells within Community Water Systems or near Public Water Supply Wells

Figure 9c Domestic Wells within Community Water Systems

Figure 10 Average Domestic Well Depths by Section

Figure 11a Well Depths by Year in Antelope Subbasin

Figure 11b Well Depths by Year in Bowman Subbasin

Figure 11c Well Depths by Year in Los Molinos Subbasin

Figure 11d Well Depths by Year in Red Bluff Subbasin

APPENDICES

Appendix 1 Land Use Codes of Inferred Residential Parcels

1 INTRODUCTION

This appendix documents the available data sources for estimating numbers and locations of domestic wells, domestic well construction details, and occurrence of domestic wells in Tehama County. To prepare this domestic well inventory, approximations of the number, depths, and locations of domestic wells were developed from available data sources. The domestic wells indicated to be present according to multiple data sources were reviewed and compared.

2 DOMESTIC WELL INVENTORY DATA SOURCES AND COMPILATION

Data from a variety of public agencies were assembled for consideration in the project. Compiled datasets included the following.

- Well Completion Report (WCR) Database from California Department of Water Resources (CDWR) Online System for WCRs (OSWCR)
- Tehama County well permit database (records since 2013)
- Tehama County assessor's parcel data
- Public Water System (PWS) service area boundaries and PWS well locations from State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW)

Except for the Tehama County well permit database, all the above-listed datasets were available in geospatial (e.g., GIS) formats. The well permit database was provided as tabular data, which was converted to geospatial information as described below.

2.1 DWR WCR Database

The primary source for well construction data in the subbasin is the CDWR WCR database (CDWR, 2020). Well drillers are required to submit a WCR to DWR for all wells drilled and constructed in the State of California. DWR tabulated information from WCRs for the State, including data from WCRs dating as far back as the early 1900s. The tabulated WCR information include well type and construction characteristics such as the intended use of the well, well depths, and screened intervals along with location, construction date, permit information, and other details. Although completed WCRs commonly include additional notes on borehole lithology and a variety of other types of information, lithology and some other well information included on WCRs is not entered or maintained in the DWR WCR database. It is notable that many well attributes in the WCR database are blank or incomplete because of missing or illegible information provided on the WCRs. Additionally, well locations in the WCR database are commonly only provided to the center of the Public Land Survey System (PLSS) section in which it is located, which translates to a locational accuracy of approximately +/- 0.5 mile.

2.1.1 Domestic Well WCRs

As part of the project, initial quality checks were conducted on the WCR database to identify obvious inconsistencies in well data, including conflicting well locations (e.g., latitude, longitude, PLSS coordinates) and construction (e.g., well depths, top and bottom of screens). Such questionable information and records were flagged for additional consideration during subsequent analyses. For this domestic well inventory analysis, only WCRs indicated to be domestic water supply wells were included. To limit potential double counting of domestic wells, only WCRs for new well construction (i.e., not well repairs/modification or destruction) were included in the domestic well inventory.

2.1.2 WCR Dates

The typical lifespan of a small water well is estimated to be about 50 years based on the durability and longevity of typical domestic well materials, which are commonly constructed of PVC casing. Using a conservative estimate of a 40-year lifespan, wells drilled prior to 1980 were considered unlikely to still be in operation or nearing the end of their lifespan.

For these reasons, only WCRs for wells with dates on or after 1980, were included in the domestic well inventory and associated analyses. A total of 5,879 domestic wells constructed since 1980 were considered in the analysis.

2.1.3 WCR Locations

Wells with WCRs marked as domestic were selected and mapped based on one of four geolocation methods, depending on what information was available in the tabulated data. Only wells with installations in 1980 or later were considered. The geolocation methods, in order of priority, are as follows:

1. GPS – 4 wells
2. Address – 85 wells
3. APN – 2,193 wells
4. PLSS – 3,597 wells

A total of 5,879 domestic wells were located within the Tehama Subbasin using these methods (**Figure 1**). Wells located by PLSS are typically placed at the center of the section in which they are located, and thus may be out of position by as much as about 0.5 mile (half the typical width of a section). Initially, 5,790 of the 5,879 domestic well completion reports were located by PLSS. 4,313 of these wells include a partial APN, none of which were formatted consistently with the Tehama County Parcel APNs (e.g., ###-###-###-000).

Potential APNs were generated for the partial APNs by adding zeroes. As an example, partial APN "79-60-3" would become "079-060-003-000" by adding leading zeroes before each 3-digit section and appending "-000" to the end. This assumes partial APNs to be partial only by losing leading zeroes; however, this is not the only possible way to format a potential APN from a partial APN.

Generated APNs were matched to Parcel APNs. Because there is uncertainty in the formatting of the partial APN, only APNs which match parcels located within the same PLSS sections as the WCR were adopted. 2,193 matching APNs were adopted, and the locations of the associated WCRs were updated from section centroids to the centroid of each matching parcel.

Other sources of location error include changes in APNs over time; poorly matched addresses; and incorrect WCR entries for PLSS values, GPS coordinates, or addresses. Since many of the location symbols for domestic wells plot on top of each other in **Figure 1**, the locations of domestic wells in the Subbasin by Township/Range/Section mapping is displayed in **Figure 2**. Domestic well completion reports are summarized by decade and subbasin in **Table 1**.

2.2 Well Permit Records

Under county regulation, a well permit is required prior to drilling and constructing a domestic well. Records of well permits were provided by Tehama County Department of Environmental Health as a tabular dataset (TCDEH, 2021); no GIS data were initially available for the well permits. The period of record for the well permits begins in 2013. The tabulated permit dataset includes permit number, permit date, APN, and well address.

2.2.1 Domestic Well Permits

There are 802 new construction permits for Tehama County. Domestic wells comprise 670 of the 802 new construction wells. Wells with uses other than domestic water supply are denoted with asterisks in the tabulated dataset. Only wells indicated as being sealed were considered.

2.2.2 Locating Well Permits

The 670 domestic well permits in Tehama County were located based on APNs associated with them. Domestic well permits in the County well permit database were located by matching the listed APN with the county parcel data, when possible. For permits with APNs not matching a parcel, the address was used to locate the permit and the APN was updated accordingly. Following this approach, all domestic well permits were matched to unique parcels located within the Tehama County.

A map of the domestic well permits located in the Tehama County is presented in **Figure 3a**. To directly compare well permits to well completion reports over the same period, a map of well completion reports completed 2013 to 2020 is presented in **Figure 3b**. Since many of the location dots for domestic wells plot on top of each other in **Figure 3a**, the count of domestic wells in the County by Township/Range/Section mapping is displayed in **Figure 4a**. Similarly, well completion reports dated 2013 to 2020 are summarized by section in **Figure 4b**.

Well completion reports and permits are additionally compared annually for Antelope, Bowman, Los Molinos, and Red Bluff Subbasins in **Figure 5a**, **Figure 5b**, **Figure 5c**, and **Figure 5d** respectively.

2.3 County Assessor Parcel Data

County Assessor parcel GIS data were provided by Tehama County (Tehama County Assessor's Office, 2021), including land use and other characteristics for each APN. The parcels dataset includes 26,600 unique APNs within the Tehama Subbasin. Of those, 15,959 are inferred as being residential. This includes parcels that are located within a public water system service area. Although the County parcel dataset does not include records related to the presence of domestic wells on parcels, the presence of a resident on a parcel is associated with a drinking water supply and potential for a domestic well. Land use codes used to infer residential parcels and therefore the presence of a domestic well are summarized in **Appendix 1**. Inferred residential parcels are displayed in **Figure 6**. Inferred domestic wells in residential parcel are also summarized by section in **Figure 7**. All known and inferred domestic well locations are combined in **Figure 8**.

2.4 Water System Data

Public Water System (PWS), State Small Water System (SSWS), and Local Small Water System (LSWS) service area boundaries from State and local data sources were used to map and evaluate where and how many inferred well locations occur inside of a water system service area and therefore may not be supplied by a domestic well. Water system boundaries are a key dataset for comparing with potential domestic well locations identified through analysis of WCRs, parcels, and permits. The service area boundaries for water systems and new construction public water supply wells since 1980 identified in the County are presented in **Figure 9**.

2.4.1 State Regulated Systems

The PWS boundaries are part of an archived dataset developed by the California Environmental Health Tracking Program (CEHTP) and now maintained by the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) (SWRCB, 2021). This dataset is a publicly available GIS feature class of system boundaries provided voluntarily by water system operators over the period from 2012 to 2019. Previous assessments of this dataset suggest it includes approximately 85 percent of community water systems, although this can vary by region within the state. Of the state regulated PWS boundaries, 42 were identified to have service areas within Tehama County.

2.4.2 Public Water System Wells

PWS well locations were downloaded from the WCR dataset and used to check for any water system wells in areas not covered by the water systems service area boundaries data. Several wells with public water supply planned used are located outside of CEHTP PWS boundaries (**Figure 9a**). These wells are considered in analyses as possibly providing water to nearby users.

3 ANALYSIS AND RESULTS

Estimates of domestic wells were developed through analysis and comparison of the data sources discussed above. Estimates of the number and locations of domestic wells in Tehama County were made using three sources of data and approaches: from WCRs, well permits, and parcels with residents. Domestic well WCRs and well permits provide a more direct indication of the existence (past or present) of a domestic well whereas the parcel data provide a basis for inferring the existence of domestic wells. The County well permit database is believed to provide the most accurate estimate of the numbers and locations of domestic wells constructed during the available data record (since 2013). However, only the WCR data have information on well depths and construction. Additionally, while WCRs and well permits generally have a date associated with each record indicating the approximate date of well construction, the parcel data do not. However, estimates of well counts based on parcel data do provide an estimate of the maximum possible number of domestic wells, and a reference on the relative spatial density of domestic wells in the County.

Water system service area boundaries were used to refine domestic well estimates derived from parcel counts, with the expectation that parcels and households within a water system boundary are served water by the water system and therefore do not have a domestic well. The number of inferred parcels, well completion reports, and unique well permits (i.e., not collocated with a WCR) are summarized for the entire County, and within two subsets of water system service areas in **Table 2**. One subset includes the number of domestic wells within the community water system boundaries and within a half-mile of other PWS wells, while the other subset includes only community water system wells. It is assumed these public water supply wells supply water in their vicinity despite being located outside of water system boundaries; however, the area served by each PWS well is unknown so this is only an estimate of how these wells might impact domestic well counts. Many wells inferred to be in a parcel located within a community water service area were likely not installed, while wells known to be installed in these areas may no longer be used for domestic water supply. Results of the well location and counts analyses are described below.

3.1 Analysis of Domestic Well Locations and Counts

3.1.1 Domestic Well WCRs

The domestic well WCRs since 1980 were compared with water system boundaries in the two methods described above (**Figure 9b**, **Figure 9c**). Because the WCRs are records of actual wells that were constructed, those located within a water system service area are assumed to be correctly located. It is possible that wells that pre-existed the establishment of a water system in an area may remain in use after the water system is operational; however, whether this occurs, and how often, is unknown.

Of the 5,879 domestic wells represented by WCRs in the County, 260 are located within the known water system boundaries (**Figure 9b**). This represents approximately four (4) % of the domestic well WCRs in the County. However, when considering the half-mile radius around public water supply wells, 1,090 wells (19% of total) are captured.

3.1.2 Domestic Well Permits

Permits are expected to accurately identify well locations, but domestic well permits may exist for wells drilled and constructed prior to the operation of a water system in an area. As shown in annual comparisons for 2020 (**Figures 5a, 5b, 5c, 5d**), permits may be processed before well completion reports and supplement recent domestic well counts.

In contrast to the WCR dataset, which relies on submittal and entry of a WCR in DWR's database, the County well permit dataset is expected to be a more comprehensive representation of the wells drilled in the County for the period over which it spans (2013 to present). Over the same period, there are 670 well permits compared to 567 WCRs.

Of the 670 well permits, 338 domestic well permits in the County are not collocated with a WCR. There are 17 of these unique permits located within known water system boundaries (**Figure 9b**). Like the domestic WCRs in water system boundaries, this represents only five (5) % of the permit dataset. When additionally considering permits located withina 0.5 mile radius around other public supply wells, 71 well permits are represented (**Figure 9c**).

3.1.3 Parcels with Residents

For assessing the maximum possible number of domestic wells in the County, all parcels inferred to be residential were counted. Parcels were inferred as residential based on land use codes listed in **Appendix 1**. Parcels within service areas were also counted but removed from the total inferred count. In this approach, a parcel is considered within a water system service area if its centroid is within the service area.

Based on these criteria, within Tehama County there are a total of 15,959 residential parcels (**Figure 6**) with residents, 8,744 of which are outside of the service area boundaries of all 42 Public Water Systems serving residential parcels. There are only 6,725 inferred parcels outside of the potential radius of influence of other public water supply wells.

3.1.4 Comparisons of Domestic Well Location Information Sources

3.1.4.1 Domestic Wells Within PWS Service Areas

While most residences within a PWS service area are supplied with drinking water by that PWS, it is not unusual for wells that were drilled prior to the creation of the PWS to be retained and used for part, or all, of a residence's use, including for drinking water or landscape irrigation.

Of the 5,879 WCRs located in Tehama County, 260 are located within a water system service area. Of the 338 unique permits located within the Tehama Subbasin, 17 were located within a water system service area.

Of the 15,959 parcels with dwellings noted in the APN dataset, 7,215 are within a water system boundary. This represents a much larger portion of the total inferred dataset (45%) compared to WCRs and permits, suggesting most of those inferred parcels do not have domestic wells.

3.1.4.2 Comparing WCR Locations to Well Permits

The Tehama County well permits dataset, by count, is more complete in representing wells drilled in the County, but it only extends back to 2013. There is no direct linkage between WCRs and well permits on record (i.e., WCRs commonly do not indicate well permit numbers) for majority of the wells, and the available method for geolocating records for a given well present in both datasets may differ. However, it was determined that 332 of the parcels associated with permit locations coincided with WCR locations for domestic wells. Many WCRs are located by the center of section and therefore may not be placed in the correct parcel. This likely explains the low rate of coincidence of well permits and WCRs within parcels.

Consequently, in attempting to tally the permits and WCRs representing known domestic well locations, unique permits may be double counted as WCRs located by TRS. Because there are more permits over the permit's period of record than WCRs, it is assumed that not all WCRs located by TRS are associated with a permit.

3.1.5 Final Domestic Well Count and Location Estimates

The County permit database includes 670 domestic wells installed since 2013. Although over the same period, there are more permits than WCRs (567 domestic WCRs), the WCRs data back further than 1950 and are the more complete dataset. Although there are only 16% more permits than WCRs, 50% of the permits appear to be uniquely located. Given available WCR and well permit data, there are 5,781 uniquely located domestic wells (WCRs and permits) outside of community water systems. Because it appears permits supplement the WCR dataset to some extent, domestic well permit totals were estimated with projected complete 1980-2020 datasets.

A possible total number of domestic wells was estimated assuming that roughly 50% of permits are uniquely located as indicated by the best available location methods for all wells. Permit counts were projected for 1980-2013 given the same distribution as in 2013-2020. The inferred unique permits for 1980-2020 in **Table 2** estimate the maximum possible number of permits to be supplementary to the WCR dataset. There is a total of 8,948 WCRs and estimated unique permits (or wells otherwise not captured by the WCR dataset) outside community water systems, compared to the inferred 8,744 residential parcels outside water system boundaries. This estimated total drops to 6,673 total WCRs and estimated unique permits when assuming there are consistently 16% more permits than WCRs as indicated by the 2013-2020 totals, and that those permits are unique.

The current dataset of permits and WCRs outside community water systems at 5,781 domestic wells represents 68% of the inferred residential parcels. Dependent on the accuracy of extrapolation techniques, the total may represent 76 – 100% of the inferred parcels with a complete dataset.

Well permits generally provide a more complete representation of wells constructed in the County, but these permit records do not contain information on well perforations and depths. An analysis of well construction information was therefore performed on the WCR data only.

3.1.6 WCR Domestic Well Construction Information

Of the 5,879 domestic well WCRs in the Tehama Subbasin, 5,860 included some information on perforated interval (top of bottom of perforations) or total depth. Only WCR records determined to have sufficiently reliable well construction information (i.e., lack of obviously conflicting information on the well construction) were included in the summary and analyses relating to domestic well construction in the County. In analyses using well perforations (screens), where data for bottom of perforations was not available, the reported total well depth was used. A total of 1,070 WCRs included top of screened interval information. Average total depths of WCRs in each section were calculated and are displayed in **Figure 10**. Additionally, to evaluate changes in well depths over time, scatterplots of completed depth over time in Antelope, Bowman, Los Molinos, and Red Bluff Subbasin were plotted in **Figure 11a**, **Figure 11b**, **Figure 11c**, and **Figure 11d**, respectively. Minimum installed depths appear to be increasing with time in all Subbasins, and depths are much more variable within Bowman and Red Bluff Subbasins.

3.2 Public Water System Wells

PWS wells data are maintained by the State Water Resources Control Board Division of Drinking Water in the Safe Drinking Water Information System (SDWIS); however, these data are incomplete at this time. The WCR database was queried for PWS wells, and there were 59 wells drilled in 1980 or later with Public Water Supply as the planned use. Of these, only 16 fall within community water system boundaries. Depth to the bottom of perforated interval ranged from 100 to 840 feet below ground surface in these wells. The wells identified here are shown in **Figure 9a**.

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TABLES

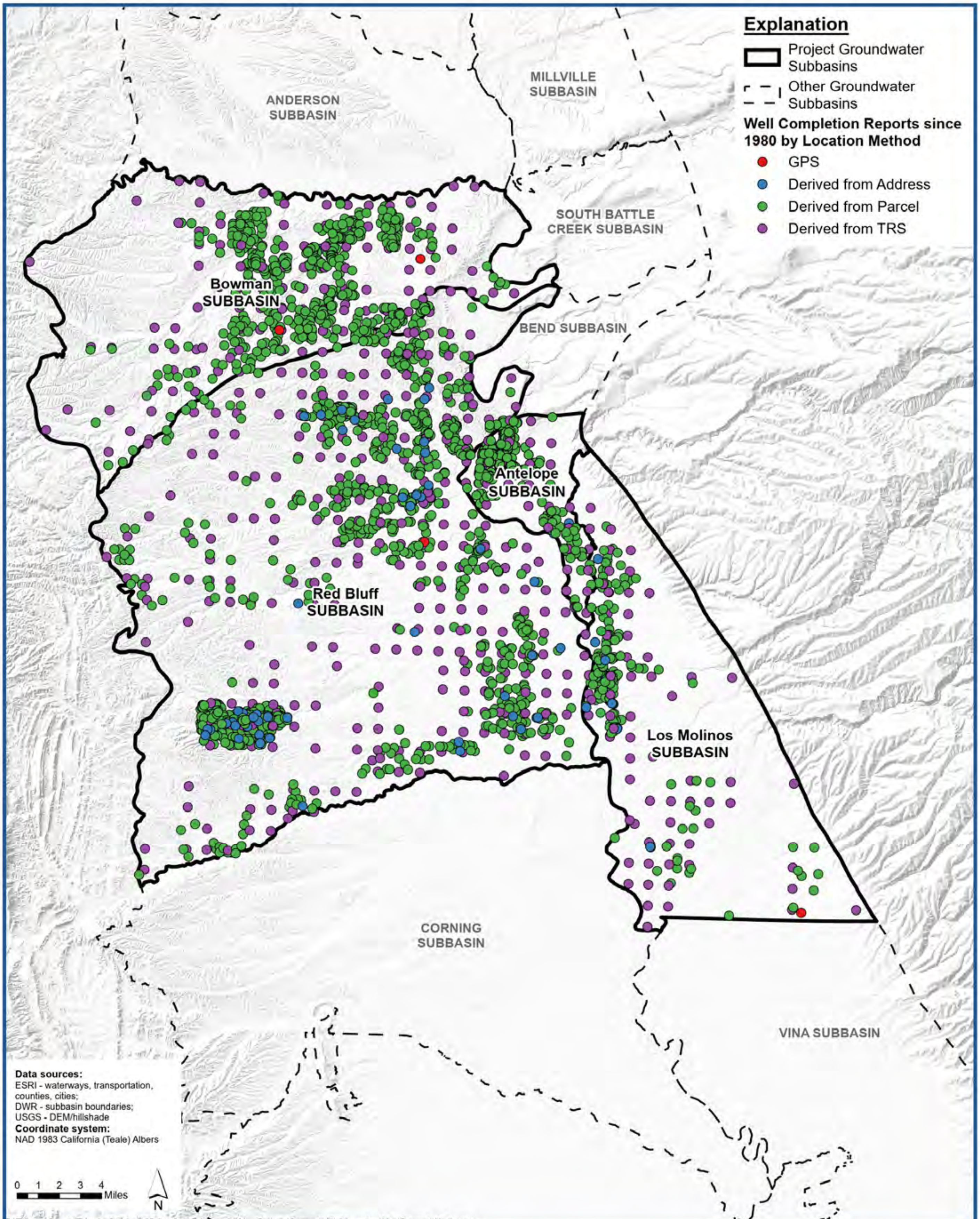
Table 1. Summary of domestic well WCRs by decade and subbasin.

WCR Date Range	Antelope WCRs in Date Range	Bowman WCRs in Date Range	Los Molinos WCRs in Date Range	Red Bluff WCRs in Date Range	Tehama WCRs in Date Range	Cumulative WCRs Since Beginning (Since 1980)
Pre-1950	16	1	9	22	48	48
1950-1959	40	14	21	77	152	200
1960-1969	123	70	47	267	507	707
1970-1979	207	411	187	812	1617	2324
1980-1989	196	421	252	853	1722	4046 (1722)
1990-1999	162	328	205	1080	1775	5801 (3497)
2000-2009	165	393	139	973	1670	7471 (5167)
2010-2019	149	122	57	374	702	8173 (5869)
Since 2020	1	4	0	5	10	8183 (**5879**)
Unknown	18	13	12	33	76	8259

Table 2. Summary of inferred and known domestic wells

Number of Inferred and Known Domestic Wells	Entire Region	Within Community Water System	Within Community Water System or near (within 0.5 mi) Public Water Supply wells
Number of Parcels with Inferred Domestic Wells	15,959	9,234	7,215
Number of Domestic Wells from WCRs 1980-2020	5,879	1,090	260
Number of Domestic Well Permits (unique; not matching WCRs) 2013-2020	338	71	17
Number of Inferred Unique Domestic Well Permits 1980-2020	3,505	736	176
Number of Domestic Wells + Unique (inferred) Permits 1980-2020	9,384	1,826	436

FIGURES



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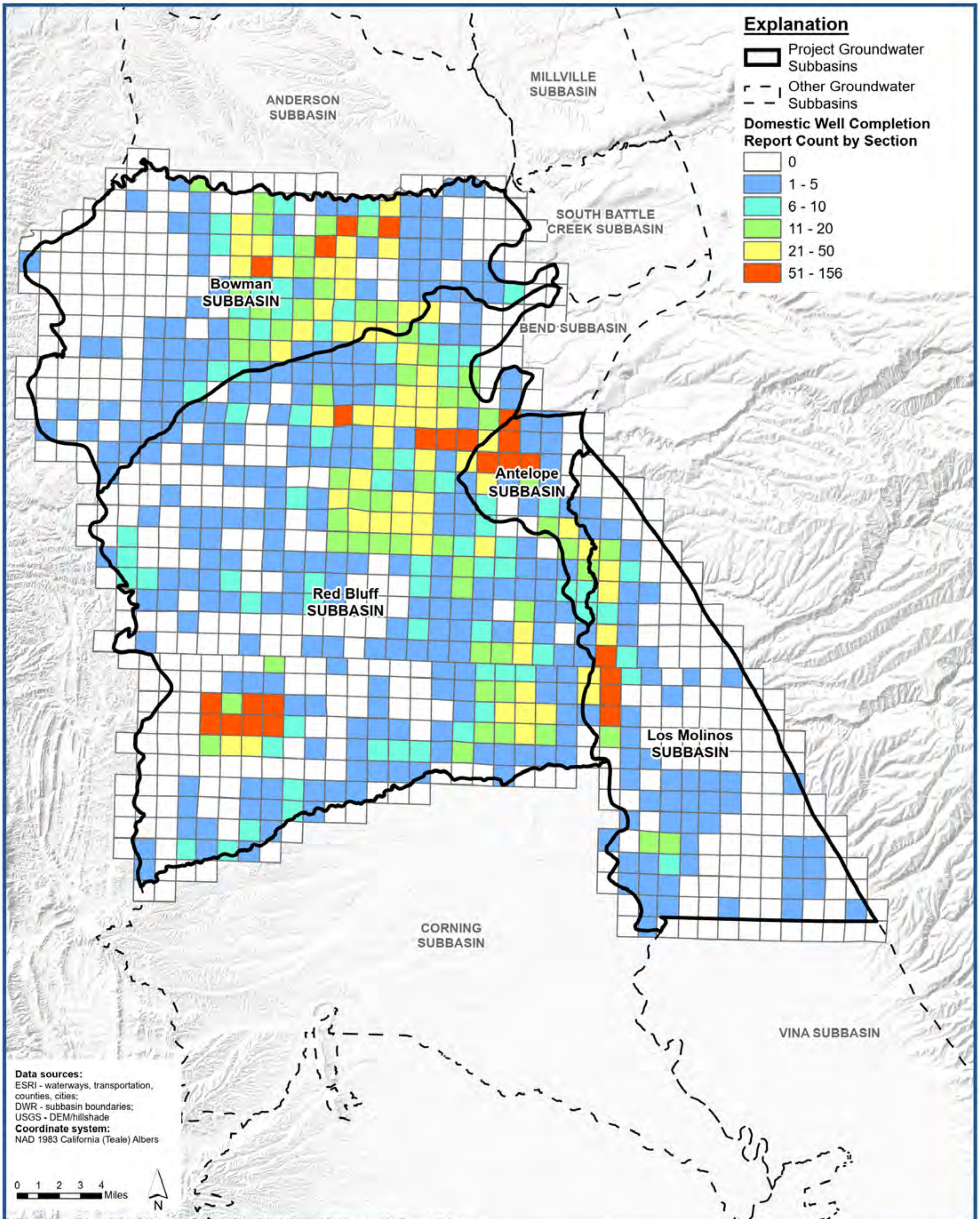
Domestic Wells from Well Completion Reports
All New Construction Wells from 1980-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 1



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Summary by Section of Domestic Well Completion Reports
All New Construction Wells from 1980-2020

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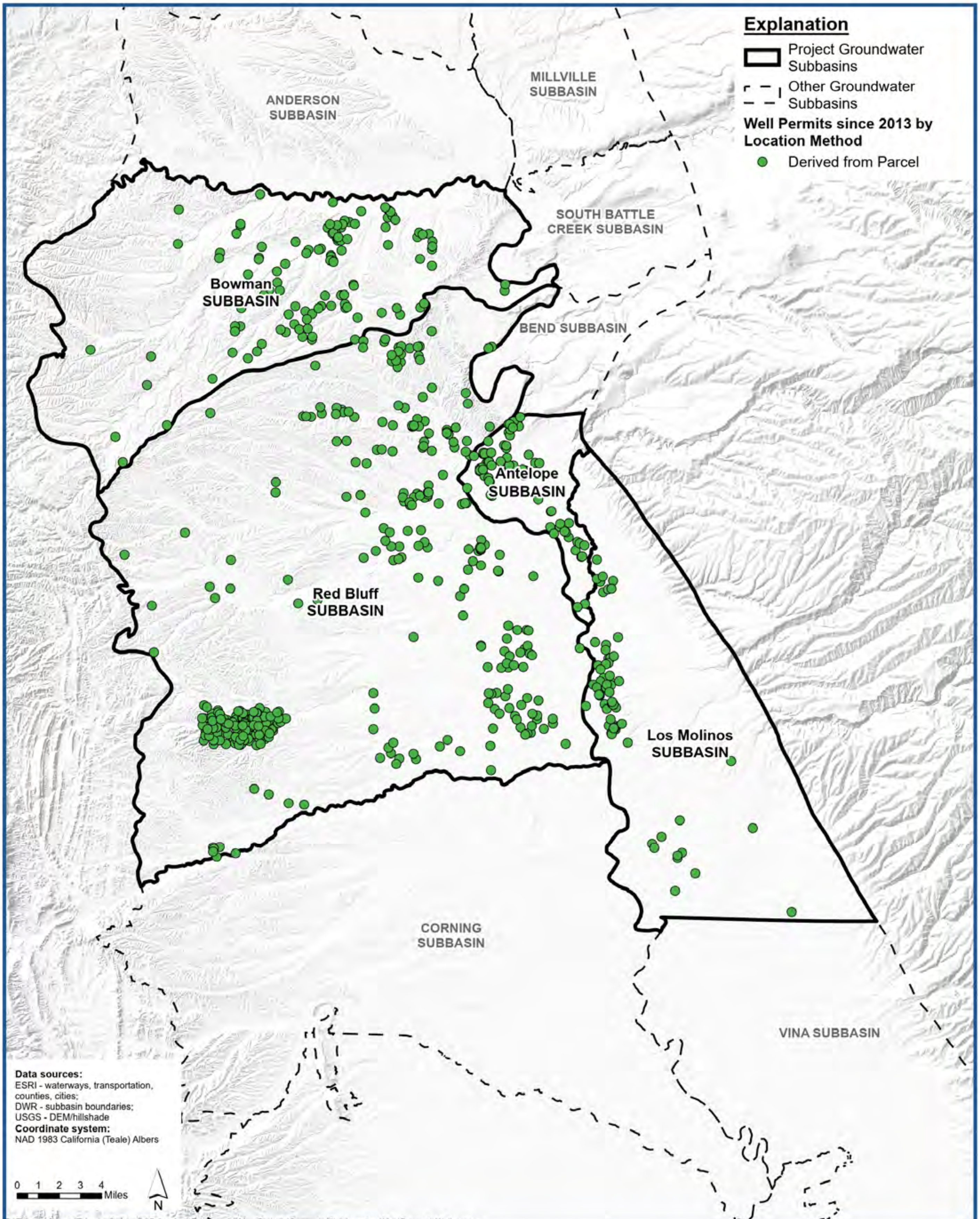
Figure 2



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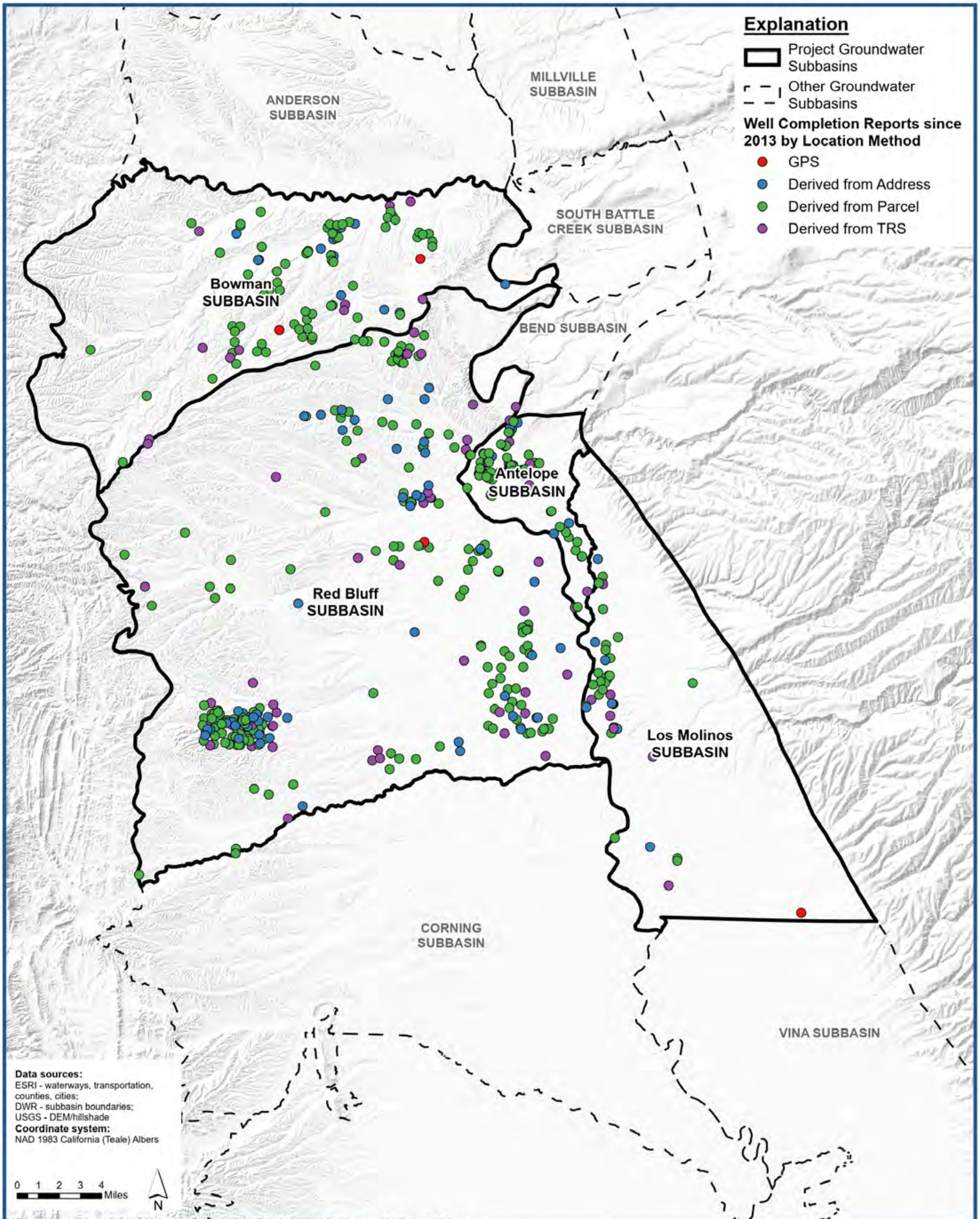
Domestic Wells from Well Permits
All New Construction Wells from 2013-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 3a



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Domestic Wells from Well Completion Reports
All New Construction Wells from 2013-2020

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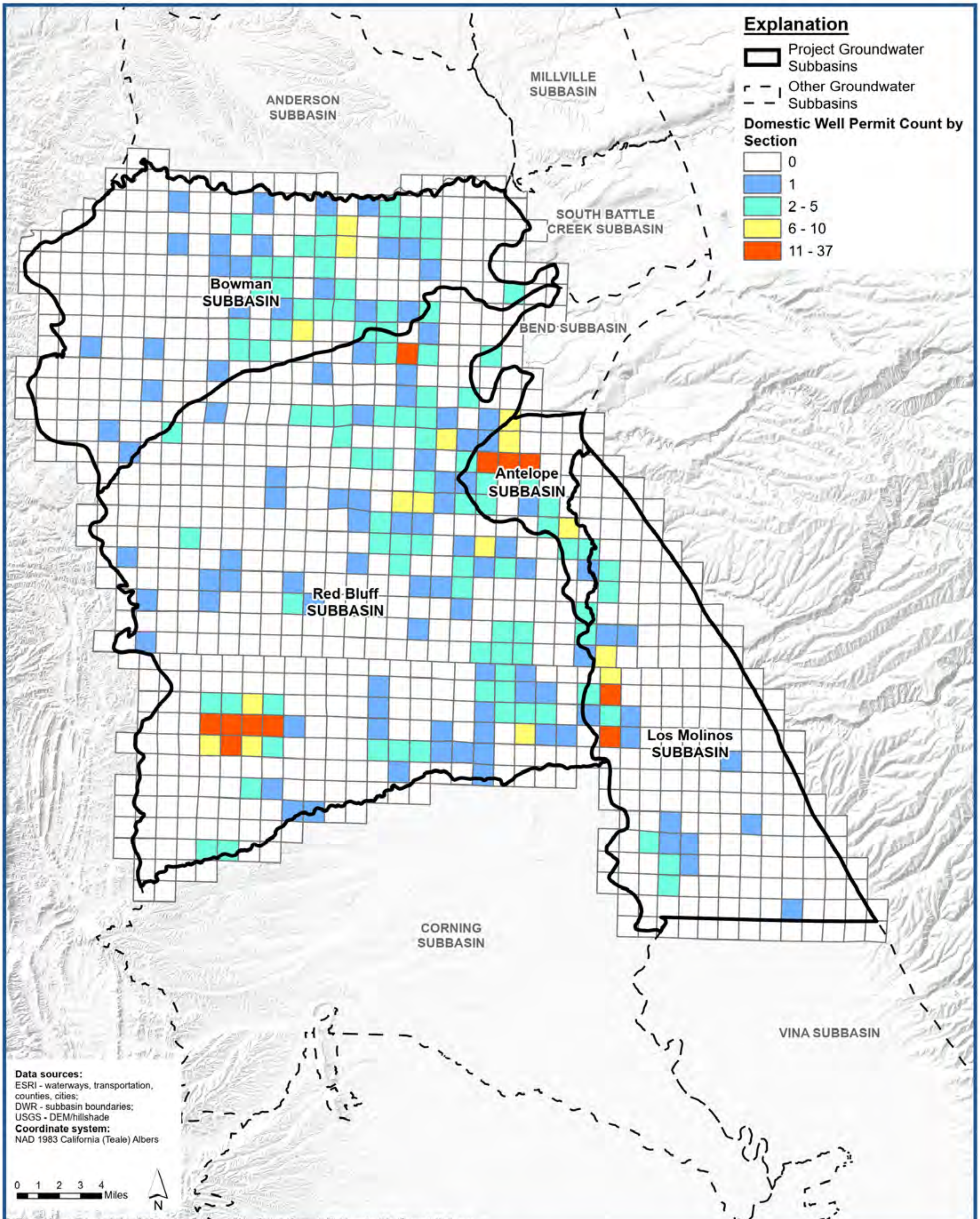
Figure 3b



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Summary by Section of Domestic Well Permits
All New Construction Wells from 2013-2020

Figure 4a

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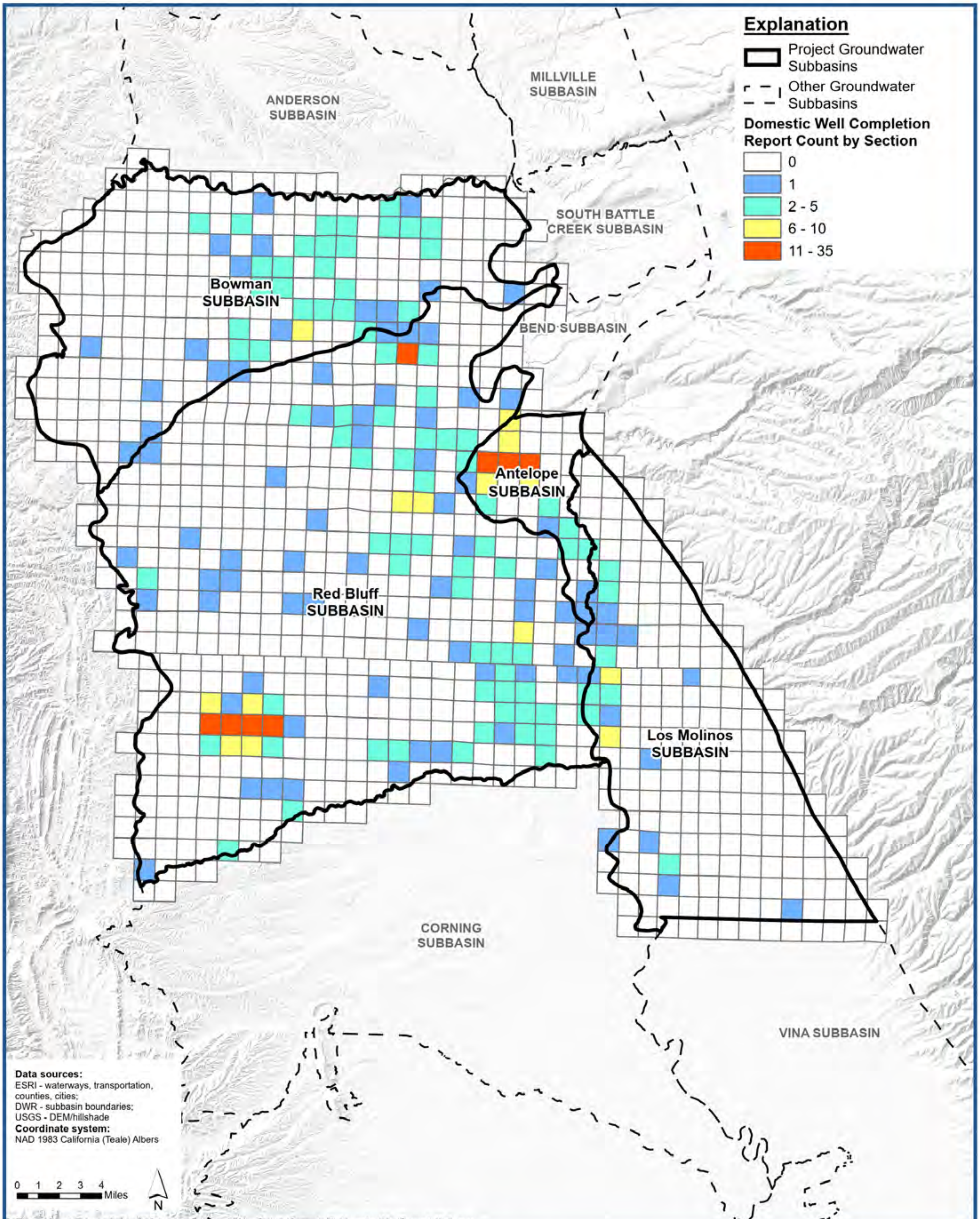

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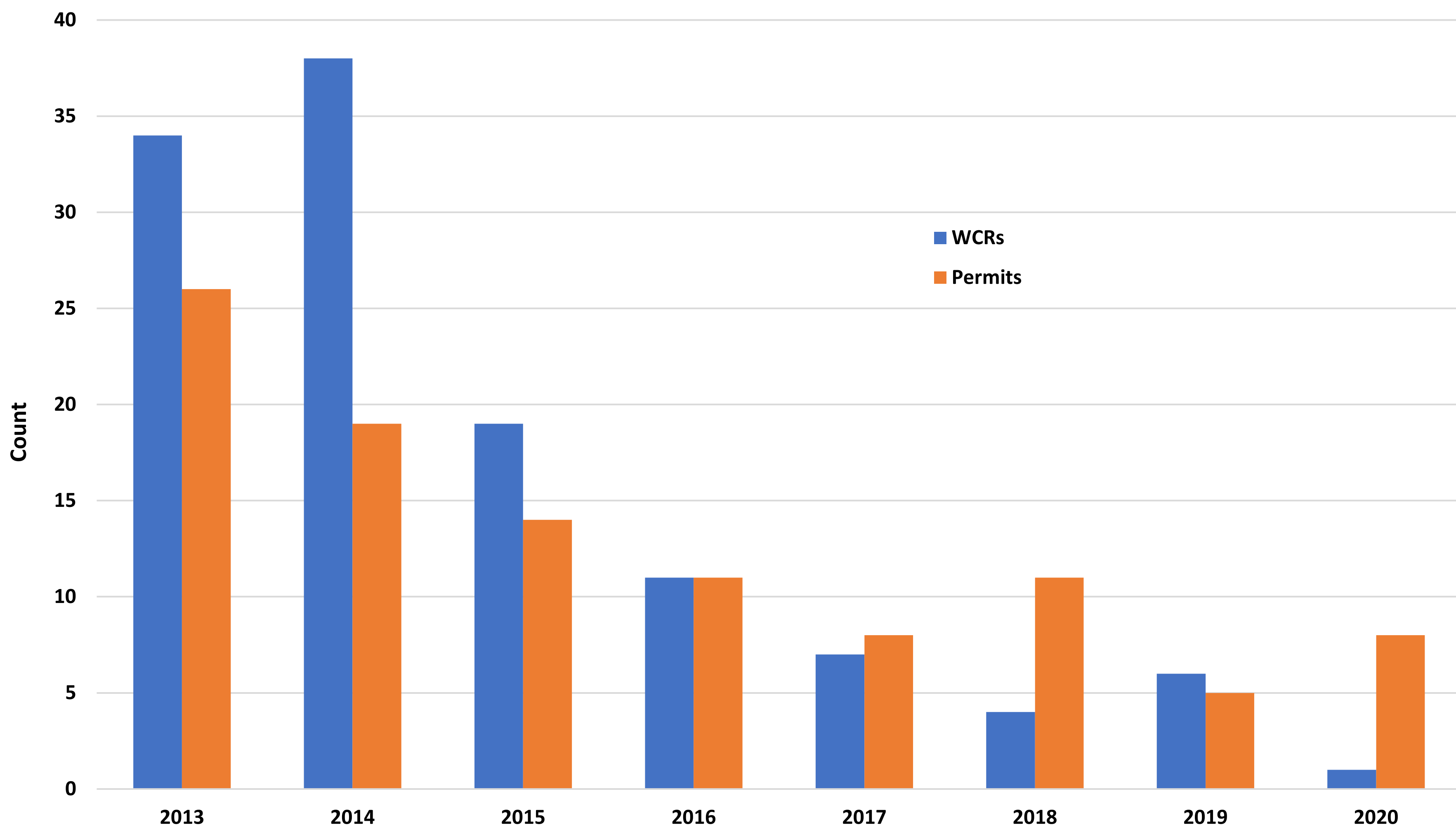
Summary by Section of Domestic Well Completion Reports
All New Construction Wells from 2013-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 4b



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Total Annual Number of WCRs and Well Permits in Antelope Subbasin
All New Construction Wells 2013-2020

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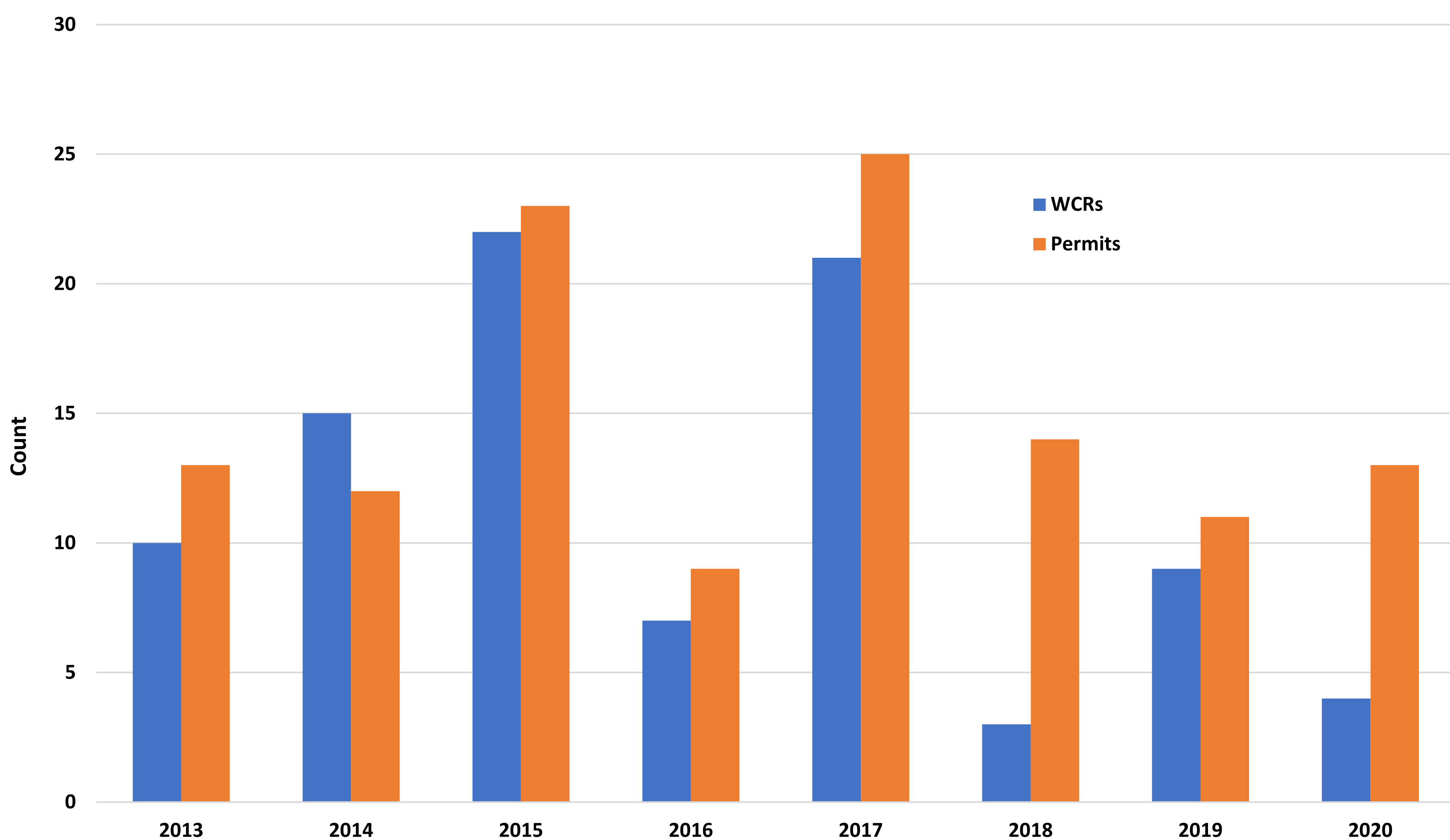
Tehama County, California

Figure 5a



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Total Annual Number of WCRs and Well Permits in Bowman Subbasin
All New Construction Wells 2013-2020

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Tehama County, California

Figure 5b

Total Annual Number of WCRs and Well Permits in Los Molinos Subbasin
All New Construction Wells 2013-2020

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Figure 5c

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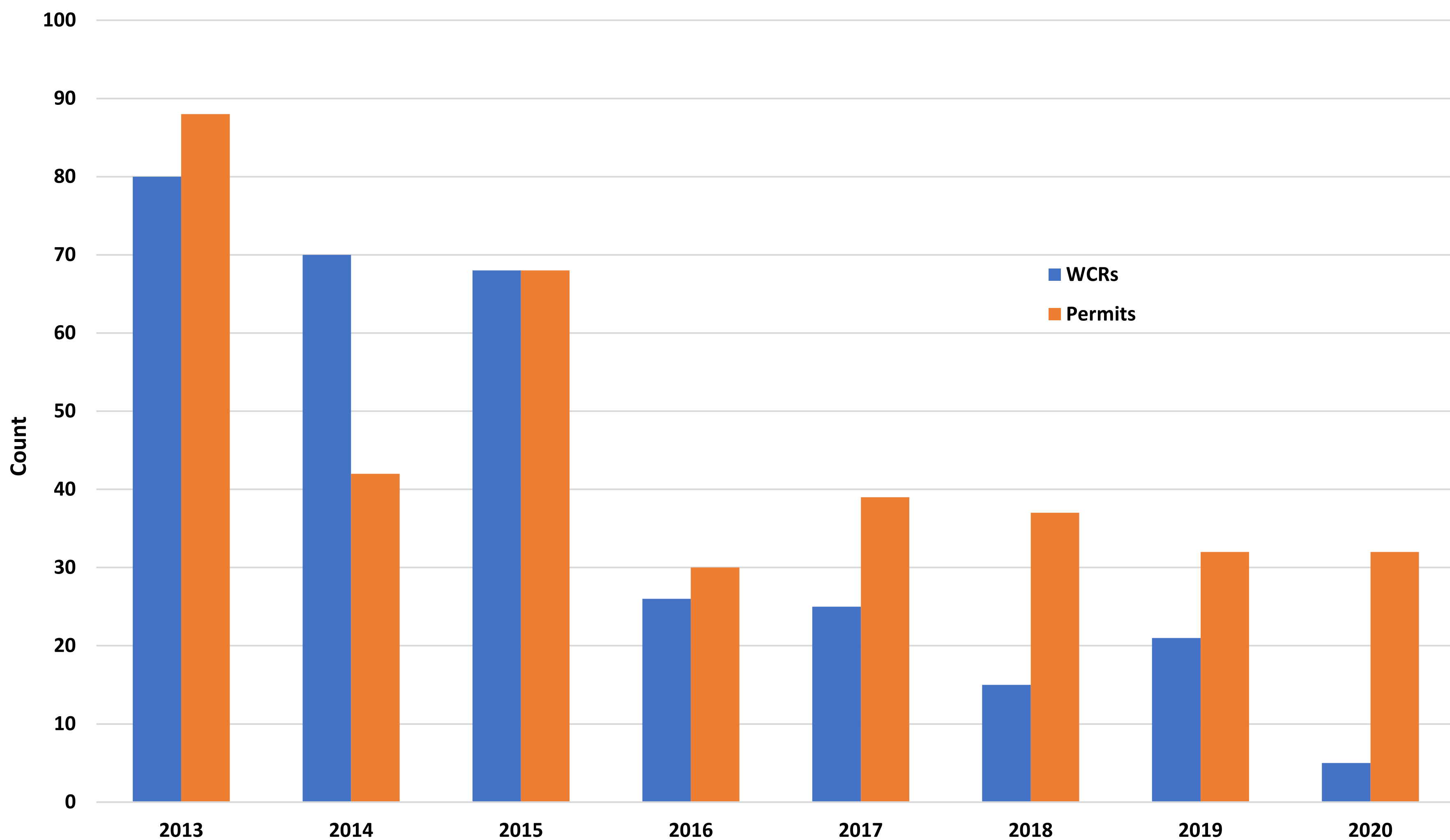

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Total Annual Number of WCRs and Well Permits in Red Bluff Subbasin
All New Construction Wells 2013-2020

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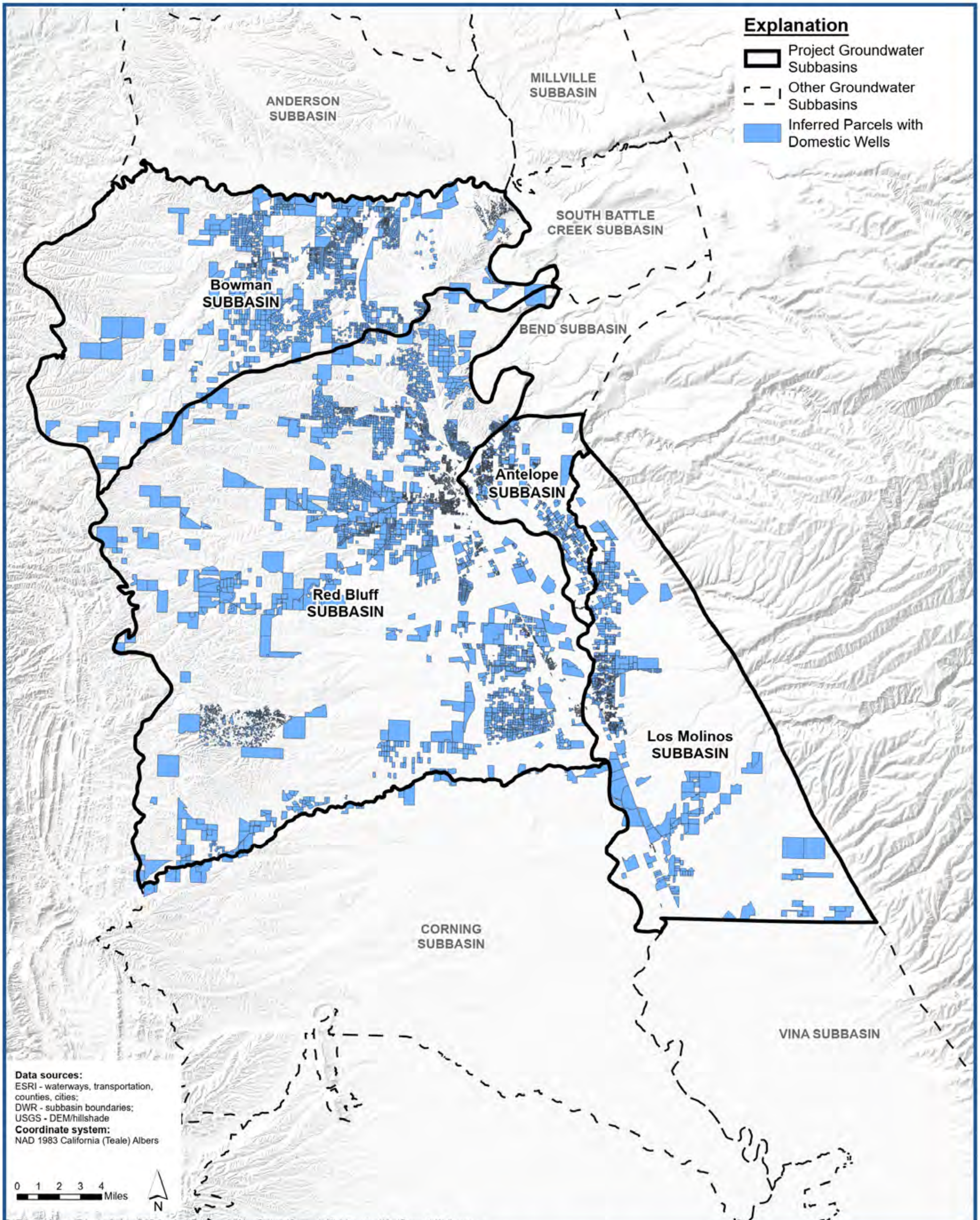
Tehama County, California

Figure 5d



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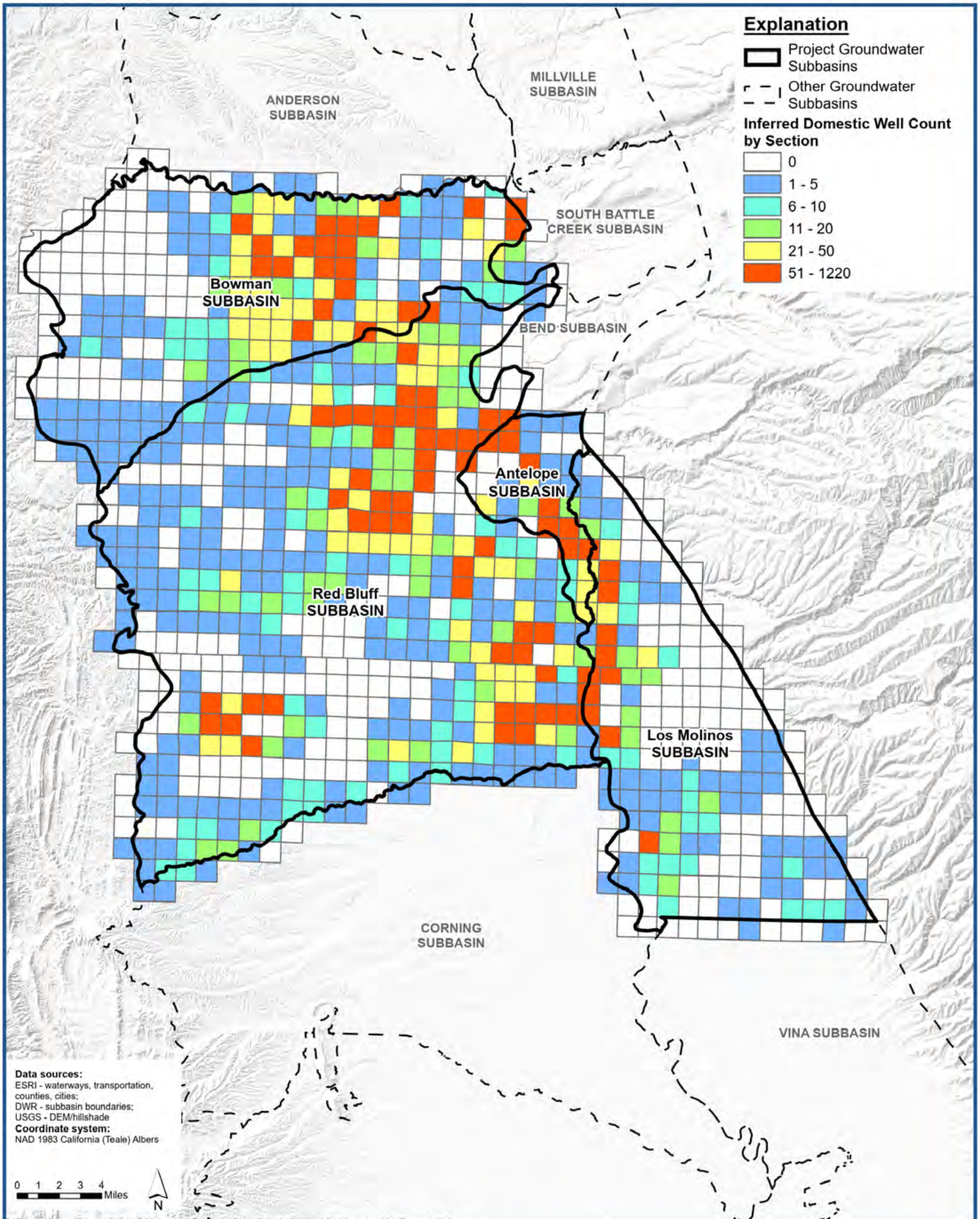
Parcels with Domestic Wells
Inferred from Land Use Codes

Figure 6

Tehama County Groundwater Sustainability Plan
Tehama County, California



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Summary by Section of Inferred Domestic Wells
Well Locations Inferred by Parcel Land Use Codes

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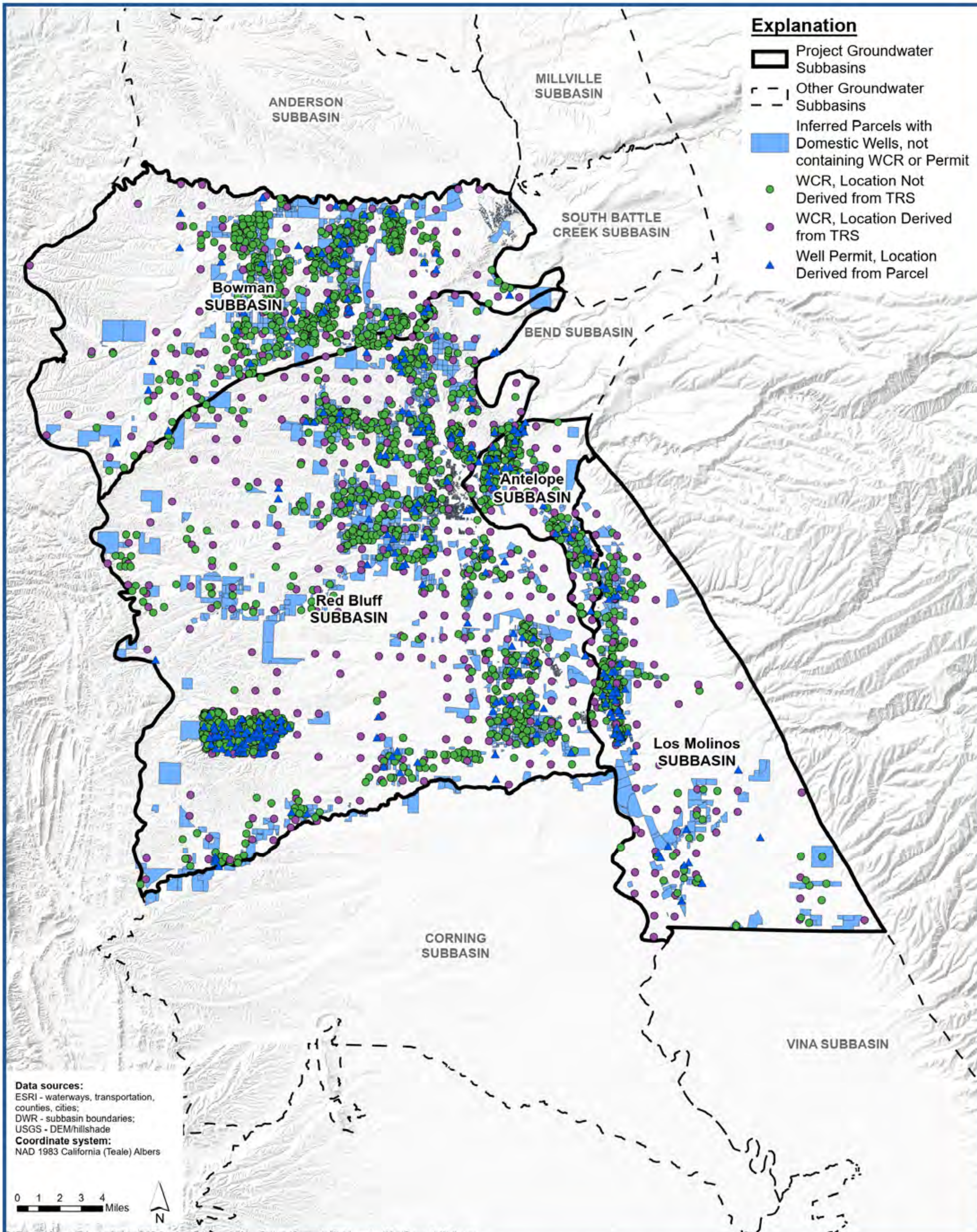
Figure 7



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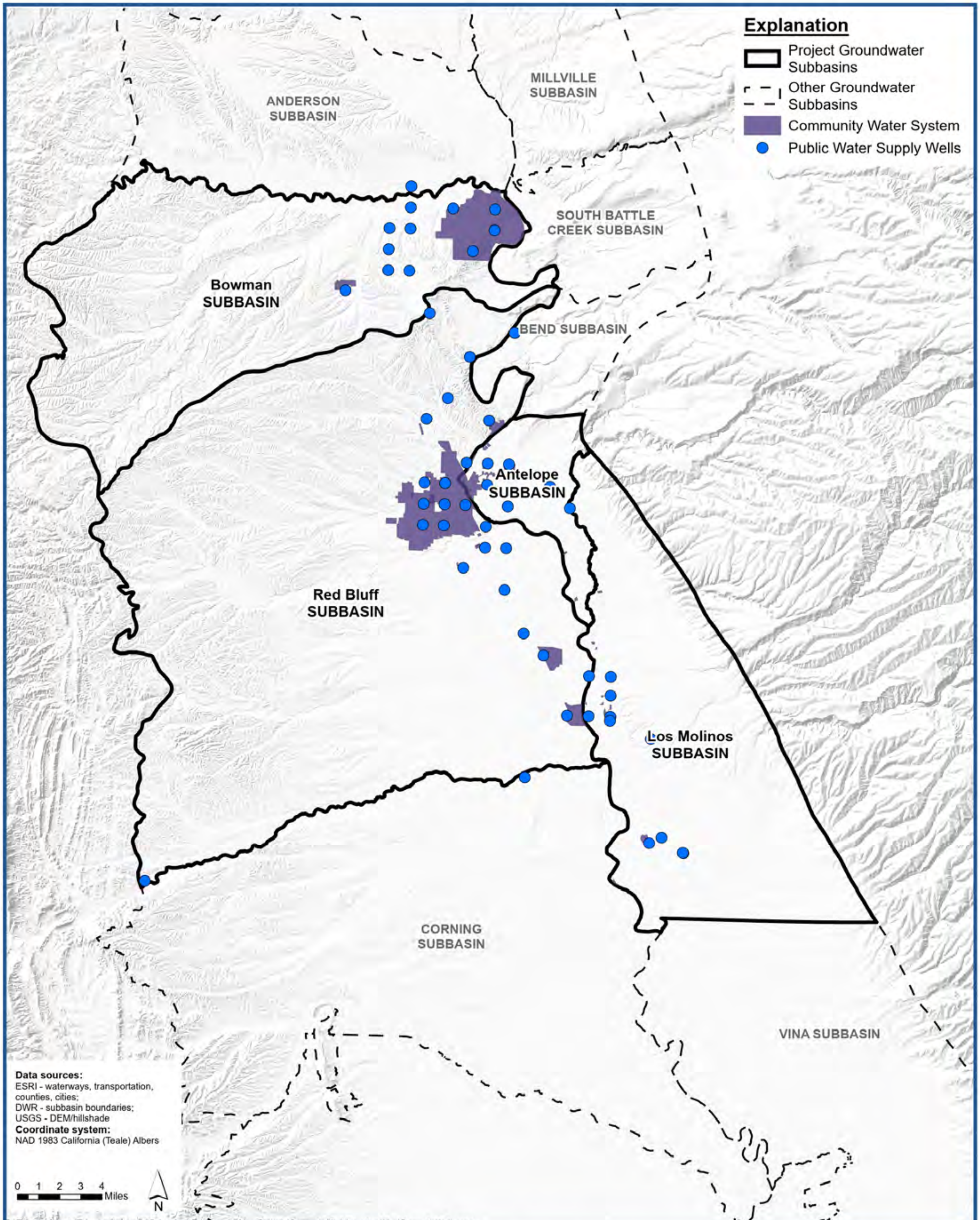
Summary of Known and Inferred Domestic Well Locations
Data from Well Completion Reports, Permits, and Parcels

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 8



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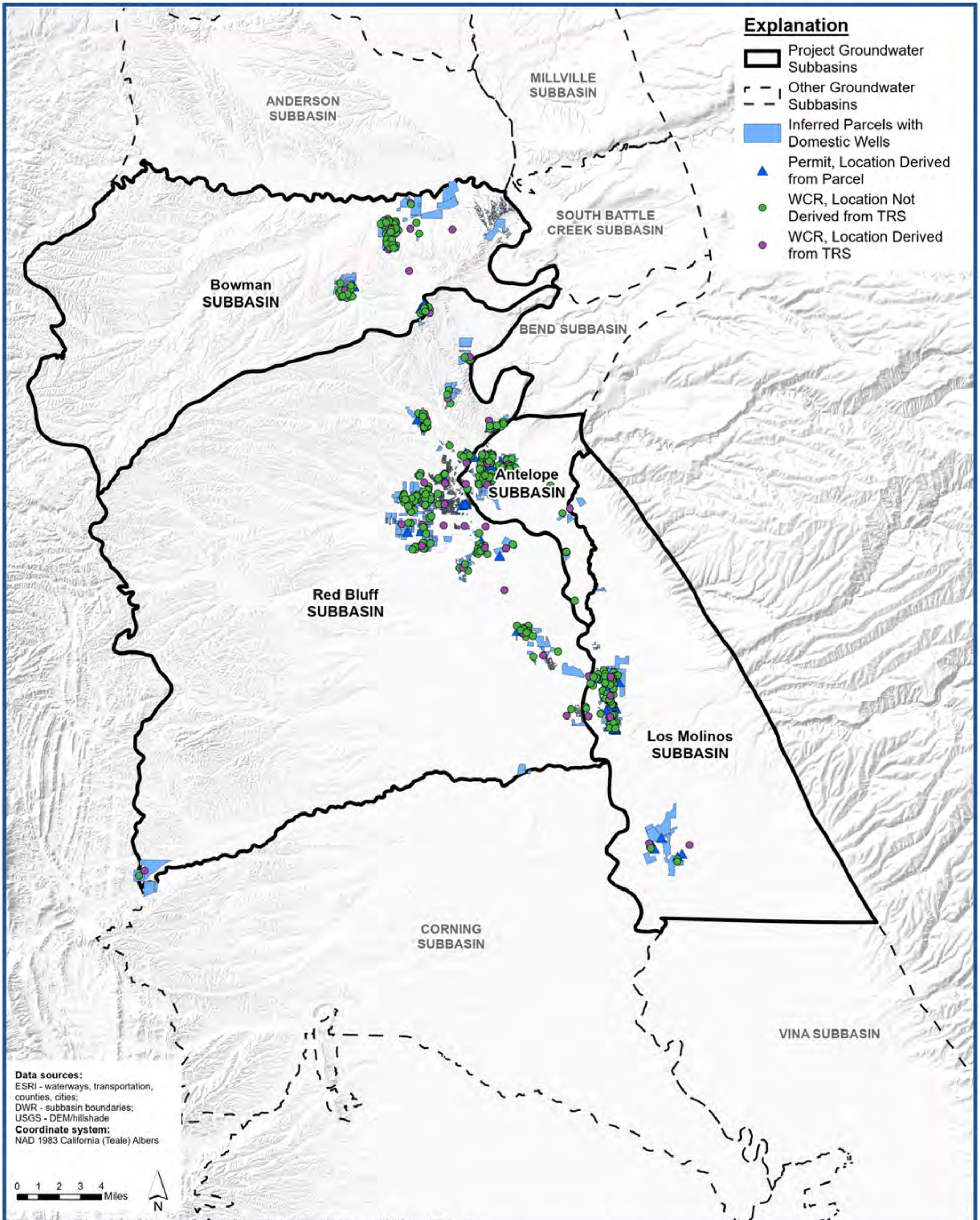
Community Water Systems and Public Supply Well Locations

Figure 9a

Tehama County Groundwater Sustainability Plan
Tehama County, California



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Known and Inferred Domestic Well Locations within Community Water Systems or near Public Supply Wells

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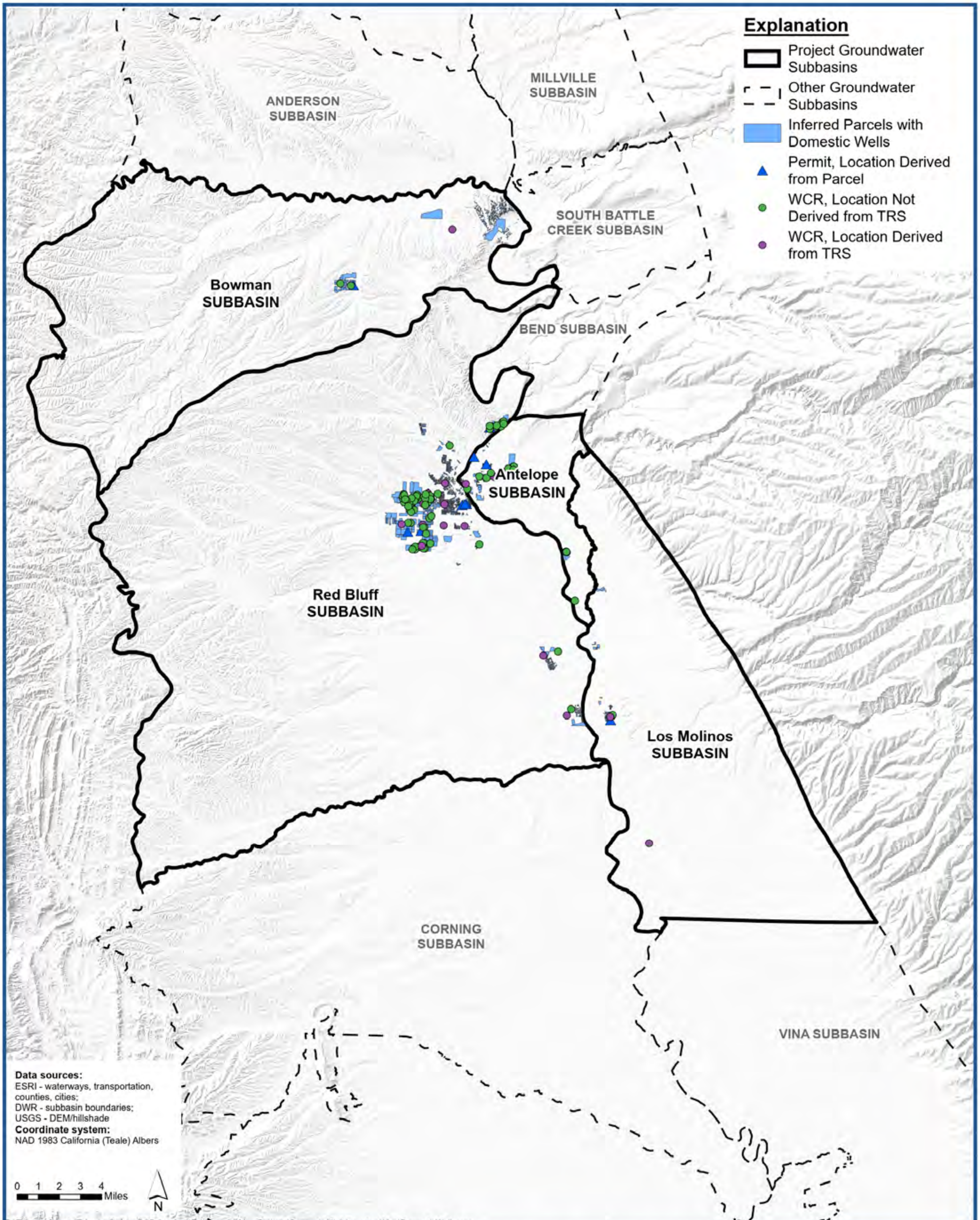
Tehama County, California

Figure 9b

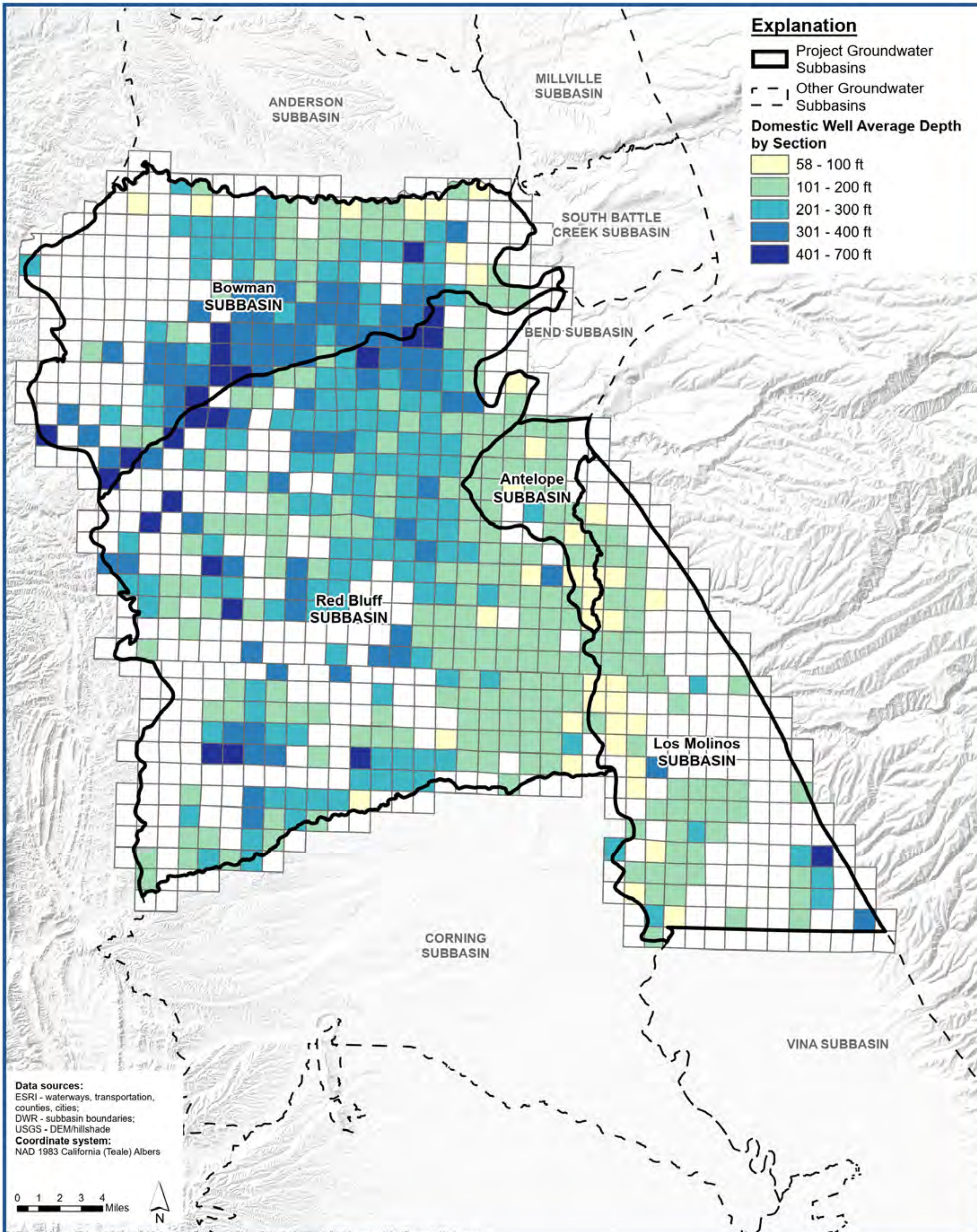


Luhdorff & Scalmanini
Consulting Engineers

Known and Inferred Domestic Well Locations Within Community Water Systems

Figure 9c

Tehama County Groundwater Sustainability Plan
Tehama County, California

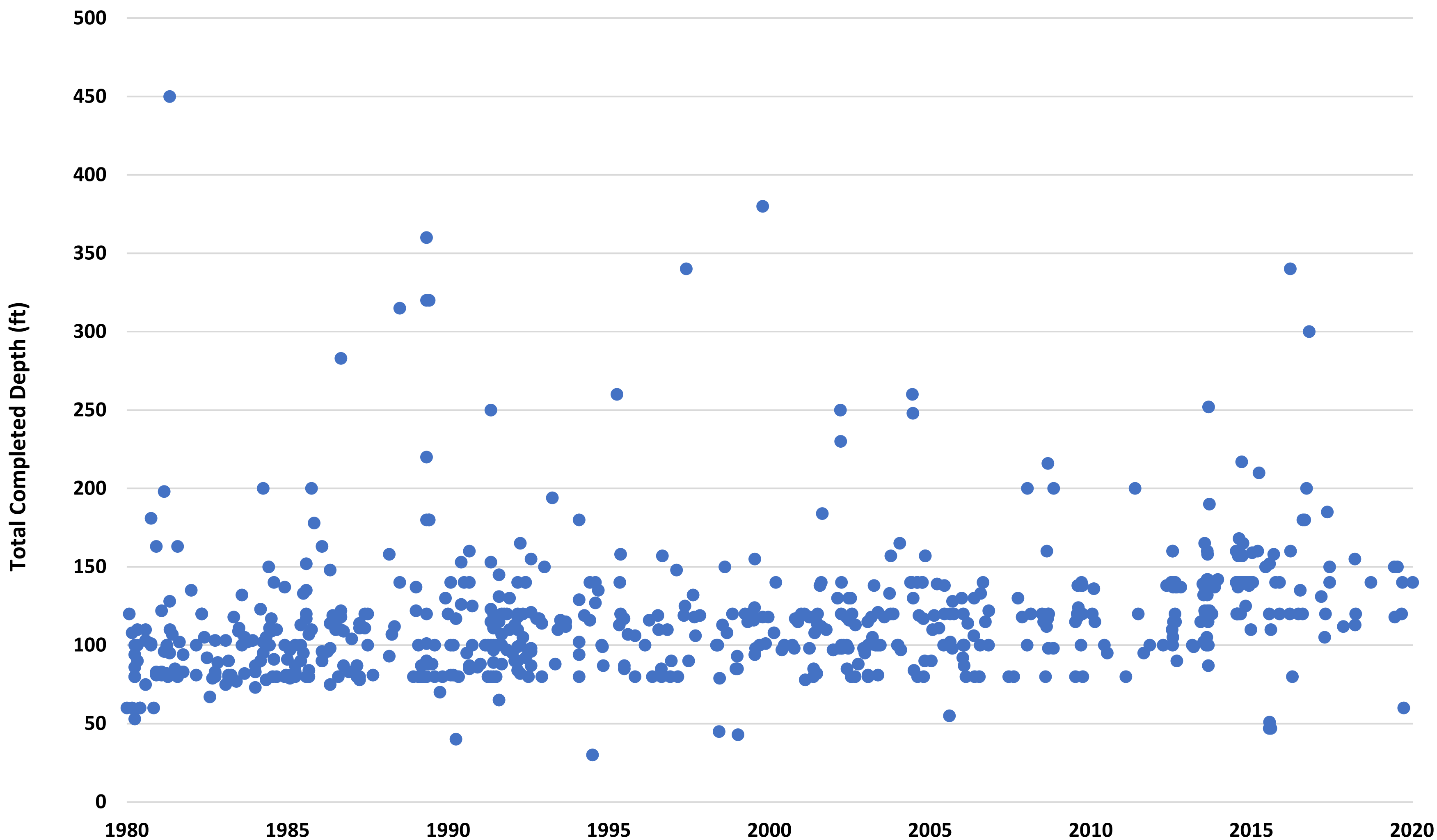


Luhdorff & Scalmanini Consulting Engineers

Average Domestic Well Depth by Section

Figure 10

Tehama County Groundwater Sustainability Plan
Tehama County, California

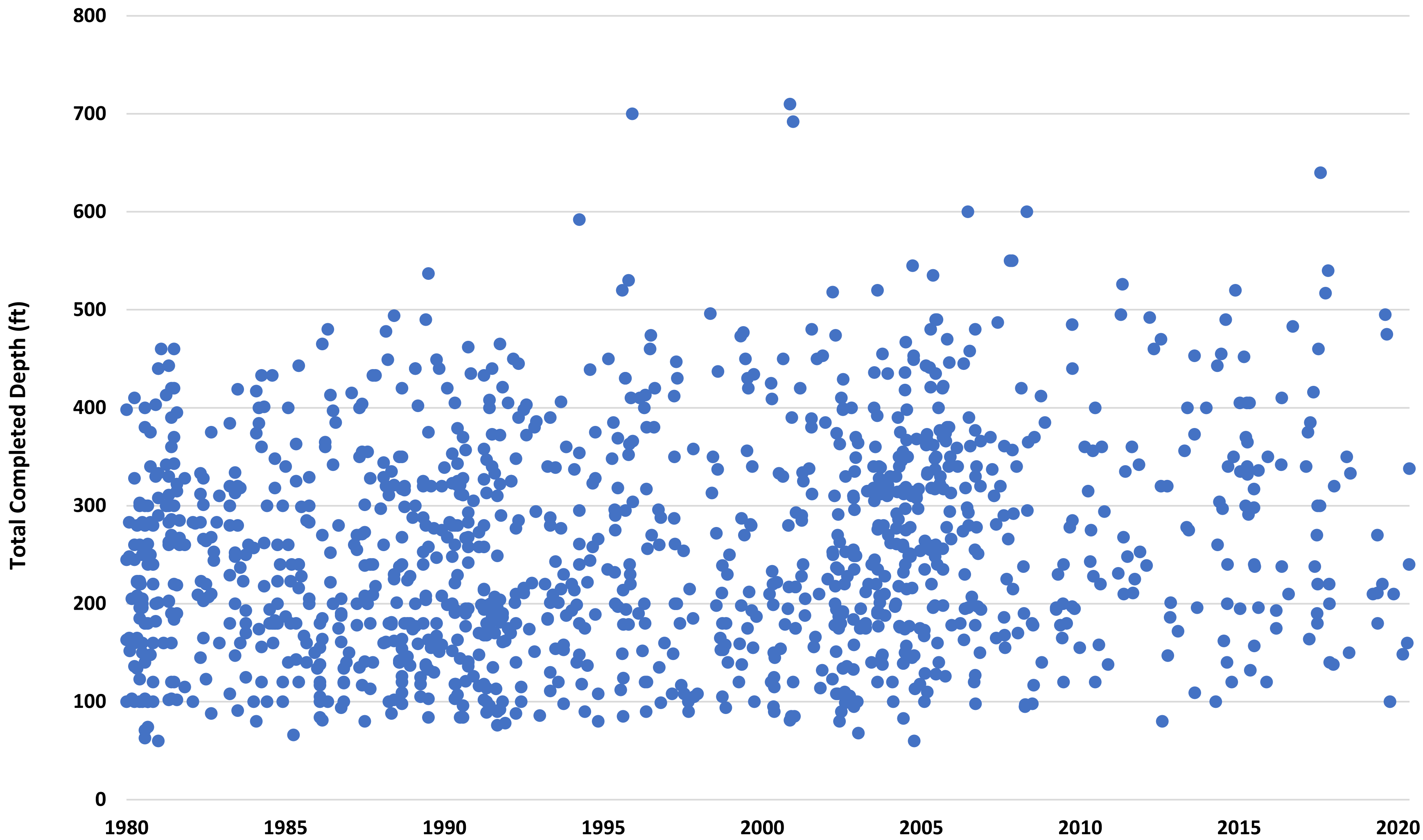


Luhdorff & Scalmanini
Consulting Engineers

Well Depths by Year in Antelope Subbasin
Well Completion Reports from 1980-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 11a



Luhdorff & Scalmanini
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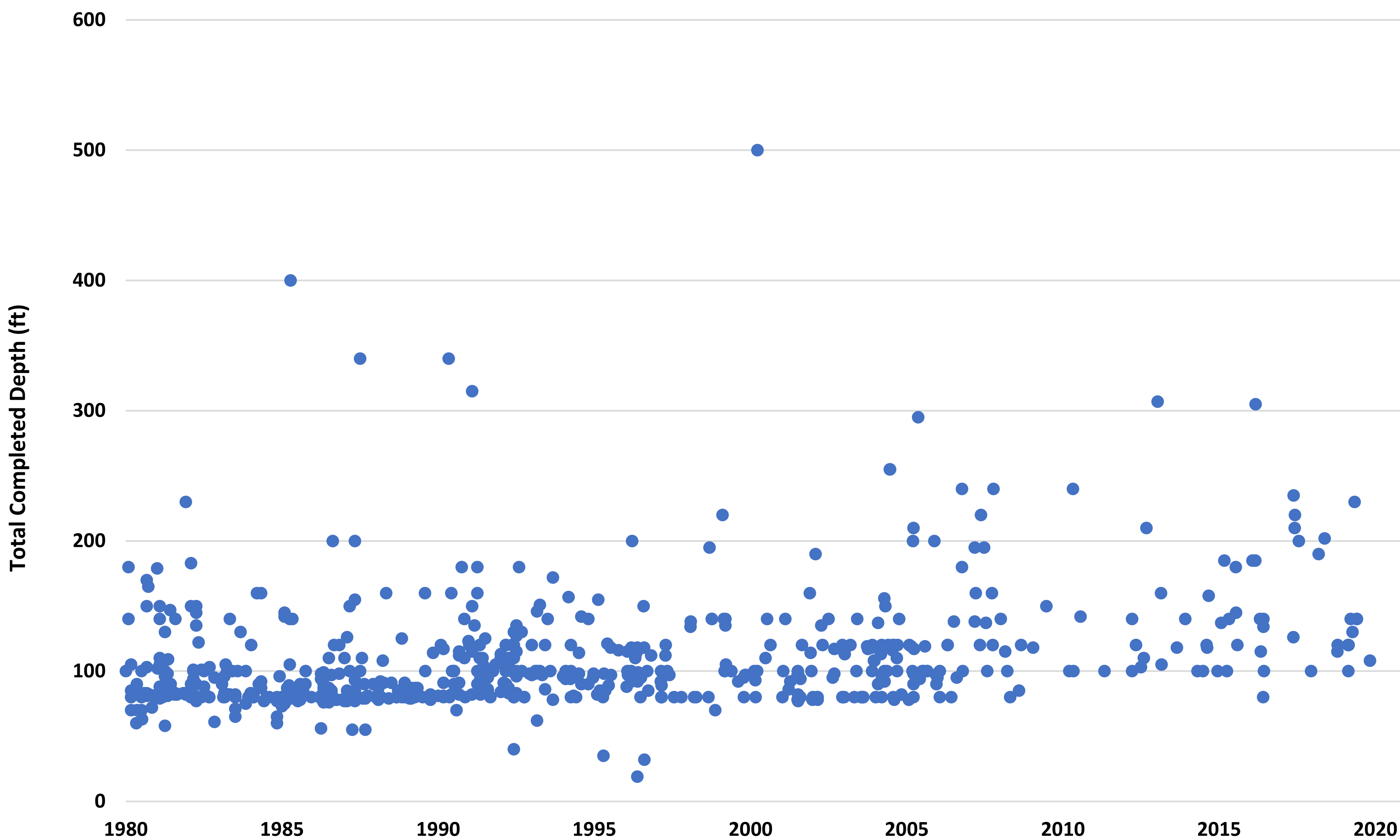
Well Depths by Year in Bowman Subbasin
Well Completion Reports from 1980-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 11b

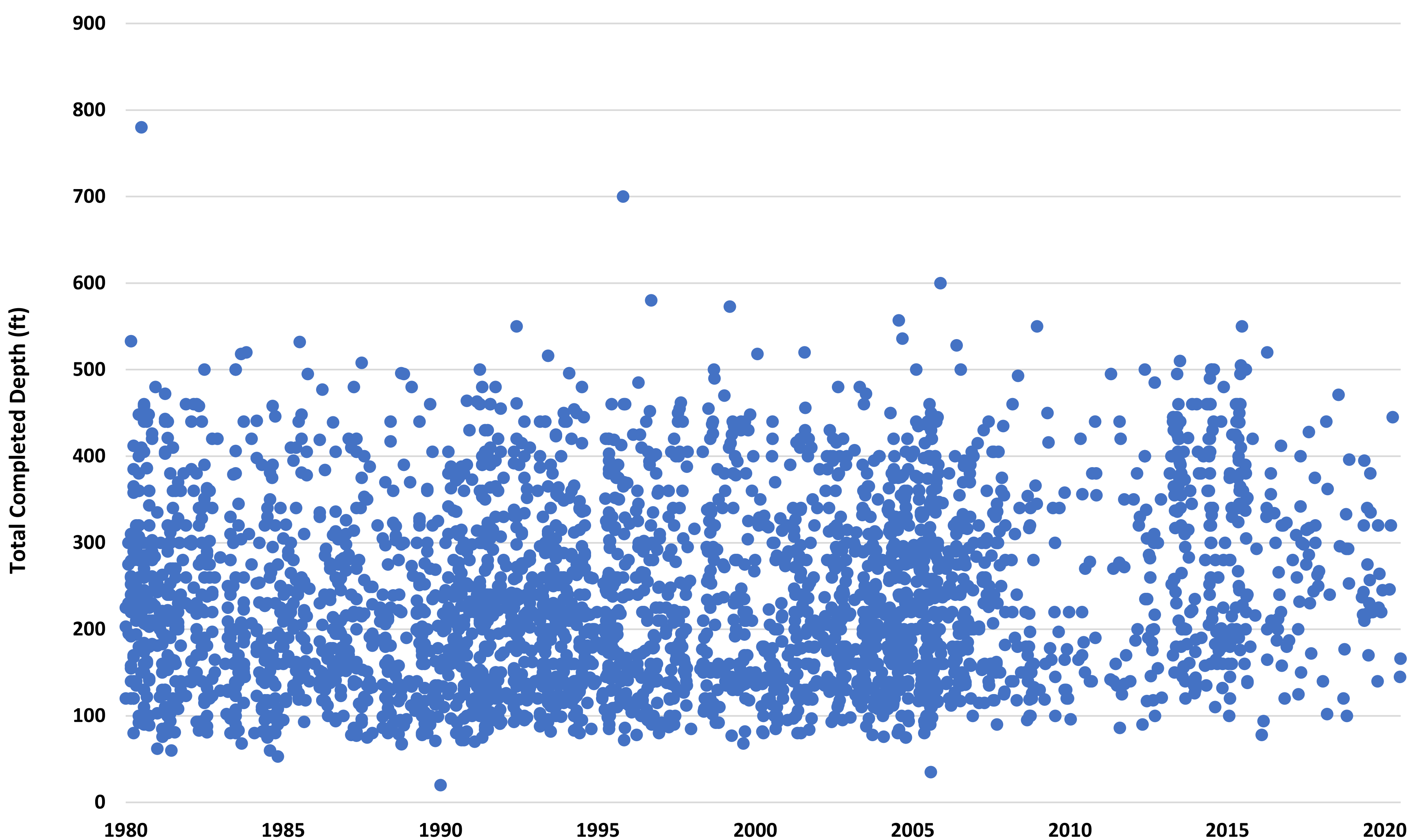


Luhdorff & Scalmanini
Consulting Engineers

Well Depths by Year in Los Molinos Subbasin
Well Completion Reports from 1980-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 11c



Luhdorff & Scalmanini
Consulting Engineers

Well Depths by Year in Red Bluff Subbasin
Well Completion Reports from 1980-2020

Tehama County Groundwater Sustainability Plan
Tehama County, California

Figure 11d

APPENDIX 1

List of Land Use Codes Appendix 1. List of Land Use Codes of Parcels with Inferred Domestic Wells

APPENDICES

Appendix 1. List of Land Use Codes of Parcels with Inferred Domestic Wells

010	Single Family Dwellings
011	Condominium Units
013	SFD – Non-Conforming Use
014	SFD w/ Secondary Use
015	Living Unit in Planned Unit Dev
016	Mobile Home
017	SFD w/ Mobile Home
021	One Duplex – One Bldg
022	Two or more SFD on Single Parcel
024	2 MH/more on Single Parcel
031	Single Triplex
032	Three Units
033	Single Fourplex
034	Four Units
041	5-10 Res Units – Single Building
042	5-10 Units (2/more Bldg)
043	11-20 Res Units – Single Bldg
044	11-20 Units (2/more Bldg)
045	21-40 Units
046	41-100 Units
047	Over 100 Units
051	Rural Res – 1 Res
052	Rural Res – 2 or more REs
055	Rural Res – w/ Mobile Home
056	Rural Res – w/MH & Res
057	Rural Res – w/2 or more MH
058	Rural Res – w/Travel Trailer
060	Motels less than 25 Units
061	Motels over 25 Units
063	Over 25 Units
065	Motels over 25 Units w/ Shops
301	Irrig Prune Orchard – w/Res
302	Irrig Prune Orchard – w/MH
303	Irrig Prune Orchard – w/Res & MH
305	Irrig Prune Orchard – w/2 or More Res
306	Irrig Prune Orchard – w/2 or more MH
311	Irrig Walnut Orchard – w/Res
312	Irrig Walnut Orchard – w/MH
313	Irrig Walnut Orchard – w/Res & MH
315	Irrig Walnut Orchard – w/2 or More Res
316	Irrig Walnut Orchard – w/2 or More MH
321	Irrig Almond Orchard – w/Res
322	Irrig Almond Orchard – w/MH
323	Irrig Almond Orchard – w/Res & MH
325	Irrig Almond Orchard – w/2 or More Res
326	Irrig Almond Orchard – w/2 or More MH
331	Irrig Olive Orchard w/Res
332	Irrig Olive Orchard w/MH
333	Irrig Olive Orchard w/Res & MH
335	Irrig Olive Orchard w/2 or more Res

336 Irrig Olive Orchard w/2 or more MH

341 Irrig Misc Orchard w/ Res

342 Irrig Misc Orchard w/MH

343 Irrig Misc Orchard w/Res & MH

346 Irrig Misc Orchard w/ 2 or more MH

351 Irrig Vines & Bush w/Res

352 Irrig Vines & Bush w/MH

361 Irrig Row Crops w/Res

365 Irrig Row Crops w/2 or More Res

371 Irrig Field Crops w/Res

372 Irrig Field Crops w/MH

373 Irrig Field Crops w/Res & MH

375 Irrig Field Crops w/2 or more Res

401 Irrig Pasture w/Res

402 Irrig Pasture w/MH

403 Irrig Pasture w/Res & MH

405 Irrig Pasture w/2 or more Res

408 Irrig Pasture w/2 or more MH

411 Dairies w/Res

413 Dairies w/MH

415 Dairies w/2 or more Res

432 Feed Lots w/ MH

521 Field Crops w/Res

522 Field Crops w/MH

523 Field Crops w/Res & MH

525 Field Crops w/2 or more Res

526 Field Crops w/2 or more MH

531 Pasture w/Res

532 Pasture w/MH

533 Pasture w/Res & MH

535 Pasture w/2 or more Res

536 Pasture w/2 or more MH

551 Specialty Farms w/Res

552 Specialty Farms w/ MH

553 Specialty Farms w/Res & MH

555 Specialty Farms w/2 or more Res

556 Specialty Farms w/2 or more MH

Appendix 2-B

Communication and Engagement Plan

Tehama County Flood Control and Water Conservation District
Groundwater Sustainability Agency

Stakeholder Communications and Engagement Plan

Sustainable Groundwater Management Act (SGMA) Implementation (2021-2023)

Prepared by the Consensus Building Institute

Version 12.15.2021

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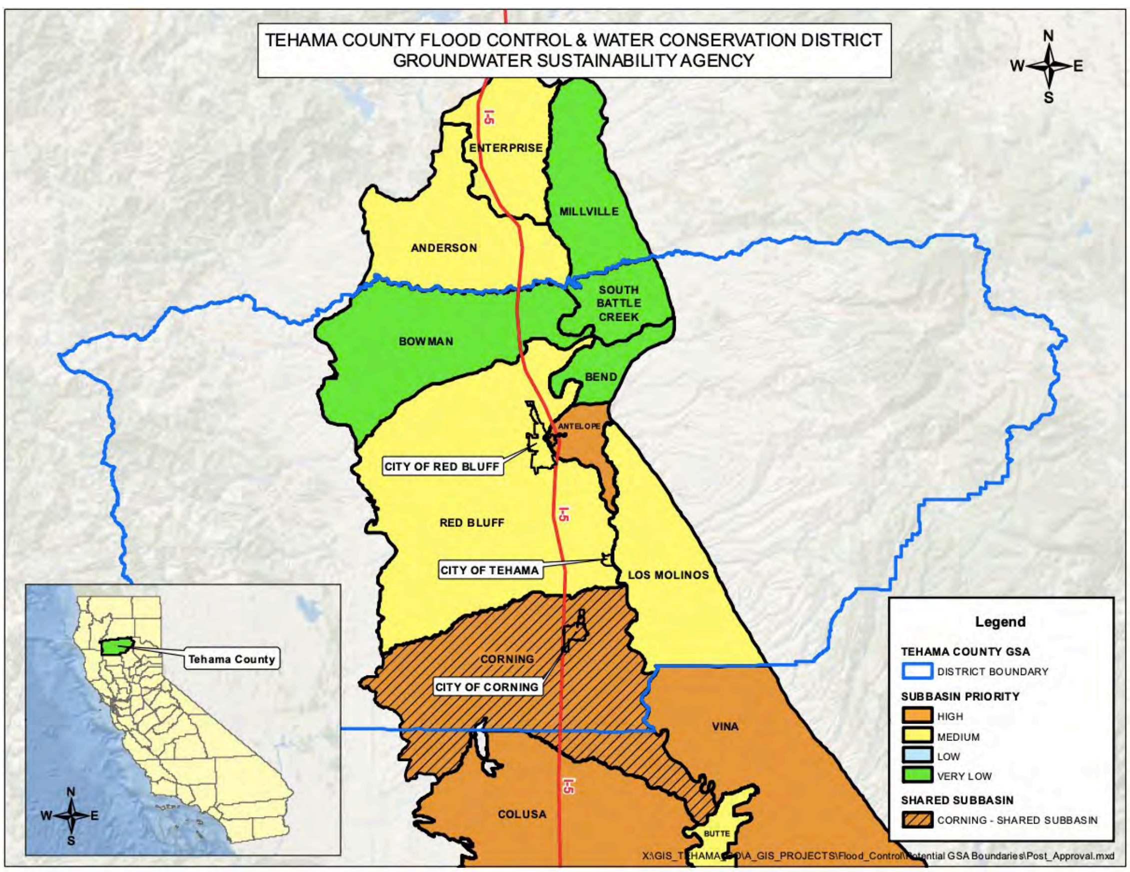
SECTION 1 | DISTRICT-WIDE COMMUNICATION & ENGAGEMENT

Background

The purpose of the Sustainable Groundwater Management Act (SGMA), signed by Governor Brown in 2014, is to ensure local sustainable groundwater management in medium- and high- priority groundwater basins statewide. California's Department of Water Resources (DWR) has determined that, in Tehama County, the Antelope Subbasin is high priority, while Los Molinos and Red Bluff are medium priority; these three subbasins are subject to SGMA. Low to very low priority subbasins in Tehama County are Bowman, South Battle Creek, and Bend, which are not subject to SGMA. The Corning Subbasin (high priority; subject to SGMA) is partially within Tehama County and extends into Glenn County. [Refer to map below.]

SGMA requires that a Groundwater Sustainability Agency (GSA) (which can be a single local water authority or cooperating collection of local authorities) develops and executes a Groundwater Sustainability Plan (GSP) to manage a basin's shared resources. The **Tehama County Flood Control & Water Conservation District** (District)[1] serves as the exclusive GSA within Tehama County. The District is responsible for managing the portions of the seven subbasins located within Tehama County. The



[1] The Tehama County Flood Control & Water Conservation District was originally established in 1957 by the Tehama County Flood Control and Water Conservation District Act. This Act defined the boundary and territory of the District as: "all that territory of the County of Tehama lying within the exterior boundaries thereof."

District is one of two GSAs coordinating within the Corning Subbasin[2] to develop a single GSP; outreach for this subbasin is being covered under a separate Communications and Engagement Plan. The District is also coordinating with multiple agencies developing GSPs that border the District.

SGMA Milestones

GSA Formation and GSP Development. There is one exclusive GSA in Tehama County – the District. The GSA formed by the state-mandated deadline of June 30, 2017, constituting SGMA's first major milestone. The District operates as the GSA governing all portions of the subbasins within the exterior boundary of Tehama County; and will develop individual GSPs for four subbasins located entirely within the District (Antelope, Los Molinos, Red Bluff, and Bowman[3]). While the four GSPs and this Communication and Engagement Plan are specific to the Red Bluff, Antelope, Los Molinos, and Bowman Subbasins, the District is still responsible for the other remaining subbasins. The Tehama GSA (District) has agreed to coordinate with the Corning Subbasin GSA via a Memorandum of Understanding (MOU) to develop a single GSP for the Corning Subbasin.

GSP Adoption. The second major milestone in SGMA is the adoption of GSPs by January 31, 2022. GSPs are prescribed by SGMA and contain required elements not specified in this Communications & Engagement Plan.

Groundwater Sustainability. The third milestone is achieving sustainability by 2042.

Figure 1. SGMA Milestones

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[2] Information on the Corning Subbasin can be found at CorningSubbasinGSP.org.

[3] Bowman Subbasin changed from a medium priority subbasin to a very low priority subbasin in 2018, and the District was able to secure funding under Proposition 1 to develop a GSP even though it is now a very low priority subbasin. Also, the District sees this as an area that may experience growth in the future and would like to manage the subbasin under a GSP.

Desired Goals and Outcomes of the Plan

Goals

SGMA requires the GSA to consider the interests of beneficial uses and users of groundwater, and encourages involvement of diverse social, cultural, and economic elements of the population within the subbasins during preparation and implementation of GSPs (Water Code Sections 10723.8(a)(4) and 10723.2).

The goals of the Stakeholder Communications & Engagement Plan are to:

1. Enhance understanding and inform the public about water and groundwater resources in the District subbasins, the purpose and need for sustainable groundwater management, the benefits of sustainable groundwater management, and the need for the GSPs.
2. Engage a diverse group of interested parties and stakeholders and promote informed feedback from stakeholders, the community, and groundwater-dependent users throughout the preparation and implementation process of the GSPs.
3. Coordinate communication and involvement between the subbasins and other local agencies, elected and appointed officials, and the general public.
4. Utilize the District Board and Groundwater Commission meetings to facilitate a public engagement process.
5. Employ a variety of outreach methods that make public participation accessible and that encourages broad participation.
6. Respond to public concerns and provide accurate and up-to-date information.
7. Manage communications and engagement in a manner that provides maximum value to the public and constitutes an efficient use of the GSA's resources.

Outcomes

The desired outcome of this Communication & Engagement Plan is to achieve understanding and support for adoption of the GSPs and implementation in consideration of the people, economy, and environment within the subbasins and in coordination with adjacent subbasins.

In practical terms, the GSP regulations require a communications section of the GSP that must include the following:

- Explanation of the GSA's decision-making process.
- Identification of opportunities for public engagement and involvement.
- Description of GSA's encouragement of active involvement of diverse elements of the population within each basin.
- Methods the GSA shall follow to inform the public about GSP progress.

This Communication & Engagement Plan forms the basis for the communications section of the GSPs.

Time Period

The Communication & Engagement Plan is intended to cover communications and engagement for August 2021 through December 2023.

In late September, the District will release the Draft GSPs (Bowman, Red Bluff, Antelope and Los Molinos subbasins) publicly for at least 45 days for public review and comment (public comment period expected: September 24 – November 19).

As required and planned, before the end of December 2021, the GSA will hold a formal public hearing on the Draft GSPs and then consider adopting the GSPs for submittal to the California Department of Water Resources in January 2022 as the law requires.

This Communication & Engagement Plan will also support the first two years of implementation. Since this is a multi-year effort, the key activities needed to achieve these goals will likely be broken down into annual work plans, and may be amended, as needed.

*Refer to **Table 1** for a summary of engagement progress to date and **Appendix A** and **Appendix B** for examples of outreach resources and coordination.*

Interested Parties and Other Stakeholders

SGMA identifies interested parties that the GSA must consider when developing and implementing the GSPs, including:

- Agricultural users of water
- Domestic well owners
- Municipal well operators
- Public water systems
- Land use planning agencies
- Environmental users of groundwater
- Surface water users
- The federal government
- California Native American Tribes (see **Appendix C** for Tribal Outreach Guidance Document)
- Disadvantaged communities (including those served by private domestic wells or small community water systems) (see **Appendix D** for DAC Guidance Document)

Outreach Roles

[Refer to the District's GSA governance structure][4]

The **District Board** of Directors (District Board) are elected officials and serve as the GSA Governing Body that has final approval authority for the GSPs and GSA. The District's five Board Members are comprised of the five County Board of Supervisors, which allows for additional collaboration within subbasins. In regard to outreach, the District Board is responsible for:

- Adopting and overseeing implementation of the Communication & Engagement Plan.
- Entering into MOUs with other public agencies to codify agency-to-agency engagement activities for the development and implementation of GSPs.

[4] http://www.tehamacountypublicworks.ca.gov/flood/sgma/governanace%20structure.pdf

- Considering the recommendations of the Groundwater Commission.
- Receiving public comments made verbally and in writing.

The **Groundwater Commission** is comprised of eleven (11) members representing the three incorporated Cities within Tehama County, private pumpers, and surface water agencies or districts.

Groundwater Commission Representation:

(1) City of Corning
(1) City of Red Bluff
(1) City of Tehama,
(1) El Camino Irrigation District
(1) Los Molinos Community Services District
(1) Rio Alto Water District
(5) County Supervisorial District representatives (one representative per district)

In regard to outreach, the Groundwater Commission is responsible for:

- Developing and implementing, with oversight from the District Board of Directors, the Communication & Engagement Plan.
- Receiving public comments made verbally and in writing.
- Considering and incorporating public and key stakeholder input during GSPs' development/implementation and making recommendations to the District Board.
- Offering the public an opportunity to be educated and to participate in the GSPs' development/implementation process through the Groundwater Commission meetings.

The District Board and Groundwater Commission are committed to keeping the **public informed**, providing the public with **balanced and objective information** to assist the public in understanding SGMA and **creating an open process** for public involvement on the development and implementation of GSPs.

Communications & Engagement for GSP Elements

To truly engage the public in development and implementation of GSPs that are science-based, complex, technical, and include achievable outcomes, the GSA will strive to meet these overall objectives:

- Educate the public in meaningful ways. Communicate what may often be complex concepts in straightforward, comprehensible ways.
- Offer the public and stakeholders a meaningful way to participate during the GSPs' development, adoption, and implementation process.
- Encourage members of the public and stakeholders to share historic data and to also help collect data to gain an improved understanding of the subbasins.
- To facilitate improved coordination amongst the seven subbasins within Tehama County, along with neighboring GSAs.
- Show how input received has been considered and incorporated as appropriate into the GSPs or planning process.
- Remain focused on results.

The GSA carried out community engagement activities during development of the GSPs. The GSPs were prepared iteratively and in a logical progression, building on previously developed technical and policy information. Throughout the process of preparing the GSPs, background materials along with draft text, figures and tables for each section were provided to the public, including other interested parties, in advance of meetings for input and comment. Received input were then incorporated as appropriate into the Draft GSPs. Draft GSPs will be available for public review and comment in Fall 2021; public workshops will be held during the public comment period. The GSA will hold a formal public hearing and consider adopting the GSPs in December 2021 for a January 2022 submittal.

Implementing the GSPs will begin at the end of January 2022. Implementation will involve advancing projects, establish funding mechanisms, addressing data gaps, monitoring, and developing additional needed projects as part of adaptive management. The GSA will need to prepare annual reports and five-year updates to demonstrate progress toward sustainability. Public outreach will inform each of these activities.

Communication & Engagement Forum

Public Meetings/Hearing

Public meetings or hearings are formal opportunities for people to provide official comments on programs, plans and proposals. The District Board of Directors meetings and the Groundwater Commission meetings[5] constitute regular public meetings that will be noticed and conducted in accordance with the Ralph M. Brown Act. SGMA requires that a public meeting be held prior to the adoption of a fee and that public hearings are held for the adoption of GSP elements and the final GSPs. There are also constitutional requirements for public hearings for some fee/rate options. Public meetings and hearings are an important forum for people to share viewpoints and concerns, but often occur at the end of a process, when only one option is under consideration. The GSA will hold required public meetings and hearings but will also use less formal public workshops to solicit feedback and information early in the process.

Stakeholder Briefings

Groundwater Commission members will meet with and communicate regularly with organizations comprised of the stakeholder groups they represent. District staff will be available to assist with presenting any information upon request.

Public Workshops

Public educational workshops provide less formal opportunities for people to learn about groundwater, SGMA, and GSP elements. Workshops can be organized in a variety of ways, including open houses, “stations” where people can ask questions one-on-one, and traditional presentations with facilitated question and answer sessions. In order to solicit feedback from people who may not be comfortable speaking in public, workshops can include small group breakout discussions, comment cards and other techniques. Whatever format is used, workshops will be designed to maximize opportunities for public input.

Public Notices

Public notices, often required by law, aim to notify agencies and the public about activities that may affect the public. As outlined in this Communications and Engagement Plan, the GSA will sponsor a variety of opportunities for people to participate in the development and implementation of the GSPs, including workshops, public hearings, providing comments at District Board meetings and Groundwater

[5] Visit www.tehamacountywater.ca.gov for meeting information.

Commission meetings and through written comments. And, the GSA will comply with public noticing requirements.

Prior to adoption of or amendment(s) to GSPs, SGMA requires that GSA:

- Provides notice to cities and counties within Plan area
- Considers comments provided by the cities and counties
- Accommodates requests for consultation received from the cities and counties within 30 days
- No sooner than 90 days following public notice, holds public hearings

In addition, when a GSA considers any fees to support the work of sustainability, the GSA will provide public notice and other engagement activities.

Communication & Engagement Tools

The GSA will use a variety of communications and engagement tools to keep the public informed, including the following.

Interested Parties List

SGMA mandates the creation of an interested parties list. SGMA does not specify the type of list (email versus hard copy). The first preference is an email list, to get information out quickly and to reduce costs. A secondary list may be developed for people who don't use email. District Board of Directors and Groundwater Commissioners (and the agencies they represent) and District staff can contribute names of organizations, agencies, and individuals to the list. Individuals may also contact the GSA to be added to the interested parties list via the District website and public meetings or workshops.

The list is broad and includes anyone who would like to stay informed about SGMA activities and anyone the District Board and Groundwater Commission think should be informed about the SGMA process and the outcomes of the planning / management effort. The Groundwater Commission will coordinate the distribution of periodic updates to the interested parties list. This list will also be used for dissemination of information about public workshops, public meetings, etc. Additionally, interested parties can sign up to receive noticed agendas for the District Board meetings and Groundwater Commission meetings.

Informational Materials

Developing a variety of informational materials is critical to successful education and necessary to circulate consistent, accurate information. The District Board with input from the Groundwater Commission may develop / update a range of materials, which may include:

- **Talking Points:** Clear, concise messages that can be used by District Board and Groundwater Commission when communicating with stakeholders, organizations, and the media.
- **Fact Sheets:** For initiating the GSPs and /or implementing elements of the GSPs.
- **Periodic Updates:** As stated above, the District staff with assistance from their consultants will coordinate on the distribution of periodic updates that can then be used by the District Board, Groundwater Commission, and participating agencies for distribution to the groups and organizations they represent using existing communications tools, such as websites, newsletters, social media, list serves, utility bills, etc.

- **Newspaper public service announcements & editorials:** The District staff, with assistance from their consultants will coordinate on information and updates for submittal to local news sources.
- **Briefing Packets:** For milestone briefings to the public and stakeholders, briefing packets may be developed. Packets may include standard talking points, and other materials to assist in educational outreach and for soliciting feedback.

Website

www.tehamacountywater.org

The District website is a tool for distributing and archiving meeting and communication materials as well as a repository for any studies, informative, and educational materials. District staff coordinates to ensure that the website is updated on a consistent basis to ensure up to date, timely information. The website includes, but is not limited to, the following information:

- Home page: example content may include an overview, calendar of meetings and events, highlighted topics, etc.
- Groundwater basics, SGMA background including links to existing sources of relevant information
- Subbasin-specific information
- District Board information: members, agendas, and meeting materials
- Groundwater Commission information: members, agendas, and meeting materials

Mailings Utility Bill Notifications

District staff may coordinate with participating agencies to utilize postcards and include updates and relevant SGMA implementation information in utility bills.

Social Media

Existing Facebook, Twitter, and other emerging social media technologies may be leveraged to provide updates on milestone progress to interested parties.

Surveys

Online tools may be used periodically to gather stakeholder ideas and to provide feedback on key issues.

Media Plan

District staff will develop press releases and Public Service Announcements (if appropriate) at each milestone and for meetings and workshops. The press releases will be distributed to local and regional media and elected officials. See **Appendix E** for a media contact list that will be updated on a periodic basis.

Outreach Partners

In addition to the communication tools listed above, other organizations can also partner to assist the GSA reach its communications and engagement goals including, but not limited to:

Countywide

- ✓ Northern Sacramento Valley (NSV) Integrated Regional Water Management (IRWM) group
- ✓ Shasta-Tehama Watershed Education Coalition

- ✓ Tehama County Farm Bureau
- ✓ Resource Conservation District of Tehama County
- ✓ Rural Community Associates Corporation
- ✓ UC Cooperative Extension
- ✓ Tehama County Cattleman's Association
- ✓ Tehama County Cattlewomen's Association

Subbasin-Specific

Antelope

- ✓ City of Red Bluff

Los Molinos

- ✓ Los Molinos Mutual Water Company
- ✓ Los Molinos Community Services District
- ✓ Stanford Vina Ranch Irrigation Company
- ✓ Deer Creek Irrigation District
- ✓ Los Molinos Chamber of Commerce

Red Bluff

- ✓ Tehama Colusa Canal Authority
- ✓ Proberta Water District
- ✓ Rawson Water District
- ✓ Elder Creek Water District
- ✓ Gerber-Las Flores CSD
- ✓ Thomes Creek Irrigation District
- ✓ Rancho Tehama Association
- ✓ El Camino Irrigation District
- ✓ City of Red Bluff
- ✓ City of Tehama
- ✓ HOAs (e.g., Surrey Village)

Bowman

- ✓ Anderson-Cottonwood Irrigation District
- ✓ Lake California Property Owners Association
- ✓ Rio Alto Water District
- ✓ Large ranches (e.g., Bengard Ranch)

Intra-Basin and Inter-Basin Coordination

The term "**basin**" under SGMA refers to a groundwater basin, or subbasin, identified and defined under the groundwater inventory Bulletin 118, which is produced by the California Department of Water Resources (DWR) (California Water Code Section 10721). Coordination within (intra-basin) and across (inter-basin) basin/subbasin boundaries is important to coordinate management actions and share information.

- **Intra-basin coordination** – coordination between two or more GSAs with jurisdiction within the same basin/subbasin (as is the case within the Corning Subbasin).
- **Inter-basin coordination** – coordination across basin/subbasin boundaries.

Intra-Basin Coordination

The Corning Subbasin GSA has jurisdiction for the portion of the Corning Subbasin overlying Glenn County. The District works with the Corning Subbasin GSA to develop and implement a single GSP for the Corning Subbasin. The primary venue for their collaboration will occur at the Corning Subbasin Advisory Board (CSAB) meetings, which are a Brown Act compliant venue for collaboration on the GSP.

Inter-Basin Coordination

Subbasins within Tehama County boundaries. Inter-basin coordination across the subbasins within Tehama County is facilitated by the District serving as the single GSA for these subbasins. For instance, regularly occurring District Board and Groundwater Commission meetings provides a standard and open forum for sharing information with all subbasins within the County.

Subbasins outside of Tehama County boundaries. While inter-basin agreements are optional under SGMA, the District intends to coordinate with adjacent GSAs to share technical information and to ensure that the implementation of the GSPs in adjacent basins are compatible and will not cause any adverse effects in the District subbasins or any other adjacent basins.

Regional coordination. GSAs in the Northern Sacramento Valley (NSV) are building on the 10+ years of NSV Integrated Regional Water Management (IRWM) collaboration. GSA representatives from the Vina, Butte, Wyandotte Creek, Corning, Colusa, Bowman, Red Bluff, Antelope and Los Molinos subbasins are meeting to consider how to share information and strategically coordinate regional water management.

Refer to the table below for subbasins within the NSV as well as Appendix B on NSV Inter-basin coordination.

Basin Coordination Summary

Coordination	Subbasin	SGMA Priority	GSA(s)	County(ies)	Nearest Tehama County Subbasins
Inter-basin	Anderson	Medium	Enterprise Anderson	Shasta	Bowman
Intra-basin & Regional	Corning	High	Tehama County FCWCD; Corning Subbasin GSA	Glenn; Tehama	Corning portion within County; Red Bluff
Inter-basin & Regional	Colusa	High	Glenn Groundwater Authority; Colusa Groundwater Authority	Glenn; Colusa; Yolo	Corning
Inter-basin & Regional	Vina	High	Vina; Rock Creek Reclamation District	Butte	Corning; Los Molinos
Regional	Butte	Medium	Butte County Dept of Water and Resource Conservation	Butte	Corning; Los Molinos
Regional	Wyandotte Creek	Medium	Wyandotte Creek	Butte	Corning; Los Molinos

Evaluation and Assessment

Any communication strategy should include opportunities to check in at various points during implementation to ensure that it is meeting the communication and engagement goals and complying with SGMA. These check-ins should occur at least on an annual basis.

Table 1. Summary of Engagement Opportunities, Milestones, and Progress to Date

Timeframe	Milestone or Stage	Required Community Engagement Under SGMA	Communication Strategies	Status (as of August 2021)
Pre-SGMA (before 2015)	Voluntary groundwater management efforts (IRWM and AB3030)	N/A	Volunteer collaboratives and advisory committees engage subject-matter experts and stakeholders	• NSV IRWM group and AB 3030 Technical Advisory Committee (TAC) • Outreach for AB 3030 Groundwater Management Plan (1996 and 2012 update)
GSA Formation (2015-2017)	During GSA governance development	Notice of Intent (NOI) of GSA Formation	• Provide notice of GSA outreach resources: website, email listserv, calendar of District Board and Groundwater Commission meetings • Develop and continue to update list of interested parties	• District Board public meetings on GSA formation • NOI for the District to be the GSA (11/4/15) • Groundwater Commission established (6/7/16) • Website and initial interested parties list established
Shortly after GSA formation	After identification of outreach responsibilities among GSA entities	Notification of GSA formation	• District Board and Groundwater Commission meetings • Email notices and updates Newspaper notice of public workshop(s)	
Before GSP Planning Activities	Prior to beginning GSP development	Provide to the public and State, notice of intent to begin GSP planning and description of opportunities for interested parties to participate in GSP development and implementation	• Public workshop(s) • District Board and Groundwater Commission meetings • Email notices and updates • Newspaper notice of public workshop(s)	• NOI for development of GSPs submitted to DWR on 6/27/18 (Bowman, Antelope, Los Molinos, and Red Bluff) and 9/19/18 (Corning)
Between Notice of GSP Planning and January 31, 2022	During GSP development	Public workshops, public meetings, District Board meetings, Groundwater Commission meetings and other opportunities providing stakeholder avenues to participate in GSP development	• Public workshops and/or public meetings on GSP development. • District Board and Groundwater Commission meetings • Email notice of public workshops / meetings • Newspaper notices of public workshops / meetings • Updates and information on GSP development at standing meetings • Disseminate updates via interested parties list, websites social media, outreach partners	• Convened Groundwater Commission Ad Hoc committees • Developed and implemented Stakeholder Communication & Engagement Plan • Professional facilitation services to support outreach and engagement • Developed/updated resources (e.g., new website, factsheet, etc.) • Emailed interested parties list with public meeting notices; notifications when draft GSP chapters were available for comment, and the quarterly eNewsletter.

Timeframe	Milestone or Stage	Required Community Engagement Under SGMA	Communication Strategies	Status (as of August 2021)
				• Regular updates to NSV IRWM TAC and Board, NCWA Groundwater Management Task Force • Groundwater Commissioner briefings to their agencies. • Public meetings Oct and Dec 2020; April, August, September, October, and November 2021
	During GSP development	Active involvement of diverse social, cultural, and economic elements of the population within the subbasins	• Provide email notices and updates • Update website regularly • Convene regular District Board and Groundwater Commission meetings • Identify and communicate opportunities for public engagement on GSP development, (providing clear messages that GSA retains legal responsibility for final GSA and GSP related decisions) • Develop consistent, coordinated messages and talking points • Arrange for technical support to stakeholder groups through presentations or workshops conducted by GSA representatives/staff • Develop content appropriate to the audience and their interests, ensuring information can be easily understood • Conduct legislative briefings at strategic milestones (and any other groups upon request) • Utilize updated interested party stakeholder list, GSA listservs delivered via email and/or U.S. Mail, outreach partners mechanisms for communications and other media outlets such as newspaper and radio to provide notices • Strategically engage local, special SGMA identified groups • Utilize local channels and meetings to identify and communicate opportunities for public engagement and/or public comment during meetings on GSP development • Leverage and support local agencies and community organizations in disseminating information and engaging stakeholders, including through existing community meetings, newsletters, websites, and social media • Organize public meetings around concrete impacts to specific stakeholders • Develop additional, locally-targeted communication strategies to engage difficult-to-reach communities and community members	In addition to the activities listed above: • Briefings upon request (e.g., County Farm Bureau, STWEC Board, Tehama County Tea Party, Board of Supervisor District 2 Town Halls, etc.) • Informal briefing with the Paskenta Tribe (4/6/21) • Online survey focused on domestic well owners • Online survey eliciting ideas for projects and management actions • Framework for receiving public comments on the Draft GSPs via online survey, standard mail, and direct emails

Timeframe	Milestone or Stage	Required Community Engagement Under SGMA	Communication Strategies	Status (as of August 2021)
GSP Adoption or Amendment (initial GSP adoption no later than 1/31/22)	Prior to GSP adoption or amendment	• Provide notice to cities and counties within Plan area • Consider comments provided by the cities and counties • Accommodate requests for consultation received from the cities and counties within 30 days	SEE ABOVE	• Notices sent to cities with the Plan areas in August 2021(See example)
	Prior to GSP adoption or amendment	No sooner than 90 days following public notice, hold public hearing/ public workshop	SEE ABOVE	District Board Public Hearing to consider adopting the final GSPs – Dec 20, 2021

SECTION 2 | SUBBASIN COMMUNICATION & ENGAGEMENT

As previously stated, the GSA must identify and consider stakeholders interests when developing and implementing the GSP, including:

- Agricultural users of water
- Domestic well owners
- Municipal well operators
- Public water systems
- Land use planning agencies
- Environmental users of groundwater
- Surface water users
- The federal government
- California Native American Tribes
- Disadvantaged communities

This section identifies stakeholder groups (both county-wide and subbasin-specific) and the associated anticipated level of engagement. It is not an exhaustive list, but provide sufficient detail to guide more meaningful focused outreach and engagement. The list is also intended to be updated periodically or as needed.

Table 2. Tehama Stakeholder Group Interests & Purpose of Engagement

Category of Interest	District-Wide	Antelope	Los Molinos	Red Bluff	Bowman	Anticipated Level of Engagement
General Public • Citizens groups • Community leaders • Interested individual • Universities/Academia	• Interested Individuals on Interested Parties List maintained by GSA • Tehama County School District[6] • Latino Outreach of Tehama County • University of California Cooperative Extension • Board of Supervisors • Shasta College • Red Bluff-Tehama County Chamber of Commerce	• Red Bluff City Council • Schools (Antelope Elementary School District	• Chamber of Commerce • Lassen View Elementary • Los Molinos Unified School District	• Rancho Tehama Association • City of Tehama • City of Red Bluff • Rancho Tehama Elementary School • Schools (Gerber Union Elementary)Red Bluff Joint Union High School District • Antelope Elementary School District	• Lake California Property Owners Association • Evergreen Union School District • Sunset Hills development	Inform to improve public awareness of sustainable groundwater management
Land Use • Municipalities • Local land use agencies • Regional land use agencies • Community Service Districts	• Tehama County Planning Department • Tehama County Environmental Health • Tehama County Agricultural Department	• City of Red Bluff • Golden Meadows CSD • Tehama County Fairgrounds	• Los Molinos CSD	• City of Red Bluff • City of Tehama • Gerber Las Flores CSD • Paskenta CSD (outside of subbasin) • Reeds Creek CSD	• [County]	Consult and involve to ensure land use policies are supporting GSP and there are no conflicting policies between the GSPs and local government agencies
Urban/ Commercial & Non-Commercial Agricultural Users • Water agencies • Irrigation districts • Municipal water companies • Mutual water companies • Resource	• Farm Bureau • Cattlemen's Association • Cattlewomen's Association • County Agricultural Commissioner • University of California Cooperative Extension • Resource Conservation District	• Rio Ranch Estates CSD • Los Molinos Mutual Water Company • City of Red Bluff	• Los Molinos Mutual Water Company • Deer Creek Irrigation District • Stanford Vina Ranch Irrigation Company • New Clairvaux Monastery	• El Camino ID • Proberta WD • Rancho Tehama Association • Elder Creek WD • Rawson WD • Gerber Las Flores CSD • City of Red Bluff • City of Tehama	• Rio Alto Water District • Anderson Cottonwood Irrigation District (ACID) • Bengard Ranch	Inform and involve to ensure sustainable management of groundwater and consider viability of agricultural economy

[6] Refer to https://www.tehamaschools.org/Districts--Schools/index.html for additional specific school districts.

Category of Interest	District-Wide	Antelope	Los Molinos	Red Bluff	Bowman	Anticipated Level of Engagement
conservation districts • Farmers/Farm Bureaus • Water Districts • Water-users associations • Irrigated Lands Regulatory Program Coalition	(RCD) of Tehama County • Shasta Tehama Watershed Education Coalition					
Other Commercial Users • Commercial and industrial self-suppliers	• Renewable power companies • Cal Fire stations • Crain processing Plants • Sierra Pacific Industries • Tehama Co.	• Crain Processing Plant	• Norcal Water Works • Anderson & Sons Walnuts • Jones & Son Orchards	• SPI • Pactiv • CAPAX • Wilcox Oaks Golf Club • Oak Creek Golf Club • LA-Pacific Corp. • Walmart Distribution Center		Inform and involve in assessing impacts to users
Environmental and Ecosystem Uses • Federal and State agencies • Wetland managers • Environmental groups	• Audubon Society • The Nature Conservancy • California Dept of Fish & Wildlife • USFWS • BOR • BLM • USFS • NRCS • DWR • CA State Parks • Fire Safe Councils (Tehama Glenn FSC)	• CDFW (Antelope Creek) • USFS (Red Bluff Rec Area) • USFWS • BLM • BOR	• Nature Conservancy • Dye Creek preserve • Mill Creek conservancy • Deer Creek Watershed Conservancy • CDFW big interests in Dye, Mill and Deer Creeks – Salmon • Deer Creek Watershed Conservancy	• CDFW (Butler Slough Eco Reserve, Thomes Creek Preserve) • USFWS • USFS • BLM		Inform and involve to consider/ incorporate potential ecosystem impacts to GSP process
Surface Water Users • Irrigation Districts • Water Districts • Water users associations • Agricultural users	• Mutual Water Co • Water District • Agricultural users • Riparian water right holders	• Edwards Dam Diversions • Los Molinos Mutual Water Company	• Los Molinos Mutual Water Company • Deer Creek Irrigation District • Stanford Vina Ranch Irrigation Company	• Corning Water District • Tehama Colusa Canal Authority • Thomes Creek WD • USFWS	• ACID • Lake California POA to divert water for lake	Inform and involve to collaborate to ensure sustainable water supplies

Category of Interest	District-Wide	Antelope	Los Molinos	Red Bluff	Bowman	Anticipated Level of Engagement
Economic Development • Chambers of commerce • Business groups/associations • Elected officials • State legislature representatives • Economic Development Team	• County Board of Supervisors • James Gallagher (SA) • Jim Neilson (Senator) • Planning Commission • Red Bluff-Tehama County Chamber of Commerce		• Los Molinos Chamber of Commerce	• Red Bluff Tehama County Chamber of Commerce • Red Bluff City Council • City of Tehama City Council		Inform and involve to support a stable economy
Human Right to Water [7] • Disadvantaged communities • Small water systems • Environmental justice groups/community-based organizations • Domestic well owners	• Private well owners • Small Water Systems • Several Disadvantaged Communities	• Unincorporated County (Antelope Area) • Portion of the City of Red Bluff • Dairyville • Riverview MHC • Gurnsey Ave MW • Modern Village MWC • Howell's Lakeside WC • Antoinette MW • Friendly Acres MHP	• Los Molinos Vina • Antelope Creek MHP • Los Molinos CSD • Woodson Bridge • Del Oro Water Co.	• Proberta • Gerber Las Flores CSD • City of Tehama • City of Red Bluff • Rancho Tehama • Mira Monte WC • Surrey Village WC • Golden Meadows CSD	• Lake California • Bowman area, unincorporated County • Rio Alto Water District • Saddleback MWC	Inform and involve to provide safe and secure groundwater supplies to all communities reliant on groundwater
Tribes • Federally Recognized Tribes • Non-Federally Recognized Tribes	• California Tribal Water Commission • Paskenta Band of the Nomlaki (Corning Subbasin) • Greenville Rancheria			• Greenville Rancheria		Inform, involve and consult with tribal government
Integrated Water Management • Regional water management groups (IRWM regions) • Flood agencies	• NSV IRWM • Mid Upper Sacramento Regional Flood Management Group					Inform, involve and collaborate to improve regional sustainability

[7] This is not an exhaustive list as there are 100+ small water systems across the four subbasins.

SECTION 3 | APPENDICES

Appendix A | Outreach Resources and Materials

Several resources and materials, including those identified below, are available on the website: https://tehamacountywater.org/gsa/library/

(Reminder that all Corning Subbasin resources are available on the Corning GSP website: https://www.corningsubbasingsp.org/. Some Corning resources are listed below for readers' convenience.)

Factsheets & Flyers

- Tehama County SGMA Factsheet – Link
- Corning General SGMA Factsheet - Link
- North Sacramento Valley SGMA Regional Coordination Flyer – Link
- Public Webinar Event flyers – October 2020 | December 2020 | April 2021 | August 2021
- Comment on Draft GSPs & Fall 2021 Public Meetings Flyer – Fall 2021

Quarterly eNewsletter

- Tehama County quarterly eNewsletter – Winter 2020 | Spring 2021 | Summer 2021 | Fall 2021

Online Surveys

Two online surveys launched in 2021. Responses were considered/incorporated into the Draft GSPs.

- Tehama County Subbasins Online Survey | Projects / Management Actions ideas (March - July 2021) – Link
  - 16 total responses.
- Tehama County Subbasins Online Survey | Domestic Well Owners (March 2021 – Present) – Link
  - To date: 17 total responses.

GSA and Advisory Boards Meetings

Updates were regularly shared at Groundwater Commission, District Board, and CSAB meetings. These resources and materials can be found on their respective meetings pages:

- Board of Directors - Link
- Groundwater Commission – Link
- Corning Subbasin Advisory Board - Link

SGMA and Tribal Engagement

- April 6, 2021 webinar presentation - Link

Public Meeting Presentations

Region-wide public meetings

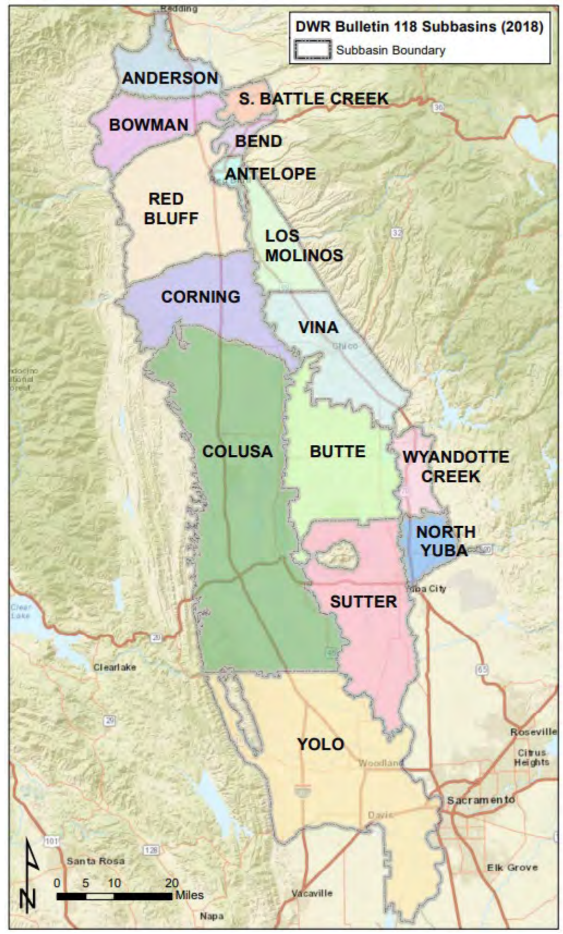
- October 8, 2020 webinar - Video | Slide Deck
- December 9, 2020 webinar - Video (subbasin-specific slide decks provided below)
- September 29, 2021 webinar – Video | Slide Deck
- October 20, 2021 webinar - Video | Slide Deck
- November 15, 2021 in-person workshop – Agenda Handout | Slide Deck

Subbasin-specific public meetings

- **Bowman Subbasin**
  - October 15, 2020 tailgate - Slide Deck
  - December 9, 2020 webinar – Slide Deck
  - April 19, 2021 webinar – Slide Deck | Video
  - August 17, 2021 webinar – Slide Deck | Video
- **Red Bluff Subbasin**
  - October 21, 2020 tailgate – Slide Deck
  - October 6, 2020 Thomes Creek community tailgate – Slide Deck
  - December 9, 2020 webinar – Slide Deck
  - April 20, 2021 webinar – Slide Deck | Video
  - August 19, 2021 webinar – Slide Deck | Video
- **Antelope Subbasin**
  - October 14, 2020 tailgate – Slide Deck
  - December 9 2020 webinar – Slide Deck
  - April 21, 2021 webinar – Slide Deck | Video
  - August 23 webinar – Slide Deck | Video
- **Los Molinos Subbasin**
  - October 22, 2020 tailgate – Slide Deck
  - December 9, 2020 webinar – Slide Deck
  - April 22, 2021 webinar – Slide Deck | Video
  - August 25, 2021 webinar – Slide Deck | Video
- **Corning Subbasin**
  - December 9, 2020 webinar – Slide Deck
  - October 4, 2021 in-person workshop, Corning – Agenda Packet | Slide Deck
  - October 13, 2021 webinar – Agenda Packet | Slide Deck | Video

  (Visit the Corning GSP website for more information specific to the Corning Subbasin – Link)

Appendix B | Inter-basin Coordination



In the Sacramento Valley, inter-basin coordination is critical as Groundwater Sustainability Agencies develop their Groundwater Sustainability Plans. We all recognize the interconnectedness of groundwater in the subbasins that together make up the larger Sacramento Valley groundwater basin.

Coordination among GSAs can be formalized through Coordination Agreements. These are voluntary, and the components of such agreements are described in the Groundwater Sustainability Regulations in Article 8.

Informal exchange of information and collaboration has been occurring between staff and consultants working on GSPs in subbasins throughout the region with facilitation support from the Consensus Building Institute. The effort began with conversations between County staff from Tehama, Glenn, Colusa, and Butte to identify priorities and resources available for inter-basin coordination.

These slides provide an overview of the scope and timeline of the Inter-basin Coordination efforts (Flier).

Framework for Inter-basin Coordination

Northern Sacramento Valley Inter-basin Coordination Report-Final

This report outlines a framework for inter-basin coordination for sustainable groundwater management in the Northern Sacramento Valley. It describes a menu of options for ongoing communication and collaboration between and among groundwater subbasins over the twenty-year implementation of the Sustainable Groundwater Management Act (SGMA). This framework can be used by Groundwater Sustainability Agencies (GSAs) to support Groundwater Sustainability Plan (GSP) development and implementation in several ways.

1. This inter-basin coordination report could be included as an appendix to the GSP and could be updated at regular intervals.
2. Individual subbasins could incorporate sections of the report into the body of the GSP, depending upon specific boundary conditions at adjoining subbasins.
3. Subbasins could draw on the inter-basin coordination framework if they would like to consider entering into one or more voluntary inter-basin agreements during GSP implementation (GSP Regulations in Article 8, Sec 357.2.

Staff throughout the region will present the framework as a supporting document to guide and inform discussions with GSA Boards and at other subbasin-specific public venues, such as advisory committees, groundwater commissions, or other relevant venues. These discussions could help determine GSA priorities and the desired approach each GSA would like to take to draw upon the inter-basin coordination framework within their individual GSPs.

Subbasin staff acknowledge that while this report builds upon a long-standing history of regional collaboration, this is just the beginning of inter-basin coordination efforts under SGMA. Therefore, this framework will be continually refined throughout GSP implementation and inter-basin coordination activities will occur on an ongoing basis.

Visit the website for more information:
https://www.buttecounty.net/waterresourceconservation/Sustainable-Groundwater-Management-Act/Inter-basin-Coordination

Appendix C | Tribal Engagement in Tehama County: Guidance Document

Meaningful tribal outreach, dialogue, and consultation is a shared obligation of the GSA in the applicable subbasins where tribal lands exist.

Tribes in Tehama County

There are two[8] federally-recognized Native American Tribes in Tehama County, including:

- Greenville Rancheria of Maidu Indians
- Paskenta Band of Nomlaki Indians

The Native American Heritage Commission (NAHC) identified eight Tribes in Tehama County and Glenn County that may have an interest in groundwater management in the Bowman, Red Bluff, Antelope, Los Molinos, and/or Corning Subbasins:

- Estom Yumeka Maidu Tribe of the Enterprise Rancheria
- Greenville Rancheria of Maidu Indians
- Grindstone Rancheria of Wintun-Wailaki
- Mechoopda Indian Tribe
- Paskenta Band of Nomlaki Indians
- Redding Rancheria
- Shasta Nation
- Wintu Tribe of Northern California

Outreach Steps – Phase I

1. Confirm that the Native American tribes identified above are correctly posed for SGMA outreach.
2. The District will prepare background materials related to Native American tribal outreach and engagement. The material will include a compilation of past Native American tribal outreach methods, goals, and results (including primary points of contact). The materials will include SGMA-related obligations for GSAs pursuant to SGMA, and interests and goals as they relate to tribal outreach and potential participation in sustainable groundwater management planning (see *Relevant DWR Information* below).
3. The District will conduct an initial, informal communication with tribal primary points of contact to clarify interest in communicating formally regarding SGMA and tribal interests; request advice about appropriate avenues for outreach; and identify next steps. In the event a tribal representative cannot be contacted within 45 days, the District will consult with DWR's Office of Tribal Policy Advisor for guidance (Anecita Agustinez, DWR Tribal Policy Advisor - Anecita.Agustinez@water.ca.gov).
4. Following successful initial communication with the Native American tribes, the District will facilitate the implementation of the next steps identified in #3. Actions may include preparation

[8] Source: https://www.ihs.gov/california/index.cfm/tribal-consultation/resources-for-tribal-leaders/links-and-resources/list-of-federally-recognized-tribes-in-ca/?mobileFormat=0

of a formal letter from the Board to each of the tribes, involvement of other GSAs with the tribes, and/or establishing a consultation framework.

Outreach Steps – Phase II

Refer to Table 1 (Summary of Engagement Opportunities, Milestones, and Progress to Date) and Table 2 (Tehama Stakeholder Group Interests & Purpose of Engagement).

Relevant DWR Information

SGMA Section 10720.3. …any federally recognized Indian Tribe, appreciating the shared interest in assuring the sustainability of groundwater resources, may voluntarily agree to participate in the preparation or administration of a groundwater sustainability plan or groundwater management plan under this part through a joint powers authority or other agreement with local agencies in the basin. A participating Tribe shall be eligible to participate fully in planning, financing, and management under this part, including eligibility for grants and technical assistance, if any exercise of regulatory authority, enforcement, or imposition and collection of fees is pursuant to the Tribe's independent authority and not pursuant to authority granted to a groundwater sustainability agency under this part.
Guidance Document for Sustainable Management of Groundwater: **Engagement with Tribal Governments** [Link]
Discussion Questions Relating to Tribal Governments Engagement with GSAs [Link]
Must a local agency exclude federal and tribal lands from its service area when forming a GSA? No, federal lands and tribal lands need not be excluded from a local agency's GSA area if a local agency has jurisdiction in those areas; however, those areas are not subject to SGMA. But, a local agency in its GSA formation notice shall explain how it will consider the interests of the federal government and California Native American tribes when forming a GSA and developing a GSP. DWR strongly recommends that local agencies communicate with federal and tribal representatives prior to deciding to become a GSA. As stated in Water Code §10720.3, the federal government or any federally recognized Indian tribe, appreciating the shared interest in assuring the sustainability of groundwater resources, may voluntarily agree to participate in the preparation or administration of a GSP or groundwater management plan through a JPA or other agreement with local agencies in the basin. Water Code References: §10720.3, §10723.2, §10723.8

Tribal Outreach Resources

The follow are links to agency tribal outreach resources and considerations, each of which captures important principles and resources for tribal outreach. A short summary of key outreach principles can be found below.

- CalEPA Tribal Consultation Policy Memo (August 2015)
- DWR Tribal Engagement Policy (May 2016)
- CA Natural Resources Agency Tribal Consultation Policy (November 2012)
- SWRCB Proposed Tribal Beneficial Uses
- CA Court Tribal Outreach and Engagement Strategies
- Traditional Ecological Knowledge resources

- Water Education Foundation Tribal Water Issues

Key Outreach Principles

- Engage early and often
- Consider tribal beneficial uses in decision-making (identified by region here); identify and seek to protect tribal cultural resources
- Share relevant documentation with tribal officials
- Conduct meetings at times convenient for tribal participation with ample notifications
- Request relevant process input/data/information from tribes
- Empower tribes to act as tribal cultural resources caretakers
- Designate a tribal liaison(s) where appropriate
- Share resources for tribal involvement as is feasible
- Develop MOUs where relevant
- Be mindful of the traditions and cultural norms of tribes in your area

Key Outreach Partners/Liaisons

The following are potential partners for Tehama County tribal SGMA outreach:

- SGMA Tribal Advisory Group (TAG): "The Tribal Advisory Group (TAG) includes tribal leadership, subject matter experts, and technical and non-technical members of local, academic, and tribal governments that are actively engaged in local groundwater management and will be key in local implementation of SGMA. TAG members will be responsible for distribution of information and resources to their respective tribes and organizations."
- California Indian Water Commission, Inc.
- DWR Office of Tribal Advisor
- DWR Northern Regional Office Contact
- Central Valley Regional Board Tribal Coordinator

Appendix D | Disadvantaged Communities Engagement in Tehama County – Guidance Document

Important consideration should be given with regard to encouraging community participation in disadvantaged communities (DACs) / severely disadvantaged communities (SDACs) and ensuring accessible and transparent meetings especially in those communities with limited access to digital resources.

Disadvantaged Communities (DACs) in Tehama County Subbasins

DAC and SDAC communities were identified based on data from DWR DAC Mapping too, 2018 Census tract (categorized as "economically distressed areas" Census blockgroup) for the Bowman, Red Bluff, Antelope, Los Molinos, and Corning Subbasins. -- *Refer to the Plan Area chapters of the subbasins' GSPs.*

Outreach Steps

Phase I

1. Use DWR Disadvantaged Communities Mapping Tool or other geographic information system technology to help identify disadvantaged, severely disadvantaged and economically distressed communities within the Cosumnes subbasin.
2. GSAs share insights on engaging with members of these communities from past projects or efforts. Also consider the key outreach principles identified below.
3. Review catalog of existing outreach materials. Modify as necessary to fit the needs of each community. This may include translating select materials into one or more languages. Develop additional materials if advantageous.
4. Identify potential points of contacts / outreach partners for DAC engagement. See preliminary list of partners below. Conduct an initial, informal communication with organizational points of contact to clarify interest in engaging DAC communities on SGMA; request advice about appropriate avenues for outreach; and identify next steps.

Phase II

Refer to Table 1 (Summary of Engagement Opportunities, Milestones, and Progress to Date) and Table 2 (Tehama Stakeholder Group Interests & Purpose of Engagement).

Relevant DWR Information

Guidance on Engaging and Communicating with Underrepresented Groundwater Users
[Link]

DWR recognizes that there are groups or communities of groundwater users that have been historically and frequently left out from decision-making with regard to sustainable groundwater management. These groups include, but are not limited to: disadvantaged communities, private domestic well owners, small growers and farmers, Tribes, and communities on small water systems. All beneficial uses and users of groundwater must be

part of the effort to achieve sustainability, and engagement should occur with all entities that could be affected by the implementation of a GSP.
California Water Code 10723.2 The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans.
23 Cal. Code Regs. §354.10 Notice and Communication. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following: (a) a description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

Outreach Resources

Tools for identifying DAC communities include:

- DWR Disadvantaged Community Mapping Tool
- DWR Economically Distressed Areas Mapping Tool
- State Water Board Human Right to Water Portal
- CalEnviroScreen
- US Census Bureau Data Portal

DAC Communications Best Practices and similar reference publications:

- DWR Guidance on Engaging and Communicating with Underrepresented Groundwater Users
- Local Government Commission Best Practices for Virtual Engagement Guide
- Self Help Enterprises webpage on SGMA engagement for DACs
- Self Help Enterprises Technical Assistance Program
- Clean Water Action's Collaborating for Success: Stakeholder Engagement for SGMA Implementation
- Water Education Foundation's Solving Water Challenges in DACs: A Handbook to Understanding the Issues in California and Best Practices for Engagement

Key Outreach and Engagement Principles[9]

- Decisions that impact DACs must be done with their guidance and input, and agencies should ensure that community residents are able to give meaningful input into the process.
- Partner with local community-based organizations as trusted messengers.
- Target outreach materials and approach appropriately by tailoring communications to the community's needs. Be mindful of language and cultural differences.
- Be aware of communities' level of access to computers, internet, and phone connections.
- Engage early and often. Reach out to community-based organizations and other stakeholders who may be in direct communication with residents early to help make sure that residents are informed and notified through multiple channels about options for public meetings.
- Understand who the target audience is (e.g., with whom you will be meeting) to understand where and when to meet (such as during the day vs. evening meetings)

[9] Principles extracted and summarized from best practices and other outreach sources noted in "Outreach Resources" section above.

- Conduct meetings at times convenient for public participation with ample notifications.
- When possible, travel to the target community to meet them in their locale.
- One-on-one meetings with individual communities and stakeholders may be more appropriate than trying to meet with several entities in one location.
- For virtual meetings, provide multiple options for teleconferencing, with two-way communication options that allows either computer-users or phone-users to engage. Consider using separate teleconference lines or audio channels to meet language access needs.
- Several meetings may be required to engage new communities and involve them in the SGMA process.
- Provide in-meeting translation and translated materials to the maximum extent possible.
- Though there may be commonalities across regions, each community/DAC/tribe/water system/stakeholder has unique and individualized water-related concerns.

Key Outreach Partners/ Liaisons

The following lists potential partners for outreach to DACs:

- Rural Community Assistance Corporation
- Self Help Enterprises
- Leadership Council for Justice and Accountability
- Clean Water Action

Appendix E | Media Contact List

Organization	Name	Email	Phone
The Sacramento Valley Mirror	Tim Crews	vmtim@pulsaroco.com	
	Doug Ross	yfyles@gmail.com	
	general	valleymirror@pulsaro.com	
Appeal Democrat (for Corning Observer)	News Room	adnewsroom@appealdemocrat.com (for paid notices)	530-749-6552
	Julie Johnson	jjohnson@tcnpress.com (for general information/ meeting notices)	
Action News Now		news@actionnewsnow.com	530-343-1212
Red Bluff Daily News	George Johnston	gjohnston@redbluffdailynews.com	
KRCR	News Room	news@krcrtv.com	530-243-7777
Multiple Spanish-speaking media	Armando Jimenez	ajimenez@bustosmedia.com	

Appendix F | Potential Venues List

The COVID-19 pandemic frequently caused the District and Groundwater Commission to meet virtually during development of the GSPs. As in-person meeting options became available, there was general interest to explore supporting virtual participation options during certain meetings such as public workshops. The following table summarizes potential venues in Tehama County subbasins for various meetings / workshops and identify key logistical amenities, particularly audio-visual capabilities that support virtual and in-person participation.

Subbasin	Name	Address	Capacity	Contact	Amenities	Notes
Red Bluff	County Board Chambers	727 Oak Street, Red Bluff		Denise Ranberg 530-527-4655	Projector & Screen, wired mics, wi-fi, teleconference; chamber is fixed seating; adjacent room is unfixed seating	GW Commission meeting location
Red Bluff	Red Bluff Community Senior Center	1500 South Jackson Street, Red Bluff	Varies, up to 120	Karen Shaffer Phone: 530-527-8181 kshaffer@cityofredbluff.org	Projector (additional fee)/Screen, microphone, wifi	
Red Bluff	County Dept. of Education	1135 Lincoln State., Red Bluff	Varies, 30-80	Melanie Lee mlee@tehamaschools.org	Projector and screen, mics, wi-fi,seating is not fixed	
Bowman	TBD					
Los Molinos	TBD					
Antelope	TBD					
Corning	Rolling Hills Casino	2655 Everett Freeman Way, Corning, California 96021	Varies	Karen Hiton eventsales@rollinghillscasino.com	Projector and screen, mics, wi-fi, Indoor and outdoor space, unfixed seating, room partitioning options	

Appendix G | Potential GSA Outreach Tasks

This appendix is intended to help identify and map out specific issues and strategies that the District, advisory groups, and/or partners may consider during implementation of the GSPs. This does not commit any entity to specific tasks nor preclude them from pursuing other strategies aligned with the subbasin GSPs, related governance documents, and the Communication & Engagement Plan.

Methods

The following are methods that have emerged as highly effective and/or strongly recommended by District Board members, Groundwater Commissioners, District staff, consultants, and/or other subject-matter experts, partners, stakeholders, and the public. As mentioned above, the list does not commit any entity to specific tasks nor preclude them from pursuing other strategies.

- Outreach/project partners and collaborative forums (mailing list networks, newsletters, events, etc.)
- Briefings upon request (communities, organizations, etc.)
- One-on-one communication with GSA representatives and staff
- District Board and Groundwater Commission meetings
- Recorded presentations (e.g., public webinars)
- District website
- Print-friendly handouts (factsheets, event flyers, etc.)
- Quarterly eNewsletter (including print-friendly format)
- Established popular physical locations to access materials (e.g., District office, library, etc.)
- Popular social media platforms / accounts
- Briefings with regulators and land managers (can inform funding and collaborative project opportunities)

Additional methods to consider during implementation of the GSPs

The following methods were not as widely used or perceived as substantially effective during development of the GSPs development, but these may be viewed as more feasible or effective going forward during implementation of the GSPs. Factors to that may influence selecting particular methods include: topic is of high interest to stakeholders / public, key milestones during SGMA implementation, available capacity and funding, etc.)

- Individual calls, texts, mailings
- Surveys
- News articles / op-eds
- Radio (e.g, 97.3, 91.7, and 88.9) / TV PSAs
- Kiosks, marquis, sign postings on community bulletin boards
- Expanding outreach partners (e.g., schools, faith-based groups, etc.)

Issues

The following are topics that have emerged as prominent issues of interest based on discussions among the District Board members, Groundwater Commissioners, District staff, consultants and other experts, partners, stakeholders, the public, etc. As mentioned above, the list does not commit any entity to specific tasks nor preclude them from pursuing other topics or strategies. Note that not all items listed below are within the groundwater management authorities granted under SGMA; however, are still of interest to those who use groundwater and/or are interested in successful long-term management of groundwater in Tehama County's subbasins.

- Funding options and fees
- Areas with particular groundwater concerns
- Major data gaps (e.g., interconnected surface waters and groundwater dependent ecosystems) -- Refer to GSPs for more details
- Regional / watershed planning (e.g., inter-basin coordination)
- Well permitting process
- Coordination with land-use planning and development entities
- Groundwater vs. surface water use
- Impacts to shallow wells
- Socioeconomic impacts
- Affordable and reliable drinking water
- Public input opportunities (confirming interests are being conveyed and considered during SGMA implementation)
- Underrepresented and hard-to-reach communities (DACs, Tribes, etc.), particularly those with limited access to reliable internet or limited familiarity/comfort with virtual participation options.
- Expanding monitoring network
- Future conditions (e.g., drought trends)
- Project feasibility

Appendix 2-C

Northern Sacramento Valley Inter-basin Coordination Report

Northern Sacramento Valley Inter-basin Coordination Report

Antelope | Bowman | Butte | Colusa | Corning | Los Molinos | Red Bluff | Sutter | Vina | Wyandotte Creek | Yolo

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Glossary of Acronyms

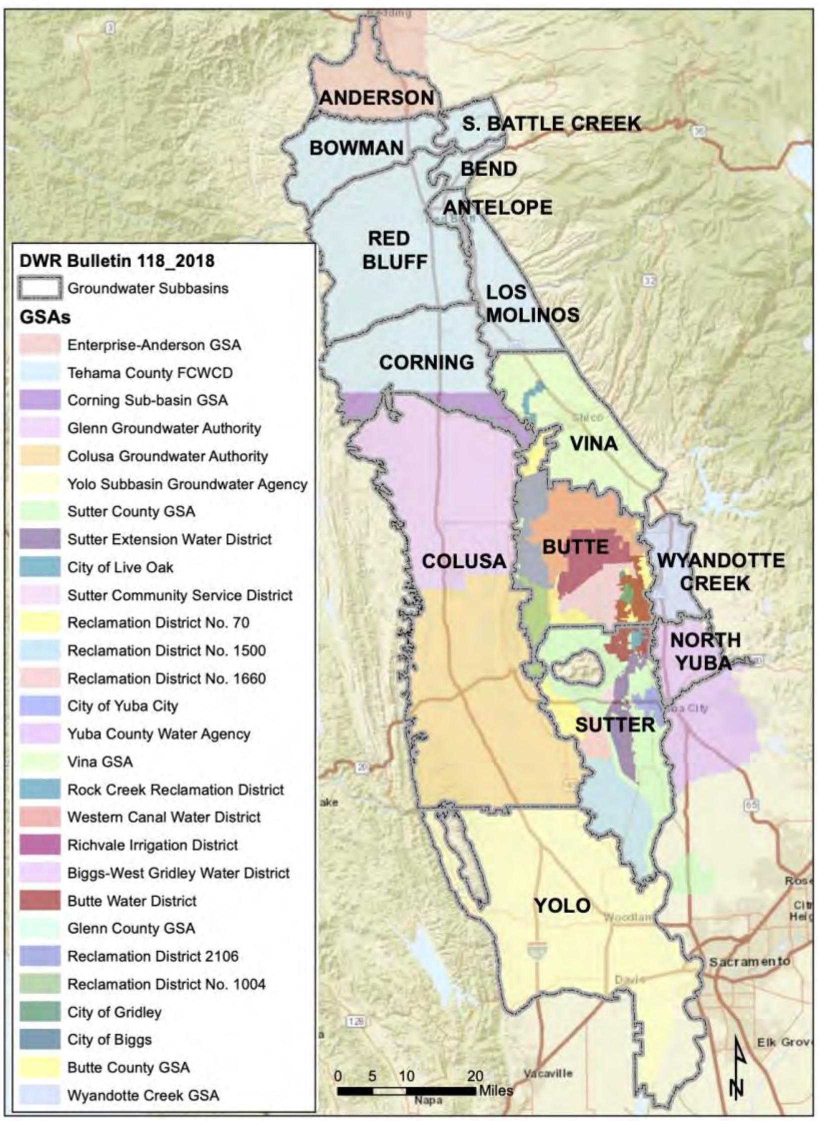
- ***CBI*** *– Consensus Building Institute [link]*
- ***DWR*** *– California Department of Water Resources*
- ***GSA*** *– Groundwater Sustainability Agency*
- ***GSP*** *– Groundwater Sustainability Plan*
- ***MOU*** *– Memorandum of Understanding*
- ***NCWA*** *– Northern California Water Association*
- ***NSV IRWM****– Northern Sacramento Valley Integrated Regional Water Management*
- ***PMAs*** *– Projects and Management Actions*
- ***SGMA*** *– Sustainable Groundwater Management Act*
- ***SMC*** *– Sustainable Management Criteria*

1. Introduction & Background

The content of the report is the result of staff recommendations resulting from regional inter-basin coordination staff meetings in the Northern Sacramento Valley (2020-2021). The content will be presented to inform discussions among Groundwater Sustainability Agencies (GSAs) and gather public input through existing public venues, such as advisory committees, groundwater commissions, and GSA Board meetings.

Inter-basin coordination is critical in the Northern Sacramento Valley as GSAs develop and implement Groundwater Sustainability Plans (GSPs). Since groundwater subbasins in the Northern Sacramento Valley are hydrologically interconnected, water management decisions and actions in subbasins (i.e., groundwater pumping and processes affecting recharge, water demand, and supply including climate change) could change aquifer conditions. Understanding and accounting for these processes is important towards achieving sustainability in all subbasins.

Figure 1. Map of the Northern Sacramento Valley



Inter-basin coordination is described in the GSP Regulations in Article 8. Under the regulations, GSAs must describe how they coordinate with adjoining subbasins to demonstrate implementation will not adversely affect adjoining subbasins. The Department of Water Resources (DWR) is required to evaluate whether a GSP adversely affects the ability of an adjacent basin to implement their GSP or impedes achievement of sustainability goals in an adjacent basin (Water Code 17033(c)). Coordination among GSAs can be formalized in different ways and inter-basin agreements are voluntary. Appendix A describes components of Sec 357.2.

Inter-basin coordination discussions among staff representatives from 11 subbasins (Antelope, Bowman, Butte, Colusa, Corning, Los Molinos, Red Bluff, Sutter, Vina, Wyandotte Creek, and Yolo), with facilitation support from the Consensus Building Institute (CBI) began during the summer of 2020. While efforts have focused on these subbasins, coordination will occur, as warranted, with other neighboring subbasins (Anderson and North Yuba).

Initial stages of inter-basin coordination efforts (May-December 2020) were closely aligned with the GSP Regulations in Article 8 components and delineated in Section 3 *Evolution of Inter-basin Coordination Efforts*. After an initial attempt to compile technical information to better understand basin conditions at respective boundaries, staff realized differing timelines for the completion of Basin Setting content in each subbasin meant there would not be sufficient time during initial GSP development to fully characterize or address major inconsistencies. Therefore, the goal for regional inter-basin coordination shifted towards establishing a framework for long-term inter-basin coordination and dialogue (post GSP submittal in 2022). Informal coordination discussions among staff and consultants between neighboring subbasins continued during the GSP development process.

This report outlines the intent and purpose of inter-basin coordination in the Northern Sacramento Valley. It describes the process followed and materials developed throughout the process. It also outlines foundational elements, referred to as "key pillars," of a framework for sustained coordination through GSP implementation.

2. Intent & Purpose

Inter-basin coordination efforts in the Northern Sacramento Valley are focused on establishing a foundation and guidelines for sustained inter-basin coordination through GSP implementation, following the initial submittal of GSPs by January 31, 2022. GSAs intend to:

1. *Establish a framework allowing for continued dialogue and a venue to address issues and discrepancies during the implementation of the GSPs;*
2. *Coordinate on consistent messaging and communicate shared expectations at a regional level;*
3. *Demonstrate regional coordination efforts and outcomes; and*
4. *Leverage existing agreements and arrangements in the region (e.g., Northern Sacramento Valley Integrated Regional Water Management (NSV IRWM), the Six County Memorandum of Understanding among Butte, Colusa, Glenn, Tehama, Shasta, and Sutter).*

The proposed deliverable from this effort is the development of a common approach and draft language for incorporation into each subbasin's GSP. This narrative describes the facilitated effort as well as the framework and scope for long-term coordination during plan implementation. The public will have opportunities to weigh in and provide input on the proposed framework through each subbasin's existing public venues, such as advisory committees, groundwater commissions, and GSA board meetings.

3. Evolution of Inter-basin Coordination Efforts

Inter-basin coordination efforts, facilitated by the Consensus Building Institute (CBI) began in summer 2020 among Subbasin staff from Antelope, Bowman, Butte, Colusa, Corning, Los Molinos, Red Bluff, Vina, and Wyandotte Creek subbasins to identify priorities and resources available for inter-basin coordination. Soon after, staff representatives from the Sutter and Yolo subbasins joined the meetings. To date, CBI has facilitated nine inter-basin coordination meetings with staff and periodically with technical consultants from the subbasins. Subbasin staff and/or CBI communicated regular updates to GSA Boards and advisory committees in each of the subbasins regarding the status of inter-basin coordination activities [Access Webpage Here].

Initial stages of inter-basin coordination efforts were closely aligned with the GSP Regulations in Article 8:

1. ***General information*** *of subbasins, plans and agencies participating in the coordination agreement,*
2. ***Technical information*** *including consistent and coordinated data or methodology for inter-basin boundary flows and stream-groundwater interactions at basin boundaries, and information on sustainable management criteria and monitoring that would confirm that no adverse impacts of implementing the GSPs would result to any party to the agreement,*
3. *A description of the* ***process for identifying and resolving conflicts*** *between Agencies that are parties to an inter-basin coordination agreement.*

   Reference: *Sections 10727.2, 10733, and 10733.2, Water Code.*

The goal at the initial stage was to compile general and technical information identified by DWR in a consistent manner to establish an accurate basis of comparison and to identify any significant inconsistencies that may need to be addressed or resolved. This included developing a series of information-sharing documents and outreach materials, summarized below.

1. ***Inter-basin Coordination Directory–*** *This document provides an updated and centralized directory with contact information for GSA managers, technical consultants, and facilitators in the various subbasins. This document seeks to facilitate communication among the various representatives leading GSP development [Access Here].*
2. ***Technical Information-Sharing Template–*** *This template was developed among the managers and technical consulting teams to compile and compare information on modeling tools and water budget results for inter-basin flows, stream-aquifer interactions, and hydro-geologic conditions in the subbasins. Potentially, this document could be used to compile information about Sustainable Management Criteria and Monitoring Networks [Access Draft Template Here]. The first output from the technical information-sharing template summarizes the highlights of compiled model information across the subbasins [Access Here].*
3. ***Outreach Presentation****–This PowerPoint presentation provides updates on inter-basin coordination activities to the various SGMA public venues (GSA boards, advisory committees, etc.) and an overview of the scope and timeline of inter-basin coordination efforts. This presentation is continuously updated*

after each inter-basin coordination staff meeting for use in consistently communicating with GSA Boards/advisory committees and the public throughout the region [Access Here].

4. ***Outreach Factsheet–*** *The inter-basin coordination factsheet aims to support public outreach and information sharing in the various subbasins. This two-page flier or factsheet summarizes why regional coordination is important under SGMA, who is involved in ongoing efforts, what the coordination priorities are, and includes a table with links to each subbasin's website for additional subbasins' specific information [Access Here].*
5. ***Inter-basin Coordination Webpage–*** *Butte County hosts a webpage to provide the most up-to-date information on inter-basin coordination efforts in the Northern Sacramento Valley. The webpage provides an overview of the scope and makes available documentation and results of the inter-basin coordination work, including meeting agendas, summaries, and outputs [Access Here].*
6. ***Meeting Summaries****–CBI develops meeting summaries after each regional inter-basin coordination staff meeting to summarize key discussion themes, action items, and next steps. These summaries are publicly available on the inter-basin coordination webpage [Access Here].*

After an initial attempt to compile technical information, staff realized the broad aspirations were not feasible during the initial stages of GSP development. The process of compiling and comparing modeling outputs from the diverse regional hydrological models required a significant amount of time, resources, and varying levels of data. Further, subbasins were at different stages of GSP development and GSAs were facing tight timelines, competing priorities, and capacity limitations to meet the regulatory deadline. While communication on a neighbor-to-neighbor basis on technical components was encouraged through GSP development, subbasin staff representatives realized more robust technical analysis and coordination between and among subbasins was not possible until initial plans (including water budgets) were more fully developed or after adoption of the initial GSPs.

Following reflection from the separate inter-basin efforts and priorities moving forward, subbasin staff recommended shifting the focus of regional coordination meetings to establishing a framework for long-term inter-basin coordination and dialogue following GSP submission in January 2022. To do so, subbasin staff identified desired outcomes in the short-term (during initial GSP development), mid-term (first 5-year update), and long-term (GSP Implementation through 2042) [Access Here]. This approach recognizes adoption of the 2022 GSPs as an initial step in sustainable groundwater management, not the final step. Subbasin staff acknowledged while model outputs may not match perfectly, the main objective is to identify and acknowledge significant discrepancies, understand why those differences exist, and evaluate to the extent they need to be reconciled. Inter-basin coordination has been characterized as "a marathon not a sprint," and current efforts will serve to pave the path for long-term collaboration. Further, GSAs can take advantage of annual reporting and five-year GSP updates to identify and address discrepancies. Lastly, subbasin staff representatives acknowledge public participants are interested in inter-basin coordination efforts and concerns from some subbasins can easily affect others. Subbasin staff understand the need to share and educate the public on what is in the various GSPs, and the SGMA requirements for inter-basin coordination. Staff will continue to provide updates and gather GSA Board and public input related to the direction of current efforts and desired priorities, shared concerns, and possible ideas for inter-basin coordination during GSP implementation.

4. Inter-basin Coordination Framework

This section outlines the foundational pillars that comprise the framework for inter-basin coordination under SGMA between and among subbasins in the Northern Sacramento Valley. These pillars build upon a long-standing history of regional collaboration and embody a commitment for continued coordination, collaboration, and communication for successful groundwater management in the region. Honoring the individual authorities of the GSAs, these pillars represent a menu of options neighboring subbasins can draw upon, based on individual or neighboring subbasins' needs and challenges. GSA Boards can decide which of these options they would like to support and implement, acknowledging circumstances may change over time.

Pillars	Scale(s)	Timing
1. Information-sharing a. Inform each other on changing conditions (i.e., surface water cutbacks, land use changes, policy changes that inform groundwater management) b. Share annual reports and interim progress reports c. Share data and technical information and work towards building shared data across and/or along basin boundaries (e.g., monitoring data, water budgets, modeling inputs and outputs, and Groundwater Dependent Ecosystems)	• Neighbor-to-neighbor • Coordination groups [Refer to section 4.1 below]	• *Ongoing (GSP Development)* • *Near-term (5-year update)* • *Long-term (GSP implementation)*
2. Joint analysis & evaluation a. Evaluate and compare contents of GSPs with a focus on establishing a common understanding of basin conditions at boundaries b. Identify significant differences, uncertainties, and potential issues of concern related to groundwater interaction at the boundaries c. Engage in analysis and evaluation of SMCs between GSPs to assess impacts and identify significant differences and possible impacts between subbasins that could potentially lead to undesirable results	• Neighbor-to-neighbor • Coordination groups [Refer to section 4.1 below]	• *Near-term (5-year update)* • *Long-term (GSP implementation)*
3. Coordination on mutually beneficial activities a. Communicate, coordinate, and collaborate on mutually beneficial activities, which could include joint monitoring, joint reporting, regional modeling, and other efforts to address data gaps at subbasin boundaries b. Collectively pursue funding and collaborate on mutually agreed upon projects and management actions that provide benefits across boundaries c. Leverage existing collaboratives (NSV IRWM, NCWA etc.)	• Neighbor-to-neighbor • Coordination groups • Regional: NSV IRWM, NCWA Groundwater Task Force	• *Ongoing (GSP Development)* • *Near-term (5-year update)* • *Long-term (GSP implementation).*
4. Coordinated communication and outreach a. Coordinate and collaborate on regional-scale public engagement and communication strategies that promote awareness on groundwater sustainability, enhance public trust, and maintain institutional knowledge b. Maintain list of GSP/subbasin staff contacts and websites	• Regional: NSV IRWM and NCWA Groundwater Task Force	• *Ongoing (GSP Development)* • *Near-term (5-year update)* • *Long-term (GSP implementation)*
5. Issue-resolution process a. Establish and follow an agreed-upon process for identifying and resolving conflicts between GSAs by the first five-year update [Refer to Appendix D for more details and discussion prompts on issue resolution processes]	• Neighbor-to-neighbor • Coordination groups	• *Near-term (5-year update)* • *Long-term (GSP implementation).*

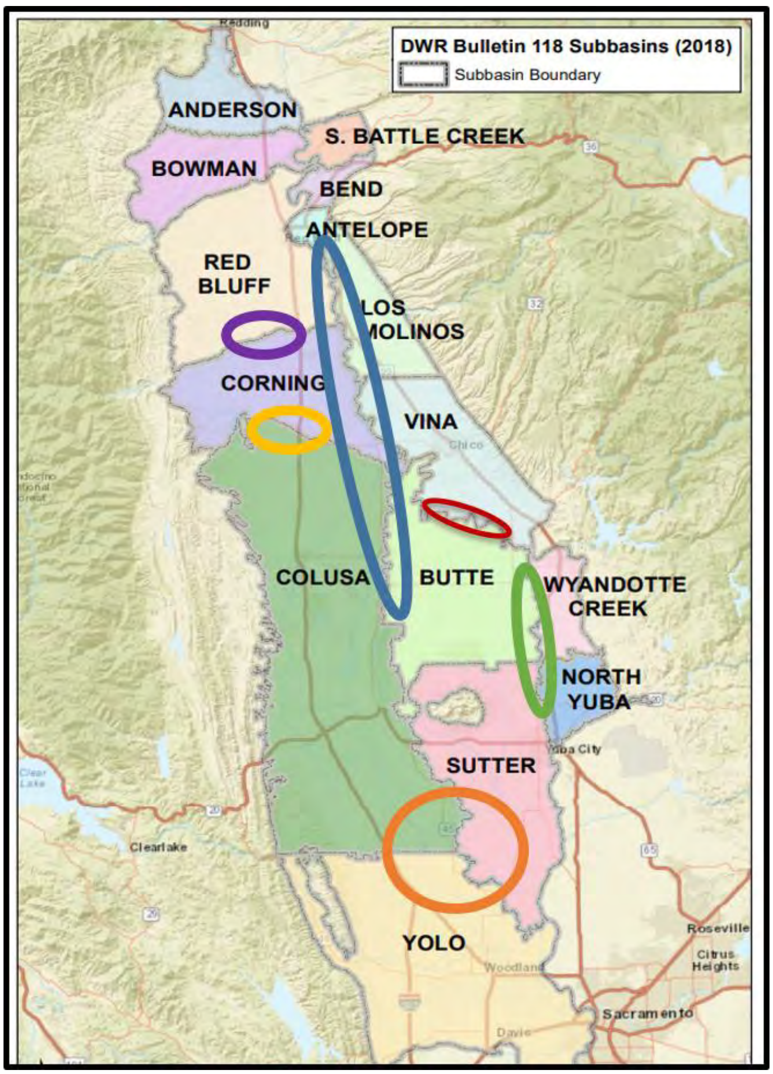
4.1. Inter-basin Coordination Groups

Inter-basin coordination efforts, as outlined in the pillars above, would require resources and technical support. Subbasin staff recommend organizing inter-basin coordination priorities by specific subbasin boundaries. One suggested approach identifies specific "Coordination Groups" (see Figure 3 and list below). Some of these groups are pairs and others include multiple subbasins around a river boundary.

1. ***Feather River Corridor****- Butte, Wyandotte Creek, North Yuba, Sutter*
2. ***North Sacramento River Corridor****- Antelope, Los Molinos, Red Bluff, Corning, Vina, Butte, Colusa*
3. ***South Sacramento Corridor****- Colusa, Sutter, Yolo*

Neighbor to Neighbor, examples:

4. ***Stony Creek****- Corning, Colusa*
5. ***Thomes Creek****- Red Bluff, Corning*
6. ***Butte/Vina****- Vina, Butte*



5. Conclusion and Next Steps

In sum, this report outlines a framework for inter-basin coordination for sustainable groundwater management in the Northern Sacramento Valley. The inter-basin coordination framework describes a menu of options for ongoing communication and collaboration around substantive issues over the twenty-year implementation of SGMA.

The pillars and other content from this report could be used by GSAs to support GSP development and implementation in a number of ways. This inter-basin coordination report could be included as an Appendix to the GSP and could be updated on a yearly basis. Individual subbasins can incorporate sections of the report into the body of the GSP, depending upon specific boundary conditions at adjoining subbasins. Finally, subbasins could draw on the inter-basin coordination framework if they would like to consider entering into one or more voluntary inter-basin agreements during GSP implementation.

The content of the report is the result of staff recommendations resulting from regional inter-basin coordination staff meetings. Staff will present the framework as a supporting document to guide and inform discussions with the GSA Boards and other existing public venues, such as advisory committees or groundwater commissions. GSAs in turn will discuss the menu of options for inter-basin coordination outlined in this report to determine their priorities and desired approach to draw on the inter-basin coordination framework in their individual GSPs. Lastly, Subbasin staff will come together to share input received and determinations from their respective GSAs.

Subbasin staff acknowledge that while this report builds upon a long-standing history of regional collaboration, this is just the beginning of inter-basin coordination efforts under SGMA. Therefore, this framework and inter-basin coordination activities will be continually refined throughout GSP implementation.

Appendices

Appendix A: GSP Emergency Regulations, Article 8: Interagency Agreements §357.2

§ 357.2. Inter-basin Agreements (access here)

Two or more Agencies may enter into an agreement to establish compatible sustainability goals and understanding regarding fundamental elements of the Plans of each Agency as they relate to sustainable groundwater management. Inter-basin agreements may be included in the Plan to support a finding that implementation of the Plan will not adversely affect an adjacent basin's ability to implement its Plan or impede the ability to achieve its sustainability goal. Inter-basin agreements should facilitate the exchange of technical information between Agencies and include a process to resolve disputes concerning the interpretation of that information. Inter-basin agreements may include any information the participating Agencies deem appropriate, such as the following:

- (a) General information:
  - (1) Identity of each basin participating in and covered by the terms of the agreement.
  - (2) A list of the Agencies or other public agencies or other entities with groundwater management responsibilities in each basin.
  - (3) A list of the Plans, Alternatives, or adjudicated areas in each basin.
- (b) Technical information:
  - (1) An estimate of **groundwater flow across basin boundaries**, including consistent and coordinated data, methods, and assumptions.
  - (2) An estimate of **stream-aquifer interactions** at boundaries.
  - (3) A **common understanding of the geology and hydrology** of the basins **and the hydraulic connectivity** as it applies to the Agency's determination of groundwater flow across basin boundaries and description of the different assumptions utilized by different Plans and how the Agencies reconciled those differences.
  - (4) **Sustainable management criteria and a monitoring network** that would confirm that no adverse impacts result from the implementation of the Plans of any party to the agreement. If minimum thresholds or measurable objectives differ substantially between basins, the agreement should specify how the Agencies will reconcile those differences and manage the basins to avoid undesirable results. The Agreement should identify the differences that the parties consider significant and include a plan and schedule to reduce uncertainties to collectively resolve those uncertainties and differences.
- (c) A description of the **process for identifying and resolving conflicts** between Agencies that are parties to the agreement.
- (d) Inter-basin agreements submitted to the Department shall be posted on the Department's website.

Note: Authority cited: Section 10733.2, Water Code.
Reference: Sections 10727.2, 10733, and 10733.2, Water Code.

Northern Sacramento Valley I Sustainable Groundwater Management Act

Regional Coordination Between Subbasins

Antelope I Bowman I Butte I Colusa I Corning I Los Molinos I Red Bluff I Sutter I Vina I Wyandotte Creek I Yolo

Sustainable Groundwater Management Act

What is SGMA? California enacted the Sustainable Groundwater Management Act (SGMA) in 2014 to better manage groundwater over the long term. Sustainability is achieved by avoiding significant and unreasonable conditions for the six "sustainability indicators."

- Lowering of Groundwater Levels
- Reduction of Groundwater Storage
- Land Subsidence
- Surface Water Depletion
- Water Quality Degradation
- Sea Water Intrusion

Why is regional coordination important? In the Sacramento Valley, inter-basin coordination is critical as Groundwater Sustainability Agencies (GSA) develop their Groundwater Sustainability Plans (GSP). Since groundwater subbasins in the Northern Sacramento Valley (NSV) are hydrologically interconnected, water management decisions and actions in one subbasin (e.g. groundwater pumping) and processes like climate change could change aquifer conditions and affect flows to other subbasins. Understanding and accounting for these processes is key to achieve sustainability in all subbasins.

Who is involved in ongoing efforts?

Collaborative efforts have begun among representatives from 11 subbasins (Antelope, Bowman, Butte, Colusa, Corning, Los Molinos, Red Bluff, Sutter, Vina, Wyandotte Creek, Yolo), with facilitation support from the Consensus Building Institute. While efforts have focused on the subbasins mentioned, coordination will occur, as warranted, with other neighboring subbasins (Anderson and North Yuba).

What are the coordination priorities?

Groundwater Sustainability Agencies are working together to establish a foundation for open and transparent inter-basin coordination and communication by developing tools to:

- SHARE & COMPILE INFORMATION IN A CONSISTENT WAY
- OUTLINE A PROCESS TO IDENTIFY & RESOLVE ISSUES
- DOCUMENT COORDINATION EFFORTS

Learn More & Get Involved

Receive Updates
Sign up for your GSA's interested parties list.

Contact Your GSA
Talk to your GSA representative

Attend Meetings
Attend public workshops, Advisory Board, and GSA Board meetings

Subbasin	GSA(s)	Website
Antelope	Tehama County Flood Control and Water Conservation District (FCWCD)	Website
Bowman	Tehama County FCWCD	Website
Butte	Biggs West Gridley WD, Butte County, Butte WD, City of Biggs, City of Gridley, Colusa Groundwater Authority, Glenn County, RD 1004, RD 2106, Richvale ID, Western Canal WD	Website
Los Molinos	Tehama County FCWCD	Website
Red Bluff	Tehama County FCWCD	Website
Corning	Corning Sub-basin GSA, Tehama County FCWCD	Website
Colusa	Glenn Groundwater Authority; Colusa Groundwater Authority	Websites (Glenn) | (Colusa)
Sutter	Butte WD, City of Live Oak, Sutter Community Service District, Sutter County, Sutter Extension Water District, RD 70, RD 1660, RD 1500, City of Yuba City	Website
Vina	Rock Creek Reclamation District, Vina GSA	Websites (Vina) | (RCDC)
Wyandotte Creek	Wyandotte Creek GSA	Website
Yolo	Yolo Subbasin Groundwater Agency	Website

Find more information about regional inter-basin coordination at:
ButteCounty.net/waterresourceconservation/Sustainable-Groundwater-Management-Act/Inter-basin-Coordination

APPENDIX C

Memorandum of Understanding
Four County (Butte, Colusa, Glenn, and Tehama Counties)
Regional Water Resource Coordination, Collaboration, and Communication

Memorandum of Understanding
Four County (Butte, Colusa, Glenn, and Tehama Counties) Regional Water Resource Coordination, Collaboration, and Communication

1. BACKGROUND

The counties of Butte, Colusa, Glenn, and Tehama share common surface water and groundwater resources. Based on these common resources, local water resource managers understand that regular coordination, collaboration, and communication can result in an improved water resource understanding at both the county and regional level.

2. PURPOSE

The purpose of this document is to establish the mutual understandings of the four counties with respect to their voluntary joint efforts toward regional coordination, collaboration, and communication.

3. GOALS

The goals of the Four County Memorandum of Understanding (MOU) are:

2.1. To foster coordination, collaboration and communication between the four counties on water-related issues, to achieve greater efficiencies, and enhance public services.

2.2. To provide a framework for the management and disbursement of funding associated with activities pursued jointly under this MOU.

2.3. To improve competitiveness for State and Federal grant funding.

4. DEFINITIONS

4.1. Four County. Participants including the counties of Butte, Colusa, Glenn, and Tehama, with representation by the following:

- Butte County: Department of Water and Resource Conservation
- Colusa County: Department of Planning and Building
- Glenn County: Department of Agriculture
- Tehama County: Flood Control and Water Conservation District

4.2. Project Manager. A project manager will be determined by the Counties signatory to this MOU for any given project regardless of funding source to meet the goals set forth in this MOU.

5. MUTUAL UNDERSTANDINGS

5.1. Participation. Signatories to this MOU constitute the current participants. Participation is strictly on a voluntary basis and may be terminated at any time without recourse. Neighboring counties who share water resources common to the participating counties and who are engaged in similar activities will be invited to be signatory to this MOU. Signatories aspire to work collaboratively with other regional programs and technical outreach efforts.

5.2. Activities. Efforts pursued under this agreement will remain consistent with and will not exceed the current authority for any individual participating county. Efforts will include the study and investigation of water resources common to participants, monitoring and reporting, information dissemination and sharing between counties and with other county departments, public outreach and education, and other activities at the agreement and direction of individual county governing bodies.

5.3. County Funding. Counties are not required to commit funding associated with activities completed under this MOU. It is understood that activities under this MOU may result in the more efficient use of existing and future department funding resulting from improved collaboration and coordination.

5.4. External Funding. Signatories will work collaboratively in pursuit of external funding associated with common interest activities based on voluntary participation and agreement. When required, a mutually agreed upon County representative will serve as the Project Manager for activities completed under a contract with an external funding source. Existing county contracting mechanisms will be utilized where available for contractual and invoicing purposes between participating counties. Nothing in this MOU precludes individual counties from the individual pursuit, contracting and completion of work from an externally funded source regardless of a real or perceived regional interest.

5.5. Decision-making. Consensus will be sought when the need for a decision arises.

5.6. Non-binding nature. This document and participation under this MOU are nonbinding, and in no way suggest that a county may not continue its own activities as each county is expected to continue its own policies and procedures and undertake efforts to secure project funding from any source. A county may withdraw from participation at any time.

5.7. Termination. Because the MOU will require periodic review and updating for use into the future, it is envisioned that the joint efforts of those involved will be ongoing in maintaining a living document. Thus this document will remain as a reflection of the understandings of the participants. Individual signatories of this MOU may terminate their involvement at any time with no recourse.

6. SIGNATORIES TO THE MEMORANDUM OF UNDERSTANDING

We, the undersigned representatives of our respective counties, acknowledge the above as our understanding of how the Four County Coordination, Collaboration, and Communication MOU will be implemented.

MAR 14 2006 APPROVED JAN 2 4 2006

Date

Curt Josiassen, Chairman
Butte County Board of Supervisors

2/28/06

Approved As To Form:
Bruce Alpert, Butte County Counsel

6. SIGNATORIES TO THE MEMORANDUM OF UNDERSTANDING
We, the undersigned representatives of our respective counties, acknowledge the above as our understanding of how the Four County Coordination, Collaboration, and Communicative MOU will be implemented.

April 4, 2006
Date

Christy Scofield
Christy Scofield, Chairperson
Colusa County Board of Supervisors

Approved As To Form:
Henry Rodegerdts, Colusa County Counsel

EXHIBIT B
PAGE 3 OF 3

CBI CATALYZING COLLABORATION

6. SIGNATORIES TO THE MEMORANDUM OF UNDERSTANDING

We, the undersigned representatives of our respective counties, acknowledge the above as our understanding of how the Four County Coordination, Collaboration, and Communication MOU will be implemented.

12-13-05

Date

Vice Chairman, Tehama County Flood Control And Water Conservation District

Approved As To Form:

by

County Counsel, Tehama County

Date

By Board Chair

County

Approved As To Form:

County Counsel

Date

By Board Chair

County

Approved As To Form:

County Counsel

Date

By Board Chair

County

Approved As To Form:

TEHAMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT MINUTE ORDER

December 13, 2005

8. Approval of Four-County Regional Water Resource Coordination- MOU: Ernie Ohlin reviewed that in August 2004, the Board authorized staff to participate in the four county water effort. The MOU attached is allowing all counties to participate together in water resource collaboration and communication. This non-binding voluntary MOU recognizes coordination among Butte, Colusa, Glenn and Tehama County.

Roger Sherrill encouraged the four-county groups to participate and noted in Item 5.1 "Participation" is strictly voluntary. Shasta County provides a major part of the recharge for the northern part of the Sacramento Valley and to move forward could only make for a stronger overall group.

Mark Black, Ag Commissioner for Glenn County, added this will be presented to Glenn County next Tuesday for support. Discussions with Sutter and Yuba County brings interest and they are awaiting the outcome of the four counties. This is a good collaborative effort, giving us strength of possible capturing of funding.

Motion by Director Warner to approve the MOU for signature.

Director Willard questioned if this has been reviewed by County Counsel. Upon his approval, signature will be completed.

Motion revised by Director Warner to approve the MOU for signature by the Chair upon review of County Counsel. Second by Director Avilla and carried by those present 3-0 with 2 absent.

Ayes: Directors':, Charles Willard; Ron Warner; Gregg Avilla
Noes: None
Absent or Not Voting: Director's: Ross Turner, George Russell

STATE OF CALIFORNIA)
) ss
COUNTY OF TEHAMA)

I, Gary Antone, Director of the Tehama County Flood Control and Water Conservation District of the County of Tehama, State of California, hereby certify the above and foregoing to be full, true and correct copy of an order adopted by said Tehama County Flood Control and Water Conservation District on this **13th day of December, 2005**

Dated: This 13th day of **December, 2005**.

Gary Antone
Director of the Tehama County Flood Control and Water Conservation District of the County of Tehama, State of California

By *Linda Madea*
Linda Madea, Deputy

F:\ADMIN\MEETING\MINORDER\05MinOrd\Dec.wpd

FOUR COUNTY MEMORANDUM OF UNDERSTANDING
ADDENDUM ONE:
Statement of Principles Regarding Water Related Programs and Projects

In recognition that certain activities related to water resources do not recognize jurisdictional boundaries and require regional solutions, the parties identified in the Four County Memorandum of Understanding hereby agree to adhere to the following Statement of Principles Regarding Water Related Programs and Projects:

1. Programs and projects related to groundwater level and water quality monitoring shall be conducted in a cooperative manner and related data shall be shared between the participants to prevent negative impacts to our constituents.
2. Environmental documents associated with water projects and programs will automatically be circulated to all four counties for review and comment.
3. Incidents of abnormal water level or water quality readings will be immediately communicated to all participating counties resulting in a collaborative review and dissemination of related information.
4. Project and program related information will be disseminated on a regional basis through the independent county websites, augmented by regional public outreach meetings.
5. The parties will work cooperatively to acquire grant funding to conduct aquifer studies that further identify the linkages of the common groundwater resources.
6. Efforts pursued under this agreement will remain consistent with and will not exceed the current authority of any participating county.

We, the undersigned representatives of our respective counties, agree to adhere to the conditions of **Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects.** The original MOU was signed by the Counties of Butte, Glenn, Colusa and Tehama in 2006.

[signature]	3/27/07	[signature]	2/23/07
Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date

1

Vice-Chair, Colusa County
Board of Supervisors

4-17-07
Date

County Counsel
Approved As to Form

Date

EXHIBIT A
PAGE 2 OF 2

CBI
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COUNTY CONTRACT
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FOUR COUNTY MEMORANDUM OF UNDERSTANDING
ADDENDUM ONE:
Statement of Principles Regarding Water Related Programs and Projects

In recognition that certain activities related to water resources do not recognize jurisdictional boundaries and require regional solutions, the parties identified in the Four County Memorandum of Understanding hereby agree to adhere to the following Statement of Principles Regarding Water Related Programs and Projects:

1. Programs and projects related to groundwater level and water quality monitoring shall be conducted in a cooperative manner and related data shall be shared between the participants to prevent negative impacts to our constituents.
2. Environmental documents associated with water projects and programs will automatically be circulated to all four counties for review and comment.
3. Incidents of abnormal water level or water quality readings will be immediately communicated to all participating counties resulting in a collaborative review and dissemination of related information.
4. Project and program related information will be disseminated on a regional basis through the independent county websites, augmented by regional public outreach meetings.
5. The parties will work cooperatively to acquire grant funding to conduct aquifer studies that further identify the linkages of the common groundwater resources.
6. Efforts pursued under this agreement will remain consistent with and will not exceed the current authority of any participating county.

We, the undersigned representatives of our respective counties, agree to adhere to the conditions of **Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects.** The original MOU was signed by the Counties of Butte, Glenn, Colusa and Tehama in 2006.

Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	4/3/2007 Date	County Counsel Approved As to Form	3/26/07 Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date

CBI
CATALYZING COLLABORATION

FOUR COUNTY MEMORANDUM OF UNDERSTANDING
ADDENDUM TWO:
Adding Sutter County to the Four County MOU

In recognition that certain activities related to water resources do not recognize jurisdictional boundaries and therefore require regional solutions, the parties identified in the original Four County Memorandum of Understanding: Counties of Butte, Colusa, Glenn and Tehama are hereby joined by Sutter County in the regional efforts discussed in the Four County MOU and the Statement of Principles Regarding Water Related Programs and Projects as discussed in Addendum One to the Four County MOU.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of the **Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects. And Addendum Two: Adding Sutter County to the Four County MOU.**

The original MOU was signed by the Counties of Butte, Glenn, Colusa and Tehama in 2006. Through approval of this addendum, Sutter County makes the same commitment to regional cooperation and coordination that is outlined in the original MOU.

Bill Connelly	05 MAY 2009	Bruce S. Alpert	
Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Colusa County Board of Supervisors	Date	County Counsel Approved As to Form	Date

C09-082

FOUR COUNTY MEMORANDUM OF UNDERSTANDING
ADDENDUM TWO:
Adding Sutter County to the Four County MOU

In recognition that certain activities related to water resources do not recognize jurisdictional boundaries and therefore require regional solutions, the parties identified in the original Four County Memorandum of Understanding: Counties of Butte, Colusa, Glenn and Tehama are hereby joined by Sutter County in the regional efforts discussed in the Four County MOU and the Statement of Principles Regarding Water Related Programs and Projects as discussed in Addendum One to the Four County MOU.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of the **Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects. And Addendum Two: Adding Sutter County to the Four County MOU.**

The original MOU was signed by the Counties of Butte, Glenn, Colusa and Tehama in 2006. Through approval of this addendum, Sutter County makes the same commitment to regional cooperation and coordination that is outlined in the original MOU.

Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date
[signature] Chair, Colusa County Board of Supervisors	5/5/09 Date	[signature] County Counsel Approved As to Form	Date 5/5/09

CBI
CATALYZING COLLABORATION

C09-082

FOUR COUNTY MEMORANDUM OF UNDERSTANDING
ADDENDUM TWO:
Adding Sutter County to the Four County MOU

In recognition that certain activities related to water resources do not recognize jurisdictional boundaries and therefore require regional solutions, the parties identified in the original Four County Memorandum of Understanding: Counties of Butte, Colusa, Glenn and Tehama are hereby joined by Sutter County in the regional efforts discussed in the Four County MOU and the Statement of Principles Regarding Water Related Programs and Projects as discussed in Addendum One to the Four County MOU.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of the **Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects. And Addendum Two: Adding Sutter County to the Four County MOU.**

The original MOU was signed by the Counties of Butte, Glenn, Colusa and Tehama in 2006. Through approval of this addendum, Sutter County makes the same commitment to regional cooperation and coordination that is outlined in the original MOU.

Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	5/21/09 Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Colusa County Board of Supervisors	5/5/09 Date	County Counsel Approved As to Form	5/5/09 Date

CBI CATALYZING COLLABORATION

Chair, Sutter County Board of Supervisors	Date	William J. Vanasek County Counsel Approved as to Form	4/14/09 Date

2

FOUR COUNTY MEMORANDUM OF UNDERSTANDING
ADDENDUM TWO:
Adding Sutter County to the Four County MOU

In recognition that certain activities related to water resources do not recognize jurisdictional boundaries and therefore require regional solutions, the parties identified in the original Four County Memorandum of Understanding: Counties of Butte, Colusa, Glenn and Tehama are hereby joined by Sutter County in the regional efforts discussed in the Four County MOU and the Statement of Principles Regarding Water Related Programs and Projects as discussed in Addendum One to the Four County MOU.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of the **Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects. And Addendum Two: Adding Sutter County to the Four County MOU.**

The original MOU was signed by the Counties of Butte, Glenn, Colusa and Tehama in 2006. Through approval of this addendum, Sutter County makes the same commitment to regional cooperation and coordination that is outlined in the original MOU.

Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
George Russell Chair, Tehama County Flood Control & Water Conservation District	6-23-09 Date	County Counsel Approved As to Form	Date
Chair, Colusa County Board of Supervisors	Date	County Counsel Approved As to Form	Date

FOUR COUNTY MEMORANDUM OF UNDERSTANDING:
ADDENDUM THREE
Expression of a Commitment to Begin An
Integrated Regional Water Management Planning Process
Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter

Through adoption of this addendum, the signatories agree to begin a regional water management planning process pursuant to the Four County MOU, geographically covering the area of Butte, Colusa, Glenn, Tehama and Sutter Counties. The planning process shall utilize and incorporate existing plans and processes. The California legislature has recently adopted new criteria associated with the Integrated Regional Water Management Planning process. This new legislative criteria requires that acceptance and approval of the composition of all Integrated Regional Water Management Planning Areas be completed prior to accepting public funding associated with IRWMP grant funds. All IRWMP planning Regions and Plans must comply with the requirements as set forth in the Final Regional Acceptance Process Program Guidelines.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of **The Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects; Addendum Two: Adding Sutter County to the Four County MOU; Addendum Three: Expression of a Commitment to Begin An Integrated Regional Water Management Planning Process Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter.**

Bill Connelly	05 MAY 2009	Bruce S. Alpert	
Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date

Chair, Colusa County Board of Supervisors	5/5/09 Date	County Counsel Approved As to Form	5/5/09 Date
Chair, Sutter County Board of Supervisors	Date	County Counsel Approved as to Form	Date

C09-095
5-5-09

FOUR COUNTY MEMORANDUM OF UNDERSTANDING:
ADDENDUM THREE
Expression of a Commitment to Begin An
Integrated Regional Water Management Planning Process
Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter

Through adoption of this addendum, the signatories agree to begin a regional water management planning process pursuant to the Four County MOU and geographically covering the area of Butte, Colusa, Glenn Tehama and Sutter Counties. The planning process shall utilize and incorporate existing plans and processes. The California legislature has recently adopted new criteria associated with the Integrated Regional Water Management Planning process. This new legislative criteria requires that acceptance and approval of the composition of all Integrated Regional Water Management Planning Areas be completed prior to accepting public funding associated with IRWMP grant funds. All IRWMP planning Regions and Plans must comply with the requirements as set forth in the Final Regional Acceptance Process Program Guidelines.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of **The Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects; Addendum Two: Adding Sutter County to the Four County MOU; Addendum Three: Expression of a Commitment to Begin An Integrated Regional Water Management Planning Process Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter.**

Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
[signature] Chair, Glenn County Board of Supervisors	5/21/09 Date	[signature] County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date

Chair, Colusa County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Sutter County Board of Supervisors	Date	County Counsel Approved as to Form	4/14/09 Date

FOUR COUNTY MEMORANDUM OF UNDERSTANDING:
ADDENDUM THREE
Expression of a Commitment to Begin An
Integrated Regional Water Management Planning Process
Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter

Through adoption of this addendum, the signatories agree to begin a regional water management planning process pursuant to the Four County MOU and geographically covering the area of Butte, Colusa, Glenn, Tehama and Sutter Counties. The planning process shall utilize and incorporate existing plans and processes. The California legislature has recently adopted new criteria associated with the Integrated Regional Water Management Planning process. This new legislative criteria requires that acceptance and approval of the composition of all Integrated Regional Water Management Planning Areas be completed prior to accepting public funding associated with IRWMP grant funds. All IRWMP planning Regions and Plans must comply with the requirements as set forth in the Final Regional Acceptance Process Program Guidelines.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of **The Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects; Addendum Two: Adding Sutter County to the Four County MOU; Addendum Three: Expression of a Commitment to Begin An Integrated Regional Water Management Planning Process Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter.**

Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
George Russell Chair, Tehama County Flood Control & Water Conservation District	6-23-09 Date	County Counsel Approved As to Form	Date

CBI
CATALYZING COLLABORATION

FOUR COUNTY MEMORANDUM OF UNDERSTANDING:
ADDENDUM FOUR
Expression of a Commitment to Begin An
Integrated Regional Water Management Planning Process
Within the Counties of Butte, Colusa, Glenn, Tehama, Sutter and Shasta

Through adoption of this addendum, the signatories agree:

1. Shasta County shall join the parties involved in the original Four County Memorandum of Understanding (MOU) and Addendum Two;

2. Signatories to the MOU and its addenda shall be called the Northern Sacramento Valley Integrated Regional Water Management Planning Group; and,

3. Begin a regional water management planning process pursuant to the Four County MOU, geographically covering the area of Butte, Colusa, Glenn, Tehama, Sutter and Shasta Counties. The planning process shall utilize and incorporate existing plans and processes. The California legislature has recently adopted new criteria associated with the Integrated Regional Water Management Planning process. This new legislative criteria requires that acceptance and approval of the composition of all Integrated Regional Water Management Planning Areas be completed prior to accepting public funding associated with IRWMP grant funds. All IRWMP planning Regions and Plans must comply with the requirements as set forth in the Final Regional Acceptance Process Program Guidelines.

4. The signatories to the MOU and its addenda reaffirm the provisions of section 5.6 of the MOU that the MOU and its addenda and participation under the MOU and its addenda are nonbinding.

We, the undersigned as representative of our respective counties, agree to adhere to the conditions of **The Four County Memorandum of Understanding; Addendum One to the Four County MOU: Statement of Principles Regarding Water Related Programs and Projects; Addendum Two: Adding Sutter County to the Four County MOU; Addendum Three: Expression of a Commitment to Begin An Integrated Regional Water Management Planning Process Within the Counties of Butte, Colusa, Glenn, Tehama and Sutter; Addendum Four: Expression of a Commitment to Begin An Integrated Regional Water Management Planning Process Within the Counties of Butte, Colusa, Glenn, Tehama, Sutter and Shasta.**

Bill Connelly	APR 13 2010	[signature]	4.9.10
Chair, Butte County Board of Supervisors	Date	County Counsel Approved As to Form	Date

Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Colusa County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Sutter County Board of Supervisors	Date	County Counsel Approved as to Form	Date
Chair, Shasta County Board of Supervisors	4/27/10 Date	County Counsel Approved as to Form	5/6/10 Date

Chair, Glenn County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Tehama County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Colusa County Board of Supervisors	Date	County Counsel Approved As to Form	Date
Chair, Sutter County Board of Supervisors	4/20/10 Date	County Counsel Approved as to Form	4/13/10 Date
Chair, Shasta County Board of Supervisors	Date	County Counsel Approved as to Form	Date

Appendix D: Issue Resolution Process for Discussion Purposes

This document aims to guide discussions and provide pertinent information as subbasins consider inclusion of an issue resolution process in the Northern Sacramento Valley inter-basin coordination framework. These discussions will take place in the period leading up to the first five-year GSP update.

Discussion Prompts

1. *What are potential benefits/challenges or concerns of including an issue/dispute resolution process in the inter-basin coordination framework?*
2. *What are shared expectations between and among subbasins?*
3. *What are the GSAs preferences for addressing conflicts if/when they arise?*

Background

The Groundwater Sustainability Plan Regulations in Article 8 recommend including a "description of a process for identifying and resolving conflicts between Agencies" as a part of inter-basin coordination (Sections 10727.2, 10733, and 10733.2, Water Code). A recent study by Tara Moran, Janet Martinez, and William Blomquist, part of Stanford University's Water in the West found that the ability of interagency coordination "to solve complex challenges will be contingent on the ability of these organizations to effectively prevent and manage conflicts before they arise and to resolve these conflicts equitably and efficiently when they do." (Moran, Martinez, and Blomquist, 2021). Further, given how likely it is for disagreements at a local level to occur during SGMA implementation, the study suggests investing in establishing issue resolution processes before disagreements arise. Meanwhile, deferring their development could complicate the resolution process in times of conflict. Given these recommendations, consider the following questions for reflection and discussion.

Purposes of issue resolution processes

There are many options to identify and resolve issues that involve different parties, goals/objectives, and resources. Ideally, issue resolution processes are thoughtfully designed and tailored to specific contexts. **The broader goal for such a process can be to meet the agencies' long-term needs, considering local dynamics, desired outcomes, and expected uses**. Goals can include keeping things simple and efficient, maintaining relationships, ensuring quality of the process, fostering participation and community engagement, etc.

The figure below shows different types of dispute resolution processes. In some cases, agencies draft clauses that outline a tiered approach. They often begin with negotiation, which gives the parties control over the process and outcomes. Then, mediation, which brings in a neutral third-party (mediator) to facilitate the discussion and help parties work towards resolving issues. Often, negotiation and mediation lead to "non-binding" outcomes, non-enforceable by courts. Parties could opt to move towards arbitration or litigation, which are controlled by a third party (arbitrator or judge/jury) and can lead to binding and non-binding outcomes (Moran, Martinez, and Blomquist, 2019).

Figure 2. The spectrum of dispute resolution process. Modified from Amsler et al. (2020a).

Negotiation	Mediation	Arbitration	Trial
• No third party	• Third part (mediator)	• Third party (arbitrators)	• Third party (judge/jury)
• Non-binding	• Non-binding	• Non-binding or binding	• Binding

From Moran, Martinez, and Blomquist, 2019

Examples

1. Example from Moran, Martinez, and Blomquist, 2019

Box 2. A Draft Dispute Resolution Clause.

The blue text notes indicate how each of the preceding five questions are incorporated into the dispute resolution language.

In the event that any dispute [Q1: Provides instruction on what disputes can be addressed. Additional process goals, while not explicit should be subject to discussion.] arises among the Members relating to (i) this Agreement, (ii) the rights and obligations arising from this Agreement, (iii) a Member proposing to withdraw from membership in the Agency, or (iv) a Member proposing to initiate litigation within the Basin or the management of the Basin, the aggrieved Member or Members proposing to withdraw from membership shall provide written notice to the other Members of the controversy or proposal to withdraw from membership [Q2: Provides instruction on who can initiate and participate in the process.]. Within forty-five (45) days after such written notice, the Members shall attempt in good faith to resolve the controversy through informal negotiation [Q3: Describes a series of processes for dispute resolution, beginning with negotiation. Also includes a timeline for process stages.]. If the Members cannot agree upon a resolution of the controversy within forty-five (45) days from the providing of written notice specified above, the dispute shall be submitted to mediation prior to commencement of any legal action or prior to withdrawal of a Member proposing to withdraw from membership. The mediation shall be no less than a full day (unless agreed otherwise among the Members) and the cost of mediation shall be paid in equal proportion among the Members [Q4: Provides instruction on who will pay for dispute resolution processes.]. The mediator shall be either voluntarily agreed to or appointed by the Superior Court upon a suit and motion for appointment of an impartial mediator [Q3a: Provides a clear process for choosing an impartial mediator.]. Upon completion of mediation, if the controversy has not been resolved, any Member may exercise all rights to bring a legal action relating to the controversy or withdraw from membership as otherwise authorized pursuant to this Agreement. The Agency may, at its discretion, participate in mediation upon request by a stakeholder [to be defined by the parties to the Agreement] concerning a dispute alleged by the stakeholder concerning the management of the Basin or rights to extract groundwater from the Basin, with the terms of such mediation to be determined in the sole discretion of the Member Directors [Q2: Allows third-party participation in the dispute resolution process].

Note: This above dispute resolution clause is not intended to serve as an endorsement or illustration of effective practice.

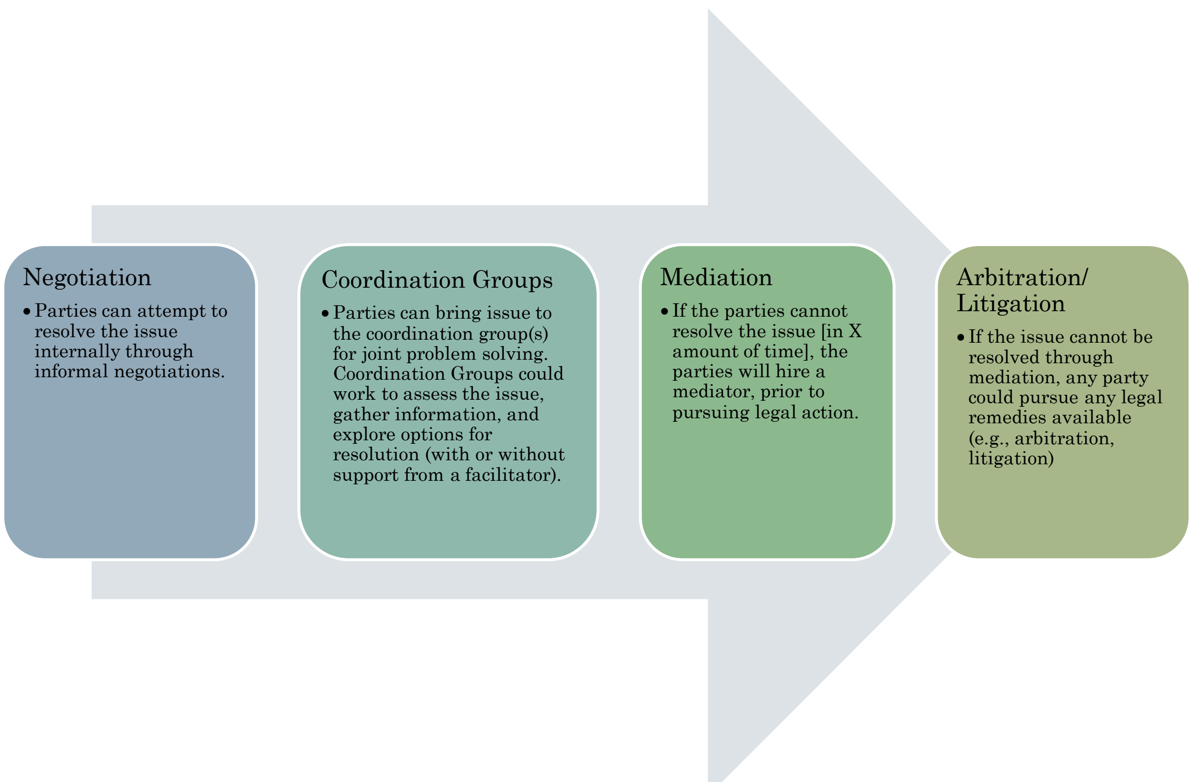
2. Example from Butte Subbasin Cooperation Agreement
Note: This example doesn't provide much specificity. However, acknowledges shared intent to resolve disputes.

ARTICLE 9. DECISION-MAKING AND DISPUTE RESOLUTION

9.1. Decision-making Authority. Topics where the Members desire coordinated decision-making will be considered by the Advisory Board, and the Member Directors will strive for unanimous recommendations that will be presented to each Member's governing body for consideration. Such topics include, but are not limited to, development and implementation of the GSP, and associated financial arrangements. When unable to reach unanimous recommendations, the Advisory Board will outline the areas in which it does not agree, providing some explanation to inform the respective GSAs' governing bodies. Despite the recommendations of the Advisory Board, ultimate decision-making authority for topics considered by the Advisory Board resides with each Member's governing body.

9.2. Dispute Resolution. It is the desire of Members to informally resolve all disputes and controversies related to this Agreement, whenever possible, at the least possible level of formality and cost. If a dispute occurs, the disputing Members shall meet and confer in an attempt to resolve the matter. If informal resolution cannot be achieved, the matter will be referred to the Advisory Board for resolution. The Advisory Board may engage the services of a trained mediator or resort to all available legal and equitable remedies to resolve disputes.

Possible Process in the Northern Sacramento Valley



Worksheet: Key Questions and Considerations for Issue Resolution Process

The questions below could be used to guide the development of a specific issue resolution process in the context of inter-basin coordination in the Northern Sacramento Valley by the first 5-year GSP update. These questions could help to clarify the level of specificity that subbasins would find beneficial and mutually agreeable when/if conflict occurs.
Adapted from Moran, Martinez, and Blomquist, 2019

1) What are the process goals? a) Consider what disputes the process aims to address – all disputes arising at basin boundaries or only a subset? b) Consider inclusivity and transparency of the process, cost efficiency for parties and the GSA(s), timeframes, and other factors important to your agency(ies). c) Other potential objectives include dispute prevention, enhanced relationships, procedural and substantive fairness, legal compliance, durability of resolution and organizational improvement.	
2) Who can initiate and participate in the dispute resolution process? a) Consider what parties can initiate the dispute resolution process – is it only parties to the agreement or can external parties invoke it? There are pros and cons to both choices, so discussing this in advance will ensure thoughtful consideration.	
3) What processes are used to make decisions related to dispute resolution and what information is necessary? a) What is the process for selecting a mediator, facilitator, lawyer or other impartial party? b) Consider including a range of processes beginning with internal negotiations and escalating based on clear timelines.	
4) Who pays for the dispute resolution process? a) Consider who will pay for the mediator, facilitator, lawyer or other impartial party. Will it be paid for by the disputing parties, the GSA(s) or through a state-funded program? b) How could you assess whether the outcome of the dispute resolution process was successful?	

Other Resources

- Dutton, A. SGMA Updates, Coordination Considerations, and Potential Next Steps, Cosumnes Subbasin Working Group. February 21, 2018. http://cosumnes.waterforum.org/wp-content/uploads/2018/02/EKI_Cosumnes_TAC_meeting_2018-02-21.pdf
- Moran T., Martinez, J., and Blomquist W. Dispute Resolution Processes: Thinking through SGMA Implementation. Water in the West. Fall, 2019. https://waterinthewest.stanford.edu/publications/dispute-resolution-processes-thinking-through-sgma-implementation
- Moran T. Basin-scale Coordination is Key to SGMA's Success: Thoughts on DWR's Draft GSP Regulations. March 1, 2016. Stanford University. Water in the West. https://waterinthewest.stanford.edu/news-events/news-press-releases/basin-scale-coordination-key-sgma%E2%80%99s-success-thoughts-dwr%E2%80%99s-draft-gsp
- Moran et al. Dispute Resolution Clauses in Interorganizational Coordination Agreements: A Comparative Analysis. 2021. pending publication.
- Butte County. 2017. Technical Collaboration on Interconnected Subbasins to Advance Sustainable Groundwater Management: Assessment of Interconnected Subbasins. Available at: https://www.buttecounty.net/wrcdocs/Reports/SpecialProjects/InterbasinGWFlow/InterbasinSBAssessment-FINAL.pdf
- Butte County. 2017. Inter-basin Groundwater Flows Fact Sheet. Available at: https://www.buttecounty.net/wrcdocs/Reports/SpecialProjects/InterbasinGWFlow/FactSheet.pdf
- Buck, Christina. 2017. Butte County Inter-Basin Groundwater Flows Presentation, https://www.buttecounty.net/wrcdocs/Reports/SpecialProjects/InterbasinGWFlow/NSVBoardAssessment20170615.pdf

Appendix 2-D

GSA Outreach Events and Interested Parties List

__**GSA Outreach Events**__

General SGMA Updates

4/4/2016	Tehama County Public Meeting	SGMA Overview
5/25/2016	Tehama County Public Meeting	SGMA Overview
6/27/2016	Tehama County Public Meeting	SGMA Overview
5/30/2017	Tehama County Public Meeting	Tehama County GSA and Current GW Conditions
8/9/2017	Tehama County Public Meeting	Tehama Co Reconnaissance Level GW Sustainability Risk Assessment
10/23/2018	Corning City Council Meeting	Tehama County GSA and Current GW Conditions
11/14/2018	Tehama County Farm Bureau Meeting	Tehama County GSA and Current GW Conditions Tehama County GSA and Current GW Conditions
4/5/2019	SGMA in the N. Sacramento Valley Forum	Tehama County GSA and Current GW Conditions
5/8/2019	Shasta Tehama Watershed Education Coalition	Tehama County GSA and Current GW Conditions
1/30/2020	Capay Land Owners Association	Tehama County GSA and Current GW Conditions

General SGMA Presentations to Community Groups

4/14/2016 – Sacramento River Discovery Center (Topic: General SGMA Overview)
9/15/2016 – Sacramento River Discovery Center (Topic: Tehama County GSA)
3/11/2020 – Tehama County Agricultural Realtor Group (Topic: General SGMA and GSA Updates, Corning Subbasin, Update on Groundwater Levels)
10/13/2020 – El Camino Irrigation District Board (Topic: General SGMA, Groundwater Levels)
3/1/2021 – Tehama County Cattlemen's Association (Topic: General SGMA Presentation)
3/17/2021 – Tehama County Farm Bureau (Topic: GSA and GSP Update)
7/13/2021 – Tehama County Board of Supervisors (General SGMA update)
7/14/2021 - Shasta Tehama Watershed Education Coalition (Topic: Current Groundwater Conditions & Progress Update on Development of GSPs)
9/15/2021 – Red Bluff Kiwanis Club Presentation (General SGMA Update)
9/21/2021 – Red Bluff Rotary (General SGMA update and GSP overview)

Tribal Presentations

6/13/2019 – Meeting with Paskenta Tribal Council (Topic: General SGMA, GSA, and GSP overview, Corning Subbasin)
4/6/2021 – Meeting with Paskenta Tribal Council (Topic: SGMA and Tribal Engagement)

Subbasin Specific Outreach Series

Oct 6, 2020 - Thomes Creek Estates Group (Red Bluff Subbasin) – SGMA and GSP Overview, next steps
Oct 14, 2020 – Antelope Subbasin – SGMA and GSP Overview, next steps
Oct 15, 2020 – Bowman Subbasin – SGMA and GSP Overview, next steps
Oct 21, 2020 – Red Bluff Subbasin – SGMA and GSP Overview, next steps
Oct 22, 2020– Los Molinos Subbasin – SGMA and GSP Overview, next steps

December 9, 2020 –All Subbasins - review of recent SGMA activities, overview of management planning areas and basin settings

April 19, 2021 - Bowman Subbasin – Plan Area and Basin Setting, SMC
April 20, 2021 - Red Bluff Subbasin – Plan Area and Basin Setting, SMC
April 21, 2021 - Antelope Subbasin – Plan Area and Basin Setting, SMC
April 22, 2021 - Los Molinos Subbasin – Plan Area and Basin Setting, SMC

Aug 17, 2021 - Bowman Subbasin – SMCs, PMAs, and Public Review Schedule
Aug 19, 2021 - Red Bluff Subbasin – SMCs, PMAs, and Public Review Schedule
Aug 23, 2021 - Antelope Subbasin – SMCs, PMAs, and Public Review Schedule
Aug 25, 2021- Los Molinos Subbasin – SMCs, PMAs, and Public Review Schedule

Quarterly eNewsletters
December 2020
March 2021
July 2021

All announcements are sent to the mailing list of the Tehama County Flood Control and Water Conservation District, Tehama County Groundwater Commission, Tehama County, and the individuals listed below:

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Shawn	Pike
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John	Leach	Greg	Long
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Eric	Willard	Bob	Williams
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Jeff	Rabo	Brad	Samuelson
John	Grennan	Cody	McCoy
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Jake	Sahl	Tia	Branton
Jim	Edwards	Harley	North
Ryan	Fulton	Darrell	Wood
Emmy	Westlake	Adam	Englehardt
Stacie	Silva	Andrew	Barron
Kari	Dodd	John	Frehse
Tyler	Christensen	Ellen	Jones
Ryan	Sale	Jim	Kerr
Claire	Taylor	Eddy	Teasdale
John	Peterson	Taylor	Wetzel
Todd	Turley	Linda	Solberg
Gib	Bonner	Robert	Rianda
Brandon	Davison	John	Edson
David	Brown	Pat	Vellines
Armando	Cervantes	Lisa	Porta
Doni	Rulofson	Charleen	Beard
Michael	Bethurem	Richa	McBrayer
Robin	Huffman	Christine	Thompson
Sam	Mudd	Fred	Hamilton

John	Veneble
Linda	Tunison
Hylon	Kauffmann
Allan	Fulton
Julie	Kelley
Les	Coke
Hal	Crain
Aimee	Zarzynski
Kim	Azevedo
Steve	Lindeman
Jim	Lowden
ryan	teubert
Bill	Hardwick
Mike	Perry
Matt	Hansen
Tamara	Williams
Aris	Babayan
Mandi	Selvester-Ownens
David	Brower
Harold	Clark
Melissa	Warner
Karin	Knorr
Bobie	Hughes
Linda	Herman
Mike	Murphy
Debi	Barnwell
Franklin	Barnes
Benjamin	Cook
Gary	Taylor
Rita	Hoofard
Melissa	Rohde
chris	payne
Shane	Overton
Codie	McKenzie
Ronald	Humphrey
Vicki	Kretsinger - Grabert
Angie	Rodriguez
Rick	Massa
Vicky	Dawley
Latisha	Miller
Johnn	Jones
Dale	Arthur
Jim	Simon
Michelle	Dooley
Becky	Gruenwald
Brendon	Flynn

John and Mary	Rochfort
Eric and Jenny	Alexander
Larry and Donna	Frew
Danny and Terrie	Rice
John and Linda	Pitter
Dave and Darlene	Yingst
Roberto and Lisa	Cruz
Mike and Patricia	Schager
Anderson	Cottonwood Irrigation District

Appendix 2-E

Comments on the Plan

Bowman Subbasin Groundwater Sustainability Plan
Public Draft Comments Received with Responses

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
Martha Slack Groundwater Commission	4-3	5		Line 6 of last paragraph- "take 0.125 MGD during dry season and up to 1MG during wet season"	LSCE	Comment noted. Text revised.
Martha Slack Groundwater Commission	4.5.3.6	70	Table 4-36	Will this groundwater snapshot include any isotope studies to try to determine the age of the lower aquifer.	LSCE	Comment noted. Isotopes will not be analyzed.
Dean Sherrill Rio Alto Water District	4.8.1	74	Table 4-38	How does this figure of 627,000 acre-feet relate to those in table 4-38?	LSCE	Comment noted. Values in Table 4-38 are for the entire Sacramento Valley, and the contribution of Cottonwood Creek is extremely small.
Martha Slack Groundwater Commission	4-3	79		Where will the proposed diversion occur?	LSCE	Comment noted. Diversion point is not finalized. A feasibility study should be conducted prior to implementing the project.
Martha Slack Groundwater Commission	5.1.2	5-5	5-2	The sentence before the tables says "dot for monitoring in the Bowman Subbasin is $104,000 as displayed by Table 5-2. The previous admin totals represented the entire annual admin costs for GSP. Then 5-3 $'s are for entire GSP and culminating in chart 5-4 which is comparing total GSP admin costs with Bowman monitoring costs. Very confusing? Chapter should either total per basin or per total plan.	LSCE	All tables represent GSA costs for all subbasins. Text clarified within chapter.
Robin Huffman Corning, CA				Public participation has appeared very low overall. Groundwater is as invisible as the greenhouse gasses in the air, measurable only by experts with sufficient equipment. Potable water, like breathable air, is a necessity for life, and we're expecting, even trusting our elected officials and the expert contractors to look out for us, the general public. As the song goes, "You never miss the water, till the well runs dry". In the plan, specify and acknowledge the level of public participation so far, outside of elected officials and their appointees to committees and outside of special interests such as Farm Bureau officials. Somewhere in the GSPs, specify, or estimate, the amount of participation to date by individuals not appointed or paid by any agency to participate	LSCE	Comment noted. Public participation is discussed within Appendix 2-A.
Robin Huffman Corning, CA				The GSP contractors have explained, during public presentations, that the possibility of correct analysis of groundwater is only as good as the available data. The experts	LSCE	Comment noted. The GSP recognizes data gaps and future efforts will be made by the GSA to fill those gaps including the installation of multi-completion wells through the TSS program.

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
				acknowledge in meetings that crucial groundwater data is missing. Data is especially missing for the very areas where the growth in agricultural pumping is occurring, and yet there is no stopping growth in these areas, mainly west of I-5. Big ag has discovered Tehama County at the very time that they have developed ways to grow nut trees in the hot and dry grasslands on the west side of I-5. Add to the plan that big ag needs to establish and pay for the monitoring of groundwater data wherever a new orchard of a defined size is established. Define such a size that would require the developer to establish a groundwater monitoring station that provides data available to the public.		
Robin Huffman Corning, CA				There is no definition of big ag in the plan. It would be helpful to make the distinction because of the massive size of the industry establishing itself the county, much occurring before this plan is adopted. There is no established precedent in the plan as to the management of overconsumption. The last should be the first to be asked to stop pumping, but it should apply only to big ag because of the scale of their extraction of groundwater	LSCE	Comment noted. Agriculture users are defined among all the water users. The plan was written to avoid undesirable results and have groundwater sustainability.
Robin Huffman Corning, CA				Add whatever you can to make this plan more sustainable before its adoption, but adopt the GSPs because they are adaptable.	LSCE	Comment noted.
Robin Huffman Corning, CA				I understand the need for GSPs and appreciate the process; however, unless the plan becomes more rigorous than it appears in this first complete draft, big ag will continue to expand and extract more groundwater, getting us all farther from sustainability and costing us each a lot to pay for executing the plan. Additionally, more families will have to pay for new and deeper residential wells because this plan allows big ag to continue to expand for awhile. This allowable decline, negotiated in ad hoc committees, is specified in the plan, and that makes the plan unsustainable as well as expensive. This version of the GSP, therefore, is a GUP, a Groundwater Unsustainability Plan	LSCE	Comment noted.
Robin Huffman Corning, CA				Depending on grants as mitigation for allowing overexploitation of the groundwater is not a plan for sustainability. Even if every family having to dig a deeper well were paid for the cost of that well, whether by big ag or the State of California, that condition would not lead to sustainability. Mitigation is not a plan for sustainability.	LSCE	Comment noted.

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
Robin Huffman Corning, CA				The baseline established in the GSP is lower than the current groundwater level. To allow the groundwater to continue to decline is not in the direction of sustainability. Sustainability at this point means stopping the decline, at the very least, and not allowing additional decline. Measurement levels are complicated by drought, and drought is given exception for management action. The drought exception is problematic and should be omitted in the GSPs	LSCE	Comment noted. Sustainability is defined in the GSP and measured through different Sustainable Management Criteria (SMC) including groundwater levels.
Robin Huffman Corning, CA				There should be a definition of sustainability in the plan using recent academic sources. The GSP should open with a discussion of what sustainability is. We can hope that future generations can access [groundwater] resources as we can, which is one early definition of sustainability. The concept of sustainability came out of efforts to continue development, to allow continued growth despite increasingly obvious limits to growth. Since then, many scholars recognize the greenwashing that comes with sustainability plans that facilitate growth. This is one such plan. Include a definition of sustainability using recent academic sources. Collaborate with authors and educators with expertise on sustainability, and do not assume sustainability needs little definition or discussion in individual GSPs. Most people have no idea of what sustainability means.	LSCE	Comment noted. Sustainability is defined on page 1-5.
Robin Huffman Corning, CA				Any process which lets big ag continue to usurp groundwater, allowing the groundwater to continue to decline to some level below the current level and call it sustainable is unsustainable. This seemingly well intended process is unlikely to produce real sustainability in groundwater use because it does not stop the current expansion of big ag wells. The GSP needs to be specifically involved in the county's well permitting process. Add this requirement to the plans	LSCE	Comment noted. Well permitting will be addressed by the Tehama County Water Commission in the future. The GSP only includes information available at the time. Review of County Well Permitting Ordinances is one of the management actions.
Robin Huffman Corning, CA				Knowing that too many current domestic wells went dry recently, knowing the groundwater levels have been declining, drought or not, because of big ag's already drawing the deep aquifer down, the authors of the GSP include more drawing down of the deep aquifer. There are currently over 50 ag well permits approved and not yet built, many likely for new orchards (the department approving the permits does not track the particular use other than "ag"). When the new orchards are	LSCE	Comments noted.

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
				established and start pumping, the groundwater will be sucked in mass quantity to water dry rangeland in the hot season, which is most of the year, to water trees which will die without regular and consistent watering. They must be irrigated, so there is no way to pause the pumping without losing the orchard. Big ag will not submit easily to their trees dying when the county gave them permit to draw water for their massive acreage of trees. This plan is not sustainable as it does not stop the expansion of big ag into dry areas of the county. There's no designation of inappropriate land use. There are no ideas specified about zoning changes needed to reach sustainability. Instead, the plan identifies the remaining creek beds and the total acreage which might yet be exploited by big ag. It's like an invitation, with a free study of where the water is, for big ag to buy rangeland and request well permits to grow nut trees. This GSP is literally a publicly funded study by a well drilling corporation seeking out where the groundwater is and how much might remain accessible to big ag. The plan does not define big ag. It does not require monitoring wells before big ag permits are granted in areas with no data. The only thing the GSP does is to establish the term sustainability, under-defined, and cost average residents lots of money while continuing to allow big ag to do whatever they want. If the Farm Bureau does not protest too much about this GSP, then we do not have a plan which could possibly get us to sustainability. The GSP, however well intended, needs to start with recommending the county instating specific restrictions and rules for new development. The plan needs to include the legality of such rules and restrictions. California has planning tools and court rulings which need to be included in the GSPs for reference by the Board of Supervisors as they must implement management actions, according to the GSPs		
Robin Huffman Corning, CA				Sometimes common sense must take over to get to sustainability because by the time that the groundwater is fully understood, it will be too late. What is generally known about the deep aquifers is that they are a gift from the last ice age; this theory, supported by academic sources, should be included in the GSPs. Nature's systems cost us nothing until we take too much. Grants for projects to clean and try to inject water into the ground are funded by debt to which we all have to pay service. There is no such thing as free money for projects. Acknowledge in the GSPs that slowing or stopping growth is the cheapest way in the direction of sustainability, and probably the only way.	LSCE	Comment noted.

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
Robin Huffman Corning, CA				Management actions should include policies, in addition to any projects. There should be recommended policies since the county's groundwater is already in decline in large areas. We cannot get to sustainability via projects alone, not to mention that projects are expensive, no matter which budget they come from. Rules, such as no more growth in the acreage of orchards, is the way to sustainability, or at least to not crashing quite as soon. Projects, such as injecting water into the ground, if possible, would be expensive, and it would be a public expense unless the agency starts collecting money for the possible projects now. The expense for future projects, needed when the groundwater declines to the unacceptable level specified in the GSPs, should be collected now from companies extracting the groundwater for profit. State that in the GSPs as a recommended management action. Fairness needs to be indicated as a working principle in the GSPs. The companies who profit directly from the mass extraction of groundwater should be the ones who pay for restoring the groundwater to a sustainable level as defined in the GSPs Management Objectives.	LSCE	Comment noted. Management actions are distinct from projects as they are designed to affect water use (behavior) compared to physical projects that require construction. Management actions can be policies.
Robin Huffman Corning, CA				The commons is a shared resource, such as groundwater. Include a discussion of the tragedy of the commons, since the GSPs are trying to prevent that.	LSCE	Comment noted.
Robin Huffman Corning, CA				Setting the MT so low means many wells will fail, due to a combination of factors, such as extended drought, a general drawdown of the groundwater in most areas over the past few decades, and new ag wells supporting new orchards. Recommended management actions should include compensation for the loss of domestic wells and the cost of digging new or deeper domestic wells, adding individual domestic water tanks, and delivering water to homes in rural areas where wells have gone dry due to unsustainable groundwater pumping.	LSCE	Comments noted. One of the management actions in the GSP is Well Deepening or Replacement Program.
Robin Huffman Corning, CA				Mitigation measures may be used to imitate sustainability, but where they cost residents not profiting from the extraction of mass quantities of groundwater for profit, a policy of fairness should be specified in the GSPs in the Management Objectives and Management Actions. Consistently recognize in specific recommended policies and actions that social equity is a major leg on which sustainability stands.	LSCE	Comments noted.

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
Robin Huffman Corning, CA				The GSPs plan to continue to draw down the water table. The Minimum Threshold is set lower than the depths of most domestic wells, with no recommendation or policy, save hoping for the drought to end, to restore the groundwater level. State the intention to limit additional industrial agricultural wells because there is no place with consistent extra water that we can afford to pipeline in; that's why we're doing groundwater sustainability planning. We cannot afford expensive projects to deepen domestic wells, build more above ground storage; every project takes money. What doesn't take money is to limit new wells. Keep the range lands for grazing with every policy recommendation and planning tool available in California. State the tools available. Keep orchards where they have surface water availability, using groundwater only during droughts. It's that simple to become more sustainable. Sustainability is about balance; it's not about drawing down the water table until Undesirable Results occur. URs are already occurring. We're at the threshold of what's minimal. Our objective should not be to make domestic wells deeper, as recommended by the Farm Bureau. Digging and pumping from deeper depths is expensive. That's an undesirable result of too much agricultural development coupled with extended drought and overall overgrowth of California. Getting to sustainability starts with no growth in industrial wells. Sustainability is about balance between economic, environmental, and equity - profit, planet, and people. There's an energy component as well, as energy costs money and affects all three Es (or Ps). More engineering is costly, and even with grants, that doesn't get us to sustainability or provide a drop of water that isn't already spoken for. Nature works for free, and she knows what she is doing. We need to get out of the way, and she will replenish our groundwater, our streams and rivers. Regenerative agriculture can help pivot methods so that less water is required. Recommend regenerative agriculture as a management tool.	LSCE	Comments noted.
Robin Huffman Corning, CA				In the GSPs, define the unacceptable consequences, the indicators of groundwater unsustainability. It is unacceptable to have domestic wells lose water due to groundwater decline from industrial pumping. Recognize that it is nearly impossible to prove that is happening to a specific resident because of a specific ag well, and that the onus currently is on the owner of the domestic well to prove. This is unfair and needs to be addressed in the GSPs. It is unacceptable to deplete the groundwater such that we lose what natural oaks remain. Nature needs more water than it's	LSCE	Comments noted.

Commenter Name	Section/ Subsection Number	Page Number	Figure/ Table Number (if applicable)	Comment	Name of Consultant Team Comment Responder	Consultant Team Response
				getting now due to the extensive extraction of groundwater. A sustainable plan would restore water for the ecosystem. Add recommendations for restoring groundwater in areas that are known to be, or are likely to be in decline. It is unacceptable to create losing streams. A sustainable groundwater management plan should restore flows in creeks, not allow continued big ag development alongside creeks. Add policy and management recommendations regarding losing streams. It is acceptable to not allow new industrial scale ag wells for water intensive perennial crops like almonds. Banning that kind of well is a relatively simple and inexpensive step towards managing groundwater that we can take now, so that we can continue living here. No one I know wants to be displaced because of almonds. The system will certainly not recover with additional wounds. Address this issue as a policy and management recommendation in the GSPs.		

November 12, 2021

From: Robin Huffman, Corning, California

The following comments are for the Red Bluff GSP, in which I live, and all Tehama County GSPs to which these comments apply. Most of the comments apply to all the GSPs. I submit that most of these comments should be addressed in all of the GSPs. The authors of the GSPs know, or can find, where in the GSPs to address the comments, and so while the following comments are general and not systematic, chapter to chapter, the formal responses should be specific to pages in applicable chapters. I am not paid to look up page numbers, even as I have much experience doing so. I cannot apologize for not putting in more time for free; nevertheless, I am participating for good reason. I look forward to reading the responses.

I am a general member of the public, a resident of Tehama County with a domestic well that is relatively deep and declining to a concerning level. Hundreds of acres of rangeland around me have, in the past two years, been converted to nut trees, and more big acreage orchards are being developed out here on the west side of I-5. I have been following the GSP process for a couple of years, and I have participated in some of the meetings, mostly listening.

Comments for the Tehama County GSPs

1. Public participation has appeared very low overall. Groundwater is as invisible as the greenhouse gasses in the air, measurable only by experts with sufficient equipment. Potable water, like breathable air, is a necessity for life, and we're expecting, even trusting our elected officials and the expert contractors to look out for us, the general public. As the song goes, "You never miss the water, till the well runs dry". In the plan, specify and acknowledge the level of public participation so far, outside of elected officials and their appointees to committees and outside of special interests such as Farm Bureau officials. Somewhere in the GSPs, specify, or estimate, the amount of participation to date by individuals not appointed or paid by any agency to participate.

2. The GSP contractors have explained, during public presentations, that the possibility of correct analysis of groundwater is only as good as the available data. The experts acknowledge in meetings that crucial groundwater data is missing. Data is especially missing for the very areas where the growth in agricultural pumping is occurring, and yet there is no stopping growth in these areas, mainly west of I-5. Big ag has discovered Tehama County at the very time that they have developed ways to grow nut trees in the hot and dry grasslands on the west side of I-5. Add to the plan that big ag needs to establish and pay for the monitoring of groundwater data wherever a new orchard of a defined size is established. Define such a size that would require the developer to establish a groundwater monitoring station that provides data available to the public.

3. There is no definition of big ag in the plan. It would be helpful to make the distinction because of the massive size of the industry establishing itself the county, much occurring before this plan is adopted. There is no established precedent in the plan as to the management of overconsumption. The last should be the first to be asked to stop pumping, but it should apply only to big ag because of the scale of their extraction of groundwater.

4. Add whatever you can to make this plan more sustainable before its adoption, but adopt the GSPs because they are adaptable.

5. I understand the need for GSPs and appreciate the process; however, unless the plan becomes more rigorous than it appears in this first complete draft, big ag will continue to expand and extract more groundwater, getting us all farther from sustainability and costing us each a lot to pay for executing the plan. Additionally, more families will have to pay for new and deeper residential wells because this plan allows big ag to continue to expand for awhile. This allowable decline, negotiated in ad hoc committees, is specified in the plan, and that makes the plan unsustainable as well as expensive. This version of the GSP, therefore, is a GUP, a Groundwater Unsustainability Plan.

6. Depending on grants as mitigation for allowing overexploitation of the groundwater is not a plan for sustainability. Even if every family having to dig a deeper well were paid for the cost of that well, whether by big ag or the State of California, that condition would not lead to sustainability. Mitigation is not a plan for sustainability.

7. The baseline established in the GSP is lower than the current groundwater level. To allow the groundwater to continue to decline is not in the direction of sustainability. Sustainability at this point means stopping the decline, at the very least, and not allowing additional decline. Measurement levels are complicated by drought, and drought is given exception for management action. The drought exception is problematic and should be omitted in the GSPs.

8. There should be a definition of sustainability in the plan using recent academic sources. The GSP should open with a discussion of what sustainability is. We can hope that future generations can access [groundwater] resources as we can, which is one early definition of sustainability. The concept of sustainability came out of efforts to continue development, to allow continued growth despite increasingly obvious limits to growth. Since then, many scholars recognize the greenwashing that comes with sustainability plans that facilitate growth. This is one such plan. Include a definition of sustainability using recent academic sources. Collaborate with authors and educators with expertise on sustainability, and do not assume sustainability needs little definition or discussion in individual GSPs. Most people have no idea of what sustainability means.

9. Any process which lets big ag continue to usurp groundwater, allowing the groundwater to continue to decline to some level below the current level and call it

sustainable is unsustainable. This seemingly well intended process is unlikely to produce real sustainability in groundwater use because it does not stop the current expansion of big ag wells. The GSP needs to be specifically involved in the county's well permitting process. Add this requirement to the plans.

10. Knowing that too many current domestic wells went dry recently, knowing the groundwater levels have been declining, drought or not, because of big ag's already drawing the deep aquifer down, the authors of the GSP include more drawing down of the deep aquifer. There are currently over 50 ag well permits approved and not yet built, many likely for new orchards (the department approving the permits does not track the particular use other than "ag"). When the new orchards are established and start pumping, the groundwater will be sucked in mass quantity to water dry rangeland in the hot season, which is most of the year, to water trees which will die without regular and consistent watering. They must be irrigated, so there is no way to pause the pumping without losing the orchard. Big ag will not submit easily to their trees dying when the county gave them permit to draw water for their massive acreage of trees. This plan is not sustainable as it does not stop the expansion of big ag into dry areas of the county. There's no designation of inappropriate land use. There are no ideas specified about zoning changes needed to reach sustainability. Instead, the plan identifies the remaining creek beds and the total acreage which might yet be exploited by big ag. It's like an invitation, with a free study of where the water is, for big ag to buy rangeland and request well permits to grow nut trees. This GSP is literally a publicly funded study by a well drilling corporation seeking out where the groundwater is and how much might remain accessible to big ag. The plan does not define big ag. It does not require monitoring wells before big ag permits are granted in areas with no data. The only thing the GSP does is to establish the term sustainability, under-defined, and cost average residents lots of money while continuing to allow big ag to do whatever they want. If the Farm Bureau does not protest too much about this GSP, then we do not have a plan which could possibly get us to sustainability. The GSP, however well intended, needs to start with recommending the county instating specific restrictions and rules for new development. The plan needs to include the legality of such rules and restrictions. California has planning tools and court rulings which need to be included in the GSPs for reference by the Board of Supervisors as they must implement management actions, according to the GSPs.

11. Sometimes common sense must take over to get to sustainability because by the time that the groundwater is fully understood, it will be too late. What is generally known about the deep aquifers is that they are a gift from the last ice age; this theory, supported by academic sources, should be included in the GSPs. Nature's systems cost us nothing until we take too much. Grants for projects to clean and try to inject water into the ground are funded by debt to which we all have to pay service. There is no such thing as free money for projects. Acknowledge in the GSPs that slowing or stopping growth is the cheapest way in the direction of sustainability, and probably the only way.

12. Management actions should include policies, in addition to any projects. There should be recommended policies since the county's groundwater is already in decline in large areas. We cannot get to sustainability via projects alone, not to mention that projects are expensive, no matter which budget they come from. Rules, such as no more growth in the acreage of orchards, is the way to sustainability, or at least to not crashing quite as soon. Projects, such as injecting water into the ground, if possible, would be expensive, and it would be a public expense unless the agency starts collecting money for the possible projects now. The expense for future projects, needed when the groundwater declines to the unacceptable level specified in the GSPs, should be collected now from companies extracting the groundwater for profit. State that in the GSPs as a recommended management action. Fairness needs to be indicated as a working principle in the GSPs. The companies who profit directly from the mass extraction of groundwater should be the ones who pay for restoring the groundwater to a sustainable level as defined in the GSPs Management Objectives.

13. The commons is a shared resource, such as groundwater. Include a discussion of the tragedy of the commons, since the GSPs are trying to prevent that.

14. Setting the MT so low means many wells will fail, due to a combination of factors, such as extended drought, a general drawdown of the groundwater in most areas over the past few decades, and new ag wells supporting new orchards. Recommended management actions should include compensation for the loss of domestic wells and the cost of digging new or deeper domestic wells, adding individual domestic water tanks, and delivering water to homes in rural areas where wells have gone dry due to unsustainable groundwater pumping.

15. Mitigation measures may be used to imitate sustainability, but where they cost residents not profiting from the extraction of mass quantities of groundwater for profit, a policy of fairness should be specified in the GSPs in the Management Objectives and Management Actions. Consistently recognize in specific recommended policies and actions that social equity is a major leg on which sustainability stands.

16. The GSPs plan to continue to draw down the water table. The Minimum Threshold is set lower than the depths of most domestic wells, with no recommendation or policy, save hoping for the drought to end, to restore the groundwater level. State the intention to limit additional industrial agricultural wells because there is no place with consistent extra water that we can afford to pipeline in; that's why we're doing groundwater sustainability planning. We cannot afford expensive projects to deepen domestic wells, build more above ground storage; every project takes money. What doesn't take money is to limit new wells. Keep the range lands for grazing with every policy recommendation and planning tool available in California. State the tools available. Keep orchards where they have surface water availability, using groundwater only during droughts. It's that simple to become more sustainable. Sustainability is about balance; it's not about drawing down the water table until

Undesirable Results occur. URs are already occurring. We're at the threshold of what's minimal. Our objective should not be to make domestic wells deeper, as recommended by the Farm Bureau. Digging and pumping from deeper depths is expensive. That's an undesirable result of too much agricultural development coupled with extended drought and overall overgrowth of California. Getting to sustainability starts with no growth in industrial wells. Sustainability is about balance between economic, environmental, and equity - profit, planet, and people. There's an energy component as well, as energy costs money and affects all three Es (or Ps). More engineering is costly, and even with grants, that doesn't get us to sustainability or provide a drop of water that isn't already spoken for. Nature works for free, and she knows what she is doing. We need to get out of the way, and she will replenish our groundwater, our streams and rivers. Regenerative agriculture can help pivot methods so that less water is required. Recommend regenerative agriculture as a management tool.

17. In the GSPs, define the unacceptable consequences, the indicators of groundwater unsustainability.

    - It is unacceptable to have domestic wells lose water due to groundwater decline from industrial pumping. Recognize that it is nearly impossible to prove that is happening to a specific resident because of a specific ag well, and that the onus currently is on the owner of the domestic well to prove. This is unfair and needs to be addressed in the GSPs.

    - It is unacceptable to deplete the groundwater such that we lose what natural oaks remain. Nature needs more water than it's getting now due to the extensive extraction of groundwater. A sustainable plan would restore water for the ecosystem. Add recommendations for restoring groundwater in areas that are known to be, or are likely to be in decline.

    - It is unacceptable to create losing streams. A sustainable groundwater management plan should restore flows in creeks, not allow continued big ag development alongside creeks. Add policy and management recommendations regarding losing streams.

    - It is acceptable to not allow new industrial scale ag wells for water intensive perennial crops like almonds. Banning that kind of well is a relatively simple and inexpensive step towards managing groundwater that we can take now, so that we can continue living here. No one I know wants to be displaced because of almonds. The system will certainly not recover with additional wounds. Address this issue as a policy and management recommendation in the GSPs.

Thank you in advance for addressing the points made in this comment letter. I look forward to reading the responses.

FW: Comments on Bowman Chapters 4 & 5.

1 message

Eddy Teasdale <eteasdale@lsce.com>
To: Stephanie Horii <shorii@cbi.org>
Cc: Nichole Bethurem <nbethurem@tcpw.ca.gov>

Mon, Oct 4, 2021 at 8:07 AM

Steph –Can you be the gate keeper for GSP comments?

Thanks,

From: Martha Slack <mslack56@sbcglobal.net>
Sent: Thursday, September 30, 2021 2:57 PM
To: Eddy Teasdale <eteasdale@lsce.com>; Nichole Bethurem <nbethurem@tcpw.ca.gov>
Subject: Comments on Bowman Chapters 4 & 5.

Attached are my comments on Chapters 4 & 5 for Bowman Subbasin.

Martha Slack

General Manager

Rio Alto Water District

Tehama-Subbasins-GSP-Public-Review-Draft-Comment_TEMPLATE.xlsx
41K

Tehama Subbasin Public Draft GSP
Comments on Chapter 4: PROJECTS AND MANAGEMENT ACTIONS (PMAs)

Comment Number	Page	Subsection	Table	Figure	Date	Commenter/Affiliation	Comment
1	5	4-3			9/30/2021	Martha Slack/Groundwater Commission	Line 6 of last paragraph- "take 0.125 MGD during dry season and up to 1MG during wet season"
2	70	4.5.3.6	4-36		9/30/2021	Martha Slack/Groundwater Commission	Will this groundwater snapshot include any isotope studies to try to determine the age of the lower acquifer.
3	74	4.8.1	4-38		9/30/2021	Dean Sherrill/ Rio Alto Water District	How does this figure of 627,000 acre-feet relate to those in table 4-38?
4	79	4-3			9/30/2021	Martha Slack/Ground Water Commission	Where will the proposed diversion occur?

Tehama Subbasin Public Draft GSP
Comments on Chapter 5: PLAN IMPLEMENTATION

Comment Number	Page	Subsection	Table	Figure	Date	Commenter/Affiliation	Comment
1	5-5	5.1.2	5-2		9/30/2021	Martha Slack/Groundwater Commission	The sentence before the tables says "dot for monitoring in the Bowman Subbasin is $104,000 as displayed by Table 5-2. The previous admin totals represented the entire annual admin costs for GSP. Then 5-3 $'s are for entire GSP and culminating in chart 5-4 which is comparing total GSP admin costs with Bowman monitoring costs. Very confusing? Chapter should either total per basin or per total plan.

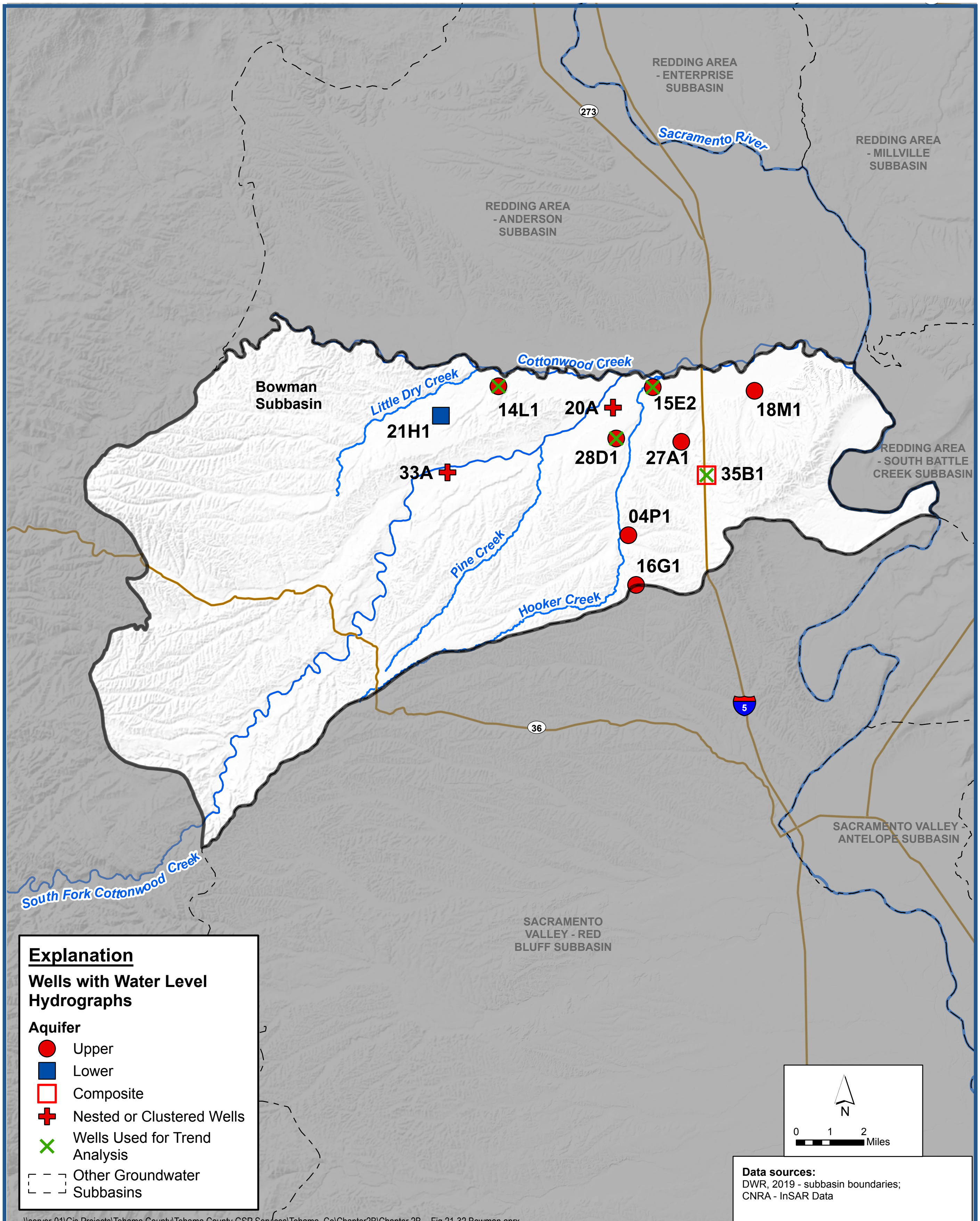
Appendix 2-F

Hydrograph Well Locations, Hydrographs, and Groundwater Level Trend Statistics

Appendix 2-F

Hydrograph Well Locations, Hydrographs, and Groundwater Level Trend Statistics

Bowman Subbasin



TEHAMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LSCE Team

Locations of Wells with Long-Term Water Level Data

Groundwater Sustainability Plan
Bowman Subbasin

Figure 1

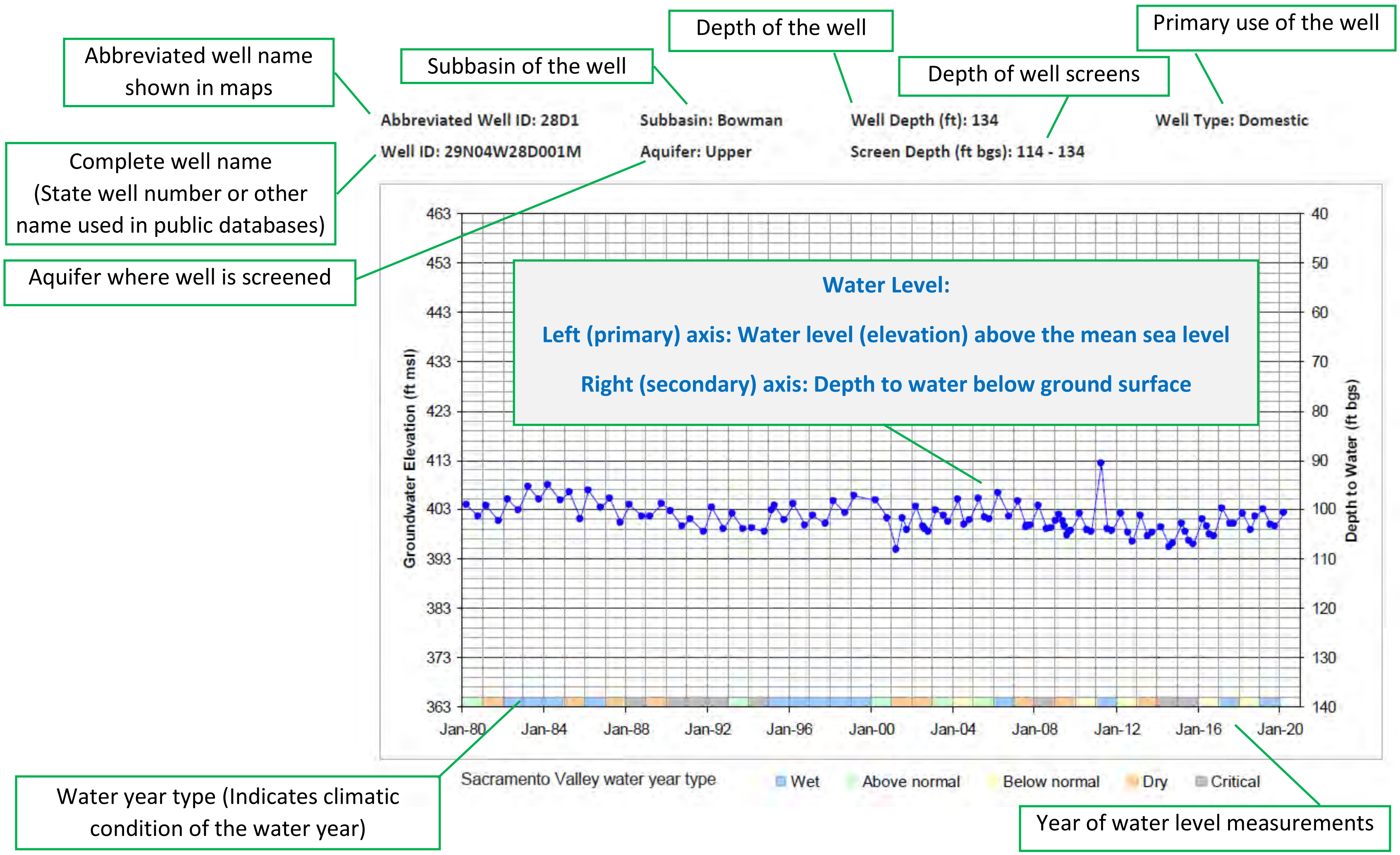
Hydrographs of Wells with Water Level Data for
1990-2018 Period

Table A1 - Trends of Groundwater Level Change from 1990 to 2018

Abbreviated Well Name	Well Name	Well Depth (ft)	Screen Interval (ft bgs)	Aquifer	Number of Seasonal High (Spring) Measurements from 1990 to 2018	Parametric Method (OLSR)			Non-parametric Methods	
						Regression of Water Level Change (ft/year)	R^2	p value	Mann-Kendall Test	Theil-Sen Slope (ft/year)
14L1	29N05W14L001M	130	110 - 130	Upper	23	-0.22	0.29	0.01	Statistically significant decreasing trend	-0.27
15E2	29N04W15E002M	90	NA	Upper	26	0.00	0.00	0.94	Insufficient evidence to identify a significant trend	0.03
28D1	29N04W28D001M	134	114 - 134	Upper	26	-0.03	0.01	0.61	Insufficient evidence to identify a significant trend	-0.04
35B1	29N04W35B001M	759	130 - 759	Composite	26	-0.01	0.00	0.86	Insufficient evidence to identify a significant trend	-0.01

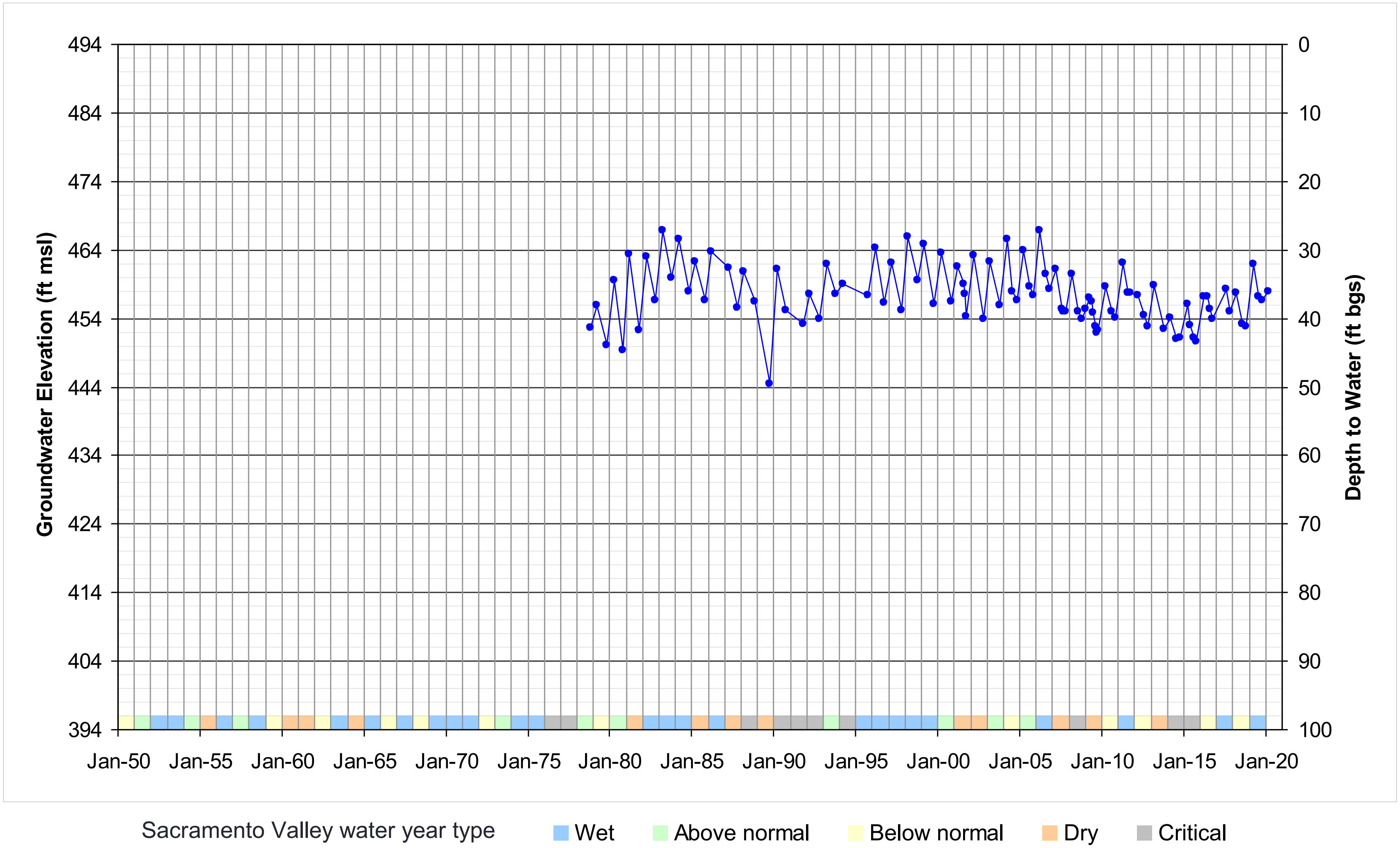
Hydrographs of wells used for groundwater level trend analysis

Water Level Hydrograph: Shows water level change over time



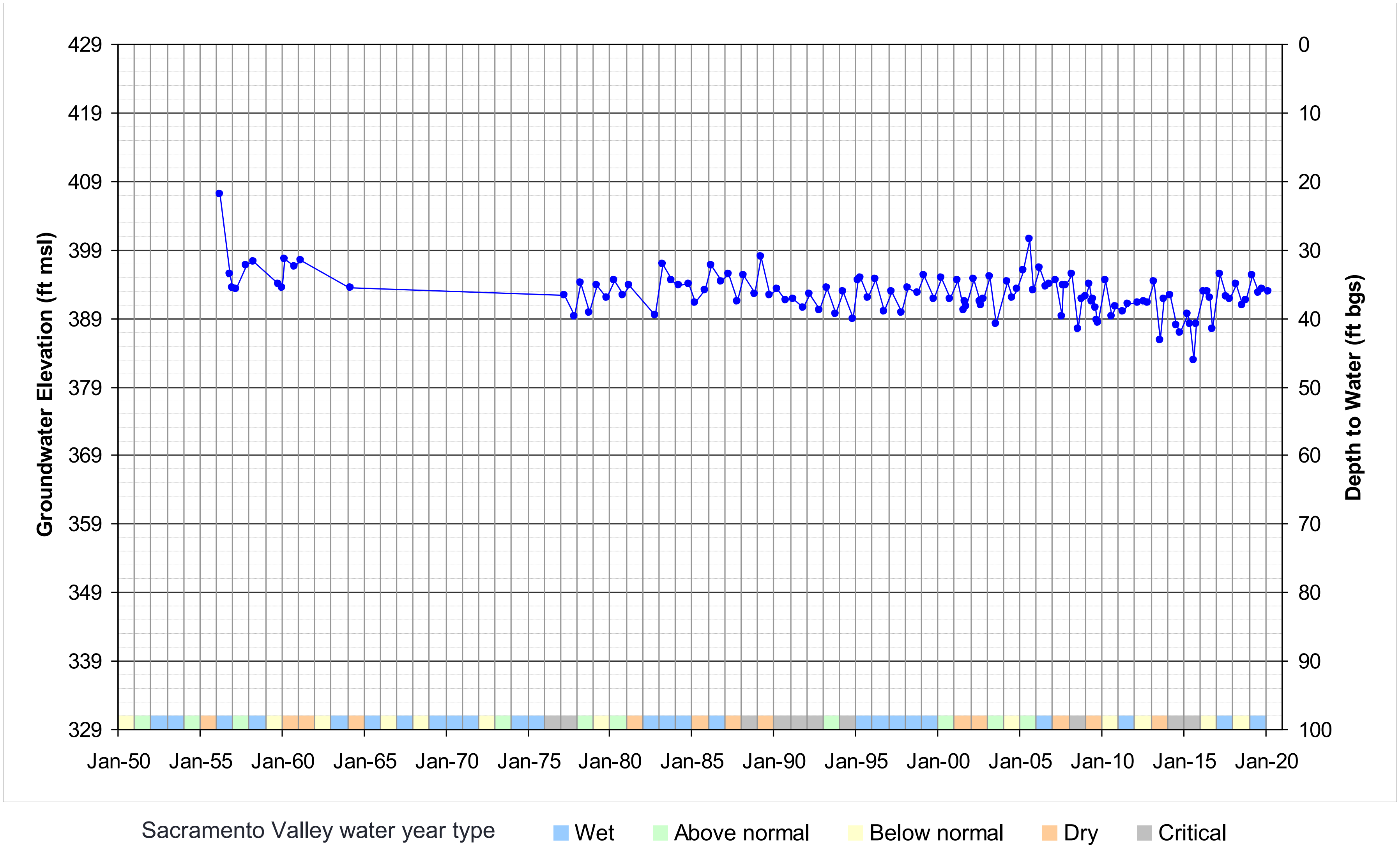
Abbreviated Well Name: 14L1 **Subbasin: Bowman** **Well Depth (ft): 130** **Well Type: Domestic**

Well Name: 29N05W14L001M **Aquifer: Upper** **Screen Depth (ft bgs): 110 - 130**



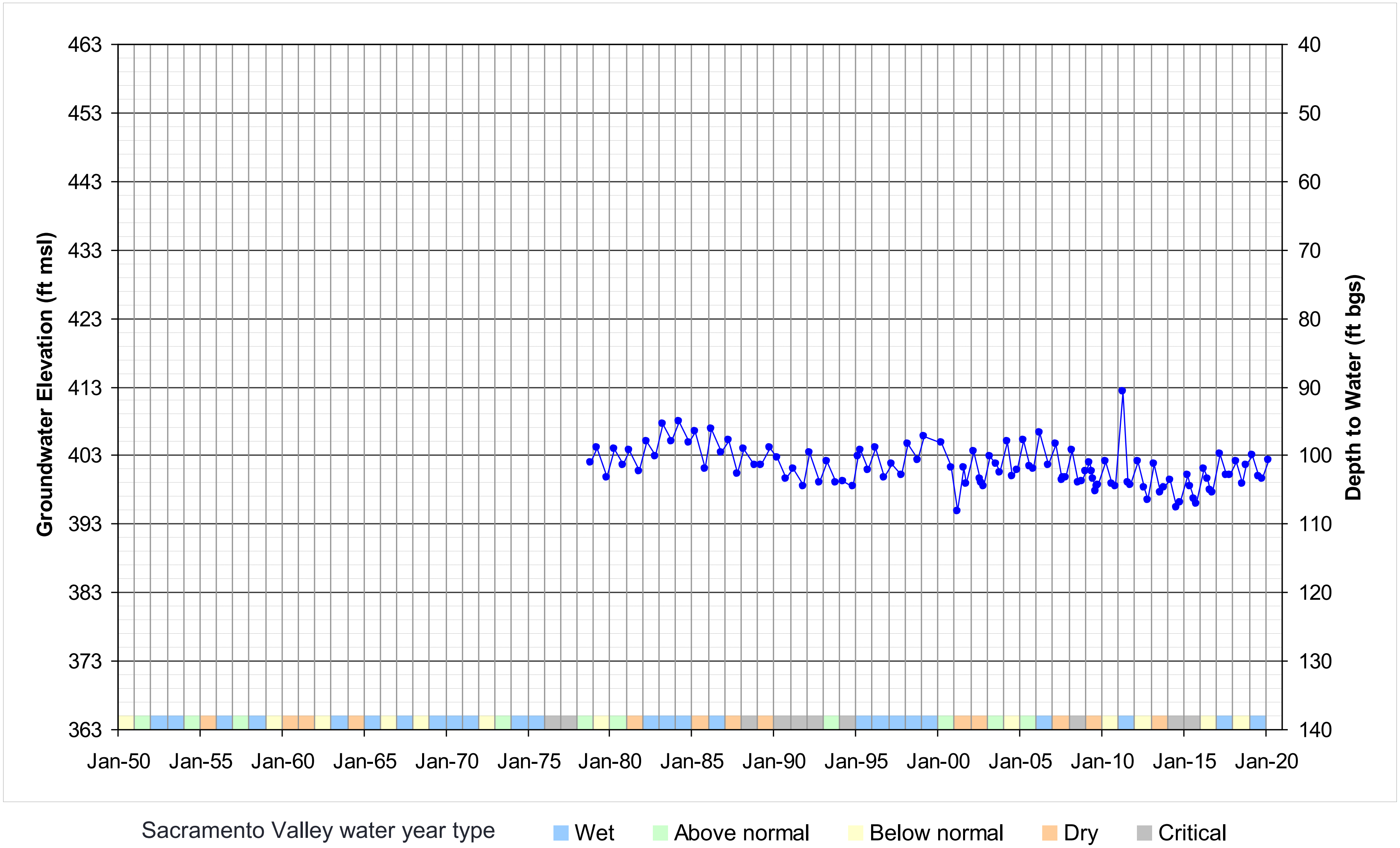
Abbreviated Well Name: 15E2 **Subbasin: Bowman** **Well Depth (ft): 90** **Well Type: Irrigation**

Well Name: 29N04W15E002M **Aquifer: Upper** **Screen Depth (ft bgs): N/A**



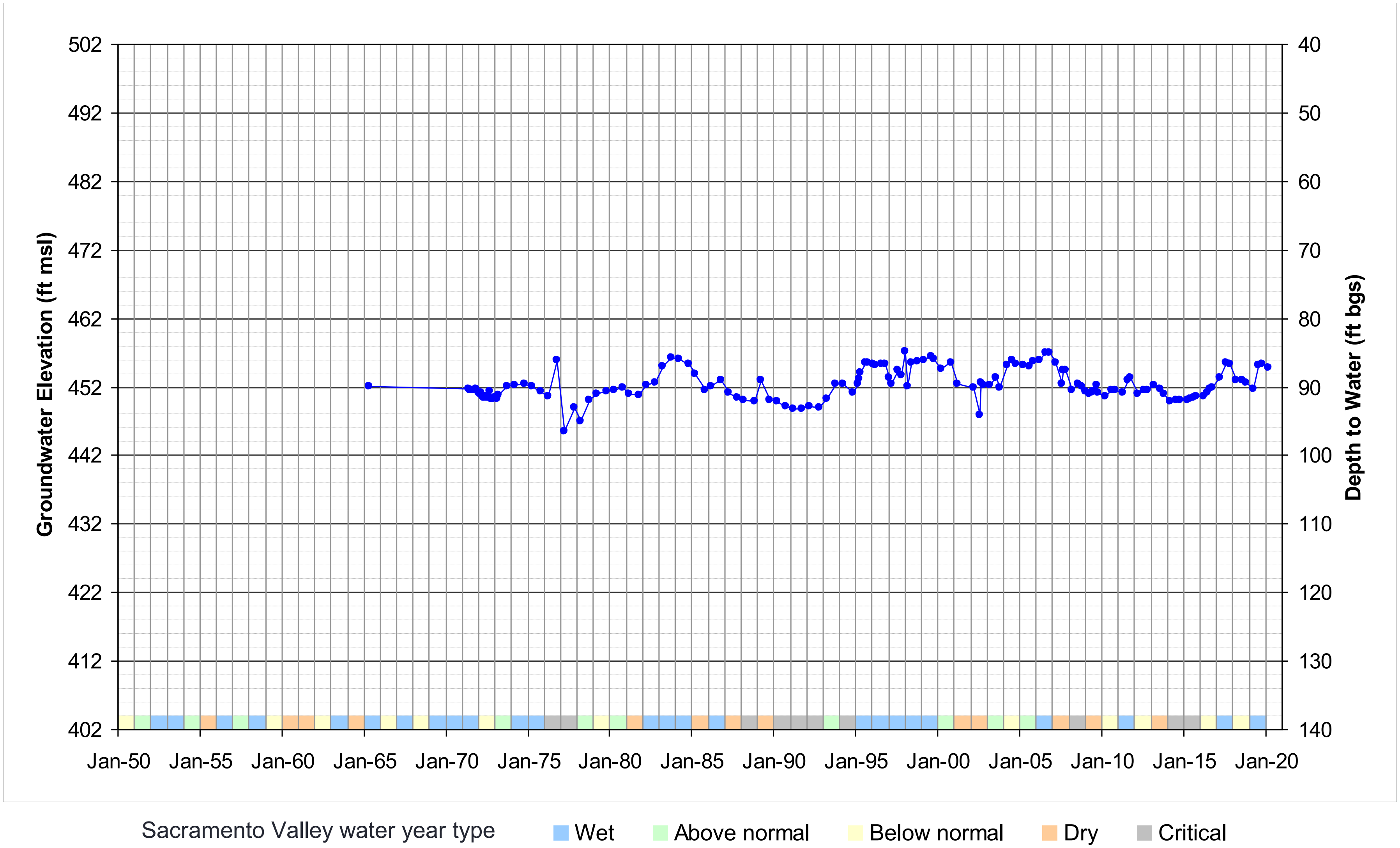
Abbreviated Well Name: 28D1 **Subbasin: Bowman** **Well Depth (ft): 134** **Well Type: Domestic**

Well Name: 29N04W28D001M **Aquifer: Upper** **Screen Depth (ft bgs): 114 - 134**



Abbreviated Well Name: 35B1 **Subbasin: Bowman** **Well Depth (ft): 759** **Well Type: Other**

Well Name: 29N04W35B001M **Aquifer: Composite** **Screen Depth (ft bgs): 130 - 759**



Hydrographs of Nested and Clustered Wells

Nested Wells:

- 29N04W20A001M
- 29N04W20A002M
- 29N04W20A003M
- 29N04W20A004M

Clustered Wells:

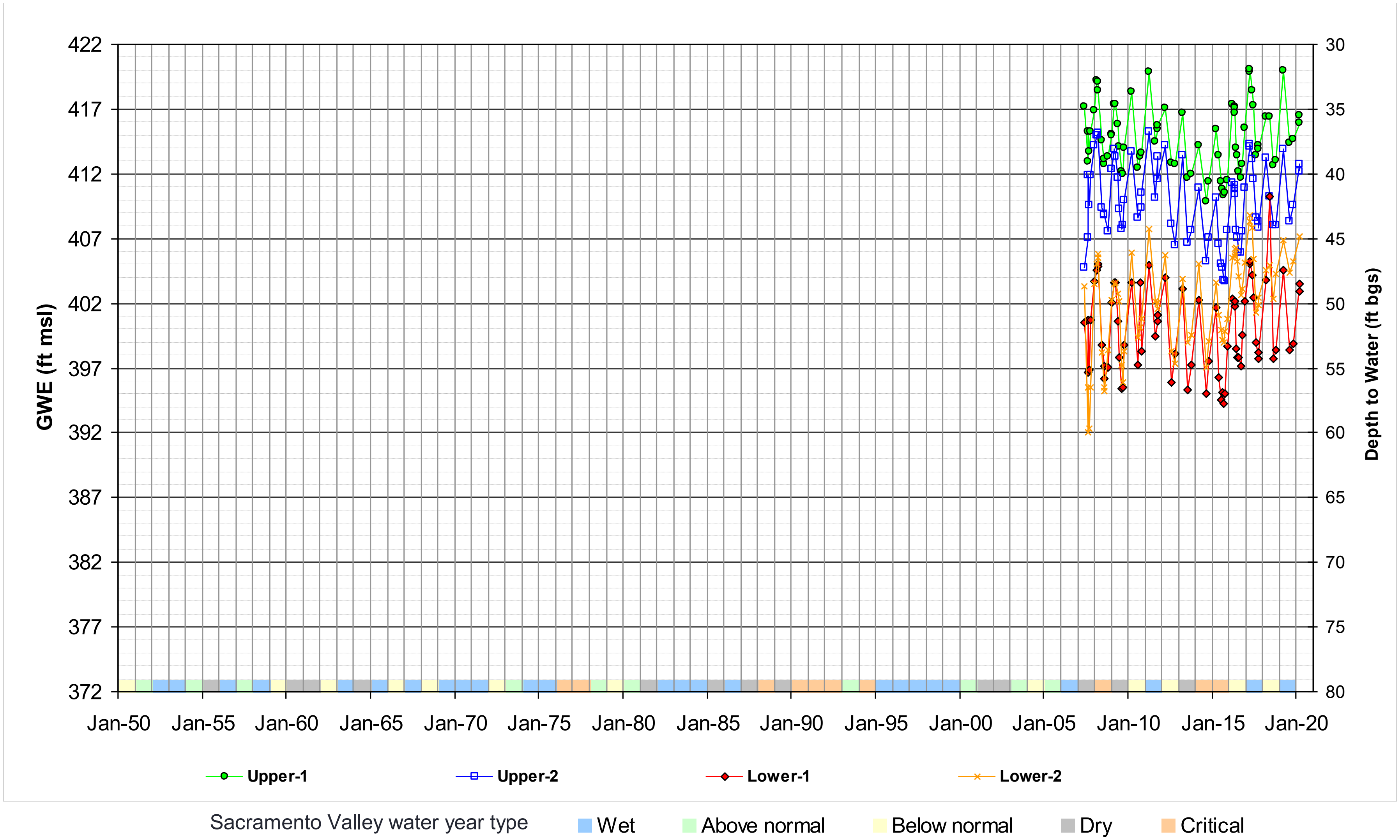
- 29N05W33A001M
- 29N05W33A003M
- 29N05W33A004M
- 29N05W33A005M

Well Nest Name: 20A

Subbasin: Bowman

Well Names: Upper-1: 29N04W20A004M; Upper-2: 29N04W20A003M; Lower-1: 29N04W20A002M; Lower-2: 29N04W20A001M

Screens (ft bgs): Upper-1: 50-60; Upper-2: 154-189; Lower-1: 360-430; Lower-2: 755-855

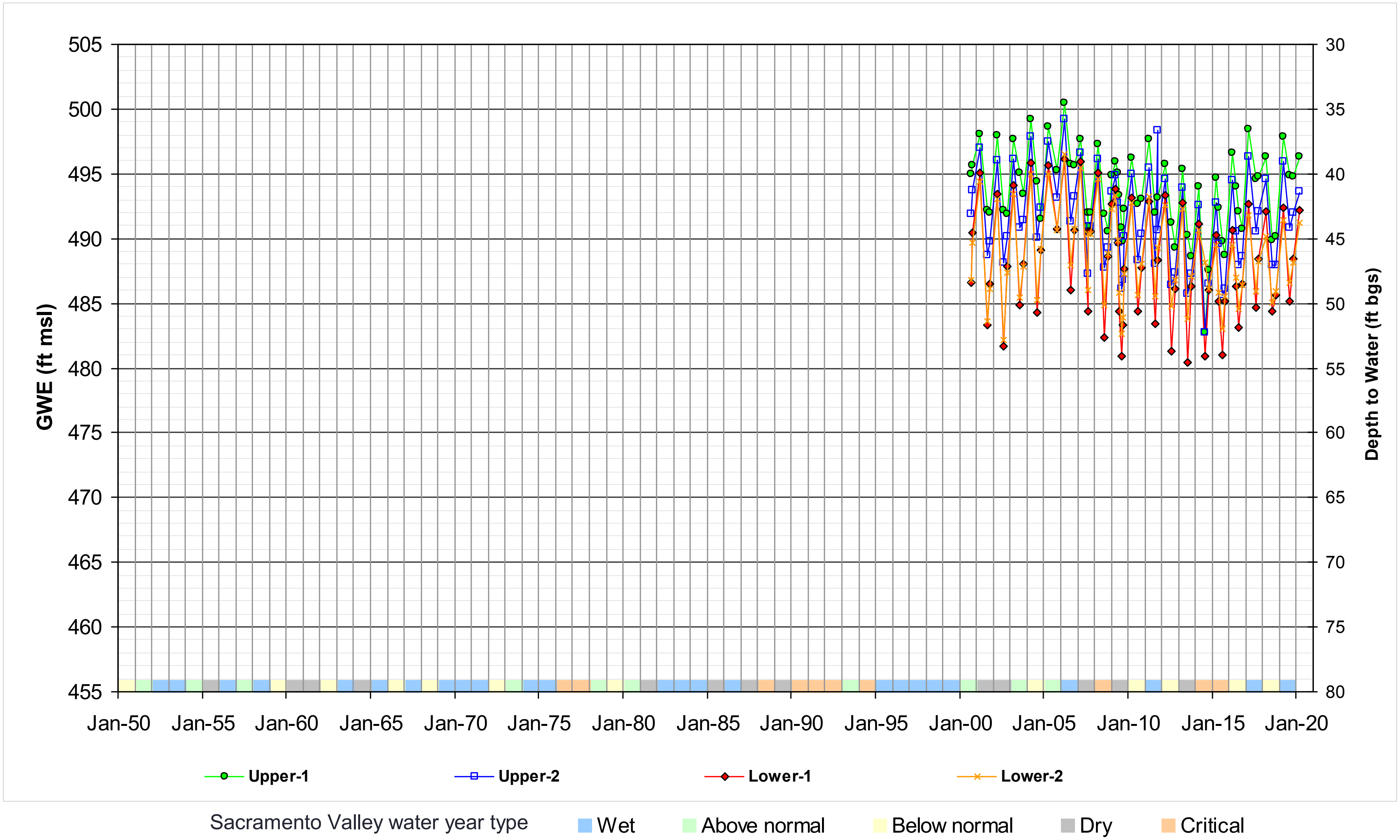


Well Cluster Name: 33A

Subbasin: Bowman

Well IDs: Upper-1: 29N05W33A005M; Upper-2: 29N05W33A004M; Lower-1: 29N05W33A003M; Lower-2: 29N05W33A001M

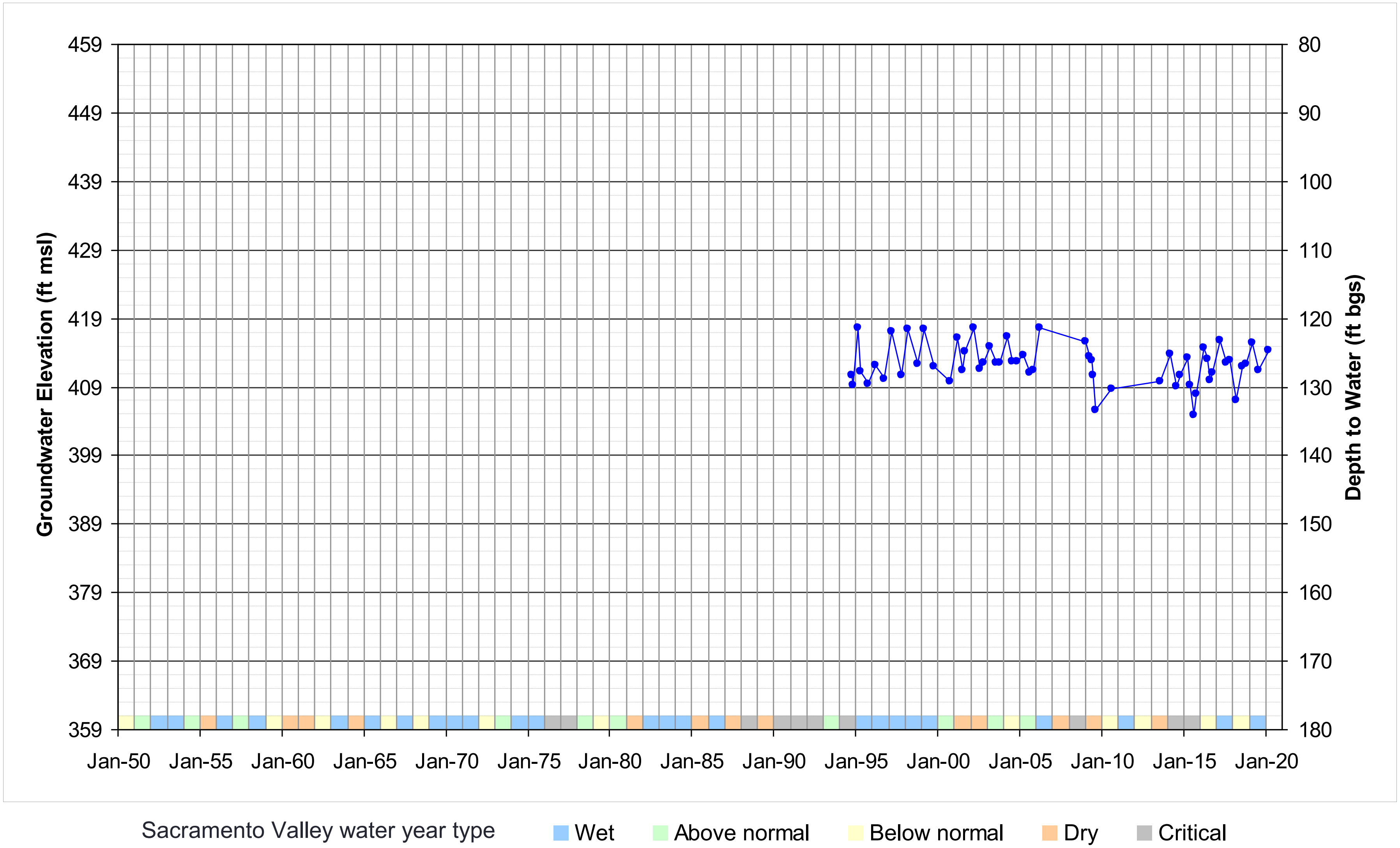
Screens (ft bgs): Upper-1: 45-95; Upper-2: 110-210; Lower-1: 210-392; Lower-2: 240-600



Other Hydrographs Used for Evaluation of Groundwater Levels

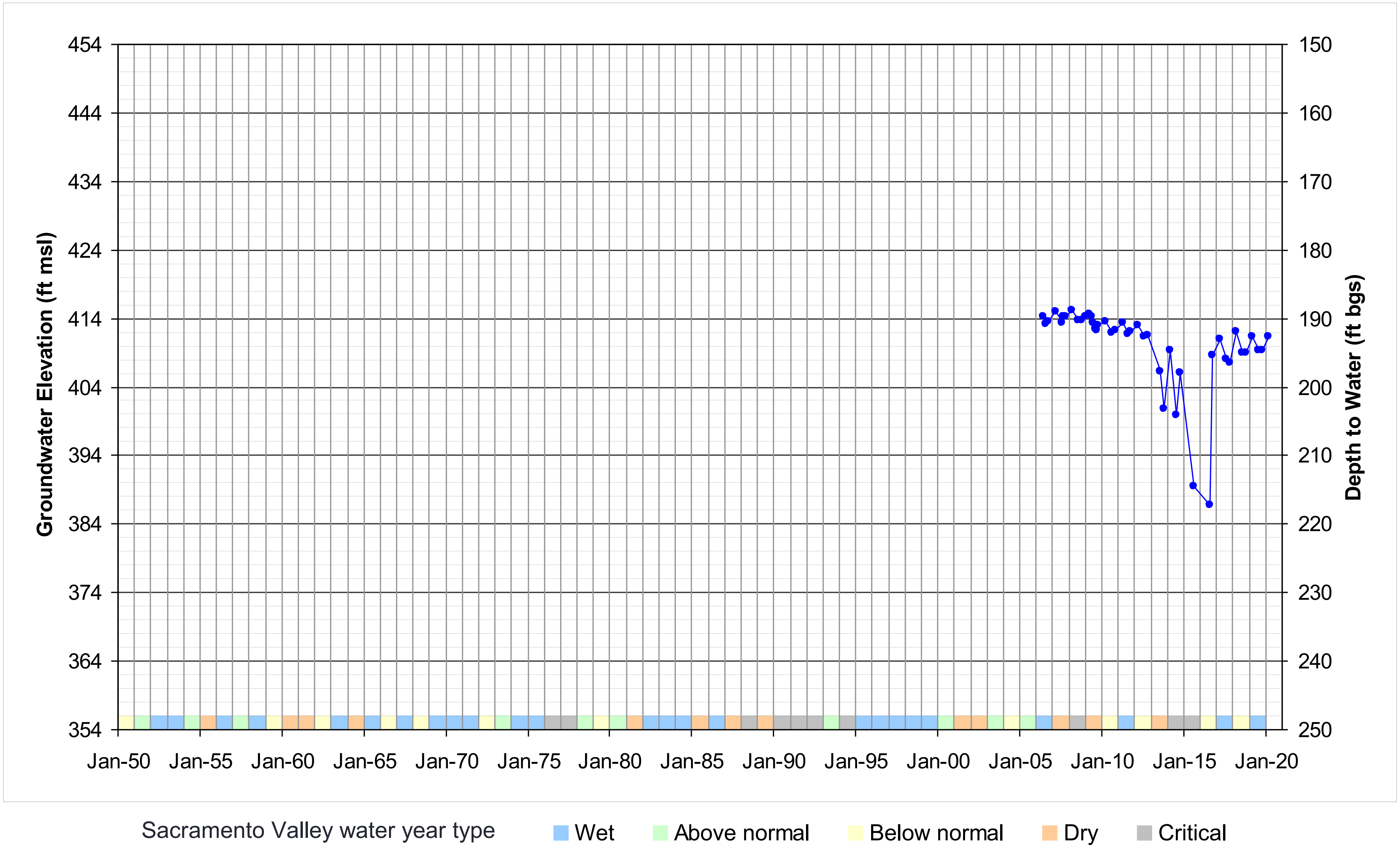
Abbreviated Well Name: 04P1 **Subbasin: Bowman** **Well Depth (ft): 270** **Well Type: Domestic**

Well Name: 28N04W04P001M **Aquifer: Upper** **Screen Depth (ft bgs): 200 - 270**



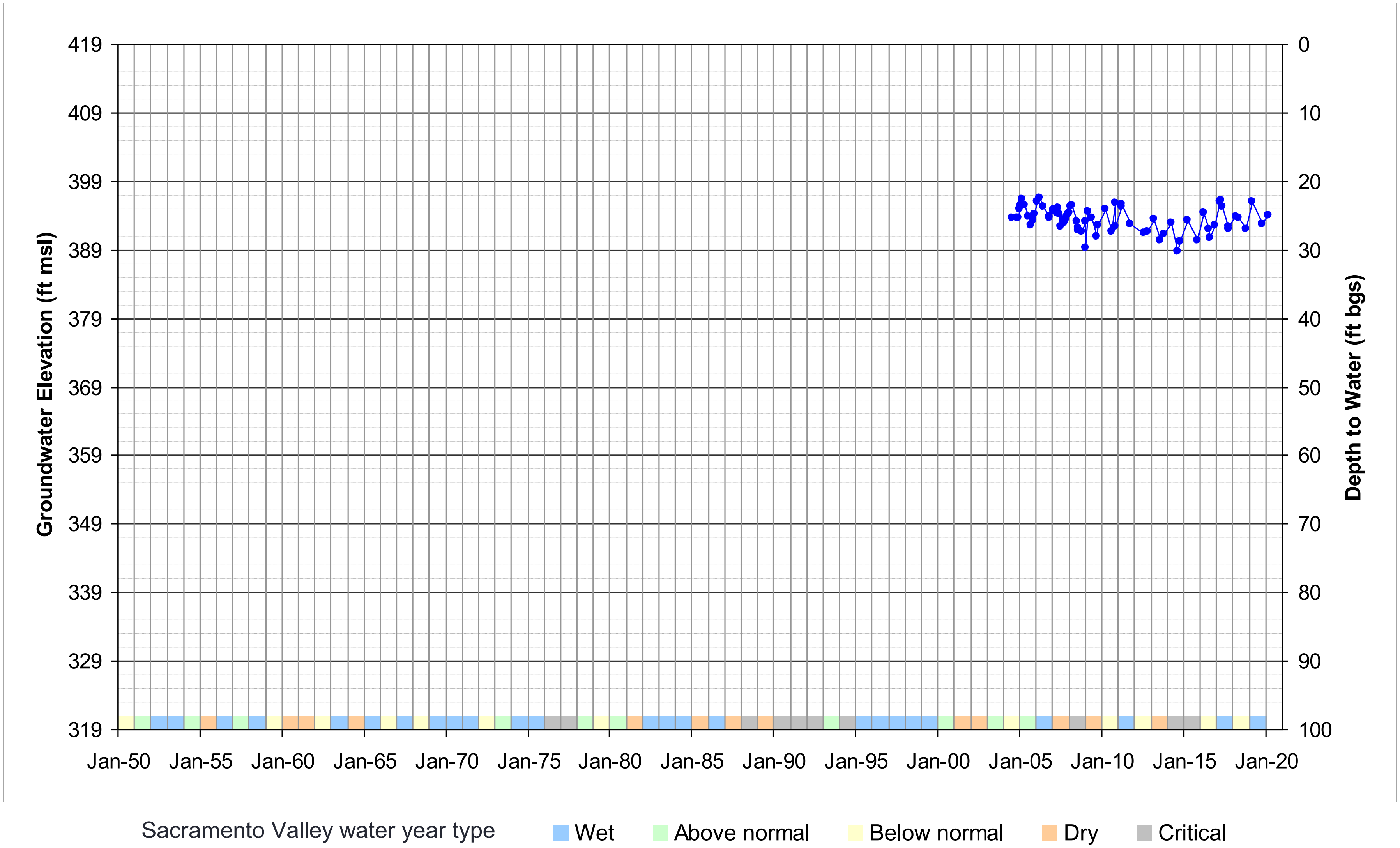
Abbreviated Well Name: 16G1 **Subbasin: Bowman** **Well Depth (ft): 260** **Well Type: Domestic**

Well Name: 28N04W16G001M **Aquifer: Upper** **Screen Depth (ft bgs): 42 - 260**



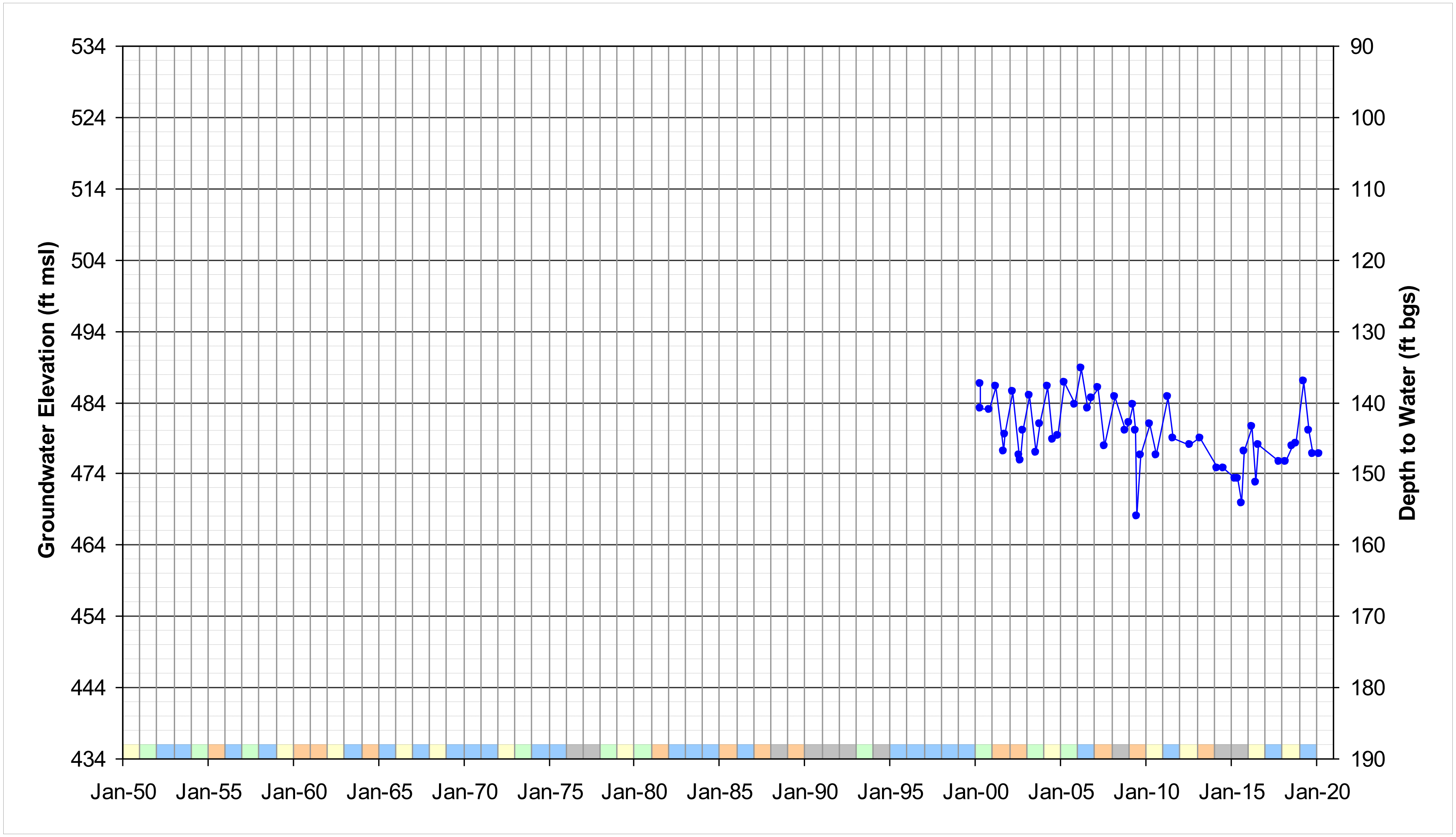
Abbreviated Well Name: 18M1 **Subbasin: Bowman** **Well Depth (ft): 234** **Well Type: Irrigation**

Well Name: 29N03W18M001M **Aquifer: Upper** **Screen Depth (ft bgs): N/A**



Abbreviated Well Name: 21H1 **Subbasin: Bowman** **Well Depth (ft): 280** **Well Type: Domestic**

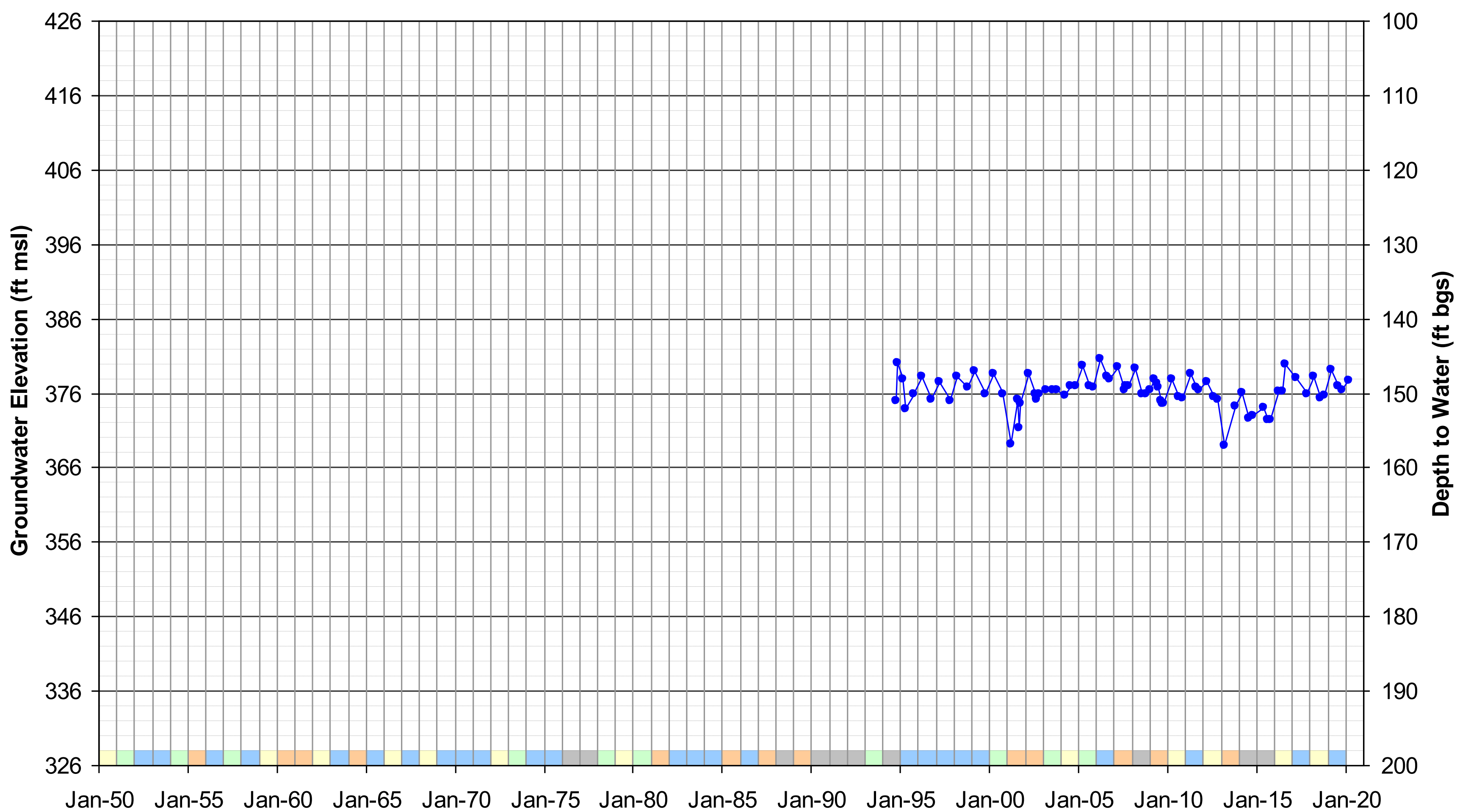
Well Name: 29N05W21H001M **Aquifer: Lower** **Screen Depth (ft bgs): 250 - 280**



Sacramento Valley water year type Wet Above normal Below normal Dry Critical

Abbreviated Well Name: 27A1 **Subbasin: Bowman** **Well Depth (ft): 225** **Well Type: Domestic**

Well Name: 29N04W27A001M **Aquifer: Upper** **Screen Depth (ft bgs): 205 - 225**



Sacramento Valley water year type: Wet, Above normal, Below normal, Dry, Critical

Appendix 2-G

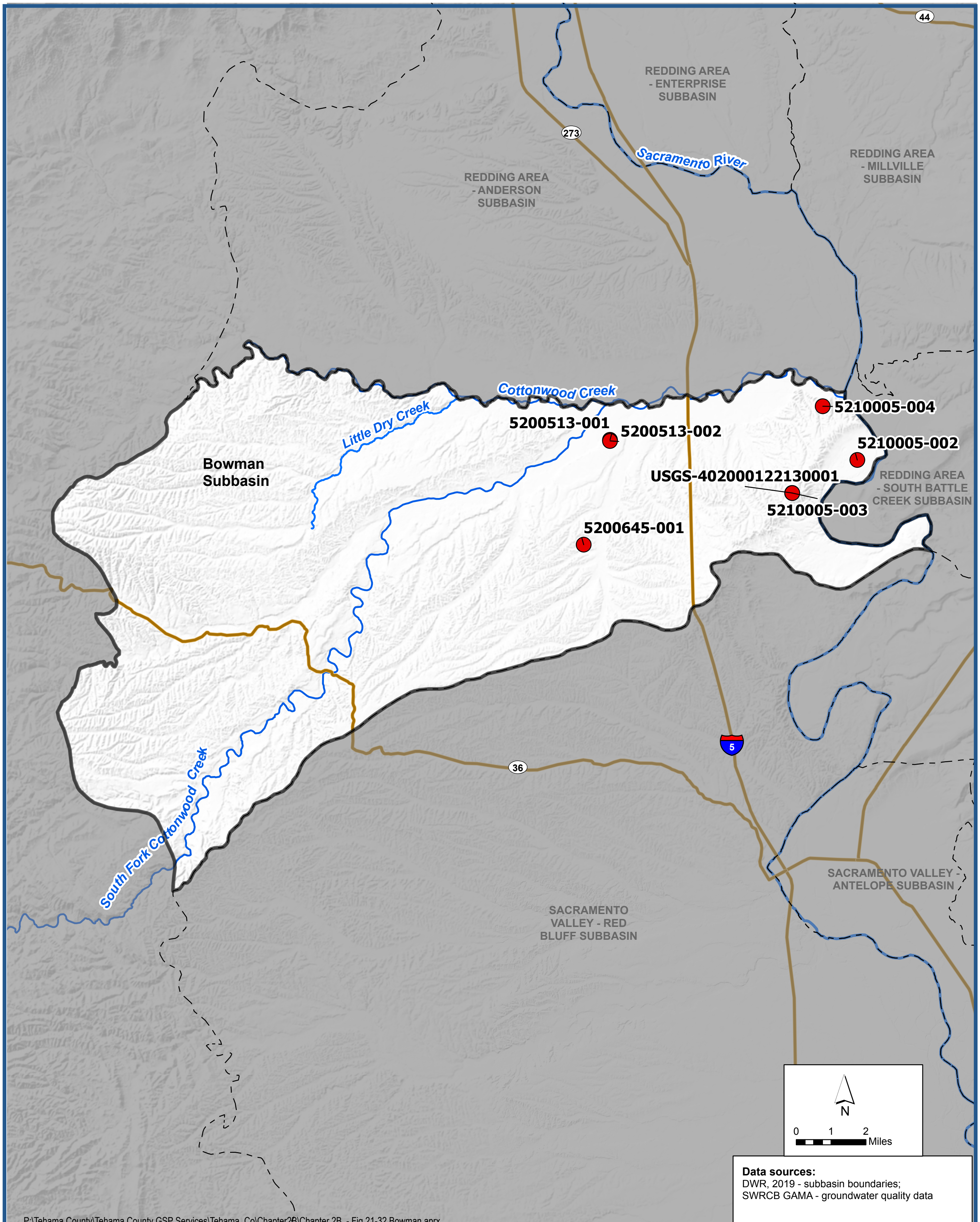
Water Quality Hydrographs

Appendix 2-G

Groundwater Quality (TDS)

Hydrographs of Select Wells

Bowman Subbasin



TEHAMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LSCE Team

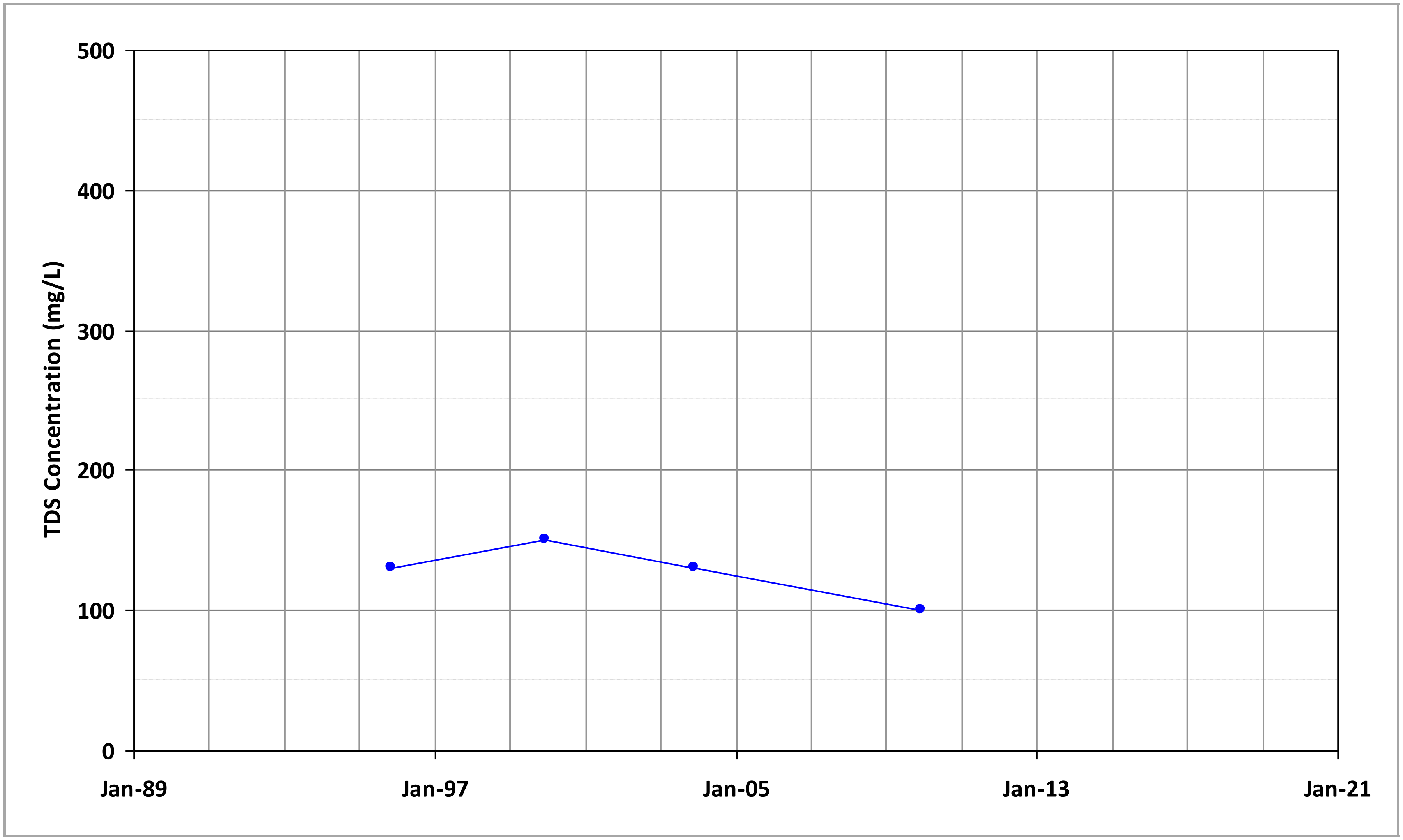
Locations of Wells with TDS Concentration Hydrographs

Groundwater Sustainability Plan
Bowman Subbasin

Figure 1

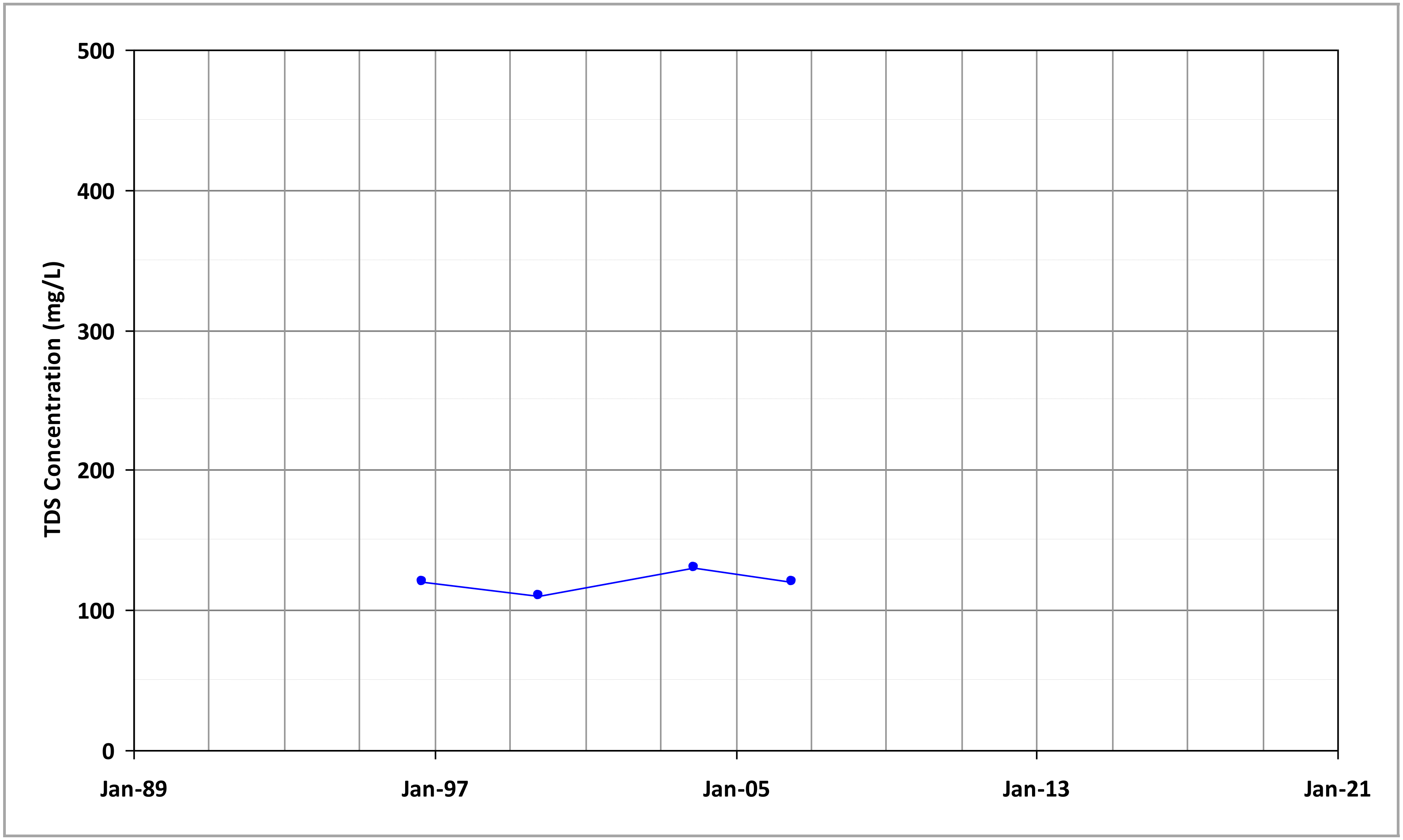
Well ID: 5200513-001 | Subbasin: Bowman | Well Depth (ft): N/A | Screen Top (ft bgs): 320

Abb. Well ID: 3-0 | Aquifer: Lower | GSE (ft NAVD88): N/A | Screen Bot (ft bgs): 400



Well ID: 5200513-002 | Subbasin: Bowman | Well Depth (ft): N/A | Screen Top (ft bgs): 320

Abb. Well ID: 3-0 | Aquifer: Lower | GSE (ft NAVD88): N/A | Screen Bot (ft bgs): 400



Well ID: 5200645-001

Abb. Well ID: 5-0

Subbasin: Bowman

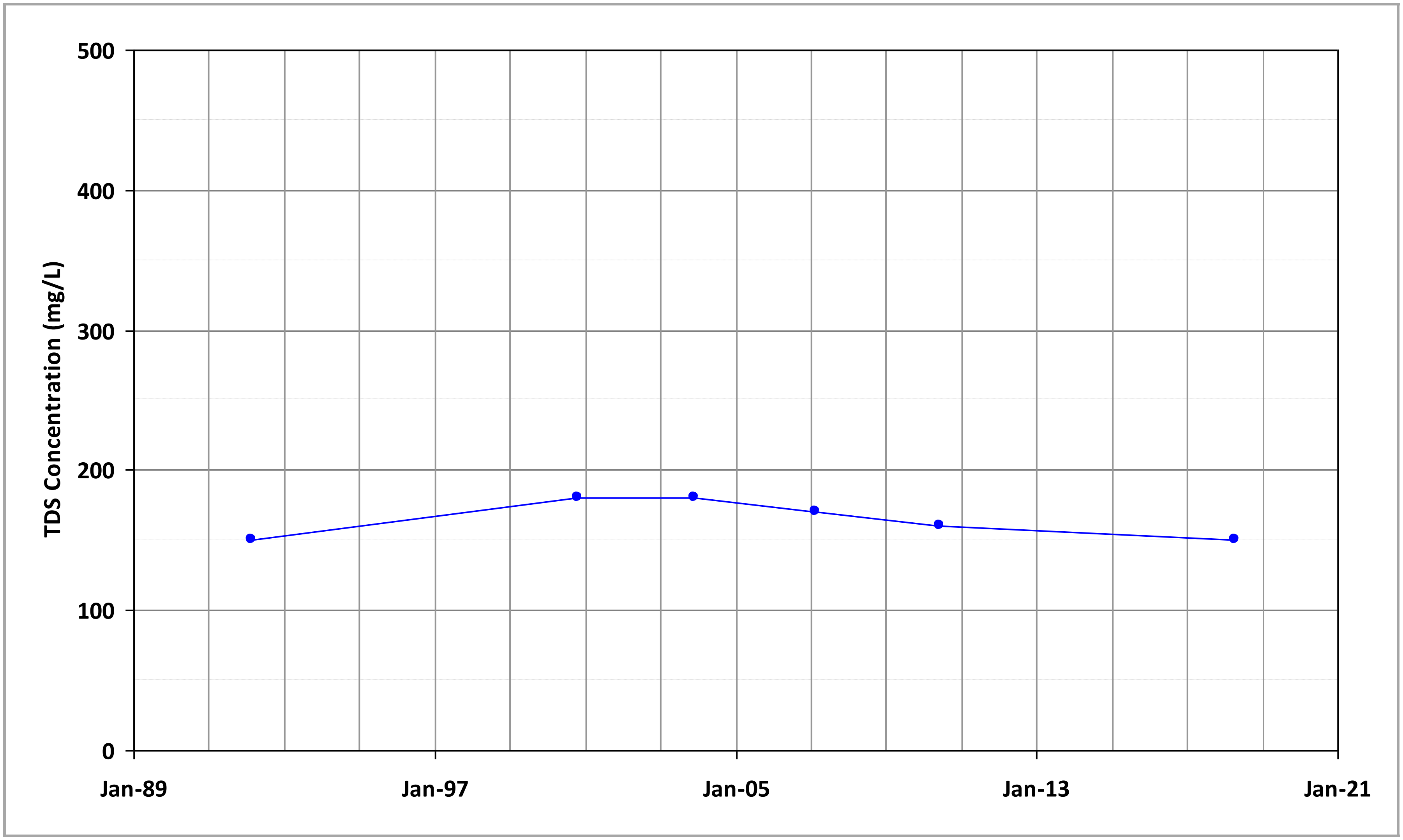
Aquifer: Unknown

Well Depth (ft): N/A

GSE (ft NAVD88): N/A

Screen Top (ft bgs): N/A

Screen Bot (ft bgs): N/A



Well ID: 5210005-002

Abb. Well ID: 5-0

Subbasin: Bowman

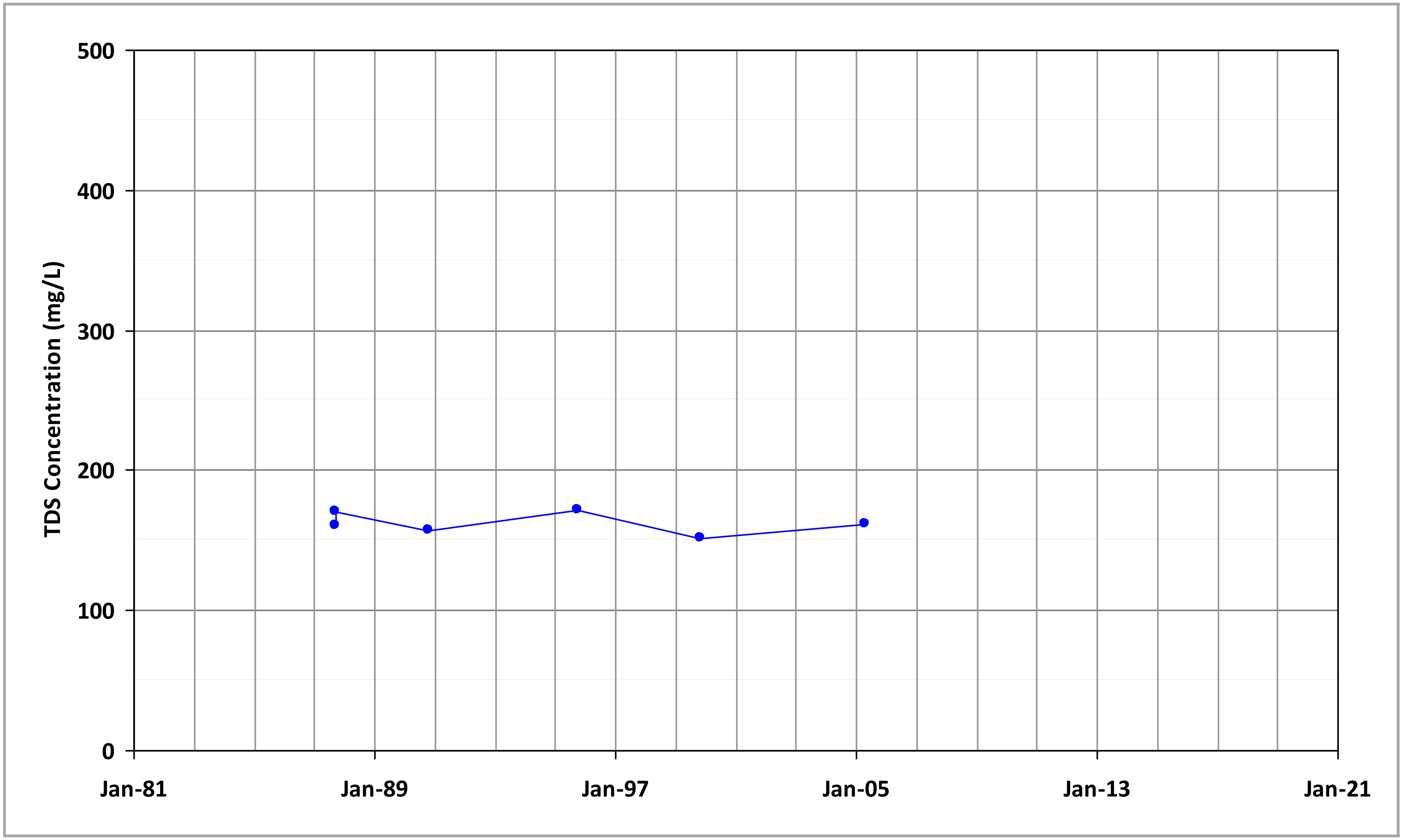
Aquifer: Composite

Well Depth (ft): N/A

GSE (ft NAVD88): N/A

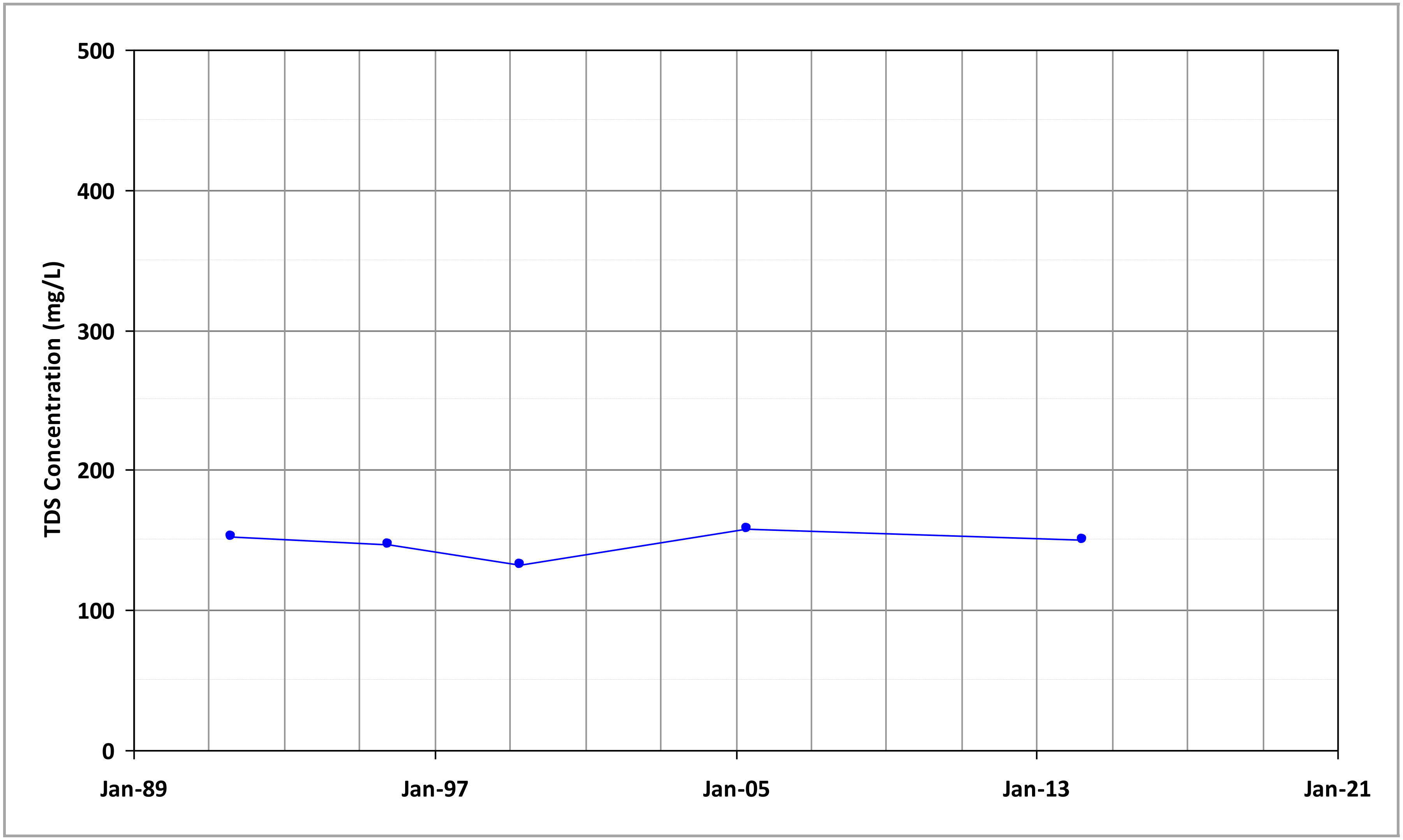
Screen Top (ft bgs): 24

Screen Bot (ft bgs): 324



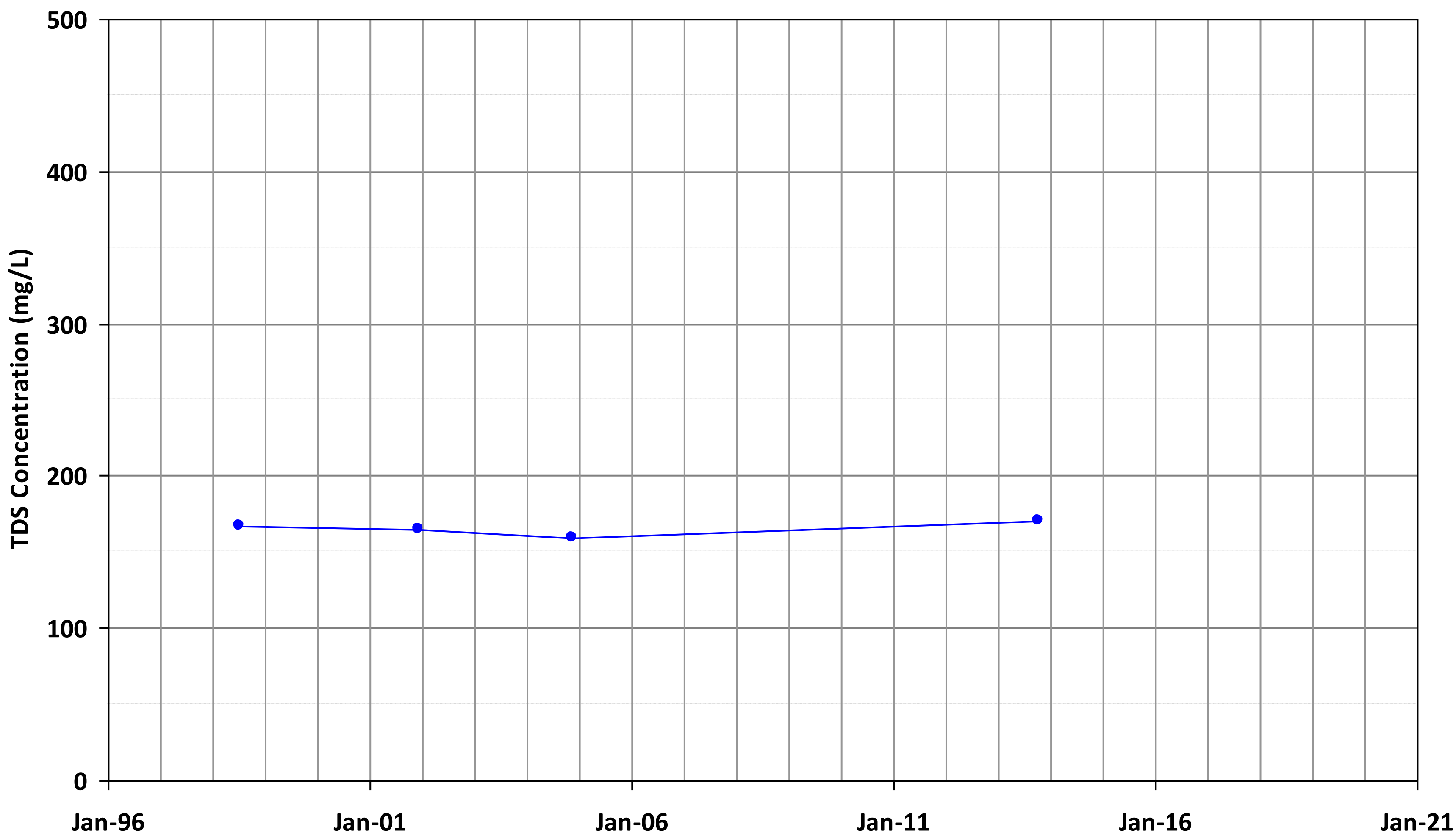
Well ID: 5210005-003 | Subbasin: Bowman | Well Depth (ft): N/A | Screen Top (ft bgs): 308

Abb. Well ID: 5-0 | Aquifer: Lower | GSE (ft NAVD88): N/A | Screen Bot (ft bgs): 398



Well ID: 5210005-004 | **Subbasin: Bowman** | **Well Depth (ft): N/A** | **Screen Top (ft bgs): N/A**

Abb. Well ID: 5-0 | **Aquifer: Unknown** | **GSE (ft NAVD88): N/A** | **Screen Bot (ft bgs): N/A**

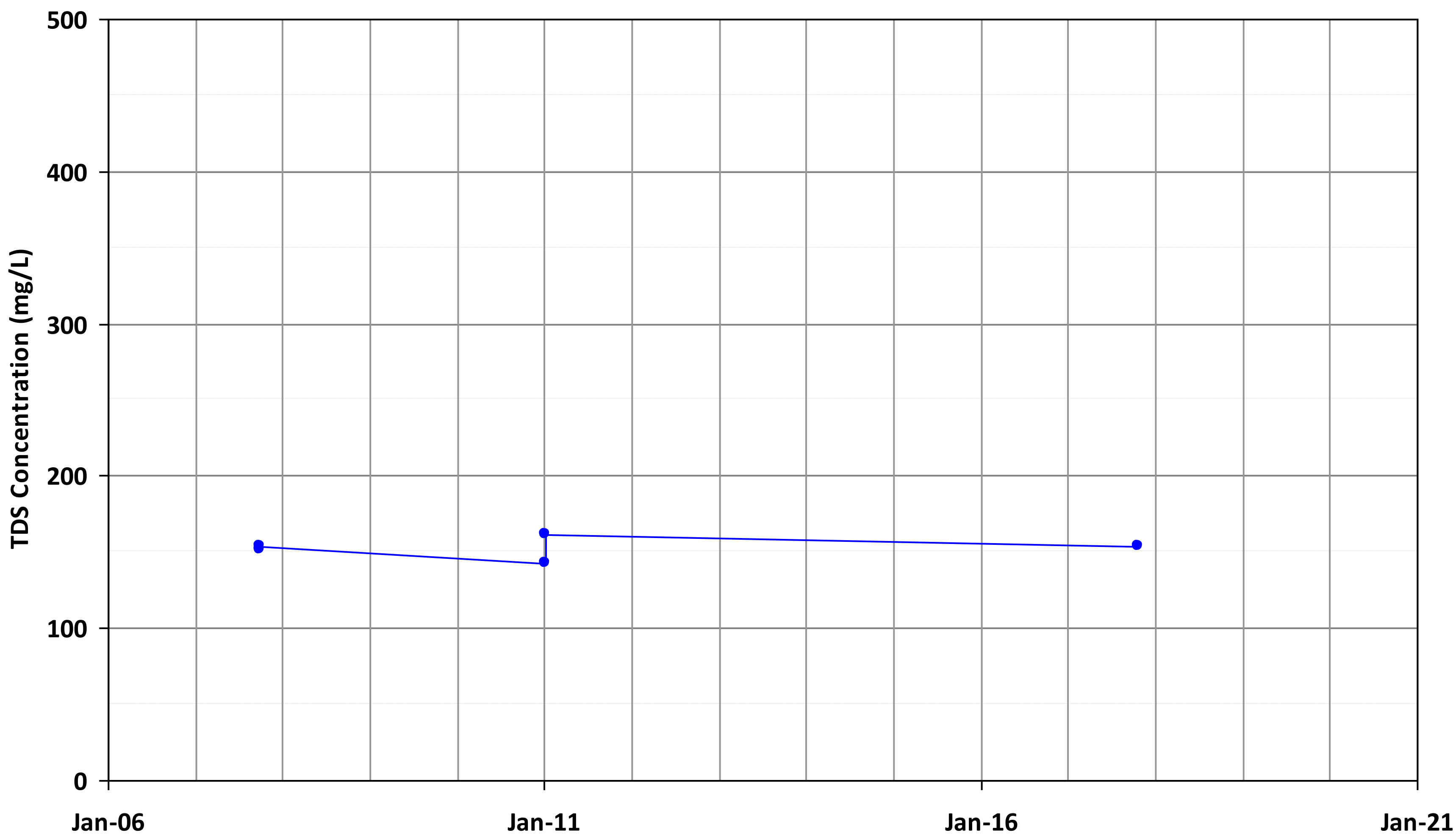


Well ID: USGS-402000122130
Abb. Well ID: 0201

Subbasin: Bowman
Aquifer: Unknown

Well Depth (ft): N/A
GSE (ft NAVD88): N/A

Screen Top (ft bgs): N/A
Screen Bot (ft bgs): N/A



Appendix 2-H

Freshwater Flora and Fauna

Freshwater Species Located in the Bowman Subbasin

Scientific Name	Common Name	Legal Protected Status		
		Federal	State	Other
BIRDS				
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo	Candidate - Threatened	Endangered	
Actitis macularius	Spotted Sandpiper			
Aechmophorus clarkii	Clark's Grebe			
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya collaris	Ring-necked Duck			
Aythya valisineria	Canvasback		Special	
Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			
Bucephala clangula	Common Goldeneye			
Butorides virescens	Green Heron			
Calidris alpina	Dunlin			
Calidris minutilla	Least Sandpiper			
Chen caerulescens	Snow Goose			
Chen rossii	Ross's Goose			
Cistothorus palustris palustris	Marsh Wren			
Cygnus columbianus	Tundra Swan			
Egretta thula	Snowy Egret			
Empidonax traillii	Willow Flycatcher	Bird of Conservation Concern	Endangered	
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Gallinula chloropus	Common Moorhen			
Geothlypis trichas trichas	Common Yellowthroat			
Grus canadensis	Sandhill Crane			

Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Himantopus mexicanus	Black-necked Stilt			
Icteria virens	Yellow-breasted Chat		Special Concern	BSSC - Third priority
Limnodromus scolopaceus	Long-billed Dowitcher			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Mergus serrator	Red-breasted Merganser			
Numenius americanus	Long-billed Curlew			
Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			
Pandion haliaetus	Osprey		Watch list	
Pelecanus erythrorhynchos	American White Pelican		Special Concern	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Setophaga petechia brewsteri	A Yellow Warbler	Bird of Conservation Concern	Special Concern	
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Vireo bellii pusillus	Least Bell's Vireo	Endangered	Endangered	
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		Special Concern	BSSC - Third priority
CRUSTACEANS				
Lepidurus packardi	Vernal Pool Tadpole Shrimp	Endangered	Special	IUCN - Endangered
Linderiella occidentalis	California Fairy Shrimp		Special	IUCN - Near Threatened
FISH				
Acipenser medirostris ssp. 1	Southern green sturgeon	Threatened	Special Concern	Endangered - Moyle 2013
Acipenser transmontanus	White sturgeon		Special	Vulnerable - Moyle 2013

Catostomus occidentalis occidentalis	Sacramento sucker			Least Concern - Moyle 2013
Cottus asper ssp. 1	Prickly sculpin			Least Concern - Moyle 2013
Cottus gulosus	Riffle sculpin		Special	Near-Threatened - Moyle 2013
Entosphenus tridentata ssp. 1	Pacific lamprey		Special	Near-Threatened - Moyle 2013
Gasterosteus aculeatus microcephalus	Inland threespine stickleback		Special	Least Concern - Moyle 2013
Hysterocarpus traskii traskii	Sacramento tule perch		Special	Near-Threatened - Moyle 2013
Lampetra richardsoni	Western brook lamprey			Near-Threatened - Moyle 2013
Lavinia exilicauda exilicauda	Sacramento hitch		Special	Near-Threatened - Moyle 2013
Lavinia symmetricus symmetricus	Central California roach		Special Concern	Near-Threatened - Moyle 2013
Mylopharodon conocephalus	Hardhead		Special Concern	Near-Threatened - Moyle 2013
Oncorhynchus gorbuscha	Pink salmon		Special Concern	Endangered - Moyle 2013
Oncorhynchus kisutch - CCC	Central Coast coho salmon	Endangered	Endangered	Endangered - Moyle 2013
Oncorhynchus mykiss - CV	Central Valley steelhead	Threatened	Special	Vulnerable - Moyle 2013
Oncorhynchus mykiss irideus	Coastal rainbow trout			Least Concern - Moyle 2013
Oncorhynchus tshawytscha - CV fall	Central Valley fall Chinook salmon	Species of Special Concern	Special Concern	Vulnerable - Moyle 2013
Oncorhynchus tshawytscha - CV late fall	Central Valley late fall Chinook salmon	Species of Special Concern		Endangered - Moyle 2013
Oncorhynchus tshawytscha - CV spring	Central Valley spring Chinook salmon	Threatened	Threatened	Vulnerable - Moyle 2013
Oncorhynchus tshawytscha - CV winter	Central Valley winter Chinook salmon	Endangered	Endangered	Vulnerable - Moyle 2013
Orthodon microlepidotus	Sacramento blackfish			Least Concern - Moyle 2013
Pogonichthys macrolepidotus	Sacramento splittail		Special Concern	Vulnerable - Moyle 2013

Ptychocheilus grandis	Sacramento pikeminnow			Least Concern - Moyle 2013
Rhinichthys osculus ssp. 1	Sacramento speckled dace			Least Concern - Moyle 2013
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Dicamptodon tenebrosus	Pacific Giant Salamander			
Lithobates pipiens	Northern Leopard Frog		Special Concern	ARSSC
Pseudacris regilla	Northern Pacific Chorus Frog			
Rana boylii	Foothill Yellow-legged Frog	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Rana draytonii	California Red-legged Frog	Threatened	Special Concern	ARSSC
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Taricha granulosa	Rough-skinned Newt			
Thamnophis atratus atratus	Santa Cruz Gartersnake			Not on any status lists
Thamnophis couchii	Sierra Gartersnake			
Thamnophis elegans elegans	Mountain Gartersnake			Not on any status lists
Thamnophis sirtalis sirtalis	Common Gartersnake			
INSECTS & OTHER INVERTS				
Acentrella insignificans	A Mayfly			
Acentrella spp.	Acentrella spp.			
Ameletus amador	A Mayfly			
Ameletus spp.	Ameletus spp.			
Antocha monticola				Not on any status lists
Baetis adonis	A Mayfly			
Baetis spp.	Baetis spp.			
Brachycentrus americanus	A Caddisfly			
Brachycentrus occidentalis				Not on any status lists
Centroptilum album	A Mayfly			
Centroptilum spp.	Centroptilum spp.			
Cheumatopsyche analis				Not on any status lists
Cheumatopsyche spp.	Cheumatopsyche spp.			

Cleptelmis addenda				Not on any status lists
Dicosmoecus atripes	A Caddisfly			
Dicosmoecus spp.	Dicosmoecus spp.			
Epeorus albertae	A Mayfly			
Epeorus spp.	Epeorus spp.			
Ephemerella alleni				Not on any status lists
Ephemerella aurivillii	A Mayfly			
Ephemerella spp.	Ephemerella spp.			
Fallceon quilleri	A Mayfly			
Glossosoma alascense	A Caddisfly			
Glossosoma spp.	Glossosoma spp.			
Heterlimnius corpulentus				Not on any status lists
Heterlimnius spp.	Heterlimnius spp.			
Hydropsyche alternans				Not on any status lists
Hydropsyche spp.	Hydropsyche spp.			
Hydroptila ajax	A Caddisfly			
Hydroptila spp.	Hydroptila spp.			
Isonychia velma	A Mayfly			
Lepidostoma acarolum				Not on any status lists
Lepidostoma spp.	Lepidostoma spp.			
Narpus angustus				Not on any status lists
Narpus spp.	Narpus spp.			
Oecetis arizonica				Not on any status lists
Oecetis spp.	Oecetis spp.			
Ophiogomphus occidentis	Sinuous Snaketail			
Optioservus canus	Pinnacles Optioservus Riffle Beetle		Special	
Optioservus quadrimaculatus				Not on any status lists
Optioservus spp.	Optioservus spp.			
Ordobrevia nubifera				Not on any status lists
Oreodytes abbreviatus				Not on any status lists
Oreodytes spp.	Oreodytes spp.			
Paraleptophlebia altana	A Mayfly			
Paraleptophlebia spp.	Paraleptophlebia spp.			
Pteronarcys californica	Giant Salmonfly			
Pteronarcys spp.	Pteronarcys spp.			
Rhithrogena decora	A Mayfly			
Rhithrogena morrisoni	A Mayfly			

Rhithrogena spp.	Rhithrogena spp.			
Rhyacophila acuminata	A Caddisfly			Not on any status lists
Sigara alternata				Not on any status lists
Sigara spp.	Sigara spp.			
Simulium anduzei				Not on any status lists
Simulium spp.	Simulium spp.			
Skwala americana	American Springfly			
Sperchon spp.	Sperchon spp.			
Sperchon stellata				Not on any status lists
Sweltsa adamantea				Not on any status lists
Sweltsa spp.	Sweltsa spp.			
Tricorythodes explicatus	A Mayfly			
Tricorythodes spp.	Tricorythodes spp.			
Wormaldia anilla	A Caddisfly			
Wormaldia spp.	Wormaldia spp.			
Zaitzevia parvula				Not on any status lists
Zaitzevia spp.	Zaitzevia spp.			
MAMMALS				
Castor canadensis	American Beaver			Not on any status lists
Lontra canadensis canadensis	North American River Otter			Not on any status lists
Neovison vison	American Mink			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
Sorex palustris	American Water Shrew			Not on any status lists
MOLLUSKS				
Anodonta californiensis	California Floater		Special	
Gonidea angulata	Western Ridged Mussel		Special	
Gyraulus circumstriatus	Disc Gyro			CS
Gyraulus spp.	Gyraulus spp.			
Lymnaea spp.	Lymnaea spp.			
Lymnaea stagnalis	Swamp Lymnaea			Not on any status lists
Margaritifera falcata	Western Pearlshell		Special	
Physa acuta	Pewter Physa			Not on any status lists
Physa spp.	Physa spp.			
Pisidium casertanum				Not on any status lists
Pisidium spp.	Pisidium spp.			

Stagnicola caperata	Wrinkled Marshsnail			CS
Stagnicola elodes	Marsh Pondsnail			CS
PLANTS				
Alnus rhombifolia	White Alder			
Alopecurus carolinianus	Tufted Foxtail			
Baccharis salicina				Not on any status lists
Brodiaea nana				Not on any status lists
Callitriche marginata	Winged Water-starwort			
Carex longii	NA			Not on any status lists
Carex nudata	Torrent Sedge			
Carex scoparia scoparia	Broom Sedge		Special	CRPR - 2B.2
Carex vulpinoidea	NA			
Cephalanthus occidentalis	Common Buttonbush			
Cicendia quadrangularis	Oregon Microcala			
Damasonium californicum				Not on any status lists
Darlingtonia californica	California Pitcherplant		Special	CRPR - 4.2
Datisca glomerata	Durango Root			
Downingia bacigalupii	Bacigalup's Downingia			
Downingia cuspidata	Toothed Calicoflower			
Downingia insignis	Parti-color Downingia			
Eleocharis parishii	Parish's Spikerush			
Elodea canadensis	Broad Waterweed			
Eryngium articulatum	Jointed Coyote-thistle			
Euthamia occidentalis	Western Fragrant Goldenrod			
Gratiola ebracteata	Bractless Hedge-hyssop			
Gratiola heterosepala	Boggs Lake Hedge-hyssop		Endangered	CRPR - 1B.2
Isoetes howellii	NA			
Isoetes nuttallii	NA			
Isoetes orcuttii	NA			
Juncus marginatus	NA			
Juncus usitatus	NA			Not on any status lists
Lasthenia fremontii	Fremont's Goldfields			
Legenere limosa	False Venus'-looking-glass		Special	CRPR - 1B.1
Limnanthes alba alba	White Meadowfoam			
Limnanthes douglasii nivea	Douglas' Meadowfoam			
Limnanthes douglasii rosea	Douglas' Meadowfoam			
Limnanthes floccosa floccosa	Woolly Meadowfoam		Special	CRPR - 4.2
Limosella acaulis	Southern Mudwort			
Lythrum californicum	California Loosestrife			

Mimulus guttatus	Common Large Monkeyflower			
Mimulus pilosus				Not on any status lists
Mimulus tricolor	Tricolor Monkeyflower			
Myosurus minimus	NA			
Navarretia heterandra	Tehama Navarretia			
Navarretia intertexta	Needleleaf Navarretia			
Navarretia leucocephala bakeri	Baker's Navarretia		Special	CRPR - 1B.1
Navarretia leucocephala leucocephala	White-flower Navarretia			
Orcuttia tenuis	Slender Orcutt Grass	Threatened	Endangered	CRPR - 1B.1
Panicum acuminatum acuminatum				Not on any status lists
Panicum dichotomiflorum	NA			
Paspalum distichum	Joint Paspalum			
Perideridia bolanderi involucrata	Bolander's Yampah			
Perideridia kelloggii	Kellogg's Yampah			
Phacelia distans	NA			
Plagiobothrys greenei	Greene's Popcorn-flower			
Plantago elongata elongata	Slender Plantain			
Pogogyne zizyphoroides				Not on any status lists
Potamogeton diversifolius	Water-thread Pondweed			
Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads			
Psilocarphus tenellus	NA			
Ranunculus bonariensis	NA			
Ranunculus hystriculus				Not on any status lists
Ranunculus pusillus pusillus	Pursh's Buttercup			
Ranunculus sardous	NA			
Ranunculus sceleratus	NA			
Rorippa palustris palustris	Bog Yellowcress			
Rotala ramosior	Toothcup			
Sagittaria latifolia latifolia	Broadleaf Arrowhead			
Sagittaria sanfordii	Sanford's Arrowhead		Special	CRPR - 1B.2
Salix exigua exigua	Narrowleaf Willow			
Salix gooddingii	Goodding's Willow			
Salix laevigata	Polished Willow			
Salix lasiolepis lasiolepis	Arroyo Willow			
Schoenoplectus mucronatus	NA			
Schoenoplectus pungens pungens	NA			
Sidalcea hirsuta	Hairy Checker-mallow			
Stachys stricta	Sonoma Hedge-nettle			

Typha domingensis	Southern Cattail			

Appendix 2-I

Surface Water Depletion and GDE Methodology and Analysis

Appendix 2-I

Part 1

Groundwater Dependent Ecosystem Analysis and Prioritization Methodology

Bowman Subbasin

MEMORANDUM

DATE: September 7, 2021

TO: Eddy Teasdale

FROM: Andrew Francis

RE: Groundwater Dependent Ecosystem Analysis and Prioritization Methodology

---

Introduction

The purpose of this memorandum is to outline the process used to identify and prioritize groundwater dependent ecosystems (GDE) in four Tehama County (TC) subbasins: the Antelope, Bowman, and Red Bluff Subbasins. The results of the identification and prioritization process is presented in the groundwater sustainability plans (GSP)s developed for the individual Subbasins. GDEs are defined under the Sustainable Groundwater Management Act (SGMA) as "ecological communities that depend on groundwater emerging from an aquifer or on groundwater occurring near the ground surface" (23 CCR § 351 (m)). GSP regulations state that GDE's are to be identified and that all beneficial users of groundwater are to be considered in the development of a GSP (23 CCR § 355.4 (b)(4)). The approach used to both identify and prioritize GDE's was based on the guidance document *Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act – Guidance for Preparing Groundwater Sustainability Plans* (Rohde et al., 2018), which provides information on the data types and methods that can be used to identify and prioritize GDEs. The guidance document was produced by The Nature Conservancy (TNC), an environmental stakeholder who has been actively involved in GSP development and review throughout the State. The identification process includes using mapped vegetation, mapped naturally occurring surface water features, and shallow groundwater level data to assess if there is a connection to groundwater in areas where vegetation or surface water is present. In addition to the information provided by TNC, feedback from local stakeholders was a key component in this process to incorporate GDE's in the four Subbasin GSPs in TC.

The following outlines the data sources and processes used to identify and prioritize GDE's:

1. GDE Identification – TNC Guidance
    a. GDE indicators (GDEi) – Natural Communities Commonly Associated with Groundwater (NCCAG)
        i. Vegetation
        ii. Wetlands
    b. Review of Aerial Imagery

            i. LandIQ, 2018
    c. Establish a connection to groundwater
            i. Depth to Water Contours
    d. Final GDE Designations
2. GDE Prioritization
    a. GDE Pulse Analysis – Vegetation Prioritization
    b. Wetlands Prioritization

1. GDE Identification – TNC Guidance

The TNC guidance document lays out a two-step process for identifying GDEs. The first is to review aerial imagery to identify land use changes that may have occurred in areas that were mapped as vegetation or surface water, and the second is to assess if there is a connection to groundwater. The TNC guidance document also recommends additional steps for specific GDE types (e.g., river, wetlands, terrestrial vegetation, springs/seeps) under conditions where there does not appear to be a connection to groundwater based on the 30-foot threshold. These additional steps require field evaluation which have not been conducted and are not discussed in this memorandum.

a. GDE Indicators (GDEi) – Natural Communities Commonly Associated with Groundwater

The mapped vegetation and surface water features used to identify GDEs was the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset. The NCCAG is a compilation of 48 publicly available state and federal agency datasets that map vegetation, wetlands, springs, and seeps in California. The NCCAG was developed by a working group comprised of the Department of Water Resources (DWR), the California Department of Fish and Wildlife (DFW), and TNC (Klausmeyer et al, 2018). Historic mapping of vegetation and surface water was screened to exclude areas that are less likely to be associated with groundwater. This resulted in two individual datasets: *Vegetation* and *Wetlands*. Both of these are geospatial datasets that can be used in a mapping software such as ArcGIS. The vegetation includes all terrestrial vegetation and identifies the dominate species for each area. The wetlands data is a collection of surface water features that are potentially reliant on groundwater including streams, springs, seeps, and wetlands. The mapped areas vegetation and surface water in NCCAG data set are considered indicators of GDEs (GDEi).

i. Vegetation

The mapped NCCAG vegetation is presented in Figure 1 is primarily located along the Sacramento River and its tributaries. There is minimal coverage in the western parts of the Red Bluff and Bowman subbasins and lighter coverage in the eastern portions of Antelope and Los Molinos. There are approximately 12,000 acres of Vegetation GDEi across the four TC Subbasins. Also symbolized in this figure is the year the individual GDEi were mapped. The dates range from 1994 to 2014.

ii. Wetlands

The mapped wetlands GDEi are presented in Figure 2. The wetlands data set includes all surface water ecosystems that are potentially supported by groundwater including wetlands, rivers, lakes, springs, and seeps. There are approximately 7,600 acres of Wetland GDEI across the four TC Subbasins. Also symbolized in this figure is the year the individual GDEi were mapped. The dates range from 1972 to 2010.

b. Review of Aerial Imagery

The first step for identifying GDEs was to determine where land use changes had occurred between the time the GDEi were originally mapped and current conditions. The timeframe for GDEi is between 1972 and 2014 and the current land use conditions are represented by a 2018 land use dataset produced by Land IQ. GDEi were reviewed by comparing the vegetation and wetlands NCCAG datasets to the 2018 Land IQ dataset. If there were GDEi that overlayed or intersected with areas in the Land IQ dataset that were identified as developed, the GDEi were removed as potential GDEs. GDEi are generally accurate based on the Land IQ data. TNC vegetation and wetlands GDEi consistently aligned with the areas that are mapped as native vegetation and surface water in the 2018 Land IQ imagery. The areas of developed and undeveloped land are presented in Figure 3.

c. Evaluate Existence of a Connection to Groundwater

i. Depth to Water Contours

Groundwater dependence is required for a GDE and depth to water measurements were used to indicate the groundwater connection. Rhode et al, 2018 provides a work sheet outlining steps to assess if there a connection to groundwater. The first and primary step of this worksheet was to identify areas where depth to groundwater is less than 30 feet bgs. Well construction and groundwater level data were obtained from multiple public agency online databases including DWR, United States Geological Survey (USGS), the State Water Resource Control Board (SWRCB).

To identify areas where depth to groundwater exceeded 30 feet, shallow groundwater level data from wells constructed to depths of up to 100 feet bgs were used to create depth to

water contours. Contours for Spring 2015 are presented in Figure 4. 2015 was selected as this is the baseline year of SGMA. There are a limited number of shallow wells with ground water level data in each of the individual subbasins. Where data gaps exist, the depth to water and groundwater connection may not be possible to determine. To generalize, water levels are shallow (less than 30 feet) along the Sacramento River and
water levels away from the Sacramento River appear to be greater than 30 feet, indicating a lack of a connection to groundwater

d. Final GDE Designation

Final GDE designation included all of those GDEi that are located in areas that have not been developed and where the depth to groundwater is not greater than 30 feet bgs.

2. GDE Prioritization

Following the identification of GDE's that currently exist (post 2015 baseline), the GDEi were prioritized using TNC's GDE Pulse tool. The GDE Pulse tool provides information on the health of vegetation. The purpose of prioritizing GDEs was to identify areas that have potentially been impacted by declining water levels. Information from the prioritized areas will assist with determining undesirable results and minimum thresholds for the groundwater sustainability indicators.

a. GDE Pulse Analysis - Vegetation Prioritization

Given the large area of all the designated GDEs, areas were prioritized based on their observed health using remote sensing data. TNC developed the GDE Pulse tool (https://gde.codefornature.org/#/map) which allowed for easy access to processed remote sensing data to evaluate vegetation health. The metric used in the GDE pulse tool to evaluate changes in vegetation health was the Normalized Derived Vegetation Index (NDVI). This NDVI is a value calculated from the measured near-infrared (NIR) radiation and visible red light. Figure 5 shows an example of healthy and unhealthy vegetation along with an example for how the NDVI value is calculated.

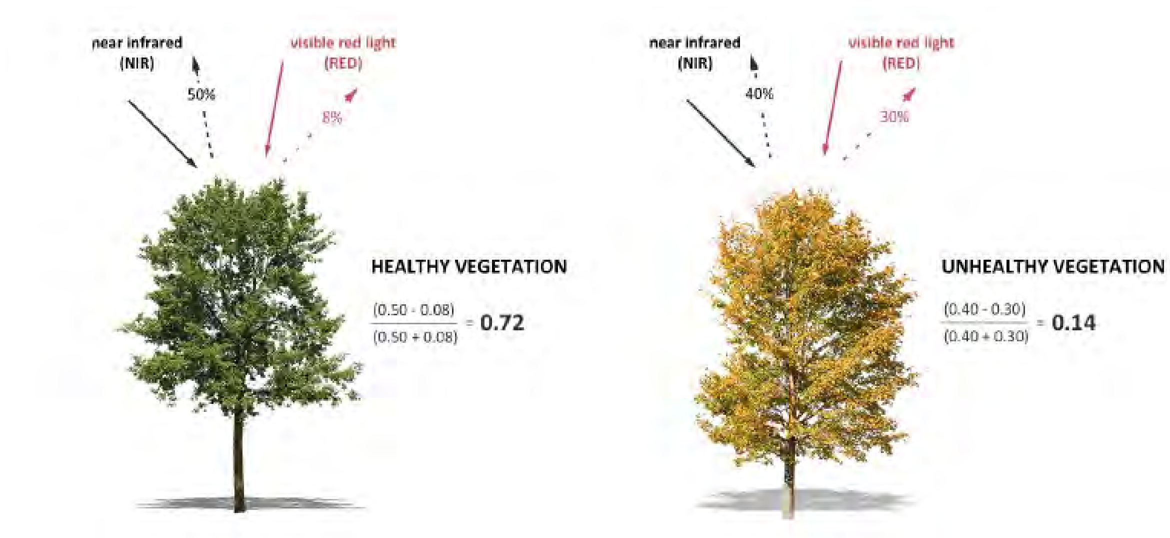


Figure 5. Example NDVI Calculation from Klausmeyer et al. 2019

The NDVI values calculated were based on images collected between July 9 and September 7 for each year. This time frame was selected based on the findings from Huntington et al., 2016 in that this is the time of year that vegetation is most likely relying on groundwater.

An annual NDVI value based on summer conditions was assigned to each individual GDE. A linear regression was performed to determine the trend of NDVI values between 1990 and 2018. This timeframe was selected as it is the baseline period for historic water conditions in the four TC Subbasins. The results from that analysis are presented in Figure 6.

NDVI trends were divided into three categories based on the magnitude of change from 1990 to 2018: *No Decline*, *Minimal Decline – Low Priority, Significant Decline – High Priority.* The magnitude of change is not a representation of actual vegetation health, but how the health of the vegetation has changed over the baseline period. High priority sites should be evaluated further to better understand the relationship between groundwater conditions and GDE health. High priority areas will also serve as the representative monitoring sites for all GDEs across the four Subbasins.

b. Wetlands Prioritization

The GDE pulse tool did not include any metrics on the health of areas in the Wetlands dataset. Wetland prioritization was determined by their proximity to Vegetation GDEs with declining NDVI values. Wetlands GDEs were assigned either high or low prioritization if in contract with or overlaying a Vegetation GDE with a high or low prioritization.

References

Huntington, Justin, Kenneth McGwire, Charles Morton, Keirith Snyder, Sarah Peterson, Tyler Erickson, Richard Niswonger, Rosemary Carroll, Guy Smith, and Richard Allen. 2016. "Assessing the Role of Climate and Resource Management on Groundwater Dependent Ecosystem Changes in Arid Environments with the Landsat Archive." *Remote Sensing of Environment.* https://doi.org/ 10.1016/j.rse.2016.07.004.

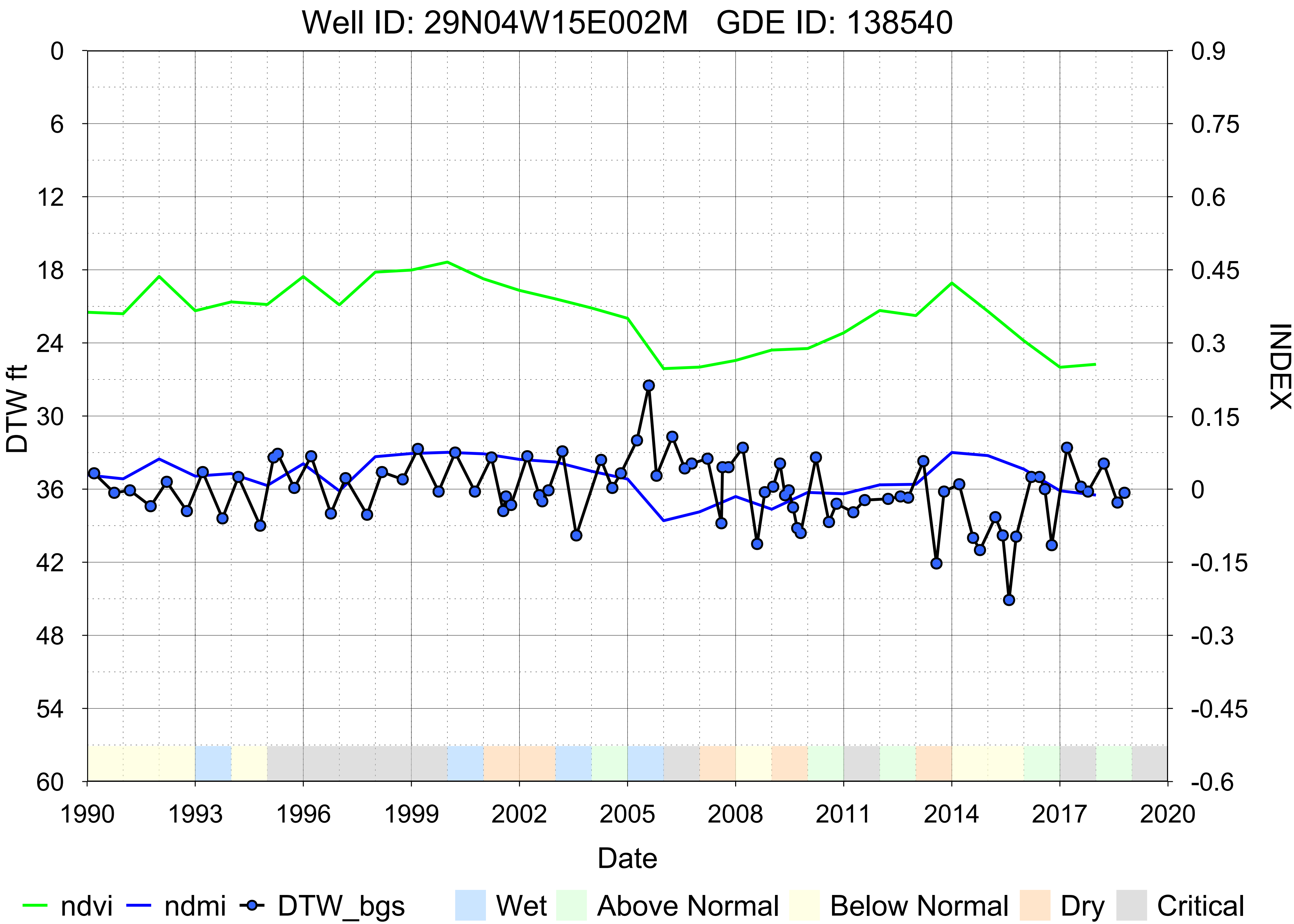
Klausmeyer, K., Howard J., Keeler-Wolf T., Davis-Fadtke K., Hull R., and Lyons A. (2018). Mapping Indicators of Groundwater dependent ecosystems in California

Rohde, M. M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. J. Remson. 2018. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans. The Nature Conservancy, San Francisco, California.

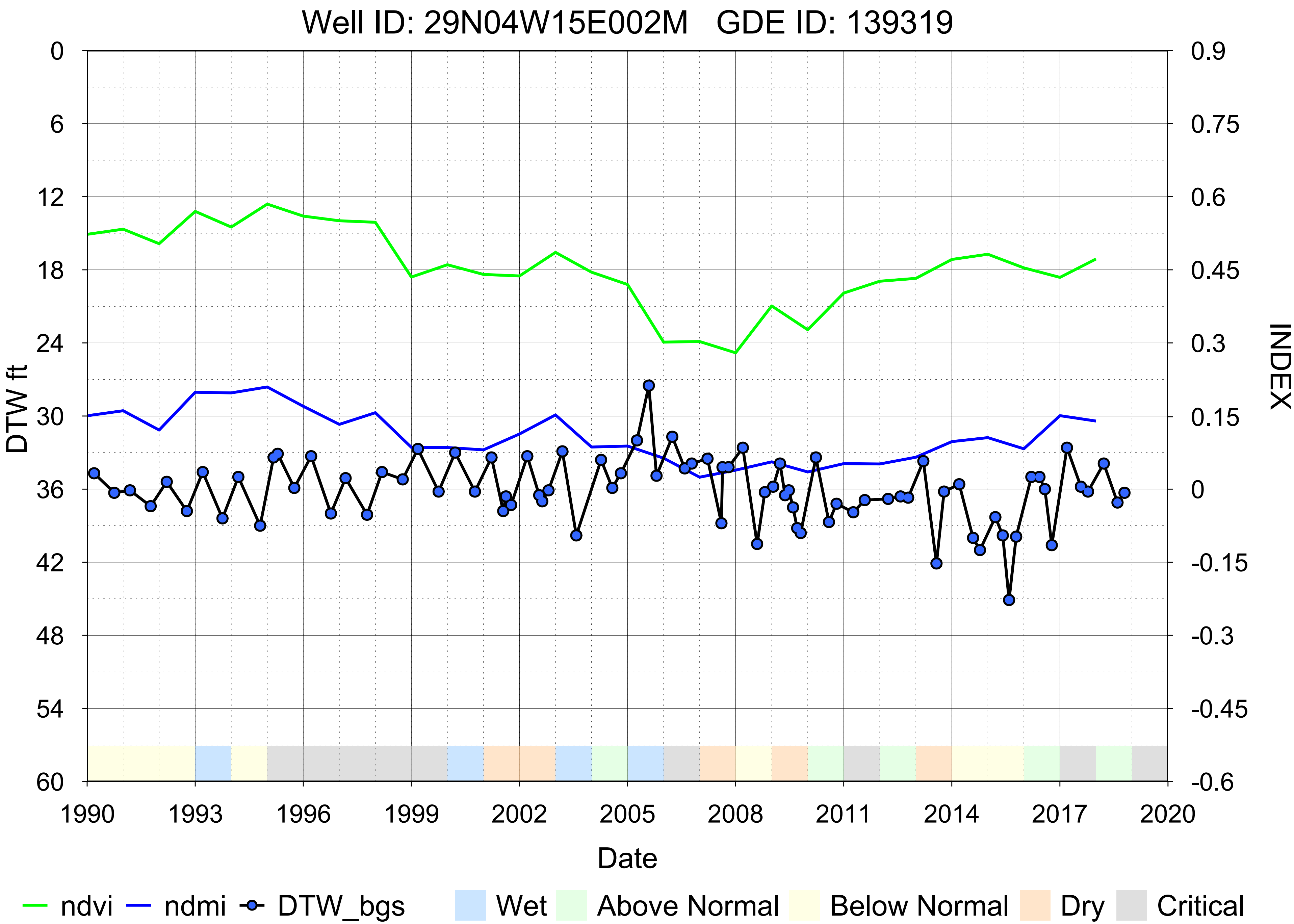
Appendix 2-I

Part 2

Timeseries Graphs of Depth to Water at Shallow Wells and NDVI and NDMI of Adjacent Vegetation



Well ID: 29N04W15E002M GDE ID: 138540
DTW ft
INDEX
Date
0
6
12
18
24
30
36
42
48
54
60
0.9
0.75
0.6
0.45
0.3
0.15
0
-0.15
-0.3
-0.45
-0.6
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



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DTW ft
INDEX
Date
0
6
12
18
24
30
36
42
48
54
60
0.9
0.75
0.6
0.45
0.3
0.15
0
-0.15
-0.3
-0.45
-0.6
1990
1993
1996
1999
2002
2005
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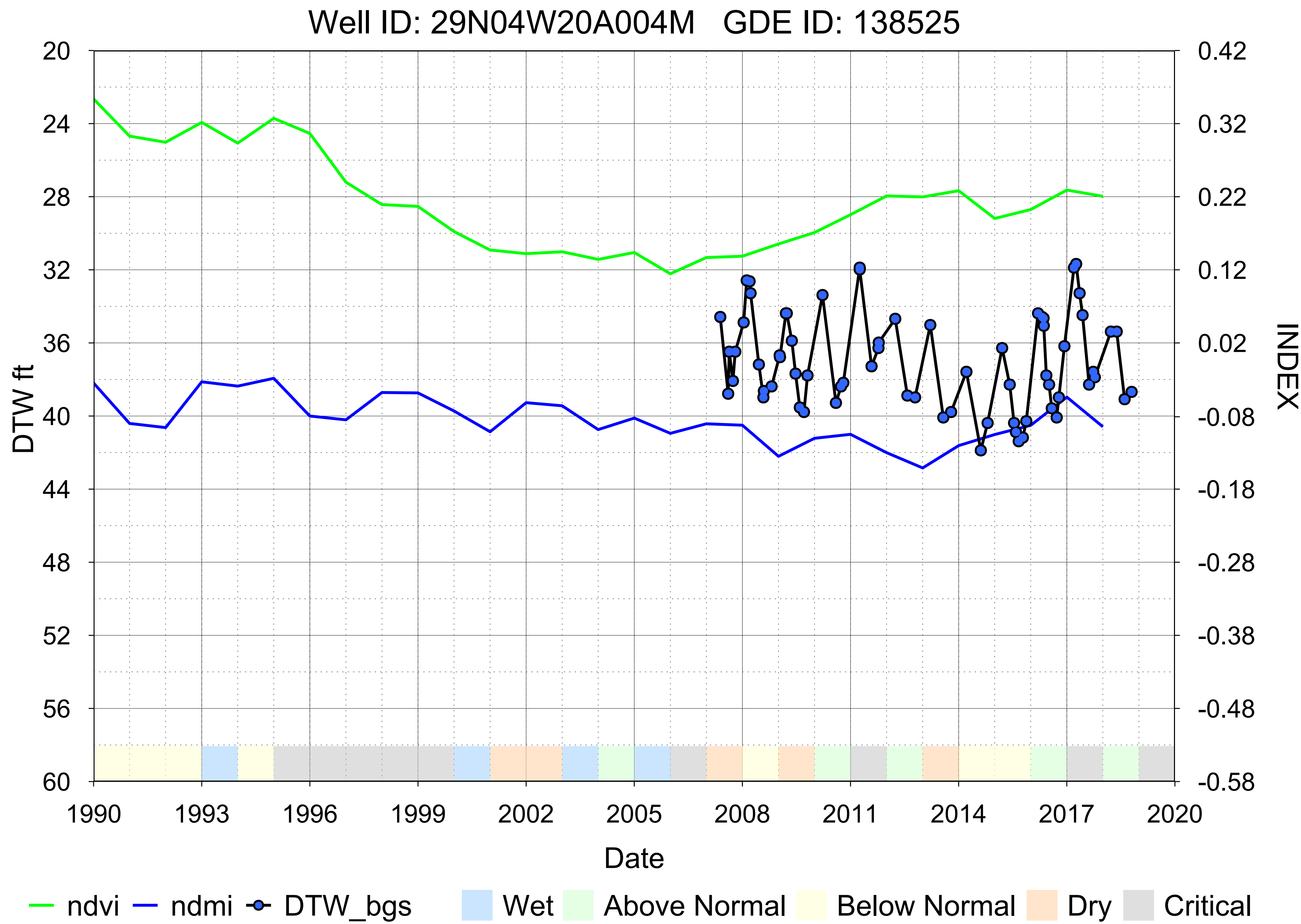
2017
2020
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



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DTW ft
INDEX
Date
20
24
28
32
36
40
44
48
52
56
60
0.42
0.32
0.22
0.12
0.02
-0.08
-0.18
-0.28
-0.38
-0.48
-0.58
1990
1993
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2002
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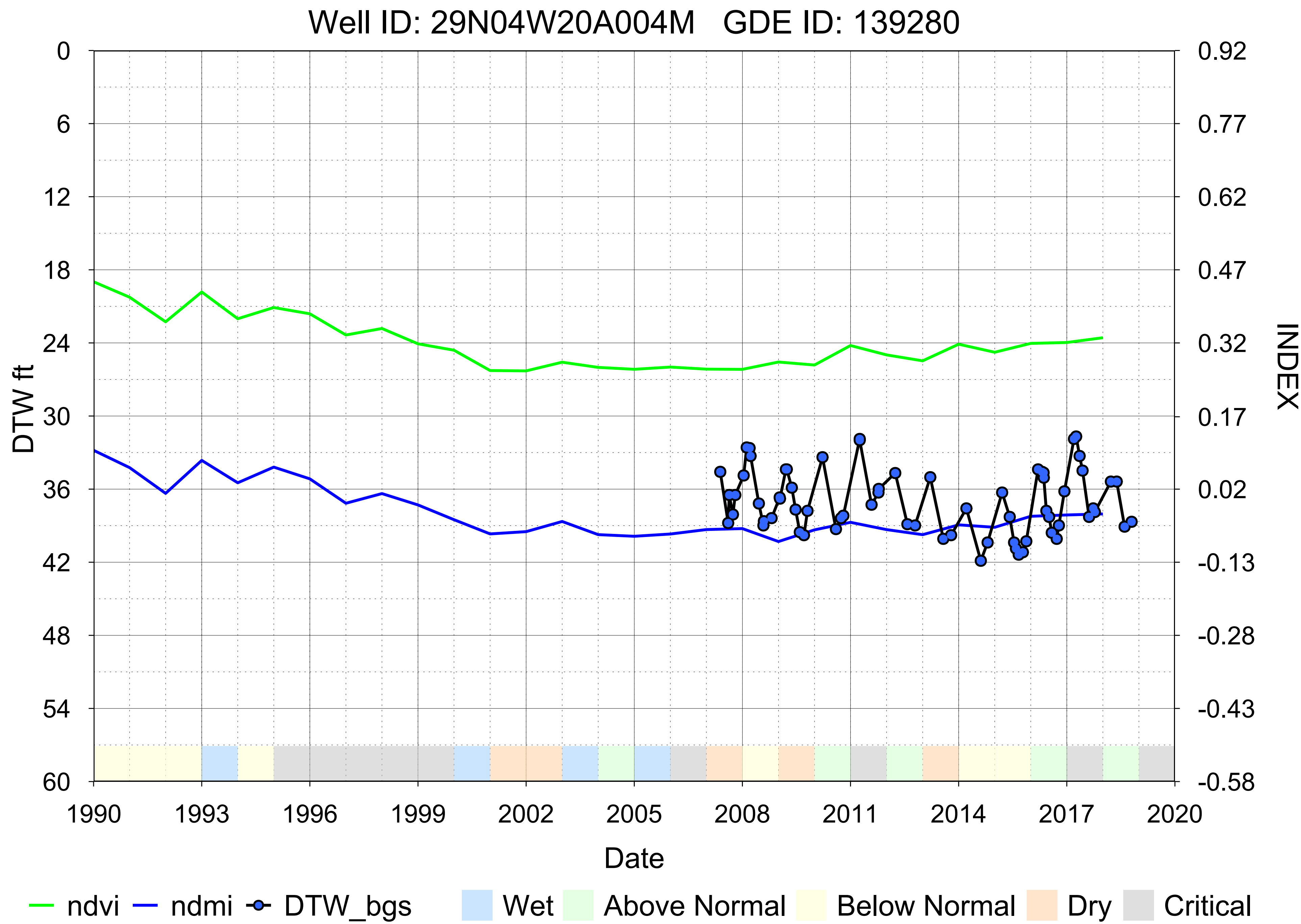
2014
2017
2020
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



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DTW ft
INDEX
Date
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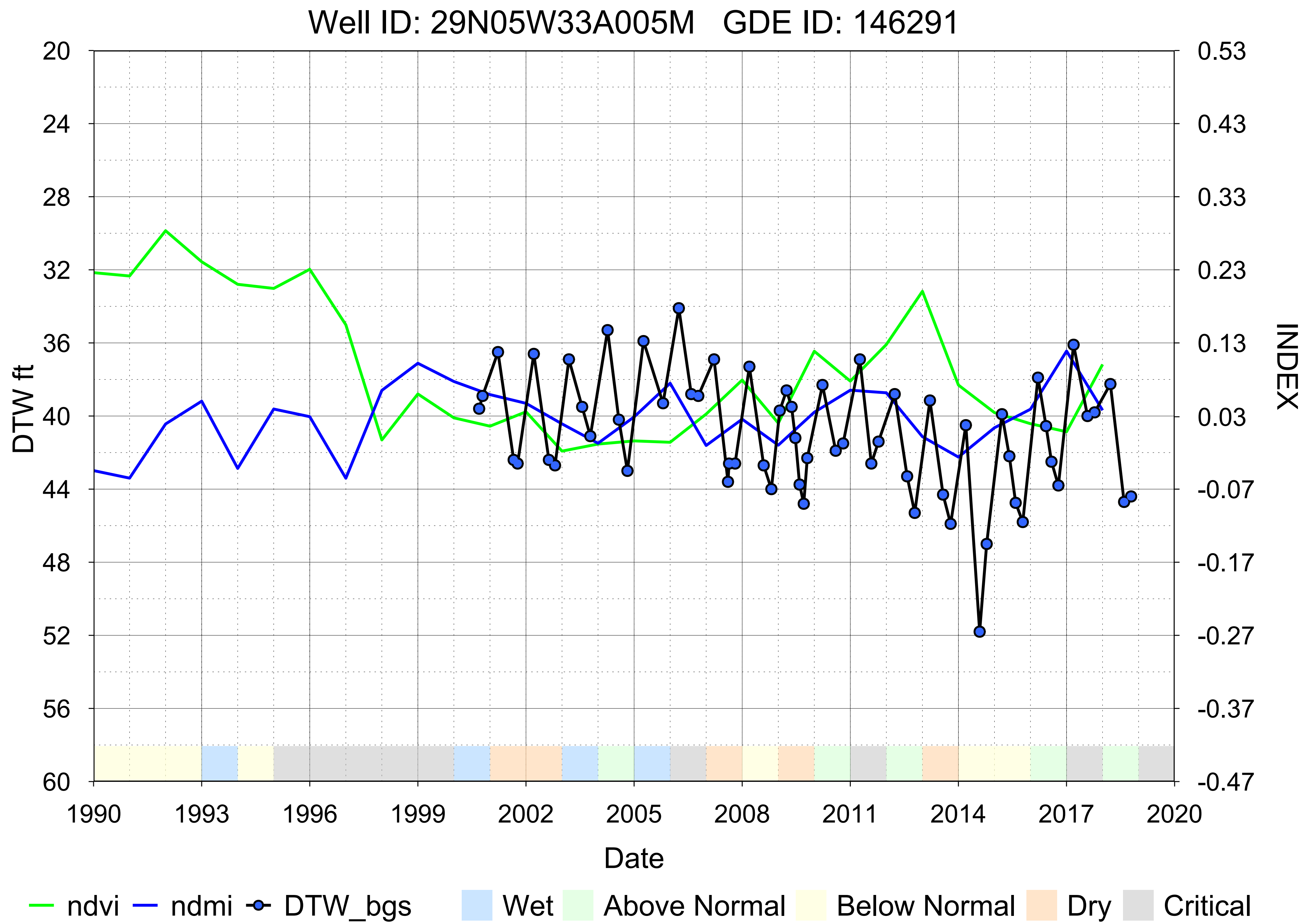
6
12
18
24
30
36
42
48
54
60
0.92
0.77
0.62
0.47
0.32
0.17
0.02
-0.13
-0.28
-0.43
-0.58
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



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Date
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28
32
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40
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48
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56
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0.53
0.43
0.33
0.23
0.13
0.03
-0.07
-0.17
-0.27
-0.37
-0.47
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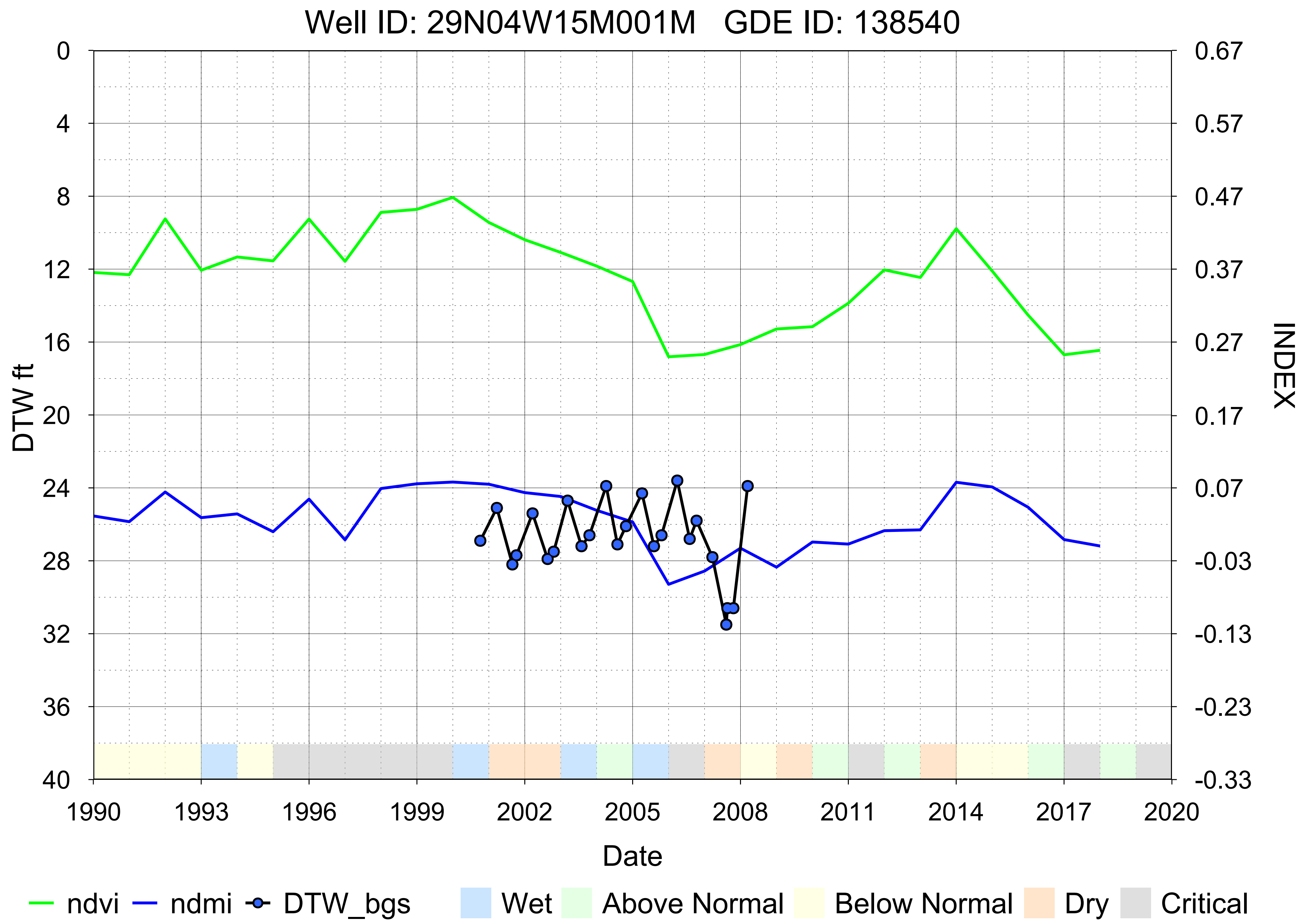
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



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DTW ft
0
4
8
12
16
20
24
28
32
36
40
INDEX
0.67
0.57
0.47
0.37
0.27
0.17
0.07
-0.03
-0.13
-0.23
-0.33
1990
1993
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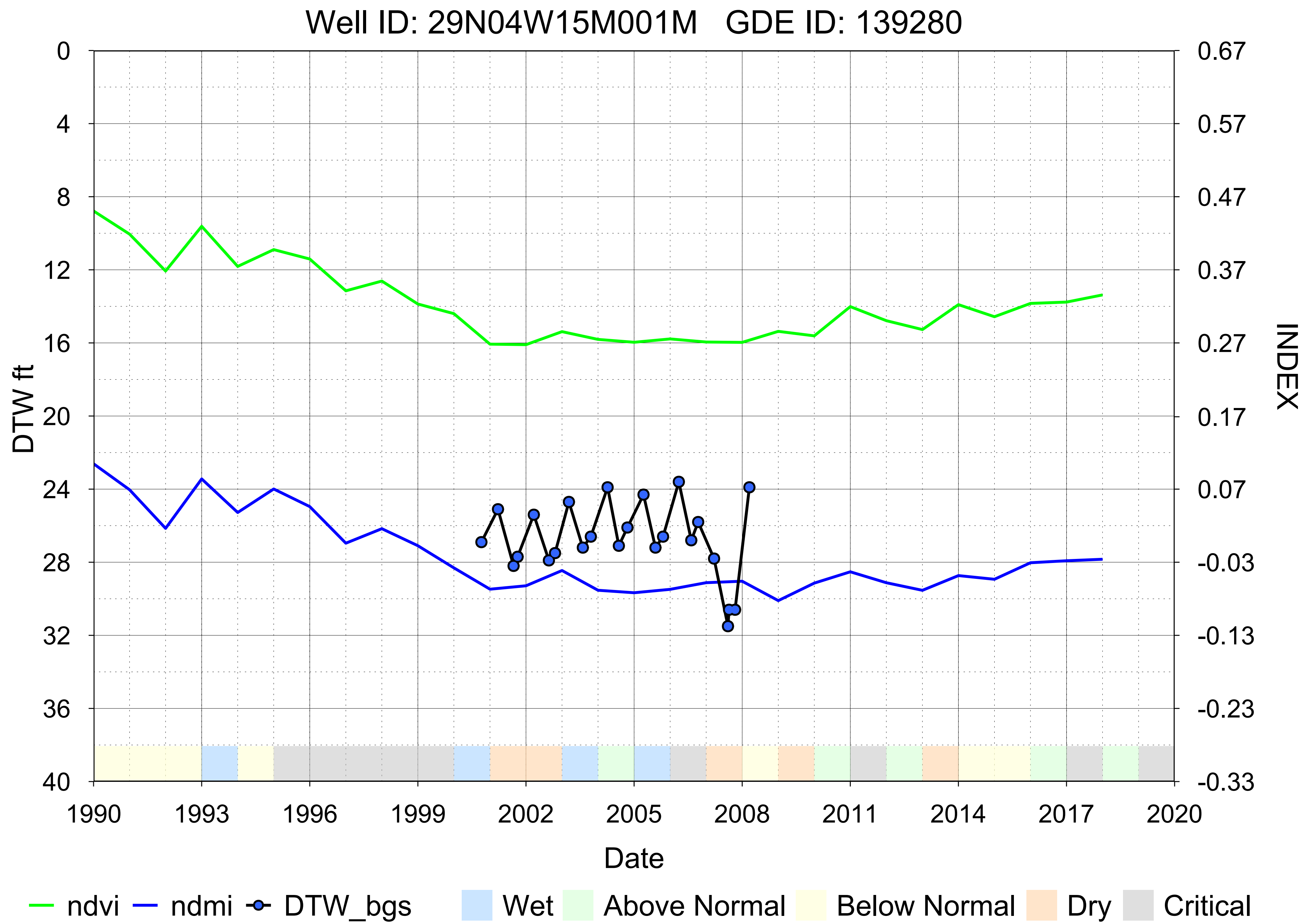
2002
2005
2008
2011
2014
2017
2020
Date
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



Well ID: 29N04W15M001M GDE ID: 139280
DTW ft
INDEX
Date
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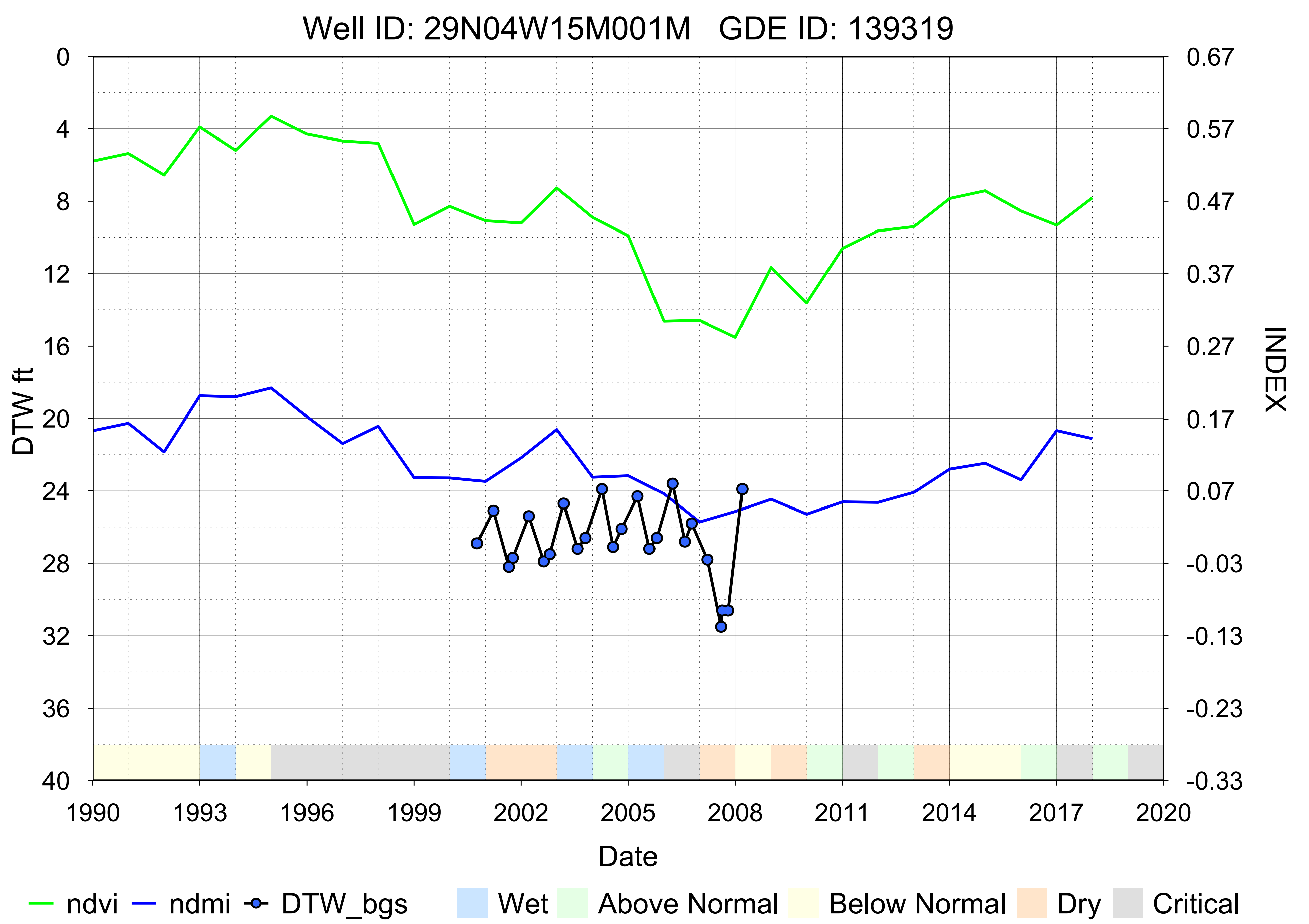
2020
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical



Well ID: 29N04W15M001M GDE ID: 139319
DTW ft
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0.17
0.07
-0.03
-0.13
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-0.33
1990
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2008
2011
2014
2017
2020
ndvi
ndmi
DTW_bgs
Wet
Above Normal
Below Normal
Dry
Critical

Appendix 2-J

Tehama Integrated Hydrologic Model Documentation Report

Tehama County

Sustainable Groundwater
Management Act

Groundwater Sustainability Plan

Tehama IHM Model Documentation

January 2022

Prepared For:

Tehama County Flood Control and Water Conservation District

Prepared By:

Luhdorff & Scalmanini, Consulting Engineers

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LIST OF ACRONYMS

AF	acre-feet
ASCE	American Society of Civil Engineers
BMP	Best Management Practices
CDEC	California Data Exchange Center
C2VSim	Central Valley Groundwater-Surface Water Simulation Model
CIMIS	California Irrigation Management Information System
CSS	Composite Scaled Sensitivity
CVP	Central Valley Project
DWR	California Department of Water Resources
ET	Evapotranspiration
Et_a	Actual Evapotranspiration
ET_{aw}	Evapotranspiration of Applied Water
ET_c	Crop Evapotranspiration
ET_o	Daily reference ET
ET_{pr}	Evapotranspiration of Precipitation
Et_r	Alfalfa Reference Evapotranspiration
eWRIMS	Electronic Water Rights Information Management System
ft/d	Feet Per Day
GDE	Groundwater Dependent Ecosystems
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWS	Groundwater System
IDC	Irrigation Demand Calculator
IWFM	Integrated Water Flow Model
Kh	Horizontal Hydraulic Conductivity
Kv	Vertical Hydraulic Conductivity
MAE	Mean of Absolute Residual Error
ME	Residual Error
METRIC	Mapping Evapotranspiration at High Resolution using Internalized Calibration
NRMSE	Normalized Root Mean of Squared Residual Error
PM	Penman-Monteith
PMAs	Projects and Management Actions
PRISM	Parameter Elevation Regression on Independent Slopes Model
R	Linear Correlation Coefficient
RMSE	Root Mean of Squared Residual Error
SEBAL	Surface Energy Balance Algorithm for Land
SGMA	Sustainable Groundwater Management Act
Ss	Specific Storage
SVSim	Sacramento Valley Groundwater-Surface Water Simulation Model
SWRCB	State Water Resources Control Board
SWS	Surface Water System
Sy	Specific Yield
TAF	Thousand Acre-Feet

Tehama IHM	Tehama Integrated Hydrologic Model
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity
WCR	Well Completion Report
WD	Water District

1. INTRODUCTION

This report documents the development and calibration of the Tehama Integrated Hydrologic Model (Tehama IHM), a numerical groundwater flow model developed for four groundwater subbasins (Antelope, Bowman, Los Molinos, and Red Bluff) within Tehama County to support preparation of the Groundwater Sustainability Plans (GSPs) for the County, along with other future potential groundwater management and planning needs. This report includes a summary of the model platform, data sources, model development and calibration, model scenarios, and model results.

1.1. Background

To support GSP preparation the Tehama County Flood Control and Water Conservation District Groundwater Sustainability Agency (GSA) developed a numerical groundwater flow model covering the Antelope, Bowman, Los Molinos, and Red Bluff Subbasins to address GSP regulations requiring use of a numerical groundwater model, or equally effective approach, to evaluate historical and projected water budget conditions and potential impacts to groundwater conditions and users from the GSP implementation while also providing a broader tool for use in groundwater management decisions in the Subbasins. The development of Tehama IHM is intended primarily to support groundwater resources management activities associated with GSP development and implementation but is also envisioned as a tool that will also support water resources management activities less related to the GSP. Tehama IHM utilizes data and the hydrogeologic conceptualization that are presented and described in the four subbasin GSPs for to improve the understanding of hydrologic processes and their relationship to key sustainability metrics within the subbasins. Tehama IHM provides a platform to evaluate potential outcomes and impacts from future management actions, projects, and adaptive management strategies through predictive modeling scenarios.

1.2. Objectives and Approach

Numerical groundwater models are structured tools developed to represent the physical basin setting and simulate groundwater flow processes by integrating many data types (e.g., lithology, groundwater levels, surface water features, groundwater pumping) that represent the conceptualization of the hydrogeologic setting and processes. Tehama IHM was developed in a manner consistent with the Modeling Best Management Practices (BMP) guidance document prepared by the California Department of Water Resources (DWR) (DWR, 2016). The objective of Tehama IHM is to simulate hydrologic processes and effectively estimate historical and projected hydrologic conditions in the four subbasins related to Sustainable Groundwater Management Act (SGMA) sustainability indicators relevant to Tehama County including:

1. Lowering of Groundwater Levels
2. Reduction of Groundwater Storage
3. Depletion of Interconnected Surface Water

The development of Tehama IHM involved starting with and evaluating the beta version of DWR's Sacramento Valley Groundwater-Surface Water Simulation Model (SVSim) (release data April 29, 2020; DWR, 2020) and eventually carving out a local model domain and conducting local refinements to the model structure (e.g., nodes, elements) and modifying or replacing inputs as needed to sufficiently and accurately simulate local conditions in Tehama County areas within the model domain. SVSim utilizes the most current version of the Integrated Water Flow Model (IWFM) code available at the time of the Tehama IHM development. IWFM and SVSim were selected as the modeling platform due to the versatility in simulating crop-water demands in the predominantly agricultural setting of the subbasins, groundwater surface-water interaction, the existing hydrologic inputs existing in the model for the time period through the end of water year 2015, and the ability to customize the existing SVSim model to be more representative of local conditions in the area of Tehama County. Tehama IHM was refined from SVSim and calibrated to a diverse set of available historical data using industry standard techniques.

1.3. Report Organization

This report is organized into the following sections:

- Section 2: Model Code and Platform
- Section 3: Groundwater Flow Model Development
- Section 4: Groundwater Flow Model Results
- Section 5: Sensitivity Analysis
- Section 6: Model Uncertainty and Limitations
- Section 7: Conclusions and Recommendations
- Section 8: References

2. MODEL CODE AND PLATFORM

The modeling code and platform utilized for Tehama IHM are described below. As required by GSP regulations, the selected model code is in the public domain. The decision to select the model codes for the Tehama IHM was based on providing Tehama County with a modeling tool that can be used for GSP development with sufficient representation of local conditions, while utilizing to the extent possible, previous modeling tools available, including regional models. With this objective in mind, the model tools and platforms described below were determined to be most suitable for adaptation for use in GSP analyses.

2.1. Integrated Water Flow Model

IWFM is a quasi-three-dimensional finite element modeling software that simulates groundwater, surface water, groundwater-surface water interaction, as well as other components of the hydrologic system (Dogrul et al., 2017). Tehama IHM is developed using the IWFM Version 2015 (IWFM-2015) code, which couples a three-dimensional finite element groundwater simulation process with one-dimensional land surface, river, lake, unsaturated zone, and small-stream watershed processes (Brush et al., 2016). A key feature of IWFM-2015 is its capability to simulate the water demand as a function of different land use and crop types and compare it to the historical or projected amount of water supply (Dogrul et al., 2017). IWFM uses a model layering structure in which model layers represent aquifer zones that are assigned aquifer properties relating to both horizontal and vertical groundwater movement (e.g., horizontal and vertical hydraulic conductivity) and storage characteristics (e.g., specific yield, specific storage) with the option to associate an aquitard to each layer, although represented aquitards are assigned a more limited set of properties relating primarily to their role in vertical flow (e.g., vertical hydraulic conductivity).

The IWFM-2015 source code and additional information and documentation relating to the IWFM-2015 code is available from DWR at the link below:

https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model

2.1.1. IWFM Demand Calculator

IWFM includes a stand-alone Integrated Water Flow Model Irrigation Demand Calculator (IDC) that calculates water demands. Agricultural water demands are calculated in IDC based on climate, land use, soil properties, and irrigation method whereas urban demands are calculated based on population and per-capita water use. Tehama IHM utilizes IDC to simulate root zone processes and water demands. The physically based IDC version 2015.0.88 (released August 25, 2020) is developed and maintained by DWR.

2.2. SVSim

The SVSim model utilizes the IWFM-2015 code and represents a refinement of the previous California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) coarse grid (CG) and fine grid (FG) models. Refinements made in the development of SVSim include a finer horizontal discretization, an updated aquifer layering scheme, updated hydrogeology, and an extended simulation period through water year 2015 (DWR, 2020). When compared with C2VSim, SVSim improves the simulation of stream-groundwater interaction with thinner shallow model layers and a finer grid adjacent to waterways (DWR, 2020). The SVSim version available from DWR at the time of the initiation of modeling efforts to support GSP preparation in Tehama County was not a calibrated model version. In January 2021, a calibrated Version 1.0 release of SVSim was made available to the public through the California Natural Resources

Agency Open Data website (https://data.cnra.ca.gov/dataset/svsim) and was reviewed and considered during the development of the Tehama IHM. The SVSim Version 1.0 was subsequently removed from the Open Data website and as of the date of this report (September 2021), a calibrated version of SVSim is no longer available.

3. GROUNDWATER FLOW MODEL DEVELOPMENT

This section describes the spatial and temporal (time-series) structure of the model and the input data that was utilized for model development. The model development process utilized data and information that was available at the time of model development and is described in greater detail in the Subbasin GSPs.

3.1. Tehama IHM – Historical Model Simulation

The Tehama IHM historical model simulates the period from October 1985 through September 2019 at a monthly time step, with a calibration period of October 1989 through September 2018. Water years, as opposed to calendar years, are used as the time unit for defining analysis, following the DWR standard water year period (October 1 through September 30). Unless otherwise noted, all years referenced in this report are water years. The historical model calibration period extends from water years 1990 through 2018. Water years 1985 through 1989 are not included as part of the historical calibration period, but are simulated to allow the model sufficient time to adjust to the specified initial conditions and spin-up prior to the calibration period starting in October 1989.

3.1.1. Historical Base Period Selection

In accordance with GSP Regulations, the historical water budget for the Subbasins must quantify all required water budget components starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the water budget (23 CCR § 354.18(c)(2)(B)). The historical water budget period effectively represents long-term average hydrologic conditions and enables evaluation of the effects of historical hydrologic conditions and water demands on the water budget and groundwater conditions within the Subbasins over a period representative of long-term hydrologic conditions.

The historical water budget period was selected to evaluate conditions over discrete representative periods considering the following criteria: Sacramento Valley water year type; long-term mean annual water supply; inclusion of both wet and dry periods, antecedent dry conditions, adequate data availability; and inclusion of current hydrologic, cultural, and water management conditions in the Subbasins. The availability of historical data for use in developing model inputs is greatly increased for years since 1990 in the Subbasins.

Based on these criteria, the historical water budget period and model calibration period was selected as water years 1990-2018 (29 years) using historical hydrologic, climate, water supply, and land use data. The period from 1990-2018 is consistent with long-term average historical hydrologic conditions in the Subbasins as illustrated in **Table 3-1**. Further information and discussion of the historical water budget period, including discussion of historical hydrology and the historical base period selection considerations, are presented in **Section 2.3** of the Subbasin GSPs.

Table 3-1. Sacramento Valley Water Year Type Classification of the Historical Water Budget Period (1990-2018)

Sacramento Valley Water Year Type	Abbreviation	Number of Years, 1990-2018	Average Water Year Index	Average Precipitation	Percent Total Years, 1990-2018
Wet	W	8	11.87	28.8	28%
Above Normal	AN	4	8.55	28.1	14%
Below Normal	BN	5	7.07	21.0	17%
Dry	D	5	5.98	17.2	17%
Critical	C	7	4.48	17.1	24%
	Total	**29**	**7.78**	**22.5**	**100%**

Note: Water Year Type is based on the Sacramento Valley Water Year Index and is classified into five types: Wet (W) ≥9.2; Above Normal (AN) 7.8-9.2; Below Normal (BN) 6.5-7.8; Dry (D) 5.4-6.5; Critical (C) ≤5.4. Precipitation data is based on Red Bluff Municipal Airport station (NOAA station ID USW00024216).

3.1.2. Model Configuration

The Tehama IHM grid of nodes and elements was carved out of the regional SVSim model domain. While Tehama IHM focuses on the Antelope, Bowman, Los Molinos, and Red Bluff Subbasins, the model domain was extended outside the Subbasins to incorporate a buffer that includes area within the Corning, Vina, Anderson, Millville, South Battle Creek, Bend, and Colusa Subbasins. The extent of the buffer is approximately five miles outside of Tehama County, or to the extent of the SVSim model where that extent is less than five miles outside the County. The appropriate extent of the buffer was determined using DWR's C2VSimFG model (DWR, 2021), a calibrated regional model, by testing the radius of influence from pumping wells. The Tehama IHM domain, shown in **Figure 3-1**, encompasses a total of 942,227 acres. All SVSim model features (e.g., nodes, elements, streams, layers) within this domain were initially included in Tehama IHM with subsequent modifications and refinements made within Tehama IHM to these model components, as described in later sections of this report.

3.1.2.1. Nodes and Elements

The Tehama IHM grid contains 5,209 nodes and 5,398 elements (**Figure 3-1**). The X-Y coordinates for node locations are presented in the UTM Zone 10N, NAD83 (meters) projected coordinate system. While the number of nodes and elements within the Tehama IHM domain were not altered from SVSim, the locations of some nodes and elements were modified to more accurately align with added streams being simulated in Tehama IHM. **Figure 3-2** highlights the modified nodes and elements in Tehama IHM. **Table 3-2** presents Tehama IHM grid characteristics.

Table 3-2. Tehama IHM Grid Characteristics

Nodes	5,209
Elements	5,398
Average Element Size (acres)	*175*
Minimum Element Size (acres)	*0.72*
Maximum Element Size (acres)	*2,122*
Subregions	4
Aquifer Layers	9

3.1.2.2. Model Subregions

Model elements are grouped into subregions to assist in the summarization of model results and development of water budgets. Tehama IHM includes four subregions (listed in **Table 3-3**). Subregions were delineated by subbasin. While subregions are used as the basis for summarizing model results, the model simulates hydrologic processes and conditions at the resolution of elements or nodes. **Figure 3-3** shows the extent of the different subregions delineated in Tehama IHM.

Table 3-3. Model Subregions within Tehama IHM

Subregion Name	Actual Acreage	Modeled Acreage
Antelope Subbasin	19,091	19,057
Bowman Subbasin	122,534	122,760
Los Molinos Subbasin	99,422	99,351
Red Bluff Subbasin	271,794	272,155

3.1.2.3. Streams

Tehama IHM includes 29 stream reaches composed of 599 stream nodes. Most of the streams explicitly simulated in Tehama IHM were streams included in SVSim. Streams that were adapted from existing streams simulated in SVSim include Antelope Creek Group, Battle Creek, Cottonwood Creek, Deer Creek Group, Elder Creek, Glenn-Colusa Canal, Mill Creek, Paynes Creek, Sacramento River, Stoney Creek, and Thomes Creek. Streams added to Tehama IHM that were not included in SVSim include Dye Creek and Red Bank Creek. Some of the model nodes were shifted to better align with the actual stream configuration of added streams. The entire stream network included in Tehama IHM is shown in **Figure 3-4**.

3.1.2.4. Model Layers

No adjustments to the layering scheme from SVSim were made in the development of Tehama IHM. Tehama IHM includes a total of nine model layers; in the IWFM model code, model layers can be subdivided into aquifer layers and aquitard layers for representation of different hydrogeologic characteristics within a single model layer. None of the model layers specifically included simulation of an aquitard layer, although finer-grained zones with potential to impede vertical flow in ways similar to an aquitard were simulated in accordance with the HCM (**Section 2.2 of the GSPs**) and available sediment texture data. **Table 3-4** presents the average thickness of each model layer in Tehama IHM. The uppermost layers are thin in order to better represent surface water-groundwater interaction. As described in the HCM presented in **Section 2.2 of the GSP**, the Subbasin has two primary aquifers: an unconfined to semi-confined Upper Aquifer and a confined to semi-confined Lower Aquifer. In general, model layers 1 through 5 correspond with the Upper Aquifer and layers 6 through 9 correspond with the Lower Aquifer. Further information about the local geology in the Tehama County Subbasins is presented in **Section 2.2 of the Subbasin GSPs**.

Table 3-4. Average Thicknesses of Tehama IHM Layers

Average Model Layer Thickness (feet)	
Layer 1	35
Layer 2	35
Layer 3	40
Layer 4	58
Layer 5	129
Layer 6	193
Layer 7	129
Layer 8	193
Layer 9	515

Elevations and thicknesses of each of the Tehama IHM model layers are shown in **Figures 3-5** through **3-23.**

3.1.3. Land Surface System Inputs

The IWFM Land Surface Process, which includes the IDC, calculates a water budget for four land use categories: non-ponded agricultural crops, ponded agricultural crops (i.e., rice), native and riparian vegetation, and urban areas. The Land Surface Process calculates water demand at the surface, allocates water to meet demands, and routes excess water through the root zone (Brush et al., 2016). The development of land surface system input files built on previous water budget data and analyses related to surface water system water budgets available for some areas of the Subbasins and was expanded to represent the entire Subbasins and a longer analysis period. The development of the land surface system model input files is described in the following section with additional detail provided in **Section 2.3 of the GSPs**.

3.1.3.1. Precipitation

For water years 1985-2019, monthly precipitation data for all elements and small watersheds in Tehama IHM were derived from the Parameter Elevation Regression on Independent Slopes Model (PRISM) system, which is operated by the PRISM Climate Group at Oregon State University. PRISM combines weather and climate data from various monitoring station networks, applies a range of modeling techniques, and develops gridded spatial climate parameter datasets for grid cells across the United States at a spatial resolution of four kilometers (NACSE, 2021). Building on previous water budget analysis work, monthly precipitation data sets were downloaded for the coordinates nearest the centroid of each element or watershed in Tehama IHM. The monthly data sets were quality controlled and provided as model inputs for the nearest corresponding element or small watershed. PRISM gridded precipitation data were extracted and interpolated, as needed, for each element in the Tehama IHM model domain, and for the centroid of each small watershed upgradient to the Tehama IHM model domain. Precipitation inflows to each small watershed were calculated as the monthly precipitation depth derived from PRISM data, applied over the total area of that small watershed.

3.1.3.2. Evapotranspiration

Monthly evapotranspiration (ET) time series data were refined for water years 1985 through 2019. Monthly ET rates were developed for individual crop types using the best available science, as described in this section.

3.1.3.2.1 Reference Evapotranspiration Development

Daily reference ET (ET_o) values for calendar years 1985-2019 were based on measured weather data obtained from the California Irrigation Management Information System (CIMIS) “Gerber” station (CIMIS station ID 008) and “Gerber South” station (station ID 222). Data from the Gerber CIMIS station were used to represent average ET_o in the Tehama County Subbasins. The Gerber CIMIS station was used because of its long period of record and generally high-quality data compared to other CIMIS stations located in or near Tehama County. When the Gerber CIMIS station became inactive in 2014, data were obtained from the Gerber South CIMIS station. Daily time series data were evaluated following standard quality control procedures recommended by the American Society of Civil Engineers (ASCE) and others (Allen, 1996; Allen et al, 1998; Allen et al, 2005; ASCE, 2016).

For any days when quality control procedures resulted in refinements to any weather data, daily ET_o values were determined following the widely accepted standardized Penman-Monteith (PM) method, as described by the ASCE Task Committee Report on the Standardized Reference Evapotranspiration Equation (ASCE-EWRI, 2005). The Task Committee Report standardizes the ASCE PM method for application to a full-cover alfalfa reference (ET_r) and to a clipped cool season grass reference (ET_o). The clipped cool season grass reference is widely used throughout California and was selected for this application. For any days when quality control procedures did not result in refinements to weather data, ET_o values reported by the station were used directly. The combined daily ET_o time series record was used to calculate crop evapotranspiration inputs for all years in the Tehama IHM historical scenario.

3.1.3.2.2 Crop Evapotranspiration Development

Crop evapotranspiration (ET_c), or crop consumptive use, represents the volume of water that is lost to the atmosphere through both evaporation from soil and transpiration from crop surfaces. ET_c time series data are provided as inputs to the Tehama IHM. As part of the internal model processes, the Tehama IHM apportions these ET_c values between ET_{pr} and ET_{aw} by water use sector (based on land use type), as required by the GSP Regulations.

ET_c for each crop and land use class in the Tehama County Subbasins was calculated using the “crop coefficient – reference crop ET” methodology. In this method, daily ET_o values are adjusted to represent the unique and varying daily ET_c rates of other specific crops throughout their growing seasons using specific crop coefficient curves. Daily crop coefficient curves for major crops, native vegetation, and urban areas were derived using spatial land use data, daily ET_o values, and actual ET (ET_a) estimates determined from satellite imagery using two remote sensing surface energy balance models – the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, et al. 2005) and Mapping Evapotranspiration at High Resolution using Internalized Calibration (METRIC) (Allen, et al. 2007a). SEBAL and METRIC estimates of ET_a account for actual, observed conditions in the Tehama County Subbasins that affect crop consumptive use, such as salinity, deficit irrigation, disease, fertilization, immature permanent crops, and crop canopy structure, and other factors. Studies by Bastiaanssen et al. (2005), Allen et al. (2007b, 2011), Thoreson et al. (2009), and others have found that when performed by an expert analyst, seasonal ET_a estimates by these models are expected to be within five percent of actual ET determined using other reliable methods.

Spatially distributed ET_a results were available with spatial cropping data for 2009 (SEBAL) and 2017 (METRIC). Crop coefficient curves developed using 2009 SEBAL results were used to calculate ET_c values during water years 1983-2014, and crop coefficient curves developed using 2017 METRIC results were used to calculate ET_c values during water years 2015-2019.

3.1.3.3. Land Use

Characterizing historical land use is foundational for accurately quantifying how and where water is beneficially used. Land use areas are also used to distinguish the water use sector in which water is consumed, as required by the GSP Regulations. In the Tehama County Subbasins, water use sectors include agricultural, urban, and native vegetation land uses. The urban water use sector covers all urban, residential, industrial, and semi-agricultural land uses. See **Section 2.1 of the Subbasin GSPs** for more detail on land use in the Subbasins.

In the Antelope Subbasin, on average, agricultural, urban, and native vegetation land uses covered approximately 8,900 acres, 1,900 acres, and 8,300 acres, respectively, between 1990 and 2018. The total acreage of each water use sector has remained relatively steady over time, with only a slight increase in native vegetation corresponding with a slight decrease in agricultural area during the late 2000s and early 2010s. Historically, a majority of the agricultural area in the Antelope Subbasin has been comprised of orchards (primarily walnuts, prunes, and almonds) and pasture, with varying acreage of grain and hay crops over time. The overall orchard acreage has generally increased since the early 2000s. **Figure 3-24** summarizes annual land use over the historical period (1990-2018) in the Antelope Subbasin.

In the Bowman Subbasin, on average, agricultural, urban, and native vegetation land uses covered an average of 5,800 acres, 1,500 acres, and 115,100 acres, respectively, between 1990 and 2018. Since 1990, approximately 1,200 acres of native vegetation in the Bowman Subbasin has been converted to agricultural and urban land uses. Historically, irrigated pasture has been the predominant agricultural land use in the Bowman Subbasin. Other irrigated crops include mainly alfalfa, grain, and various orchard crops, especially walnuts, almonds, and prunes. Flood irrigation is typically used to support pasture, alfalfa, and grain crops in the Bowman Subbasin. **Figure 3-25** summarizes annual land use over the historical period (1990-2018) in the Bowman Subbasin.

In the Los Molinos Subbasin, on average, agricultural, urban, and native vegetation land uses covered approximately 18,200 acres, 1,600 acres, and 79,500 acres, respectively, between 1990 and 2018. The total area of each water use sector has remained relatively constant over time, though slight expansion of urban land uses in the 1990s coincided with a similar decrease in agricultural acreage. Historically, a majority of the agricultural area in the Los Molinos Subbasin has been comprised of pasture and various orchard crops, especially walnuts and prunes. The total area used to cultivate these primary crops has remained relatively constant over time, though the composition of orchard crops has shifted in recent years, with decreased acreage of prunes and increased acreage of walnuts. Slight decreases in agricultural land use have instead resulted from loss of other irrigated crop areas, such as alfalfa, grain, and safflower. **Figure 3-26** summarizes annual land use over the historical period (1990-2018) in the Los Molinos Subbasin.

In the Red Bluff Subbasin, on average, agricultural, urban, and native vegetation land uses covered approximately 36,000 acres, 6,400 acres, and 229,500 acres, respectively, between 1990 and 2018. Since 1990, the total area of native vegetation has decreased by approximately 10,000 acres, corresponding with a similar increase in agricultural acreage. Historically, a majority of the agricultural area in the Red Bluff Subbasin has been comprised of pasture, grain, and various orchard crops. Since the early 2000s, irrigated agricultural areas within the Red Bluff Subbasin have expanded, primarily due to increases in orchard acreage, especially walnuts and almonds. **Figure 3-27** summarizes annual land use over the historical period (1990-2018) in the Red Bluff Subbasin.

3.1.4. Surface Water System Inputs

The IWFM Surface Water Process calculates a water budget along each stream reach between inflows and outflows, including stream-groundwater interactions (Brush et al., 2016). The development of surface water system input files is explained in this section.

3.1.4.1. Stream Characteristics

Stream bed parameters were taken from SVSim for those stream nodes extracted from the SVSim regional model. For additional stream nodes in Tehama IHM, stream bed parameters were developed through review of stream characteristics of similar water features represented in SVSim and those characteristics were adopted for the new stream segments, as appropriate, using professional judgement and local knowledge of stream characteristics. Stream bed parameters, particularly stream bed conductivity, were further refined during the calibration process.

3.1.4.2. Surface Water Inflows

Surface water inflows into the model domain were specified in Tehama IHM for 16 surface water inflow locations shown in **Figure 3-28.** Surface water inflows to Tehama IHM were taken from SVSim or developed from data reported by the United States Geological Survey (USGS) or the United States Army Corps of Engineers (USACE), or some adjustment or correlation of these sources as noted in **Table 3-5**. Streamflow gage data were used to quantify surface water inflows, where available, through water year 2019.

Table 3-5. Information Sources to Quantify Surface Water Inflows

Waterway	Information Source
Antelope Creek	Correlation with USGS Gage 11381500
Battle Creek	USGS Gage 11376550
Black Butte Releases to Stony Creek	BLB report from USACE
Cottonwood Creek (North Fork, Middle Fork, South Fork)	SVSim inputs
Deer Creek	Correlation with USGS Gage 11383500
Dye Creek	SVSim inputs for small watershed 325
Elder Creek	USGS Gage 11379500
Mill Creek	USGS Gage 11381500
Paynes Creek (and Sevenmile Creek)	Correlation with USGS Gage 11381500
Red Bank Creek	USGS Gage 11379500 (assumed to be same as Elder Creek)
Sacramento River	SVSim inputs, adjusted to Tehama IHM model domain boundary
Stony Creek (North Fork, South Fork)	SVSim inputs
Thomes Creek	Correlation with USGS Gage 11376000

The primary surface water inflow to the Tehama IHM model domain is the Sacramento River, which flows along the boundaries of all four Subbasins. A regional SVSim model was run to adjust the Sacramento River inflows from the upstream inflow point simulated in the SVSim model domain to the inflow point in the Tehama IHM model domain.

Two additional stream reaches were added to the Tehama IHM representing inflows to Red Bank Creek and Dye Creek. Neither reach was discretely modeled in SVSim, though Dye Creek was taken to be equivalent to SVSim small watershed inflow 325. The Dye Creek inflow therefore replaced small watershed inflow 325.

3.1.4.3. Surface Water Diversions and Deliveries

Surface water diversions and deliveries were simulated in the model as diversions from a stream node with an assigned delivery destination (referred to as the element group). A total of 50 surface water diversions are included in Tehama IHM, with 30 adapted from SVSim and 20 newly added or revised in Tehama IHM. Diversion locations are shown in **Figure 3-29**. **Table 3-6** summarizes the data sources and used to quantify diversions and spillage within the four Subbasins in the Tehama IHM model domain.

Diversions and spillage of supply that is used within the four Subbasins are generally quantified based on outside data sources, including: delivery records reported by the United States Bureau of Reclamation (USBR), groundwater management or water planning documents developed by water agencies, and publicly available records maintained by the State Water Resources Control Board (SWRCB) in the

Electronic Water Rights Information Management System (eWRIMS). For water agencies without available spillage data, the percent spillage was estimated based on the conveyance system type (canal versus pipe), and the assumption that systems of adjacent suppliers or suppliers with similar systems have the same average spillage fraction.

Diversions of supply used outside the subbasins are generally assumed to be equal to diversions data specified in SVSim. Those diversions specified in SVSim that were retained unchanged, or with only slight area modifications in the Tehama IHM model domain are identified in **Table 3-6.**

Deliveries are generally calculated by Tehama IHM as the water supply used to meet simulated crop water demands, after accounting for seepage, evaporation, and spillage of the diverted supply.

For agencies that span portions of more than one subbasin, diversions, deliveries, and losses are also distributed across the relevant subbasins.

Table 3-6. Information Sources to Quantify Diversions and Spillage Within the Four Subbasins.[1]

Water Agency	Volume Specified		Delivery Location in Tehama IHM Domain Relative to Four Subbasins					Information Source	Note
	Diversion	Spillage	Antelope	Bowman	Los Molinos	Red Bluff	Outside		
Rio Alto Water District	X			X				USBR CVP delivery records (Sacramento River)	No reported volume in historical water budget period, not listed as CVP contractor in 2016.
Anderson-Cottonwood Irrigation District	X	X		X			X	USBR CVP delivery records (Sacramento River)	Service area boundaries partly overlie the Bowman Subbasin, areas in the Tehama IHM model domain but outside the subbasins, and areas outside the model domain; prorated diversion to percent irrigated area in the model domain; CVP delivery records available 1997-2019, estimated by average monthly volume earlier; Spillage fraction from 2012 Sacramento Valley Regional Water Management Plan, estimated to be similar in all years
Stanford Vina Ranch Irrigation	X	X			X			South Main Diversion: Water Data Library Site A04330 “SVWC Deer Creek South Diversion near Vina”; Cone Kimball and North Main Diversion: Tehama Regional Water Supply Inventory	South Main diversion records available 2002-2005, estimated in other years by correlation with Deer Creek Irrigation District diversion; Cone Kimball and North Main diversions estimated from relative fractions given in Table 4-9 of Tehama County Water Inventory and Analysis Report, estimated to be similar in all years; Spillage fraction estimated to be similar to Deer Creek Irrigation District
Deer Creek Irrigation District	X	X			X			Diversions: Water Data Library Site A43100 “DCID Deer Creek Diversion near Vina”; Spillage: 2011 Deer Creek Irrigation District	Diversion records available 1999-2016, estimated average monthly volume in other years; Spillage fraction from 2006-2007 water balance analysis, average estimated to be similar in all years

Water Agency	Volume Specified		Delivery Location in Tehama IHM Domain Relative to Four Subbasins					Information Source	Note
	Diversion	Spillage	Antelope	Bowman	Los Molinos	Red Bluff	Outside		
								Long Term System Improvements Feasibility Study	
Los Molinos Mutual Water Company	X	X	X		X			Upper Diversion and East Ditch Diversion: Los Molinos Mutual Water Company 2018 Northside Water Use Efficiency Master Plan; Ward Diversion: Los Molinos Mutual Water Company Southside Service Area Water Budget Results and Analysis	Diversion and spillage volumes based on Northside and Southside water budgets (2010-2017), diversions estimated by average monthly volume in other years, average spillage estimated to be similar in all years
Proberta Water District	X	X				X		USBR CVP delivery records (Corning Canal deliveries)	Volume of total CVP deliveries prorated based on contract amount; District has a piped conveyance system with approximately zero spillage, seepage, or evaporation.
Corning Water District	X	X					X	USBR CVP delivery records (Corning Canal deliveries)	Volume of total CVP deliveries prorated based on contract amount; District has a piped conveyance system with approximately zero spillage, seepage, or evaporation.
Thomes Creek Water District	X	X				X	X	USBR CVP delivery records (Corning Canal deliveries, prorated based on contract amount)	Volume of total CVP deliveries prorated based on contract amount; Spillage fraction estimated to be similar to Deer Creek Irrigation District
Thomes Creek Water Users Association	X						X	eWRIMS (S022584)	Diversion data in 2014, 2016-2019, estimated by average monthly volume in other years; Spillage estimated to

Water Agency	Volume Specified		Delivery Location in Tehama IHM Domain Relative to Four Subbasins					Information Source	Note
	Diversion	Spillage	Antelope	Bowman	Los Molinos	Red Bluff	Outside		
									occur through runoff (estimated zero spillage fraction; outside Subbasins)
Kirkwood Water District	X						X	USBR CVP delivery records (Tehama-Colusa Canal deliveries)	Spillage estimated to occur through runoff (estimated zero spillage fraction; outside Subbasins)
Edwards Ranch	X	X	X					eWRIMS (S003134, S016326)	Diversion data when available, estimated by average monthly volume in other years; Spillage fraction estimated to be similar to Los Molinos Mutual Water Company (northside)
The Nature Conservancy	X	X	X		X			eWRIMS (S020690, S028341, S028342, S028354)	Diversions are assumed to be applied to the Los Molinos Mutual Water Company service area; Diversion data when available, estimated by average monthly volume in other years; Spillage fraction estimated to be similar to Los Molinos Mutual Water Company (northside)
J.B. Unlimited, Inc.	X		X					USBR CVP delivery records (Sacramento River)	Diversion estimated by contract amount; Spillage estimated to be zero (Direct diverter, estimated to occur through runoff)
Leviathan, Inc.	X			X				USBR CVP delivery records (Sacramento River)	Diversion estimated by contract amount; Spillage estimated to be zero (Direct diverter, estimated to occur through runoff)
Micke, Daniel and Nina	X		X					USBR CVP delivery records (Sacramento River)	Diversion estimated by contract amount; Spillage estimated to be zero (Direct diverter, estimated to occur through runoff)
Sacramento River RM 273 to misc.	X			X			X	SVSim Div ID 14	Volume and specifications unchanged from SVSim (misc. diversions of relatively small volume mainly outside

Water Agency	Volume Specified		Delivery Location in Tehama IHM Domain Relative to Four Subbasins					Information Source	Note
	Diversion	Spillage	Antelope	Bowman	Los Molinos	Red Bluff	Outside		
Ag diverters (03_NA)									Bowman Subbasin; assumed that SVSim data were the best available)
Cottonwood Creek to misc. Ag diverters (02_NA)	X			X			X	SVSim Div ID 16	Volume and specifications unchanged from SVSim (misc. diversions of relatively small volume; assumed that SVSim data were the best available)
Elder Creek riparian diversions for Ag (04_NA)	X					X		SVSim Div ID 27	Volume and specifications unchanged from SVSim (misc. diversions of relatively small volume; assumed that SVSim data were the best available)
Tehama-Colusa Canal Losses (Import)	X					X	X	SVSim Div ID 35	Volume and specifications unchanged from SVSim (misc. canal losses; assumed that SVSim data were the best available)

[1] Other diversions specified in SVSim that are outside the four subbasins, but inside the Tehama IHM model domain, are retained with the same monthly volumes and specifications as established in SVSim, except those that are duplicates of diversions specified in this table.

3.1.4.4. Surface Water Bypasses

Surface water bypasses defined in the model simulate the movement of surface water between different waterways based on specified volumes or fractions. These bypasses can be used to simulate flood bypasses or water system operations. Twenty surface water bypasses were included in Tehama IHM. These bypasses represent conveyance losses from surface water diversions.

3.1.5. Groundwater System Inputs

The IFWM Groundwater Flow Process balances subsurface inflows and outflows and manages groundwater storage within each element and layer (Brush et al., 2016). The development of groundwater system input files is explained in this section.

3.1.5.1. Aquifer Parameters

At the time of the commencement of GSP analyses in the Subbasins, SVSim was not available in a calibrated form. Therefore, aquifer parameters were defined in Tehama IHM through subsurface lithologic textural analysis in conjunction with calibration of parameters based on texture. Aquifer parameters in Tehama IHM are assigned to each node for each model layer and were developed to represent subsurface hydrogeologic characteristics.

3.1.5.1.1 Lithologic Texture Data

A lithologic texture model was developed using borehole lithology data from 672 Well Completion Reports (WCRs) located within the model domain. Lithology and texture data for 615 of these well WCRs were obtained from the textural dataset developed utilized for SVSim and available from DWR, which included considerable textural data from the US Geological Survey (USGS) Central Valley Hydrologic Model (CVHM). Texture data were compiled from an additional 57 wells selected to fill spatial (lateral and vertical) gaps in the SVSim textural dataset using information available in WCRs. Textural classification of additionally compiled lithology data (i.e., identifying coarse or fine-grained texture categories based on lithological descriptions given in WCRs) was performed following procedures used by DWR and USGS in developing the initial textural dataset using lookup tables for classifying lithology descriptions by texture. Consistent with the approach by DWR in developing the SVSim textural dataset, the texture of “top soil” description given in WCRs was determined using the Natural Resources Conservation Service SSURGO soils data.

Translating the point textural dataset to a continuous textural model for use in Tehama IHM was done by assigning values for the percent coarse at each textural borehole datapoint to each model layer penetrated by the borehole and then interpolating percent coarse by layer across the entire model domain. In this process, the intervals of fine and coarse-grained textured sediments were calculated for model layers at each WCR location and the thickness-weighted percentage of coarse-grained materials within each model layer were estimated. Using values for percent coarse-grained materials by model layer at each borehole point, spatially continuous datasets representing the percentage of coarse-grained materials were developed for each model layer through point interpolation methods. Interpolation was performed using ordinary kriging interpolation tool in the ESRI ArcGIS software package, which applies a semivariogram approach. An appropriate semivariogram model was selected through exploration of the data. The resulting kriged spatial distribution of percent coarse by model layer is shown in **Figures 3-30** through **3-38**. During model development and calibration, aquifer parameters were assigned to model nodes and layers using parameter values specified for both the fine and coarse end members and relating these to the percent coarse values developed from the textural model. The process used to assign and calibrate aquifer parameters in the model based on the percent coarse values are described in the discussions of model calibration in **Section 3.2** of this document.

3.1.5.1.2 Aquifer Parameter Zones

To better represent the geology within the Tehama IHM domain, a set of aquifer parameter zones were developed to enable for more refined assignment of aquifer parameters based on the lithologic texture values, especially recognizing that aquifer properties for similar textured materials (based on the textural model) may differ by geologic formation. Informed by the HCM, four zones (Alluvium, Tehama Formation, Tuscan Formation, and Non-Tehama/Non-Tuscan Zone) were delineated for using multipliers applied to parameter values derived from the textural data. The extents of the different geologic units used to delineate aquifer parameter zones are shown in **Figures 3-39** through **3-42**.

The alluvium zone is present in layers 1 and 2. The extent of this zone was developed after review of surficial geology maps. The Tehama Formation, Tuscan Formation, and Non-Tehama/Non-Tuscan Zone are present in all model layers. Maps illustrating the assignment of nodes to parameter zones within layers 1 and 2 are presented in **Figure 3-43**, and within layers 3 through 9 are presented in **Figure 3-44**. The discussion of the calibration of aquifer parameters using the parameter zones described above, and the results of the model calibration, are presented in **Sections 3.2 and 4.7** below.

3.1.5.2. Boundary Conditions

Tehama IHM utilizes time-varying general head boundary conditions to simulate groundwater levels and fluxes at the extent of the model domain. A map of nodes where general head boundary conditions were specified in the model is presented in **Figure 3-45**. In specifying general head boundary conditions, hydraulic conductance was estimated at each boundary node by layer based on average horizontal hydraulic conductivity (Kh), cross-sectional area associated with each boundary node (product of distance between nodes and saturated layer thickness), and the distance from the model boundary (set as 1,000-feet). Transient historical water level boundary conditions were developed by using the interpreted initial head conditions in 1985 and applying relative changes for each model time step based on simulated water levels from the calibrated version of SVSim provided by DWR for each model time step for the period 1985 to 2015. Because the available version of SVSim only simulates conditions through 2015, substitute years based on similar water year conditions were used to extend the simulated heads in SVSim through 2019 using relative water levels changes. Some additional refinements were made to the boundary conditions after comparing modeled water levels to observed data.

3.1.5.3. Groundwater Pumping

Pumping within Tehama IHM is primarily determined by element based on land use characteristics and simulated demand and is calculated internally by the IDC to meet both agricultural and urban demands after available surface water deliveries have been accounted for. The vertical distribution of pumping by layer in Tehama IHM was modified from SVSim based on review of well construction information in DWR's WCR database for wells within the model domain. Agricultural and urban pumping were distributed vertically based on well construction information data in DWR's Online System for Well Completion Reports (OSWCR) for respective well types. In an effort to represent wells that are likely or potentially active in the model area, WCRs classified as well constructions (as opposed to well destructions) since 1970 in the OSWCR database were used to assign the vertical distribution of pumping in Tehama IHM.

The vertical distribution of pumping does not change over the historical simulation period. Maps of the vertical distribution of agricultural pumping by layer are presented in **Figures 3-46** through **3-54** and for urban pumping by layer in **Figures 3-55** through **3-63**.

3.1.6. Small Watersheds

A total of 33 small watersheds were included in Tehama IHM from SVSim. **Table 3-7** summarizes the contributions of small watersheds to modeled streams. Modifications were made to SVSim small watersheds to properly route water through the additional streams modeled in Tehama IHM. Nodes receiving small watershed contributions are shown in **Figure 3-64**.

Table 3-7. Summary of Tehama IHM Small Watersheds

Streams Fed by Small Watersheds	Count of Contributing Watersheds	Total Contributing Watershed Acreage
Antelope Creek Group	7	34,861
Cottonwood Creek	1	1,904
Elder Creek	3	2,645
Mill Creek	1	272
Paynes Creek	2	3,021
Sacramento River	15	120,921
Thomes Creek	4	16,055
TOTAL	**33**	**179,679**

3.1.7. Initial Conditions

Initial groundwater levels conditions for Tehama IHM were generated from mapped groundwater conditions based on groundwater level contours developed from observed data in conjunction with simulated water level output from SVSim regional model for October 1984, which represents the start of the historical model period. Available historical groundwater level data were used to interpret groundwater elevations across the domain in Fall 1985 for use in representation of initial model water level (head) conditions. The Upper Aquifer (Layers 1 through 5) were assigned initial head conditions from the interpreted observed groundwater surface. Initial heads in the Lower Aquifer (Layers 6 through 9) were then assigned by applying an offset to the observed groundwater levels based on observed offsets between depths from nested monitoring wells. Initial water level conditions used in the historical Tehama IHM runs are shown in **Figures 3-65** through **3-73**. All other initial conditions (e.g., soil moisture) were specified using the simulated conditions in October 1984 from SVSim.

3.2. Model Calibration

Tehama IHM was calibrated using a trial and error approach in conjunction with utilization of automated calibration and parameter estimation techniques involving application of UCODE-2014, an inverse modeling computer code developed by the US Geological Survey. Automated techniques were used at stages during the calibration to explore model sensitivity and inform the trial and error calibration efforts.

The calibration process focused on adjusting key model parameter values to improve the fit of simulated historical groundwater levels and streamflows to observed (measured) data. The key model parameters included in calibration were aquifer properties and streambed properties.

Aquifer parameters were developed by assigning end member values to the percent coarse-grained materials in the textural model described in **Section 3.1.5.1.1** of this report. Texture end member values are the aquifer parameter values at the two ends of the percent coarse spectrum, either 100% (coarse) or 0% (fine). The equations used to calculate the aquifer parameter values for each node and layer from the specified end-member values are presented below. For aquifer parameter zones where a multiplier was included in the calibration, the multiplier was applied to the parameter values resulting from calculations using these equations. The equations used for estimating aquifer parameters from textural model information are consistent with the methods used and described in development of the hydrogeologic conceptual model and model parameterization for SVSim (DWR, 2020).

Horizontal hydraulic conductivity (Kh) is calculated using the following equation:

$$Kh = (PCT * ({Kh_{C0}}^{pKh}) + (1 - PCT) * ({Kh_{F0}}^{pKh}))^{\frac{1}{pKh}}$$

Where: PCT is the percent coarse

Kh_{C0} is the Kh end member of coarse materials

Kh_{F0} is the Kh end member of fine materials

pKh is the power law empirical parameter for Kh

Vertical hydraulic conductivity (Kv) end members are calculated through application of an anisotropy ratio (Kv / Kh) to the Kh endmember values. The Kv value at each node and layer is then calculated using the following equation:

$$Kv = (PCT * ({Kv_{C0}}^{pKv}) + (1 - PCT) * ({Kv_{F0}}^{pKv}))^{\frac{1}{pKv}}$$

Where: PCT is the percent coarse

Kv_{C0} is the Kv end member of coarse materials

Kv_{F0} is the Kv end member of fine materials

pKv is the power law empirical parameter for Kv

Specific storage (Ss) is calculated using the following equation:

$$Ss = PCT * Ss_C + (1 - PCT) * Ss_F$$

Where: PCT is the percent coarse

Ss_C is the Ss end member of coarse materials

Ss_F is the Ss end member of fine materials

Specific yield (Sy) is calculated using the following equation:

$$SY = PCT * Sy_C + (1 - PCT) * Sy_F$$

Where: PCT is the percent coarse

Sy_C is the Sy end member of coarse materials

Sy_F is the Sy end member of fine materials

Calibrated end member values are presented in **Section 4.9** of this report.

Observations used in the calibration of aquifer parameters included approximately 7,900 groundwater level observations from 93 wells across the model domain selected based on historical data record, well construction, and spatial representation (lateral and vertical distribution) (**Figure 3-74**).

Streambed properties adjusted during the calibration included streambed conductivity. Observations used to constrain stream bed parameters included approximately 3,900 stream flow measurements from 12 gage stations (**Figure 3-75**). The results of the model calibration are presented and discussed in **Section 4.8** below.

3.3. Tehama IHM – Projected Model Simulations

The projected model simulations are intended to evaluate the effects of anticipated future conditions of hydrology, water supply availability, and water demand on the Tehama County Subbasins water budget and groundwater conditions over a 51-year GSP planning period from WY 2022 through 2072 starting October 1, 2022 and ending September 30, 2072. The projected model scenarios incorporate consideration of potential climate change and water supply availability scenarios and evaluation of the need for and benefit of any projects and management actions to be implemented in the Subbasins to maintain or achieve sustainability. The projected model scenarios use hydrologic conditions representative of the most recent 50 years of hydrology in the Subbasins, with adjustments applied in scenarios for evaluating the water budgets under climate change and/or altered water supply and demand conditions. The entire projected simulation period runs from WY 2020 through 2072, on a monthly time step, although the 51-year GSP planning period evaluated in the projected modeling covers water years 2022 through 2072. The development of the projected scenarios in Tehama IHM is described in the following sections.

3.3.1. Projected Hydrology Selection and Development

Establishing a sequence of projected hydrology is key to the development of the projected model scenarios. Future hydrology model inputs were developed based on review and consideration of the recent 51 years of hydrology for 1969-2019 and utilization of a hydrologic sequence that replicates the hydrologic patterns and trends over this period. Because of the availability of higher quality data and characterization of conditions in the Subbasins during the most recent 29 years spanning the historical base period (1990-2018), the projected analyses used surrogate years from the historical period to construct a future hydrology and analysis period representative and consistent with hydrologic conditions over the 51-year period from 1969 to 2019. Surrogate years from the historical period were assigned to represent 51 years of future hydrology based on 1) the Sacramento Valley water year index from DWR for each year and 2) mimicking variability (wet and dry) in the historical precipitation conditions in the Subbasins and replicating precipitation consistent with the annual average historical precipitation.

The projected water year type and assigned surrogate water years for use in developing the projected hydrology are shown in **Table 3-8a.** The frequency of water year types used in the projected hydrology is representative of the 51 years of hydrology for the period 1969-2019 and includes approximately equal proportions of water years with above normal (wet and above normal; 49%) and below normal (below normal, dry, critical; 51%) hydrologic conditions (**Table 3-8b**). **Figures 3-76 and 3-77** show graphs of the precipitation cumulative departure from the mean based on data at the Red Bluff and Orland Stations, respectively, over the projected period. The overall averages and cumulative departure curves highlight how closely the projected hydrology (using surrogate years) mimics the recent 51-year period. The average annual precipitation in the projected simulation period is 22.9 inches at the Red Bluff Municipal Airport station (**Table 3-8b**), similar but slightly below the average annual precipitation over the 51-year historical period from 1969 through 2019 of 23.3 inches at the Red Bluff Municipal Airport station. For comparison, the average annual precipitation over the historical water budget period of 1990-2018 is 22.5 inches based on measurements at the Red Bluff Municipal Airport station (**Table 3-1b**).

Table 3-8a. Summary of Projected Water Years in Tehama IHM

Simulation WY	WY Type	WY Index
1991	C	4.21
1992	C	4.06
1993	AN	8.54
1994	C	5.02
1995	W	12.89
1996	W	10.26
1997	W	10.82
1998	W	13.31
1999	W	9.8
2000	AN	8.94
2001	D	5.76
2002	D	6.35
2003	AN	8.21
2004	BN	7.51
2005	AN	8.49
2006	W	13.2
2007	D	6.19
2008	C	5.16
2009	D	5.78
2010	BN	7.08
2011	W	10.54
2012	BN	6.89
2013	D	5.83
2014	C	4.07
2015	C	4
2016	BN	6.71
2017	W	14.14
2018	BN	7.14
2019	W	10.34

Simulation WY	Surrogate WY	WY Type	WY Index
2020*	2007	D	6.19
2021*	2014	C	4.07
2022	2019	W	10.34
2023	1996	W	10.26
2024	1996	W	10.26
2025	2018	BN	7.14
2026	1993	AN	8.54
2027	2006	W	13.2
2028	1999	W	9.8
2029	2008	C	5.16
2030	2014	C	4.07
2031	1993	AN	8.54
2032	2012	BN	6.89
2033	2000	AN	8.94
2034	2002	D	6.35
2035	2006	W	13.2
2036	1998	W	13.31
2037	1996	W	10.26
2038	2002	D	6.35
2039	1996	W	10.26
2040	2001	D	5.76
2041	1990	C	4.81
2042	2007	D	6.19
2043	1994	C	5.02
2044	1994	C	5.02
2045	1992	C	4.06
2046	1993	AN	8.54

Simulation WY	Surrogate WY	WY Type	WY Index
2047	1994	C	5.02
2048	1995	W	12.89
2049	1996	W	10.26
2050	1997	W	10.82
2051	1998	W	13.31
2052	1999	W	9.8
2053	2000	AN	8.94
2054	2001	D	5.76
2055	2002	D	6.35
2056	2003	AN	8.21
2057	2004	BN	7.51
2058	2005	AN	8.49
2059	2006	W	13.2
2060	2007	D	6.19
2061	2008	C	5.16
2062	2009	D	5.78
2063	2010	BN	7.08
2064	2011	W	10.54
2065	2012	BN	6.89
2066	2013	D	5.83
2067	2014	C	4.07
2068	2015	C	4
2069	2016	BN	6.71
2070	2017	W	14.14
2071	2018	BN	7.14
2072	2019	W	10.34

*Years 2020-2021 were used to span the transitional period between the historical model period 1990-2019 and the projected model period 2022-2072.

Table 3-8b. Sacramento Valley Water Year Type Classification of the Projected Water Budget Period (2022-2072)

Sacramento Valley Water Year Type	Abbreviation	Number of Years, 2022-2072	Average Water Year Index	Average Precipitation	Percent Total Years, 2022-2072
Wet	W	18	11.46	27.9	35%
Above Normal	AN	7	8.60	29.3	14%
Below Normal	BN	7	7.05	19.7	14%
Dry	D	9	6.06	17.4	18%
Critical	C	10	4.64	16.6	20%
	Total	**51**	**8.17**	**22.9**	**100%**

3.3.2. Climate Change Adjustments

Climate change adjustments were also included in selected projected scenarios to evaluate the potential influence of climate change on future conditions. Adjustments to the projected hydrology were performed following DWR's Resource Guide on climate change in GSP development (DWR, 2018) using climate change adjustment factors provided by DWR for use in developing GSPs through the DWR SGMA Data Viewer (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#waterbudget). Using the DWR-provided climate adjustment factors, adjustments were made to ET, precipitation, and surface water inflow model inputs to account for the potential effects of 2030 mean (or central tendency) and 2070 mean (or central tendency) climate change conditions. The climate change adjustment factors provided by DWR were calculated from data developed for the Variable Infiltration Capacity (VIC) model as described in the DWR Resource Guide and on the SGMA Data Viewer.

For ET and precipitation adjustments, monthly change factors were averaged across the VIC grids in the Tehama IHM model domain and applied to the individual precipitation and ET inputs. For surface water inflow adjustments, monthly streamflow change factors were summarized from the HUC 8 watershed covering the majority of the Tehama IHM model domain and applied to individual surface water inflows in the model.

For each of the model inputs adjusted in the climate change scenarios (e.g., ET, precipitation, surface water inflow), the baseline projected inputs were multiplied by the 2030 or 2070 change factors corresponding to the specific historical year that was used as a surrogate year in the projected simulations. Because climate change factors were only provided for historical years through 2011, the average factors (by water year type) for the period provided were applied to historical years after 2011. The average change factors applied by model input and water year type in the 2030 and 2070 climate change scenarios are presented in **Table 3-9**. As indicated in **Table 3-9**, on average the climate change adjustments tend to increase ET, increase precipitation, and increase stream inflow volumes by varying degrees. From a water budget standpoint, increases in ET will tend to increase the water demands (outflows), whereas increases to precipitation and stream inflows will tend to increase water supplies (inflows).

Table 3-9. Climate Change Adjustment Change Factors by Data Type and Water Year Type in Tehama IHM

	No Adjustment	Climate Change 2030	Climate Change 2070
		Evapotranspiration	
Wet (W)	1.00	1.04	1.09
Above Normal (AN)	1.00	1.04	1.09
Below Normal (BN)	1.00	1.04	1.09
Dry (D)	1.00	1.04	1.08
Critical (C)	1.00	1.04	1.09
TOTAL	**1.00**	**1.04**	**1.09**
		Precipitation	
Wet (W)	1.00	1.04	1.07
Above Normal (AN)	1.00	1.02	1.06
Below Normal (BN)	1.00	1.05	1.05
Dry (D)	1.00	1.05	1.05
Critical (C)	1.00	1.04	1.06
TOTAL	**1.00**	**1.04**	**1.06**
		Stream Inflow	
Wet (W)	1.00	1.04	1.12
Above Normal (AN)	1.00	1.01	1.04
Below Normal (BN)	1.00	1.03	1.06
Dry (D)	1.00	1.06	1.07
Critical (C)	1.00	1.02	1.05
TOTAL	**1.00**	**1.04**	**1.09**

3.3.3. Overview of Projected Scenarios

Multiple projected model scenarios were developed to compare potential outcomes and evaluate the future sustainability of the Subbasins. These scenarios include two baseline projected scenarios, one with a current land use condition and another with future land use conditions. Additional scenarios were developed with each of the baseline projected scenarios with both 2030 and 2070 climate change conditions. Lastly, a projected model scenario was developed to evaluate the benefits of potential projects and management actions. **Table 3-10** outlines the different model scenarios evaluated, including seven projected scenarios in addition to the historical base period model scenario. The projected current land use scenarios assume a static land use condition based on 2018 land use conditions. The projected future land use scenarios also assume a static land use condition based on a projected land use condition in 2072 reflective of anticipated land use changes within the four Subbasins. The projected scenarios with different climate change scenarios incorporate either the 2030 mean or the 2070 mean climate change condition adjustments for precipitation, ET, stream inflows, and surface water diversion volumes in accordance with guidance provided by DWR.

Table 3-10. Summary of Tehama IHM Projected Scenarios

Scenario #	Model Scenario Name/Description	Time Period (Water Years)	Land Use Conditions	Climate Change	Projects
	Historical/Calibration	1990-2018	Historical (Transient)	None	No
1	Projected (Current Land Use)	2022-2072	Current (2018)	None	No
2	Projected (Future Land Use)	2022-2072	Future (2072)	None	No
3	Projected (Current Land Use) with 2030 Climate Change	2022-2072	Current (2018)	2030	No
4	Projected (Future Land Use) with 2030 Climate Change	2022-2072	Future (2072)	2070	No
5	Projected (Current Land Use) with 2070 Climate Change	2022-2072	Current (2018)	2070	No
6	Projected (Future Land Use) with 2070 Climate Change	2022-2072	Future (2072)	2070	No
7	Projected (Future Land Use) with Projects and 2070 Climate Change	2022-2072	Future (2072)	2070	Yes

3.3.4. Land Surface System Inputs

The development of land surface system inputs for the projected model scenarios is described below.

3.3.4.1. Precipitation

The precipitation inputs for the projected simulation period were developed through use of surrogate years from the historical model as described in **Section 3.3.1** and presented in **Table 3-8a.** As described in **Section 3.3.2**, for scenarios including climate change, precipitation inputs were modified using the climate change adjustment factors for 2030 and 2070 central tendency climate change conditions using the guidance and adjustment factors provided by DWR.

3.3.4.2. Evapotranspiration

The evapotranspiration inputs for the projected simulation period were developed through use of surrogate years from the historical model as described in **Section 3.3.1** and presented in **Table 3-8a.** As described in **Section 3.3.2**, for scenarios including climate change, precipitation inputs were modified using the climate change adjustment factors for 2030 and 2070 central tendency climate change conditions using the guidance and adjustment factors provided by DWR.

3.3.4.3. Land Use

Characterizing projected land use is foundational for predicting how and where water is beneficially used in future scenarios. Land use areas are also used to distinguish the water use sector in which water is consumed. In Tehama County, water use sectors include agricultural, urban, and native vegetation land uses. The urban water use sector covers all urban, residential, industrial, and semi-agricultural land uses. The projected scenarios include two different land use conditions: a current land use condition representative of 2018 conditions held constant over the entire simulation period and a static future land use condition based on land use change anticipated to occur in Tehama County over a 50-year planning horizon and reflecting land use conditions estimated to exist in 2072. In the projected model simulations, the land use conditions outside of Tehama County are assumed to stay as they are represented in 2018 in the historical model simulation.

3.3.4.3.1 Current Land Use Scenarios

Projected scenarios with current land use conditions include a static land use condition based on 2018 conditions.

Figure 3-78 illustrates the unchanging land use areas over the projected period (2022-2072) in the Antelope Subbasin. In the current land use scenario, agricultural, urban, and native vegetation land uses covered approximately 9,100 acres, 1,900 acres, and 8,000 acres, respectively. A majority of the agricultural area in the Antelope Subbasin is comprised of deciduous crops, pasture, and grain crops.

Figure 3-79 illustrates the unchanging land use areas over the projected period (2022-2072) in the Bowman Subbasin. In the current land use scenario, agricultural, urban, and native vegetation land uses covered approximately 6,100 acres, 1,900 acres, and 115,000 acres, respectively. A majority of the agricultural area in the Bowman Subbasin is comprised of pasture and grain crops.

Figure 3-80 illustrates the unchanging land use areas over the projected period (2022-2072) in the Los Molinos Subbasin. In the current land use scenario, agricultural, urban, and native vegetation land uses covered approximately 18,000 acres, 1,600 acres, and 79,000 acres, respectively. A majority of the agricultural area in the Los Molinos Subbasin is comprised of pasture and various orchard crops.

Figure 3-81 illustrates the unchanging land use areas over the projected period (2022-2072) in the Red Bluff Subbasin. In the current land use scenario, agricultural, urban, and native vegetation land uses covered approximately 46,000 acres, 7,000 acres, and 207,000 acres, respectively. A majority of the agricultural area in the Red Bluff Subbasin is comprised of pasture, grain, and various orchard crops.

3.3.4.3.2 Future Land Use Scenarios

The projected scenarios with future land use conditions include a static land use condition based on anticipated changes by the Subbasins in the future. The future land use conditions were developed through discussion with local stakeholders and consultation with the Tehama County Planning Department. The future land use conditions include increases in urban area reflecting expansion of urban areas focused around each urban center with native vegetation and idle cropland areas decreasing by similar amounts within all of Tehama County. In Red Bluff, there was also an increase in almonds within orchard areas.

Figure 3-82 presents the annual land use areas over the projected period (2022-2072) in the Antelope Subbasin. In the future land use scenario, there is an increase in urban acreage with a corresponding decrease in native vegetation, and relatively no change in agricultural acreage.

Figure 3-83 presents the annual land use areas over the projected period (2022-2072) in the Bowman Subbasin. In the future land use scenario, there is a very slight increase in urban acreage with a corresponding decrease in native vegetation, but overall, there is relatively no change.

Figure 3-84 presents the annual land use areas over the projected period (2022-2072) in the Los Molinos Subbasin. In the future land use scenario, there is a very slight increase in urban acreage with a corresponding decrease in native vegetation, but overall, there is relatively no change.

Figure 3-85 presents the annual land use areas over the projected period (2022-2072) in the Red Bluff Subbasin. In the future land use scenario, there is an increase in agricultural area, specifically almonds and pistachios, with a corresponding decrease in urban acreage and native vegetation.

3.3.5. Surface Water System Inputs

The development of surface water system inputs for projected future scenarios is described below.

3.3.5.1. Stream Inflows

The stream inflow volumes in each future year was assumed to be equal to the amount in the historical water year assigned to that future year (**Table 3-8a**). For scenarios with climate change adjustments, the historical stream inflow volumes were adjusted by using the CalSim II 2030 mean or 2070 mean climate change scenario monthly water year type multiplier.

3.3.5.2. Surface Water Diversions and Deliveries

The diversion volumes of each projected year were assigned by considering the diversion volumes from the associated historical year (**Table 3-8a**). For all diversions where historical data suggest the diversion was continuously active throughout the historical model period, the volume of water diverted in the projected year was assigned based on the associated historical year. For any surface water diversions that ceased diverting during the historical period 1990 through 2019, the volumes associated with these diversions were assumed to be zero for the entire projected period. The historical time-series data for each surface water diversion were evaluated and if a long period without any diversions occurred at the end of the period of available historical data, the diversion was assumed to be discontinued and assigned zero diversions for the entirety of the projected model period.

3.3.6. Groundwater System Inputs

The development of groundwater system inputs for projected future scenarios is described below.

3.3.6.1. Boundary Conditions

As described above in **Section 3.3.1**, the hydrology for the 51-year projected simulations mimics the hydrology of the historical period from 1969 through 2019 and the model inputs were developed using comparable surrogate years from the historical model period (1990-2019). The groundwater level of year 2019 was used as the initial groundwater head in boundaries for the prediction run. The groundwater levels of general head boundary condition for the predictive analysis were developed by using the associated historical boundary heads for each predictive year. For the last 31 years (2042-2072) of the projected model period , the general head boundary conditions were modified to represent long-term stability in general head conditions around the model domain. This is intended to reflect the expected achievement or maintenance of sustainable groundwater conditions around the extent of the model resulting from the implementation of groundwater management efforts associated with GSPs and elimination of any chronically declining trends in water levels.

3.3.6.2. Groundwater Pumping

The pumping specification inputs for all projected simulations used the same pumping specifications as the historical simulation, described in **Section 3.1.5.3**.

3.3.7. Initial Conditions

Initial conditions used for projected simulations starting in 2020 utilized the final conditions from the historical model at the end of 2019. The initial conditions included use of the final conditions of the historical simulation period for the unsaturated zone, root zone, small watersheds, and groundwater levels. Initial groundwater levels are shown in **Figures 3-86** through **3-94** by model layer**.**

3.3.8. Simulation of Potential Projects and Management Actions

Projects and management actions (PMAs) were developed to achieve and maintain the Red Bluff Subbasin sustainability goal by 2042 and avoid undesirable results over the GSP planning and implementation horizon. PMAs developed for implementation would help to achieve and maintain groundwater sustainability while supporting other local goals. These PMAs include a project that would divert available surface water from Thomes and Elder Creek onto fields in the Subbasin for direct or in-lieu recharge benefits, and an in-lieu recharge project that would expand use of existing Central Valley Project (CVP) contract supplies in Proberta Water District (WD) and Thomes Creek WD. Other PMAs developed for implementation include a proposed grower education program, a proposed multi-benefit groundwater recharge project that would supply groundwater recharge and provide habitat for migrating shorebirds, a proposed pump restoration project in El Camino Irrigation District, and two projects aimed at invasive species removal along various waterways in the Red Bluff Subbasin.

A projected simulation was conducted to evaluate the potential benefits that might occur from implementation of various project concepts. Stream diversions were added to the model in order to simulate the recharge projects along Thomes and Elder Creeks, while existing diversions were modified in order to simulate the recharge projects in Proberta WD and Thomes Creek WD. Additionally, in order to simulate a management action related to well permitting, all new agricultural pumping in the Red Bluff Subbasin was shifted from the Upper Aquifer to the Lower Aquifer. Maps of the vertical distribution of agricultural pumping by layer in with projects scenario are presented in **Figures 3-95** through **3-103**.

Additional detail about the projects and management actions implemented in the Red Bluff Subbasin are included in the **Red Bluff GSP Chapter 4**.

4. GROUNDWATER FLOW MODEL RESULTS

This section presents the results of Tehama IHM. Results presented in this section include Subbasin water budgets, groundwater levels, and streamflows for various scenarios, and calibrated aquifer parameters. The water budget results presented in this section are rounded to two significant digits consistent with the typical uncertainty associated with the methods and sources used in the analysis. Water budget component results may not sum to the totals presented because of rounding.

4.1. Antelope Subbasin

The following section summarizes the analyses and results relating to the Antelope Subbasin. Detailed water budget results for each of the individual model scenarios are presented in **Appendix A**.

4.1.1. Historical Water Budget Results

Annual inflows, outflows, and change in surface water system (SWS) root zone storage during the historical water budget period (1990-2018) are summarized in **Table 4-1**. Of particular note in the historical SWS water budget results are the volumes of groundwater discharge to surface water that make up a large part of the Subbasin SWS inflows. Over the historical period, groundwater discharge to surface water averaged a little over 53 thousand acre-feet (taf) per year. Surface water inflows and precipitation also represent larger SWS inflow components averaging about 43 taf per year and 41 taf per year, respectively. Groundwater extraction and uptake represent a smaller SWS inflow in the Subbasin averaging about 15 taf per year over the historical water budget period.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 89 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of precipitation averaging about 25 taf per year and average ET of applied water totaling about 19 taf per year on average. All other outflow components from the SWS are relatively smaller. The outflow of deep percolation of precipitation and applied water to the groundwater system (GWS) are about 7.2 and 4.6 taf per year, respectively, and infiltration (seepage) of surface water to the GWS totals about 4.9 taf per year on average. ET of groundwater uptake averages about 1.5 taf per year and evaporation from surface water averages about 150 af per year over the historical water budget period.

Table 4-1. Antelope Subbasin Historical Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (1990-2018)
Inflows	Surface Water Inflow	43,000
	Precipitation	41,000
	Groundwater Extraction	15,000
	Groundwater Discharge	53,000
Outflows	Surface Water Outflow	89,000
	ET of Applied Water	19,000
	ET of Groundwater Uptake	1,500
	ET of Precipitation	25,000
	Evaporation	150
	Deep Percolation of Applied Water	4,500
	Deep Percolation of Precipitation	7,200
	Infiltration of Surface Water	4,900
Annual Change in Root Zone Storage		**-88**

Summarized results for major components of the historical water budget as they relate to the GWS are presented in **Table 4-2**. Among the outflows from the Subbasin GWS, groundwater pumping makes up the largest fraction of the total GWS outflows (on average -13 taf per year). Highly negative net seepage values (on average -48 taf per year) represent net groundwater discharging to surface water features and leaving the GWS. Deep percolation is the largest net inflow component averaging about 12 taf per year. Positive net subsurface flows (on average 50 taf per year) represent the combined subsurface inflows from adjacent subbasins and upland areas. Groundwater (root water) uptake directly from shallow groundwater (on average -1.5 taf per year) represents a smaller outflow from the GWS. Overall, the water budget results for the 29-year historic period indicate a cumulative change in groundwater storage of about -7 taf, which equals an average annual change in groundwater storage of only about -610 acre-feet (af) per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 0.77 af per acre on average over the 29 years and an annual decrease of less than 0.07 af per acre across the entire Subbasin (approximately 9,130 acres).

Detailed results for each of the individual water budget components in the historical water budget are presented in **Appendix A-1**.

Table 4-2. Antelope Subbasin Historical Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (1990-2018)
Total Net Seepage	-48,000
Deep Percolation	12,000
Groundwater Pumping	-13,000
Groundwater Uptake	-1,500
Total Net Subsurface Flows	50,000
Annual Change in Groundwater Storage	**-610**

4.1.2. Projected (Current Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (current land use) water budget period (2022-2072) are summarized in **Table 4-3**. Of particular note in the projected (current land use) SWS water budget results are the volume of surface water inflows that makes up a large part of the Subbasin SWS inflows. Over the projected (current land use) period, surface water inflows average about 43 taf per year. Precipitation also represents a large SWS inflow component averaging about 43 taf per year. Groundwater extraction and groundwater discharge to surface water represent relatively smaller SWS inflows in the Subbasin averaging about 16 and 43 taf per year, respectively over the projected (current land use) water budget period.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 81 taf per year on average. ET of applied water and ET of precipitation also represent large SWS outflow components, averaging about 20 taf and 26 taf, respectively, per year. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for deep percolation of applied water averaging about 4.2 taf per year. The outflows of deep percolation of precipitation and infiltration (seepage) of surface water are about 7.2 and 4.9 taf per year on average, respectively. ET of groundwater uptake averages about 1.2 taf per year and evaporation from surface water averages about 150 af per year over the projected (current land use) water budget period.

Table 4-3. Antelope Subbasin Projected (Current Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	43,000
	Precipitation	43,000
	Groundwater Extraction	16,000
	Groundwater Discharge	43,000
Outflows	Surface Water Outflow	81,000
	ET of Applied Water	20,000
	ET of Groundwater Uptake	1,200
	ET of Precipitation	26,000
	Evaporation	150
	Deep Percolation of Applied Water	4,200
	Deep Percolation of Precipitation	7,200
	Infiltration of Surface Water	4,900
Annual Change in Root Zone Storage		**5**

Summarized results for major components of the projected (current land use) water budget as they relate to the GWS are presented in **Table 4-4**. The positive net subsurface flows (on average 42 taf per year) represent the combined subsurface flows from adjacent subbasins and upland areas and deep percolation represents another large net inflow averaging about 11 taf per year. The large negative net seepage values (on average -38 taf per year) represent net stream seepage to groundwater and groundwater pumping (on average -15 taf per year) is another large outflow from the GWS. Groundwater (root water) uptake directly from shallow groundwater (on average -1.2 taf per year) represents a smaller outflow from the GWS. Overall, the water budget results for the 51-year projected (current land use) period indicate a cumulative change in groundwater storage of about -15 taf, which equals an average annual change in groundwater storage of only about -290 af per year. These change in storage estimates equate to total decreases in storage in the Subbasin of about 0.03 af per acre on average over the 51 years and an annual decrease of less than 0.002 af per acre across the entire Subbasin (approximately 9,130 acres).

Detailed results for each of the individual water budget components in the projected (current land use) water budget are presented in **Appendix A-2**.

Table 4-4. Antelope Subbasin Projected (Current Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	-38,000
Deep Percolation	11,000
Groundwater Pumping	-15,000
Groundwater Uptake	-1,200
Total Net Subsurface Flows	42,000
Annual Change in Groundwater Storage	**-290**

4.1.3. Projected (Future Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (future land use) water budget period (2022-2072) are summarized in **Table 4-5**. Of particular note in the projected (future land use) SWS water budget results are the volume of surface water inflows and precipitation that make up a large part of the Subbasin SWS inflows. Over the projected (future land use) period, surface water inflows and precipitation each average about 43 taf per year. Groundwater Discharge to surface water also represents a large SWS inflow component averaging about 33 taf per year. Groundwater represents a relatively smaller SWS inflow in the Subbasin averaging about 16 taf per year over the projected (future land use) water budget period.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 72 taf per year on average, a value that corresponds with the large volumes of surface water inflow. ET of applied water and ET of precipitation also represent large SWS outflow components, averaging about 20 taf and 26 taf, respectively, per year. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for deep percolation of precipitation averaging about 7 taf per year. The outflows of deep percolation of applied water and infiltration (seepage) of surface water are about 4.2 and 4.9 taf per year on average, respectively. Evaporation from surface water averages about 150 af per year over the projected (future land use) water budget period.

Table 4-5. Antelope Subbasin Projected (Future Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	43,000
	Precipitation	43,000
	Groundwater Extraction	16,000
	Groundwater Discharge	33,000
Outflows	Surface Water Outflow	72,000
	ET of Applied Water	20,000
	ET of Groundwater Uptake	820
	ET of Precipitation	26,000
	Evaporation	150
	Deep Percolation of Applied Water	4,200
	Deep Percolation of Precipitation	7,100
	Infiltration of Surface Water	4,900
Annual Change in Root Zone Storage		**5**

Summarized results for major components of the projected (future land use) water budget as they relate to the GWS are presented in **Table 4-6**. Among the outflows from the Subbasin GWS, net seepage makes up the largest fraction of the total GWS outflows (on average -28 taf per year). Net seepage represents net groundwater discharging to surface waterways and leaving the GWS. Groundwater pumping additionally makes up a large portion of GWS outflows (on average -15 taf per year). Positive net subsurface flows and deep percolation are the largest net inflow components averaging about 33 and 11 taf per year, respectively. Groundwater (root water) uptake directly from shallow groundwater (on average -820 af per year) represents a smaller outflow from the GWS. Overall, the water budget results for the 51-year projected (future land use) period indicate a cumulative change in groundwater storage of about -17 taf, which equals an average annual change in groundwater storage of only about -330 af per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 0.9 af per acre on average over the 51 years and an annual decrease of about 0.02 af per acre across the entire Subbasin (approximately 19,040 acres).

Detailed results for each of the individual water budget components in the projected (future land use) water budget are presented in **Appendix A-3**.

Table 4-6. Antelope Subbasin Projected (Future Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	-28,000
Deep Percolation	11,000
Groundwater Pumping	-15,000
Groundwater Uptake	-820
Total Net Subsurface Flows	33,000
Annual Change in Groundwater Storage	**-330**

4.1.4. Projected (Current Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (current land use) with climate change water budget as they relate to the GWS are presented in **Table 4-7**. Net seepage becomes less negative under climate change scenarios, indicating less groundwater flow to SWS. Deep percolation and net subsurface flows remain nearly unchanged under climate change scenarios. Groundwater pumping increases under climate change scenarios, becoming a greater outflow from the groundwater system. Groundwater uptake remains nearly unchanged under climate change scenarios.

Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2030) water budget are presented in **Appendix A-4**. Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2070) water budget are presented in **Appendix A-5**.

Table 4-7. Comparison of Antelope Subbasin Projected (Current Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Current Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	-38,000	-36,000	-33,000
Deep Percolation	11,000	12,000	11,000
Groundwater Pumping	-15,000	-16,000	-17,000
Groundwater Uptake	-1,200	-1,200	-1,100
Total Net Subsurface Flows	42,000	42,000	39,000
Annual Groundwater Storage Change	**-290**	**-300**	**-340**

4.1.5. Projected (Future Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (future land use) with climate change water budget as they relate to the GWS are presented in **Table 4-8**. Overall, the climate change scenarios to not appear to change the overall Subbasin GWS water budget in a considerable way. Net seepage becomes less negative under climate change scenarios, indicating a reduction of the net volume of groundwater discharging to the surface waters. Deep percolation remains nearly unchanged under climate change scenarios. Net subsurface flows to the Subbasin decrease slightly under climate change scenarios, primarily a result of reduced subsurface inflows from Red Bluff Subbasin. Groundwater extractions increase vary slightly under climate change scenarios, becoming a greater outflow from the groundwater system.

Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2030) water budget are presented in **Appendix A-6**. Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2070) water budget are presented in **Appendix A-7**.

Table 4-8. Comparison of Antelope Subbasin Projected (Future Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Future Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	-28,000	-26,000	-22,000
Deep Percolation	11,000	11,000	11,000
Groundwater Pumping	-15,000	-16,000	-18,000
Groundwater Uptake	-820	-830	-810
Total Net Subsurface Flows	33,000	32,000	29,000
Annual Groundwater Storage Change	**-330**	**-340**	**-390**

Note: positive values indicate inflows/increasing storage, negative values indicate outflows/decreasing storage.

4.1.6. Projected (Future Land Use) with Projects and Climate Change Water Budget Results

Summarized results for major components of the projected (future land use) with projects and climate change (2070) water budget as they relate to the GWS are presented in **Table 4-9**. Among the outflows from the Subbasin GWS, net seepage makes up the largest fraction of the total GWS outflows (on average -22 taf per year). Net seepage represents net groundwater discharging to surface waterways and leaving the GWS. Groundwater pumping additionally makes up a large portion of GWS outflows (on average -18 taf per year). Positive net subsurface flows and deep percolation are the largest net inflow components averaging about 29 and 11 taf per year, respectively. Groundwater (root water) uptake directly from shallow groundwater (on average -820 af per year) represents a smaller outflow from the GWS. Overall, the water budget results for the 51-year projected (future land use) with projects and climate change (2070) period indicate a cumulative change in groundwater storage of about -19 taf, which equals an average annual change in groundwater storage of only about -380 af per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about -1.0 af per acre on average over the 51 years and an annual decrease of about -0.02 af per acre across the entire Subbasin (approximately 19,040 acres).

Detailed results for each of the individual water budget components in the projected (future land use) with projects and climate change (2070) water budget are presented in **Appendix A-8**.

Table 4-9. Antelope Subbasin Projected (Future Land Use) with Projects and Climate Change (2070) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	-22,000
Deep Percolation	11,000
Groundwater Pumping	-18,000
Groundwater Uptake	-820
Total Net Subsurface Flows	29,000
Annual Change in Groundwater Storage	**-380**

4.2. Bowman Subbasin

The following section summarizes the analyses and results relating to the historical scenario for the Bowman Subbasin. Detailed water budget results for each of the individual model scenarios are presented in **Appendix B**.

4.2.1. Historical Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the historical water budget period (1990-2018) are summarized in **Table 4-10**. Of particular note in the historical SWS water budget results are the volume of precipitation that makes up a large part of the Subbasin SWS inflows averaging about 290 taf per year over the historical period. By comparison, other SWS inflows in the Subbasin are relatively smaller. Surface water inflows average about 81 taf per year. Groundwater extraction and uptake represents a relatively small SWS inflow averaging about 9.1 taf per year, and groundwater discharge to surface water is negligible over the historical water budget period.

Among the outflows from the Subbasin SWS, ET of precipitation makes up a large fraction of the total Subbasin SWS outflows averaging about 160 taf per year over the historical period. The surface water outflows total about 110 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for deep percolation of precipitation about 44 taf per year and infiltration (seepage) of surface water about 43 taf per year on average. ET of applied water and deep percolation of applied water are about 11 and 8.6 taf per year on average, respectively. The outflows of ET of groundwater uptake and evaporation from surface water average about 3.0 and 0.7 taf per year, respectively.

Table 4-10. Bowman Subbasin Historical Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (1990-2018)
Inflows	Surface Water Inflow	81,000
	Precipitation	290,000
	Groundwater Extraction	9,100
	Groundwater Discharge	0
Outflows	Surface Water Outflow	110,000
	ET of Applied Water	11,000
	ET of Groundwater Uptake	3,000
	ET of Precipitation	160,000
	Evaporation	700
	Deep Percolation of Applied Water	8,600
	Deep Percolation of Precipitation	44,000
	Infiltration of Surface Water	43,000
Annual Change in Root Zone Storage		**-870**

Summarized results for major components of the historical water budget as they relate to the GWS are presented in **Table 4-11**. Deep percolation represents the largest inflow averaging nearly 53 taf per year while net seepage represents an inflow of about 43 taf per year. Net subsurface flows (combined subsurface flows with adjacent subbasins and upland areas) represent the largest net outflow totaling about -88 taf per year of outflow from the Bowman Subbasin on average. Groundwater pumping (on average -6.1 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -3.0 taf per year) represent smaller outflows from the GWS. Overall, the water budget results for the 29-year historical period indicate a cumulative change in groundwater storage of about -50 taf, which equals an average annual change in groundwater storage of only about -1.7 taf per year. These changes in storage estimates equate to total decreases in storage in the Subbasin of about -0.41 af per acre over the 29 years and an annual decrease of less than -0.01 af per acre across the entire Subbasin (approximately 122,425 acres).

Detailed results for each of the individual water budget components in the historical water budget are presented in **Appendix B-1**.

Table 4-11. Bowman Subbasin Historical Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (1990-2018)
Total Net Seepage	43,000
Deep Percolation	53,000
Groundwater Pumping	-6,100
Groundwater Uptake	-3,000
Total Net Subsurface Flows	-88,000
Annual Change in Groundwater Storage	**-1,700**

4.2.2. Projected (Current Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (current land use) water budget period (2022-2072) are summarized in **Table 4-12**. Of particular note in the projected (current land use) SWS water budget results is the volume of precipitation that makes up the largest part of the Subbasin SWS inflows averaging about 300 taf per year over the projected period. By comparison, other SWS inflows in the Subbasin are relatively smaller. Surface water inflows average about 83 taf per year. Groundwater extraction and uptake represents a relatively small SWS inflow averaging about 9.1 taf per year, and groundwater discharge to surface water is negligible over the projected (current land use) water budget period.

Among the outflows from the Subbasin SWS, ET of precipitation makes up a large fraction of the total Subbasin SWS outflows averaging about 160 taf per year over the projected (current land use) period. The surface water outflows total about 120 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for each deep percolation of precipitation totaling about 46 taf per year and infiltration (seepage) of surface water totaling about 43 taf per year, on average. ET of applied water and deep percolation of applied water are about 11 and 7.3 taf per year on average, respectively. The outflows of ET of groundwater uptake and evaporation from surface water average about 2.9 and 0.85 taf per year, respectively.

Table 4-12. Bowman Subbasin Projected (Current Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	83,000
	Precipitation	300,000
	Groundwater Extraction	9,100
	Groundwater Discharge	0
Outflows	Surface Water Outflow	120,000
	ET of Applied Water	11,000
	ET of Groundwater Uptake	2,900
	ET of Precipitation	160,000
	Evaporation	850
	Deep Percolation of Applied Water	7,300
	Deep Percolation of Precipitation	46,000
	Infiltration of Surface Water	46,000
Annual Change in Root Zone Storage		**-69**

Summarized results for major components of the projected (current land use) water budget as they relate to the GWS are presented in **Table 4-13**. Deep percolation represents the largest inflow averaging nearly 53 taf per year while net seepage represents an inflow of about 46 taf per year. Net subsurface flows (combined subsurface flows with adjacent subbasins and upland areas) represent the largest net outflow totaling about -90 taf per year of outflow from the Bowman Subbasin on average. Groundwater pumping (on average -6.2 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -2.9 taf per year) represent smaller outflows from the GWS. Overall, the water budget results for the 51-year projected (current land use) period indicate a cumulative change in groundwater storage of about -11 taf, which equals an average annual change in groundwater storage of about -0.2 taf per year. These changes in storage estimates equate to total decreases in storage in the Subbasin of about -0.09 af per acre over the 51 years and an annual decrease of -0.002 af per acre across the entire Subbasin (approximately 122,425 acres).

Detailed results for each of the individual water budget components in the projected (current land use) water budget are presented in **Appendix B-2**.

Table 4-13. Bowman Subbasin Projected (Current Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	46,000
Deep Percolation	53,000
Groundwater Pumping	-6,200
Groundwater Uptake	-2,900
Total Net Subsurface Flows	-90,000
Annual Change in Groundwater Storage	**-210**

4.2.3. Projected (Future Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (future land use) water budget period (2022-2072) are summarized in **Table 4-14**. Of particular note in the projected (future land use) SWS water budget results is the volume of precipitation that makes up the largest part of the Subbasin SWS inflows averaging about 300 taf per year over the projected period. By comparison, other SWS inflows in the Subbasin are relatively smaller. Surface water inflows average about 83 taf per year. Groundwater extraction and uptake represents a relatively small SWS inflow averaging about 9.2 taf per year, and groundwater discharge to surface water is negligible over the projected (future land use) water budget period.

Among the outflows from the Subbasin SWS, ET of precipitation makes up a large fraction of the total Subbasin SWS outflows averaging about 160 taf per year over the projected (future land use) period. The surface water outflows total about 120 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for infiltration (seepage) of surface water and deep percolation of precipitation totaling about 47 taf and 46 taf per year on average, respectively. ET of applied water and deep percolation of applied water are about 11 and 7.3 taf per year on average, respectively. The outflows of ET of groundwater uptake and evaporation from surface water average about 2.8 and 0.85 taf per year, respectively.

Table 4-14. Bowman Subbasin Projected (Future Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	83,000
	Precipitation	300,000
	Groundwater Extraction	9,200
	Groundwater Discharge	0
Outflows	Surface Water Outflow	120,000
	ET of Applied Water	11,000
	ET of Groundwater Uptake	2,800
	ET of Precipitation	160,000
	Evaporation	850
	Deep Percolation of Applied Water	7,300
	Deep Percolation of Precipitation	46,000
	Infiltration of Surface Water	47,000
Annual Change in Root Zone Storage		**-70**

Summarized results for major components of the projected (future land use) water budget as they relate to the GWS are presented in **Table 4-15**. Deep percolation represents the largest inflow averaging nearly 53 taf per year while net seepage represents an inflow of about 47 taf per year. Net subsurface flows (combined subsurface flows with adjacent subbasins and upland areas) represent the largest net outflow totaling about -91 taf per year of outflow from the Bowman Subbasin on average. Groundwater pumping (on average -6.4 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -2.8 taf per year) represent smaller outflows from the GWS. Overall, the water budget results for the 51-year projected (future land use) period indicate a cumulative change in groundwater storage of about -15 taf, which equals an average annual change in groundwater storage of about -0.30 taf per year. These changes in storage estimates equate to total decreases in storage in the Subbasin of about -0.13 af per acre over the 51 years and an annual decrease of -0.002 af per acre across the entire Subbasin (approximately 122,425 acres).

Detailed results for each of the individual water budget components in the projected (future land use) water budget are presented in **Appendix B-3**.

Table 4-15. Bowman Subbasin Projected (Future Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	47,000
Deep Percolation	53,000
Groundwater Pumping	-6,400
Groundwater Uptake	-2,800
Total Net Subsurface Flows	-91,000
Annual Change in Groundwater Storage	**-300**

4.2.4. Projected (Current Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (current land use) with climate change water budget as they relate to the GWS are presented in **Table 4-16**. Net seepage increases under climate change scenarios, indicating greater stream seepage to groundwater. Deep percolation and net subsurface flows remain nearly unchanged under climate change scenarios. Groundwater pumping increases under climate change scenarios, becoming a greater outflow from the groundwater system. Groundwater uptake remains nearly unchanged under climate change scenarios.

Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2030) water budget are presented in **Appendix B-4**. Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2070) water budget are presented in **Appendix B-5**.

Table 4-16. Comparison of Bowman Subbasin Projected (Current Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Current Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	46,000	47,000	48,000
Deep Percolation	53,000	53,000	51,000
Groundwater Pumping	-6,200	-6,400	-6,900
Groundwater Uptake	-2,900	-2,900	-2,900
Total Net Subsurface Flows	-90,000	-91,000	-89,000
Annual Groundwater Storage Change	**-210**	**-240**	**-420**

4.2.5. Projected (Future Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (future land use) with climate change water budget as they relate to the GWS are presented in **Table 4-17**. Overall, the climate change scenarios do not appear to change the overall Subbasin GWS water budget in a considerable way. Net seepage increases under both 2030 and 2070 climate change scenarios and deep percolation decreases by a small amount. Net subsurface flows also do not change much under climate change scenarios. Groundwater pumping increases slightly under climate change scenarios. Groundwater uptake remains nearly unchanged under climate change scenarios.

Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2030) water budget are presented in **Appendix B-6**. Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2070) water budget are presented in **Appendix B-7**.

Table 4-17. Comparison of Bowman Subbasin Projected (Future Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Future Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	47,000	48,000	49,000
Deep Percolation	53,000	53,000	51,000
Groundwater Pumping	-6,400	-6,600	-7,100
Groundwater Uptake	-2,800	-2,800	-2,800
Total Net Subsurface Flows	-91,000	-92,000	-90,000
Annual Groundwater Storage Change	**-300**	**-340**	**-530**

Note: positive values indicate inflows/increasing storage, negative values indicate outflows/decreasing storage.

4.2.6. Projected (Future Land Use) with Projects and Climate Change Water Budget Results

Summarized results for major components of the projected (future land use) with projects and climate change (2070) water budget as they relate to the GWS are presented in **Table 4-18**. Deep percolation represents the largest inflow averaging nearly 51 taf per year while net seepage represents an inflow of about 49 taf per year. Net subsurface flows (combined subsurface flows with adjacent subbasins and upland areas) represent the largest net outflow totaling about -91 taf per year of outflow from the Bowman Subbasin on average. Groundwater pumping (on average -7.1 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -2.8 taf per year) represent smaller outflows from the GWS. Overall, the water budget results for the 51-year projected (future land use) with projects and climate change (2070) period indicate a cumulative change in groundwater storage of about -27 taf, which equals an average annual change in groundwater storage of about -530 af per year. These changes in storage estimates equate to decreases in storage in the Subbasin of about -0.22 af per acre over the 51 years and an annual decrease of about -0.004 af per acre across the entire Subbasin (approximately 122,425 acres).

Detailed results for each of the individual water budget components in the projected (future land use) with projects and climate change (2070) water budget are presented in **Appendix B-8**.

Table 4-18. Bowman Subbasin Projected (Future Land Use) with Projects and Climate Change (2070) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	49,000
Deep Percolation	51,000
Groundwater Pumping	-7,100
Groundwater Uptake	-2,800
Total Net Subsurface Flows	-91,000
Annual Change in Groundwater Storage	**-530**

4.3. Los Molinos Subbasin

The following section summarizes the analyses and results relating to the historical scenario for the Los Molinos Subbasin. Detailed water budget results for each of the individual model scenarios are presented in **Appendix C**.

4.3.1. Historical Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the historical water budget period (1990-2018) are summarized in **Table 4-19**. Of particular note in the historical SWS water budget results are the volumes of surface water inflows that make up a large part of the Subbasin SWS inflows. Over the historical period, surface water inflows to surface water averaged about 630 taf per year. Precipitation also represents a large SWS inflow component averaging about 210 taf per year. Groundwater extraction and uptake represent a small SWS inflow in the Subbasin averaging about 33 taf per year over the historical water budget period. Groundwater discharge to surface water represents a smaller SWS inflow averaging about 2 taf per year.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 620 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of precipitation about 120 taf per year and deep percolation of precipitation totaling about 39 taf per year on average. The outflow of ET of applied water, infiltration (seepage) of surface water, and ET of groundwater uptake are about 36, 35 and 17 taf per year on average, respectively. The outflows of deep percolation of applied water and evaporation from surface water are about 15 and 2.1 taf per year, respectively.

Table 4-19. Los Molinos Subbasin Historical Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (1990-2018)
Inflows	Surface Water Inflow	630,000
	Precipitation	210,000
	Groundwater Extraction	33,000
	Groundwater Discharge	2,000
Outflows	Surface Water Outflow	620,000
	ET of Applied Water	36,000
	ET of Groundwater Uptake	17,000
	ET of Precipitation	120,000
	Evaporation	2,100
	Deep Percolation of Applied Water	15,000
	Deep Percolation of Precipitation	39,000
	Infiltration of Surface Water	35,000
Annual Change in Root Zone Storage		**-630**

Summarized results for major components of the historical water budget as they relate to the GWS are presented in **Table 4-20**. The positive net seepage values (on average 33 taf per year) and deep percolation values (on average 54 taf per year) represent the major inflows to the GWS. The net subsurface flows average about -56 taf per year represent the combined net subsurface outflows from the Subbasin to adjacent subbasins. Groundwater (root water) uptake directly from shallow groundwater (on average -17 taf per year) and groundwater pumping (on average -16 taf per year) are somewhat smaller outflows from the GWS. Overall, the water budget results for the 29-year historic period indicate a cumulative change in groundwater storage of about -74 taf, which equals an average annual decrease in groundwater storage of approximately -2.5 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about -0.74 af per acre over the 29 years and an annual decrease of about -0.03 af per acre across the entire Subbasin (approximately 99,000 acres).

Detailed results for each of the individual water budget components in the historical water budget are presented in **Appendix C-1**.

Table 4-20. Los Molinos Subbasin Historical Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (1990-2018)
Total Net Seepage	33,000
Deep Percolation	54,000
Groundwater Pumping	-16,000
Groundwater Uptake	-17,000
Total Net Subsurface Flows	-56,000
Annual Change in Groundwater Storage	**-2,500**

4.3.2. Projected (Current Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (current land use) water budget period (2022-2072) are summarized in **Table 4-21**. Of particular note in the projected (current land use) SWS water budget results are the volumes of surface water inflows that make up a large part of the Subbasin SWS inflows. Over the projected (current land use) period, surface water inflows to surface water averaged about 650 taf per year. Precipitation also represents a large SWS inflow component averaging about 220 taf per year. Groundwater extraction and uptake represent a small SWS inflow in the Subbasin averaging about 27 taf per year over the projected (current land use) water budget period. Groundwater discharge to surface water is negligible throughout the projected (current land use) period.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 610 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of precipitation about 120 taf per year and infiltration (seepage) of surface water totaling about 59 taf per year on average. The outflow of ET of applied water, deep percolation of precipitation, and deep percolation of applied water are about 41, 38 and 14 taf per year on average, respectively. The outflows of ET of groundwater uptake and evaporation from surface water are about 7.3 and 2.2 taf per year, respectively.

Table 4-21. Los Molinos Subbasin Projected (Current Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	650,000
	Precipitation	220,000
	Groundwater Extraction	27,000
	Groundwater Discharge	0
Outflows	Surface Water Outflow	610,000
	ET of Applied Water	41,000
	ET of Groundwater Uptake	7,300
	ET of Precipitation	120,000
	Evaporation	2,200
	Deep Percolation of Applied Water	14,000
	Deep Percolation of Precipitation	38,000
	Infiltration of Surface Water	59,000
Annual Change in Root Zone Storage		**24**

Summarized results for major components of the projected (current land use) water budget as they relate to the GWS are presented in **Table 4-22**. The positive net seepage values (on average 59 taf per year) and deep percolation values (on average 52 taf per year) represent the major inflows to the GWS. The net subsurface flows average about -86 taf per year represent the combined net subsurface outflows from the Subbasin to adjacent subbasins. Groundwater pumping (on average -20 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -7.3 taf per year) are somewhat smaller outflows from the GWS. Overall, the water budget results for the 51-year projected (current land use) period indicate a cumulative change in groundwater storage of about -93 taf, which equals an average annual decrease in groundwater storage of approximately -1.8 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about -0.94 af per acre over the 51 years and an annual decrease of about -0.02 af per acre across the entire Subbasin (approximately 99,000 acres).

Detailed results for each of the individual water budget components in the projected (current land use) water budget are presented in **Appendix C-2**.

Table 4-22. Los Molinos Subbasin Projected (Current Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	59,000
Deep Percolation	52,000
Groundwater Pumping	-20,000
Groundwater Uptake	-7,300
Total Net Subsurface Flows	-86,000
Annual Change in Groundwater Storage	**-1,800**

4.3.3. Projected (Future Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (future land use) water budget period (2022-2072) are summarized in **Table 4-23**. Of particular note in the historical SWS water budget results are the volumes of surface water inflows that make up a large part of the Subbasin SWS inflows. Over the projected (future land use) period, surface water inflows to surface water averaged about 650 taf per year. Precipitation also represents a large SWS inflow component averaging about 220 taf per year. Groundwater extraction and uptake represent a small SWS inflow in the Subbasin averaging about 27 taf per year over the projected (current land use) water budget period. Groundwater discharge to surface water is negligible throughout the projected (current land use) period.

Among the outflows from the Subbasin SWS, surface water outflow makes up a large fraction of the total Subbasin SWS outflows. The surface water outflows total about 610 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of precipitation about 120 taf per year and infiltration (seepage) of surface water totaling about 63 taf per year on average. The outflow of ET of applied water, deep percolation of precipitation, and deep percolation of applied water are about 42, 38 and 14 taf per year on average, respectively. The outflows of ET of groundwater uptake and evaporation from surface water are about 6.1 and 2.2 taf per year, respectively.

Table 4-23. Los Molinos Subbasin Projected (Future Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	650,000
	Precipitation	220,000
	Groundwater Extraction	27,000
	Groundwater Discharge	0
Outflows	Surface Water Outflow	610,000
	ET of Applied Water	42,000
	ET of Groundwater Uptake	6,100
	ET of Precipitation	120,000
	Evaporation	2,200
	Deep Percolation of Applied Water	14,000
	Deep Percolation of Precipitation	38,000
	Infiltration of Surface Water	63,000
Annual Change in Root Zone Storage		**25**

Summarized results for major components of the projected (future land use) water budget as they relate to the GWS are presented in **Table 4-24**. The positive net seepage values (on average 63 taf per year) and deep percolation values (on average 51 taf per year) represent the major inflows to the GWS. The net subsurface flows average about -89 taf per year represent the combined net subsurface outflows from the Subbasin to adjacent subbasins. Groundwater pumping (on average -21 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -6.1 taf per year) are somewhat smaller outflows from the GWS. Overall, the water budget results for the 51-year projected (future land use) period indicate a cumulative change in groundwater storage of about -100 taf, which equals an average annual decrease in groundwater storage of approximately -2.0 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 1.0 af per acre over the 51 years and an annual decrease of about -0.02 af per acre across the entire Subbasin (approximately 99,000 acres).

Detailed results for each of the individual water budget components in the projected (future land use) water budget are presented in **Appendix C-3**.

Table 4-24. Los Molinos Subbasin Projected (Future Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	63,000
Deep Percolation	51,000
Groundwater Pumping	-21,000
Groundwater Uptake	-6,100
Total Net Subsurface Flows	-89,000
Annual Change in Groundwater Storage	**-2,000**

4.3.4. Projected (Current Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (current land use) with climate change water budget as they relate to the GWS are presented in **Table 4-25**. Net seepage increases under climate change scenarios, indicating greater stream seepage to groundwater. Deep percolation and net subsurface flows decrease slightly under climate change scenarios. Groundwater pumping increases slightly under climate change scenarios, but the overall water budget results suggest that annual change in storage is only very slightly more negative under the climate change scenarios.

Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2030) water budget are presented in **Appendix C-4**. Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2070) water budget are presented in **Appendix C-5**.

Table 4-25. Comparison of Los Molinos Subbasin Projected (Current Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Current Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	59,000	62,000	67,000
Deep Percolation	52,000	52,000	50,000
Groundwater Pumping	-20,000	-22,000	-24,000
Groundwater Uptake	-7,300	-7,100	-6,400
Total Net Subsurface Flows	-86,000	-87,000	-88,000
Annual Groundwater Storage Change	**-1,800**	**-1,900**	**-2,100**

4.3.5. Projected (Future Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (future land use) with climate change water budget as they relate to the GWS are presented in **Table 4-26**. Overall, the climate change scenarios do not appear to change the overall Subbasin GWS water budget in a considerable way. Net seepage increases under climate change scenarios, indicating greater stream seepage to groundwater. Deep percolation and net subsurface flows decrease slightly under climate change scenarios. Groundwater pumping under climate change scenarios, but the overall change in storage is only slightly more negative under the climate change scenarios.

Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2030) water budget are presented in **Appendix C-6**. Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2070) water budget are presented in **Appendix C-7**.

Table 4-26. Comparison of Los Molinos Subbasin Projected (Future Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Future Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	63,000	66,000	71,000
Deep Percolation	51,000	51,000	49,000
Groundwater Pumping	-21,000	-22,000	-25,000
Groundwater Uptake	-6,100	-5,900	-5,100
Total Net Subsurface Flows	-89,000	-91,000	-92,000
Annual Groundwater Storage Change	**-2,000**	**-2,100**	**-2,300**

Note: positive values indicate inflows/increasing storage, negative values indicate outflows/decreasing storage.

4.3.6. Projected (Future Land Use) with Projects and Climate Change Water Budget Results

Summarized results for major components of the projected (future land use) with projects and climate change (2070) water budget as they relate to the GWS are presented in **Table 4-27**. The positive net seepage values (on average 70 taf per year) and deep percolation values (on average 49 taf per year) represent the major inflows to the GWS. The net subsurface flows average about -92 taf per year represent the combined net subsurface outflows from the Subbasin to adjacent subbasins.

Groundwater pumping (on average -25 taf per year) and groundwater (root water) uptake directly from shallow groundwater (on average -5.2 taf per year) are somewhat smaller outflows from the GWS. Overall, the water budget results for the 51-year projected (future land use) with projects and climate change (2070) period indicate a cumulative change in groundwater storage of about -120 taf, which equals an average annual decrease in groundwater storage of approximately -2.3 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about -1.2 af per acre over the 51 years and an annual decrease of about -0.02 af per acre across the entire Subbasin (approximately 99,000 acres).

Detailed results for each of the individual water budget components in the projected (future land use) with projects and climate change (2070) water budget are presented in **Appendix C-8**.

Table 4-27. Los Molinos Subbasin Projected (Future Land Use) with Projects and Climate Change (2070) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	70,000
Deep Percolation	49,000
Groundwater Pumping	-25,000
Groundwater Uptake	-5,200
Total Net Subsurface Flows	-92,000
Annual Change in Groundwater Storage	**-2,300**

4.4. Red Bluff Subbasin

The following section summarizes the analyses and results relating to the historical scenario for the Red Bluff Subbasin. Detailed water budget results for each of the individual model scenarios are presented in **Appendix D**.

4.4.1. Historical Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the historical water budget period (1990-2018) are summarized in **Table 4-28**. Of particular note in the historical SWS water budget results are the volume of precipitation that makes up a large part of the Subbasin SWS inflows. Over the historical period, precipitation to surface water averaged about 580 taf per year. Surface water inflows and groundwater extraction and uptake also represent large SWS inflow components averaging about 120 and 90 taf per year, respectively. Groundwater discharge to surface water represents a relatively smaller SWS inflow in the Subbasin, averaging about 42 taf per year over the historical water budget period.

Among the outflows from the Subbasin SWS, ET of precipitation and surface water outflow make up large fractions of the total Subbasin SWS outflows. ET of precipitation averages about 350 taf per year, while surface water outflows total about 340 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of applied water and deep percolation of precipitation averaging about 61 and 55 taf per year, respectively. The outflows of deep percolation of applied water, ET of groundwater uptake and infiltration (seepage) of surface water are about 15, 9.7, and 2.4 taf per year on average, respectively. Evaporation from surface water averages about 0.7 taf per year over the historical water budget period.

Table 4-28. Red Bluff Subbasin Historical Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (1990-2018)
Inflows	Surface Water Inflow	120,000
	Precipitation	580,000
	Groundwater Extraction	90,000
	Groundwater Discharge	42,000
Outflows	Surface Water Outflow	340,000
	ET of Applied Water	61,000
	ET of Groundwater Uptake	9,700
	ET of Precipitation	350,000
	Evaporation	680
	Deep Percolation of Applied Water	15,000
	Deep Percolation of Precipitation	55,000
	Infiltration of Surface Water	2,400
Annual Change in Root Zone Storage		**-1,600**

Summarized results for major components of the historical water budget as they relate to the GWS are presented in **Table 4-29**. Among the outflows from the Subbasin GWS, groundwater pumping makes up the largest fraction of the total GWS outflows (on average -80 taf per year). Highly negative net seepage values (on average -39 taf per year) represent net groundwater discharging to surface waterways and leaving the GWS. Groundwater (root water) uptake directly from shallow groundwater (on average -9.7 taf per year) represents a smaller outflow from the GWS. Deep percolation is the largest net inflow component averaging about 70 taf per year. Positive net subsurface flows (on average 49 taf per year) represent the combined subsurface inflows from adjacent subbasins and upland areas. Overall, the water budget results for the 29-year historic period indicate a cumulative change in groundwater storage of about -310 taf, which equals an average annual change in groundwater storage of only about -11 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 1.1 af per acre on average over the 29 years and an annual decrease of less than 0.04 af per acre across the entire Subbasin (approximately 272,000 acres).

Detailed results for each of the individual water budget components in the historical water budget are presented in **Appendix D-1**.

Table 4-29. Red Bluff Subbasin Historical Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (1990-2018)
Total Net Seepage	-39,000
Deep Percolation	70,000
Groundwater Pumping	-80,000
Groundwater Uptake	-9,700
Total Net Subsurface Flows	49,000
Annual Change in Groundwater Storage	**-11,000**

4.4.2. Projected (Current Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (current land use) water budget period (2022-2072) are summarized in **Table 4-30**. Of particular note in the projected (current land use) SWS water budget results are the volume of precipitation that makes up a large part of the Subbasin SWS inflows (average about 600 taf per year over the projected period). Surface water inflows and groundwater extraction also represent large SWS inflow components averaging about 120 and 100 taf per year, respectively. Groundwater discharge to surface water is a relatively smaller SWS inflow in the Subbasin averaging about 26 taf per year over the projected (current land use) water budget period.

Among the outflows from the Subbasin SWS, ET of precipitation and surface water outflow make up large fractions of the total Subbasin SWS outflows. ET of precipitation averages about 360 taf per year, while surface water outflows total about 330 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of applied water and deep percolation of precipitation averaging about 80 taf and 54 taf per year, respectively. The outflows of deep percolation of applied water, ET of groundwater uptake and infiltration (seepage) of surface water are about 13, 6.3, and 4.5 taf per year on average, respectively. Evaporation from surface water averages about 0.9 taf per year over the projected (current land use) water budget period.

Table 4-30. Red Bluff Subbasin Projected (Current Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	120,000
	Precipitation	600,000
	Groundwater Extraction	100,000
	Groundwater Discharge	26,000
Outflows	Surface Water Outflow	330,000
	ET of Applied Water	80,000
	ET of Groundwater Uptake	6,300
	ET of Precipitation	360,000
	Evaporation	910
	Deep Percolation of Applied Water	13,000
	Deep Percolation of Precipitation	54,000
	Infiltration of Surface Water	4,500
Annual Change in Root Zone Storage		**-46**

Summarized results for major components of the projected (current land use) water budget as they relate to the GWS are presented in **Table 4-31**. Among the outflows from the Subbasin GWS, groundwater pumping makes up the largest fraction of the total GWS outflows (on average -94 taf per year). Highly negative net seepage values (on average -21 taf per year) represent net groundwater discharging to surface waterways and leaving the GWS. Groundwater (root water) uptake directly from shallow groundwater (on average -6.3 taf per year) represents a smaller outflow from the GWS. Deep percolation is the largest net inflow component averaging about 67 taf per year. Positive net subsurface flows (on average 53 taf per year) represent the combined subsurface inflows from adjacent subbasins and upland areas. Overall, the water budget results for the 51-year projected (current land use) period indicate a cumulative change in groundwater storage of about -94 taf, which equals an average annual change in groundwater storage of only about -1.8 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 0.34 af per acre on average over the 51 years and an annual decrease of less than 0.01 af per acre across the entire Subbasin (approximately 272,000 acres).

Detailed results for each of the individual water budget components in the projected (current land use) water budget are presented in **Appendix D-2**.

Table 4-31. Red Bluff Subbasin Projected (Current Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	-21,000
Deep Percolation	67,000
Groundwater Pumping	-94,000
Groundwater Uptake	-6,300
Total Net Subsurface Flows	53,000
Annual Change in Groundwater Storage	**-1,800**

4.4.3. Projected (Future Land Use) Water Budget Results

Annual inflows, outflows, and change in SWS root zone storage during the projected (future land use) water budget period (2022-2072) are summarized in **Table 4-32**. Of particular note in the projected (future land use) SWS water budget results are the volume of precipitation that makes up a large part of the Subbasin SWS inflows (average about 600 taf over the projected period). Groundwater extraction and surface water inflows also represent large SWS inflow components averaging about 140 and 120 taf per year, respectively. Groundwater discharge to surface water is a relatively smaller SWS inflow in the Subbasin averaging about 16 taf per year over the projected (future land use) water budget period.

Among the outflows from the Subbasin SWS, ET of precipitation and surface water outflow make up large fractions of the total Subbasin SWS outflows. ET of precipitation averages about 360 taf per year, while surface water outflows total about 330 taf per year on average. By comparison, other SWS outflows in the Subbasin are relatively smaller, with values for ET of applied water and deep percolation of precipitation averaging about 110 and 51 taf per year, respectively. The outflows of deep percolation of applied water, infiltration (seepage) of surface water, and ET of groundwater uptake are about 17, 7.1, and 4.8 taf per year on average, respectively. Evaporation from surface water averages about 0.97 taf per year over the projected (current land use) water budget period.

Table 4-32. Red Bluff Subbasin Projected (Future Land Use) Surface System Annual Water Budget Summary (acre-feet)

Water Budget Component		Average (2022-2072)
Inflows	Surface Water Inflow	120,000
	Precipitation	600,000
	Groundwater Extraction	140,000
	Groundwater Discharge	16,000
Outflows	Surface Water Outflow	330,000
	ET of Applied Water	110,000
	ET of Groundwater Uptake	4,800
	ET of Precipitation	360,000
	Evaporation	970
	Deep Percolation of Applied Water	17,000
	Deep Percolation of Precipitation	51,000
	Infiltration of Surface Water	7,100
Annual Change in Root Zone Storage		**-50**

Summarized results for major components of the projected (future land use) water budget as they relate to the GWS are presented in **Table 4-33**. Among the outflows from the Subbasin GWS, groundwater pumping makes up the largest fraction of the total GWS outflows (on average -130 taf per year). Negative net seepage values (on average -9.3 taf per year) represent net groundwater discharging to surface waterways and leaving the GWS. Groundwater (root water) uptake directly from shallow groundwater (on average -4.8 taf per year) represents a smaller outflow from the GWS. Positive net subsurface flows and deep percolation are the largest net inflow components averaging about 74 and 68 taf per year, respectively. Overall, the water budget results for the 51-year projected (future land use) period indicate a cumulative change in groundwater storage of about -150 taf, which equals an average annual change in groundwater storage of only about -2.9 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about 0.54 af per acre on average over the 51 years and an annual decrease of about 0.01 af per acre across the entire Subbasin (approximately 272,000 acres).

Detailed results for each of the individual water budget components in the projected (future land use) water budget are presented in **Appendix D-3**.

Table 4-33. Red Bluff Subbasin Projected (Future Land Use) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	-9,300
Deep Percolation	68,000
Groundwater Pumping	-130,000
Groundwater Uptake	-4,800
Total Net Subsurface Flows	74,000
Annual Change in Groundwater Storage	**-2,900**

4.4.4. Projected (Current Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (current land use) with climate change water budget as they relate to the GWS are presented in **Table 4-34**. Net seepage becomes less negative under climate change scenarios, indicating less groundwater discharge to streams. Deep percolation decreases slightly, while net subsurface flows increase slightly under climate change scenarios. Groundwater pumping increases under climate change scenarios, becoming a greater outflow from the groundwater system. Overall, the annual change in groundwater storage becomes more negative under climate change scenarios.

Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2030) water budget are presented in **Appendix D-4**. Detailed results for each of the individual water budget components in the projected (current land use) with climate change (2070) water budget are presented in **Appendix D-5**.

Table 4-34. Comparison of Red Bluff Subbasin Projected (Current Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Current Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	-21,000	-18,000	-12,000
Deep Percolation	67,000	67,000	64,000
Groundwater Pumping	-94,000	-99,000	-110,000
Groundwater Uptake	-6,300	-6,200	-5,500
Total Net Subsurface Flows	53,000	54,000	56,000
Annual Groundwater Storage Change	**-1,800**	**-1,900**	**-2,400**

4.4.5. Projected (Future Land Use) with Climate Change Water Budget Results

A comparison of the major components of the projected (future land use) with climate change water budget as they relate to the GWS are presented in **Table 4-35**. Net seepage becomes less negative under 2030 climate change scenario indicating a reduction of groundwater discharge to streams. Net seepage becomes slightly positive under 2070 climate change scenario indicating seepage from surface water to groundwater. Deep percolation decreases slightly under climate change scenarios, while net subsurface flows increase slightly under climate change scenarios. Groundwater pumping increases under climate change scenarios, becoming a greater outflow from the groundwater system. Overall, the annual change in groundwater storage becomes more negative under climate change scenarios.

Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2030) water budget are presented in **Appendix D-6**. Detailed results for each of the individual water budget components in the projected (future land use) with climate change (2070) water budget are presented in **Appendix D-7**.

Table 4-35. Comparison of Red Bluff Subbasin Projected (Future Land Use) Groundwater System Annual Water Budgets with Climate Change Adjustments (acre-feet)

GWS Water Budget Component	Projected (Future Land Use)		
	Baseline Scenario	Climate Change (2030)	Climate Change (2070)
Total Net Seepage	-9,300	-6,000	830
Deep Percolation	68,000	68,000	66,000
Groundwater Pumping	-130,000	-140,000	-150,000
Groundwater Uptake	-4,800	-4,600	-4,100
Total Net Subsurface Flows	74,000	77,000	80,000
Annual Groundwater Storage Change	**-2,900**	**-3,000**	**-4,100**

Note: positive values indicate inflows/increasing storage, negative values indicate outflows/decreasing storage.

4.4.6. Projected (Future Land Use) with Projects and Climate Change Water Budget Results

Summarized results for major components of the projected (future land use) with projects and climate change (2070) water budget as they relate to the GWS are presented in **Table 4-36**. Among the outflows from the Subbasin SWS, groundwater pumping makes up the largest fraction of the total SWS outflows (on average -150 taf per year). Groundwater (root water) uptake directly from shallow groundwater (on average -4.8 taf per year) represents a smaller outflow from the GWS. Positive net subsurface flows and deep percolation are the largest net inflow components averaging about 74 and 68 taf per year, respectively. Net seepage values (on average 0.3 taf per year) represents a smaller inflow to the GWS. Overall, the water budget results for the 51-year projected (future land use) with projects and climate change (2070) period indicate a cumulative change in groundwater storage of about -180 taf, which equals an average annual change in groundwater storage of only about -3.5 taf per year. This change in storage estimates equate to total decreases in storage in the Subbasin of about -0.66 af per acre on average over the 51 years and an annual decrease of about -0.01 af per acre across the entire Subbasin (approximately 272,000 acres).

Detailed results for each of the individual water budget components in the projected (future land use) with projects and climate change (2070) water budget are presented in **Appendix D-8**.

Table 4-36. Red Bluff Subbasin Projected (Future Land Use) with Projects and Climate Change (2070) Groundwater System Annual Water Budget Summary (acre-feet)

Water Budget Component	Average (2022-2072)
Total Net Seepage	300
Deep Percolation	67,000
Groundwater Pumping	-150,000
Groundwater Uptake	-4,300
Total Net Subsurface Flows	79,000
Annual Change in Groundwater Storage	**-3,500**

4.5. Summary of Subbasin Water Budget Results by Aquifer Zone

This section provides a summary comparison of the Subbasin water budget results for the different historical and projected conditions evaluated, including by primary aquifer zone.

4.5.1. Antelope Subbasin

Table 4-37 provides a summary comparison of the Antelope Subbasin water budget results for the different historical and projected conditions evaluated, including by primary aquifer zone. Net seepage becomes less negative in the projected scenarios as compared to the historical scenario, indicating less groundwater discharge to streams. The decrease in groundwater discharge to streams is greatest in the climate change scenarios which correlated with higher surface water inflows occurring under the climate change scenarios. Deep percolation from the SWS to the GWS is relatively stable between the historical and projected scenarios, but decreases slightly under the climate change scenarios. Net subsurface flows decrease in the projected scenarios as compared to the historical scenario, indicating decreased inflows to the Subbasin. These subsurface inflows decrease slightly under climate change scenarios. Groundwater pumping increases slightly in the projected scenarios as compared to the historical scenario and increases only modestly under climate change scenarios. Overall, all historical and projected water budgets suggest decreases in groundwater storage by varying magnitudes. The projected changes in storage are likely within the range of uncertainty in the water budget estimates.

As presented in **Table 4-37**, groundwater pumping in the Antelope Subbasin occurs primarily from the Upper Aquifer and historically averaged about 15 taf per year from the Upper Aquifer; in projected water budget scenarios, average groundwater pumping from the Upper Aquifer is estimated to range between 16 and 18 taf per year, depending on the water budget scenario. In the historical water budget period, groundwater pumping from the Lower Aquifer was estimated to average about 27 af per year; under projected water budget scenarios groundwater pumping from the Lower Aquifer is estimated to average between 36 and 45 af per year, depending on the water budget scenario.

Net subsurface flows in the Subbasin occur primarily from the Upper Aquifer and historically averaged about 51 taf per year of inflow to the Upper Aquifer; in projected water budget scenarios, average net subsurface flows to the Upper Aquifer are estimated to range between 29 and 42 taf per year of inflow, depending on the water budget scenario. All subsurface flows are inflows the Upper Aquifer along all boundaries. Net subsurface flows from the Red Bluff Subbasin were historically inflows to the Upper Aquifer, but shift to outflows in the projected (future land use) scenarios.

In the historical water budget period, net subsurface flows to the Lower Aquifer were estimated to average about 260 af per year of outflows; under projected water budget scenarios net subsurface flows to the Lower Aquifer are estimated to average between 99 and 140 af per year of outflows, depending on the water budget scenario. The majority of net subsurface inflows to the Lower Aquifer come from the Red Bluff Subbasin and Bend Subbasin. The majority of net subsurface outflows from the Lower Aquifer are to the Los Molinos Subbasin and to the Upper Aquifer.

The average change in groundwater storage within each of the two primary aquifers in the Subbasin are very minor under all historical and projected water budget scenarios. The water budget results suggest that slight decreases in groundwater storage are projected to occur in the Upper and Lower Aquifers, depending on the projected water budget scenario. The projected changes in storage are likely within the range of uncertainty in the water budget estimates.

Table 4-37. Comparison of Antelope Subbasin GWS Water Budgets (acre-feet)

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Upper Aquifer							
Net Seepage	-48,000	-38,000	-36,000	-33,000	-28,000	-26,000	-22,000
Deep Percolation	12,000	11,000	12,000	11,000	11,000	11,000	11,000
Groundwater Extraction	-15,000	-16,000	-17,000	-18,000	-16,000	-17,000	-18,000
Net Subsurface Flows	51,000	42,000	42,000	39,000	33,000	32,000	29,000
Horizontal flow from (+)/to (-) Los Molinos Subbasin	12,000	9,900	9,800	9,200	8,900	8,700	8,100
Horizontal flow from (+)/to (-) Red Bluff Subbasin	3,500	1,200	980	430	-2,500	-2,900	-3,700
Horizontal flow from (+)/to (-) Bend Subbasin	2,000	2,100	2,100	2,200	2,200	2,200	2,300
Vertical flow from (+)/to (-) Lower Aquifer	34,000	29,000	29,000	27,000	24,000	23,000	22,000
Annual Groundwater Storage Change	**-330**	**-160**	**-160**	**-180**	**-170**	**-180**	**-200**
Lower Aquifer							

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Net Seepage	0	0	0	0	0	0	0
Deep Percolation	0	0	0	0	0	0	0
Groundwater Extraction	-27	-36	-39	-45	-36	-39	-45
Net Subsurface Flows	-260	-99	-100	-110	-120	-120	-140
Horizontal flow from (+)/to (-) Los Molinos Subbasin	-6,900	-7,000	-7,000	-7,100	-6,200	-6,200	-6,200
Horizontal flow from (+)/to (-) Red Bluff Subbasin	22,000	17,000	16,000	15,000	10,000	9,700	8,100
Horizontal flow from (+)/to (-) Bend Subbasin	18,000	19,000	19,000	19,000	20,000	20,000	20,000
Vertical flow from (+)/to (-) Upper Aquifer	-34,000	-29,000	-29,000	-27,000	-24,000	-23,000	-22,000
Annual Groundwater Storage Change	**-290**	**-130**	**-140**	**-160**	**-160**	**-160**	**-180**
Entire Groundwater System							
Net Seepage	-48,000	-38,000	-36,000	-33,000	-28,000	-26,000	-22,000
Deep Percolation	12,000	11,000	12,000	11,000	11,000	11,000	11,000
Groundwater Extraction	-15,000	-16,000	-17,000	-18,000	-16,000	-17,000	-18,000
Net Subsurface Flows	50,000	42,000	42,000	39,000	33,000	32,000	29,000
Horizontal flow from (+)/to (-) Los Molinos Subbasin	4,700	2,900	2,800	2,100	2,600	2,600	1,900
Horizontal flow from (+)/to (-) Red Bluff Subbasin	25,000	18,000	17,000	15,000	8,000	6,800	4,400
Horizontal flow from (+)/to (-) Bend Subbasin	20,000	21,000	21,000	21,000	22,000	22,000	22,000
Annual Groundwater Storage Change	**-610**	**-290**	**-300**	**-340**	**-330**	**-340**	**-390**

4.5.2. Bowman Subbasin

Table 4-38 provides a summary comparison of the Bowman Subbasin water budget results for the different historical and projected conditions evaluated, including by primary aquifer zone. Net seepage increases in the projected scenarios as compared to the historical scenario, indicating greater stream seepage to groundwater. The increases in stream seepage are greatest in the climate change scenarios which correlated with higher surface water inflows occurring under the climate change scenarios. Deep percolation from the SWS to the GWS is relatively stable between the historical and projected scenarios, but decreases slightly under the climate change scenarios. Net subsurface flows become slightly more negative in the projected scenarios as compared to the historical scenario, indicating greater outflows from the Subbasin. These subsurface outflows vary slightly under climate change scenarios. Groundwater pumping increases slightly in the projected scenarios as compared to the historical scenario, and increases under climate change scenarios. Overall, all historical and projected water budgets suggest decreases in groundwater storage by varying magnitudes. The projected changes in storage are likely within the range of uncertainty in the water budget estimates.

As presented in **Table 4-38**, groundwater pumping in the Bowman Subbasin occurs primarily from the Upper Aquifer and historically averaged about 6.9 taf per year from the Upper Aquifer; in projected water budget scenarios, average groundwater pumping from the Upper Aquifer is estimated to range between 7.1 and 7.6 taf per year, depending on the water budget scenario. In the historical water budget period, groundwater pumping from the Lower Aquifer was estimated to average about 2.2 af per year; under projected water budget scenarios groundwater pumping from the Lower Aquifer is estimated to average between 2 and 2.3 af per year, depending on the water budget scenario.

Net subsurface flows in the Subbasin occur primarily from the Upper Aquifer and historically averaged about 89 taf per year of outflow from the Upper Aquifer; in projected water budget scenarios, average net subsurface flows from the Upper Aquifer are estimated to range between 91 and 94 taf per year of outflow, depending on the water budget scenario. The majority of net subsurface inflows to the Upper Aquifer come from the Anderson Subbasin and South Battle Creek Subbasin. The majority of net subsurface outflows from the Upper Aquifer are to the Red Bluff Subbasin and to the Lower Aquifer.

In the historical water budget period, net subsurface flows to the Lower Aquifer were estimated to average about 1.1 taf per year of inflows; under projected water budget scenarios net subsurface flows to the Lower Aquifer are estimated to average between 2.1 and 2.2 taf per year of inflows, depending on the water budget scenario. The majority of net subsurface inflows to the Lower Aquifer come from the Anderson Subbasin, South Battle Creek Subbasin, and Upper Aquifer. The majority of net subsurface outflows from the Lower Aquifer are to the Red Bluff Subbasin.

The average change in groundwater storage within each of the two primary aquifers in the Subbasin are very minor under all historical and projected water budget scenarios. The water budget results suggest that slight decreases in groundwater storage are projected to occur in the Upper and Lower Aquifers, depending on the projected water budget scenario. The projected changes in storage are likely within the range of uncertainty in the water budget estimates.

Table 4-38. Comparison of Bowman Subbasin GWS Water Budgets (acre-feet)

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Upper Aquifer							
Net Seepage	43,000	46,000	47,000	48,000	47,000	48,000	49,000
Deep Percolation	53,000	53,000	53,000	51,000	53,000	53,000	51,000
Groundwater Extraction	-6,900	-7,100	-7,300	-7,600	-7,100	-7,300	-7,600
Net Subsurface Flows	-89,000	-92,000	-93,000	-91,000	-94,000	-94,000	-93,000
Horizontal flow from (+)/to (-) Red Bluff Subbasin	-10,000	-11,000	-11,000	-11,000	-11,000	-11,000	-11,000
Horizontal flow from (+)/to (-) Anderson Subbasin	960	1,200	1,200	1,400	1,200	1,300	1,400
Horizontal flow from (+)/to (-) South Battle Creek Subbasin	4,200	4,400	4,500	4,500	4,600	4,600	4,600
Vertical flow from (+)/ to (-) Lower Aquifer	-84,000	-87,000	-88,000	-87,000	-89,000	-89,000	-88,000
Annual Groundwater Storage Change	**-620**	**-320**	**-330**	**-380**	**-340**	**-350**	**-400**
Lower Aquifer							
Net Seepage	0	0	0	0	0	0	0
Deep Percolation	0	0	0	0	0	0	0
Groundwater Extraction	-2,200	-2,000	-2,100	-2,200	-2,100	-2,200	-2,300
Net Subsurface Flows	1,100	2,100	2,200	2,100	2,200	2,200	2,100
Horizontal flow from (+)/to (-) Red Bluff Subbasin	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000
Horizontal flow from (+)/to (-) Anderson Subbasin	21,000	21,000	21,000	21,000	22,000	22,000	22,000
Horizontal flow from (+)/to (-) South Battle Creek Subbasin	5,300	5,800	5,900	5,900	6,200	6,200	6,300
Vertical flow from (+)/to (-) Upper Aquifer	84,000	87,000	88,000	87,000	89,000	89,000	88,000
Annual Groundwater Storage Change	**-1,100**	**110**	**91**	**-33**	**35**	**11**	**-120**

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Entire Groundwater System							
Net Seepage	43,000	46,000	47,000	48,000	47,000	48,000	49,000
Deep Percolation	53,000	53,000	53,000	51,000	53,000	53,000	51,000
Groundwater Extraction	-9,100	-9,100	-9,300	-9,800	-9,200	-9,500	-9,900
Net Subsurface Flows	-88,000	-90,000	-91,000	-89,000	-91,000	-92,000	-90,000
Horizontal flow from (+)/to (-) Red Bluff Subbasin	-120,000	-120,000	-120,000	-120,000	-130,000	-130,000	-130,000
Horizontal flow from (+)/to (-) Anderson Subbasin	22,000	22,000	22,000	23,000	23,000	23,000	24,000
Horizontal flow from (+)/to (-) South Battle Creek Subbasin	9,400	10,000	10,000	10,000	11,000	11,000	11,000
Annual Groundwater Storage Change	**-1,700**	**-210**	**-240**	**-420**	**-300**	**-340**	**-530**

4.5.3. Los Molinos Subbasin

Table 4-39 provides a summary comparison of the Los Molinos Subbasin water budget results for the different historical and projected conditions evaluated, including by primary aquifer zone. Net seepage increases in the projected scenarios as compared to the historical scenario, indicating greater stream seepage to groundwater. The increases in stream seepage are greatest in the climate change scenarios which correlated with higher surface water inflows occurring under the climate change scenarios. Deep percolation from the SWS to the GWS decreases in the projected scenarios as compared to the historical scenario, and decreases slightly under the climate change scenarios. Net subsurface flows become more negative in the projected scenarios as compared to the historical scenario, indicating greater outflows from the Subbasin. These subsurface outflows become more negative under climate change scenarios. Groundwater pumping decreases slightly in the projected scenarios as compared to the historical scenario, and increases under climate change scenarios. Overall, all historical and projected water budgets suggest decreases in groundwater storage by varying magnitudes.

As presented in **Table 4-39**, groundwater pumping in the Los Molinos Subbasin occurs primarily from the Upper Aquifer and historically averaged about 30 taf per year from the Upper Aquifer; in projected water budget scenarios, average groundwater pumping from the Upper Aquifer is estimated to range between 24 and 27 taf per year, depending on the water budget scenario. In the historical water budget period, groundwater pumping from the Lower Aquifer was estimated to average about 2.7 af per year; under projected water budget scenarios groundwater pumping from the Lower Aquifer is estimated to average between 3.2 and 3.7 af per year, depending on the water budget scenario.

Net subsurface flows in the Subbasin occur primarily from the Upper Aquifer and historically averaged about 57 taf per year of outflow from the Upper Aquifer; in projected water budget scenarios, average net subsurface flows from the Upper Aquifer are estimated to range between 88 and 95 taf per year of outflow, depending on the water budget scenario. All subsurface flows from the Upper Aquifer are outflows from the Los Molinos Subbasin.

In the historical water budget period, net subsurface flows to the Lower Aquifer were estimated to average about 2.7 taf per year of inflows; under projected water budget scenarios net subsurface flows to the Lower Aquifer are estimated to average between 3.2 and 3.7 taf per year of inflows, depending on the water budget scenario. The majority of net subsurface inflows to the Lower Aquifer come from the Antelope Subbasin, Red Bluff Subbasin, and Upper Aquifer. The majority of net subsurface outflows from the Lower Aquifer are to the Corning Subbasin and Vina Subbasin.

The average change in groundwater storage within each of the two primary aquifers in the Subbasin are very minor under all historical and projected water budget scenarios. The water budget results suggest that slight decreases in groundwater storage are projected to occur in the Upper and Lower Aquifers, depending on the projected water budget scenario.

Table 4-39. Comparison of Los Molinos Subbasin GWS Water Budgets (acre-feet)

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Upper Aquifer							
Net Seepage	33,000	59,000	62,000	67,000	63,000	66,000	71,000
Deep Percolation	54,000	52,000	52,000	50,000	51,000	51,000	49,000
Groundwater Extraction	-30,000	-24,000	-25,000	-27,000	-24,000	-25,000	-26,000
Net Subsurface Flows	-57,000	-88,000	-90,000	-91,000	-92,000	-93,000	-95,000
Horizontal flow from (+)/to (-) Antelope Subbasin	-12,000	-9,900	-9,800	-9,200	-8,900	-8,700	-8,100
Horizontal flow from (+)/to (-) Red Bluff Subbasin	-3,200	-2,400	-2,500	-2,500	-2,900	-3,000	-3,000
Horizontal flow from (+)/to (-) Corning Subbasin	-390	-3,200	-3,400	-3,900	-3,500	-3,800	-4,300
Horizontal flow from (+)/to (-) Vina Subbasin	-13,000	-16,000	-16,000	-16,000	-16,000	-16,000	-16,000
Vertical flow from (+)/to (-) Lower Aquifer	-30,000	-58,000	-59,000	-61,000	-62,000	-63,000	-65,000
Annual Groundwater Storage Change	**-1,100**	**-1,100**	**-1,100**	**-1,300**	**-1,200**	**-1,200**	**-1,400**

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Lower Aquifer							
Net Seepage	0	0	0	0	0	0	0
Deep Percolation	0	0	0	0	0	0	0
Groundwater Extraction	-2,700	-3,200	-3,400	-3,700	-3,200	-3,400	-3,700
Net Subsurface Flows	1,300	2,500	2,700	2,800	2,400	2,600	2,700
Horizontal flow from (+)/to (-) Antelope Subbasin	6,900	7,000	7,000	7,100	6,200	6,200	6,200
Horizontal flow from (+)/to (-) Red Bluff Subbasin	5,400	3,300	2,900	2,100	870	320	-620
Horizontal flow from (+)/to (-) Corning Subbasin	840	-4,000	-4,500	-5,400	-5,100	-5,700	-6,700
Horizontal flow from (+)/to (-) Vina Subbasin	-43,000	-62,000	-63,000	-63,000	-62,000	-62,000	-62,000
Vertical flow from (+)/to (-) Upper Aquifer	30,000	58,000	59,000	61,000	62,000	63,000	65,000
Annual Groundwater Storage Change	**-1,400**	**-730**	**-760**	**-860**	**-810**	**-850**	**-960**
Entire Groundwater System							
Net Seepage	33,000	59,000	62,000	67,000	63,000	66,000	71,000
Deep Percolation	54,000	52,000	52,000	50,000	51,000	51,000	49,000
Groundwater Extraction	-33,000	-27,000	-29,000	-31,000	-27,000	-28,000	-30,000
Net Subsurface Flows	-56,000	-86,000	-87,000	-88,000	-89,000	-91,000	-92,000
Horizontal flow from (+)/to (-) Antelope Subbasin	-4,700	-2,900	-2,800	-2,100	-2,600	-2,600	-1,900
Horizontal flow from (+)/to (-) Red Bluff Subbasin	2,200	880	390	-360	-2,000	-2,600	-3,700
Horizontal flow from (+)/to (-) Corning Subbasin	450	-7,100	-7,900	-9,300	-8,700	-9,600	-11,000
Horizontal flow from (+)/to (-) Vina Subbasin	-56,000	-79,000	-79,000	-79,000	-78,000	-78,000	-78,000
Annual Groundwater Storage Change	**-2,500**	**-1,800**	**-1,900**	**-2,100**	**-2,000**	**-2,100**	**-2,300**

4.5.4. Red Bluff Subbasin

Table 4-40 provides a summary comparison of the Red Bluff Subbasin water budget results for the different historical and projected conditions evaluated, including by primary aquifer zone. Net seepage becomes less negative in the projected scenarios as compared to the historical scenario, indicating less groundwater discharge to streams. The decreases in groundwater discharge to streams are greatest in the climate change scenarios which correlated with higher surface water inflows occurring under the climate change scenarios. Deep percolation from the SWS to the GWS decreases between the historical and projected scenarios, and decreases slightly under the climate change scenarios. Net subsurface flows increase in the projected scenarios as compared to the historical scenario, indicating greater inflows to the Subbasin. These subsurface inflows increase under climate change scenarios. Groundwater pumping increases in the projected scenarios as compared to the historical scenario, and increases under climate change scenarios. Overall, all historical and projected water budgets suggest decreases in groundwater storage by varying magnitudes.

As presented in **Table 4-40**, groundwater pumping in the Red Bluff Subbasin occurs primarily from the Upper Aquifer and historically averaged about 78 taf per year from the Upper Aquifer; in projected water budget scenarios, average groundwater pumping from the Upper Aquifer is estimated to range between 84 and 130 taf per year, depending on the water budget scenario. In the historical water budget period, groundwater pumping from the Lower Aquifer was estimated to average about 12 af per year; under projected water budget scenarios groundwater pumping from the Lower Aquifer is estimated to average between 16 and 21 af per year, depending on the water budget scenario.

Net subsurface flows in the Subbasin occur primarily from the Upper Aquifer and historically averaged about 43 taf per year of inflow from the Upper Aquifer; in projected water budget scenarios, average net subsurface flows from the Upper Aquifer are estimated to range between 39 and 62 taf per year of inflow, depending on the water budget scenario. The majority of net subsurface inflows to the Upper Aquifer come from the Bowman Subbasin, Los Molinos Subbasin, South Battle Creek Subbasin, and the Lower Aquifer. The majority of net subsurface outflows from the Upper Aquifer are to the Corning Subbasin and to the Bend Subbasin. Net subsurface flows from the Antelope Subbasin were historically outflows to the Upper Aquifer, but shift to inflows in the projected (future land use) scenarios.

In the historical water budget period, net subsurface flows to the Lower Aquifer were estimated to average about 5.3 taf per year of inflows; under projected water budget scenarios net subsurface flows to the Lower Aquifer are estimated to average between 15 and 18 taf per year of inflows, depending on the water budget scenario. The majority of net subsurface inflows to the Lower Aquifer come from the Bowman Subbasin and South Battle Creek Subbasin. The majority of net subsurface outflows from the Lower Aquifer are to the Antelope Subbasin, Los Molinos Subbasin, Corning Subbasin, and Bend Subbasin, and Upper Aquifer.

The average change in groundwater storage within each of the two primary aquifers in the Subbasin are very minor under all historical and projected water budget scenarios. The water budget results suggest that slight decreases in groundwater storage are projected to occur in the Upper and Lower Aquifers, depending on the projected water budget scenario.

Table 4-40. Comparison of Red Bluff Subbasin GWS Water Budgets (acre-feet)

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Upper Aquifer							
Net Seepage	-39,000	-21,000	-18,000	-12,000	-9,300	-6,000	830
Deep Percolation	70,000	67,000	67,000	64,000	68,000	68,000	66,000
Groundwater Extraction	-78,000	-84,000	-88,000	-93,000	-120,000	-120,000	-130,000
Net Subsurface Flows	43,000	39,000	39,000	40,000	58,000	59,000	62,000
Horizontal flow from (+)/to (-) Antelope Subbasin	-3,500	-1,200	-980	-430	2,500	2,900	3,700
Horizontal flow from (+)/to (-) Bowman Subbasin	10,000	11,000	11,000	11,000	11,000	11,000	11,000
Horizontal flow from (+)/to (-) Los Molinos Subbasin	3,200	2,400	2,500	2,500	2,900	3,000	3,000
Horizontal flow from (+)/to (-) Corning Subbasin	-4,700	-5,800	-5,900	-5,900	-4,300	-4,300	-4,200
Horizontal flow from (+)/to (-) Bend Subbasin	-3,900	-3,700	-3,700	-3,700	-3,500	-3,500	-3,400
Horizontal flow from (+)/to (-) South Battle Creek Subbasin	660	670	670	660	670	670	660
Vertical flow from (+)/to (-) Lower Aquifer	41,000	35,000	35,000	36,000	48,000	49,000	51,000
Annual Groundwater Storage Change	**-3,500**	**-510**	**-560**	**-750**	**-740**	**-810**	**-1,000**
Lower Aquifer							
Net Seepage	0	0	0	0	0	0	0
Deep Percolation	0	0	0	0	0	0	0
Groundwater Extraction	-12,000	-16,000	-17,000	-18,000	-19,000	-20,000	-21,000
Net Subsurface Flows	5,300	15,000	15,000	16,000	16,000	17,000	18,000
Horizontal flow from (+)/to (-) Antelope Subbasin	-22,000	-17,000	-16,000	-15,000	-10,000	-9,700	-8,100

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Horizontal flow from (+)/to (-) Bowman Subbasin	110,000	110,000	110,000	110,000	110,000	110,000	110,000
Horizontal flow from (+)/to (-) Los Molinos Subbasin	-5,400	-3,300	-2,900	-2,100	-870	-320	620
Horizontal flow from (+)/to (-) Corning Subbasin	-23,000	-30,000	-30,000	-31,000	-27,000	-27,000	-27,000
Horizontal flow from (+)/to (-) Bend Subbasin	-14,000	-14,000	-14,000	-13,000	-13,000	-13,000	-13,000
Horizontal flow from (+)/to (-) South Battle Creek Subbasin	850	860	860	860	860	870	860
Vertical flow from (+)/to (-) Upper Aquifer	-41,000	-35,000	-35,000	-36,000	-48,000	-49,000	-51,000
Annual Groundwater Storage Change	**-7,100**	**-1,300**	**-1,400**	**-1,700**	**-2,100**	**-2,200**	**-2,600**
Entire Groundwater System							
Net Seepage	-39,000	-21,000	-18,000	-12,000	-9,300	-6,000	830
Deep Percolation	70,000	67,000	67,000	64,000	68,000	68,000	66,000
Groundwater Extraction	-90,000	- 100,000	- 100,000	- 110,000	- 140,000	- 140,000	- 150,000
Net Subsurface Flows	49,000	53,000	54,000	56,000	74,000	77,000	80,000
Horizontal flow from (+)/to (-) Antelope Subbasin	-25,000	-18,000	-17,000	-15,000	-8,000	-6,800	-4,400
Horizontal flow from (+)/to (-) Bowman Subbasin	120,000	120,000	120,000	120,000	130,000	130,000	130,000
Horizontal flow from (+)/to (-) Los Molinos Subbasin	-2,200	-880	-390	360	2,000	2,600	3,700
Horizontal flow from (+)/to (-) Corning Subbasin	-28,000	-36,000	-36,000	-37,000	-31,000	-31,000	-31,000
Horizontal flow from (+)/to (-) Bend Subbasin	-18,000	-17,000	-17,000	-17,000	-16,000	-16,000	-16,000

GWS Water Budget Component	Historical	Projected (Current Land Use)			Projected (Future Land Use)		
		No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)	No Climate Adjust-ment	Climate Change (2030)	Climate Change (2070)
Horizontal flow from (+)/to (-) South Battle Creek Subbasin	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Annual Groundwater Storage Change	**-11,000**	**-1,800**	**-1,900**	**-2,400**	**-2,900**	**-3,000**	**-3,600**

4.6. Modeled Groundwater Levels

A number of wells were selected to evaluate simulated groundwater elevations within Tehama IHM. Wells with constructions data and a long period of record were selected to provide good horizontal and vertical spatial representation and to represent various aquifer parameter zones. Hydrographs of simulated groundwater elevations are presented in **Appendix E**. In general, water levels in the projected (current land use) and projected (future land use) scenarios follow the same trends as the historical scenario. In the climate change scenarios, water levels begin showing slight declines over the projected period. Maps of historical simulated groundwater elevation for key time periods are presented in **Appendix F**.

4.7. Modeled Streamflows

A number of stream nodes were selected to evaluate simulated streamflows within Tehama IHM. These nodes represent flows through Antelope Creek Group, Cottonwood Creek , Deer Creek Group, Dye Creek, Elder Creek, Mill Creek, Red Bank Creek, Sacramento River, and Thomes Creek. Hydrographs of historical simulated streamflows are presented in **Appendix G**. In general, average monthly flows in the projected (current land use) and projected (future land use) scenarios are slightly increased in the winter and spring months and relatively unchanged in the summer and fall months. In general, average monthly flows in the winter months are significantly increased during the winter months under climate change scenarios. Flows are decreased slightly in the spring to early summer months and are relatively unchanged in the late summer through fall months under climate change scenarios.

4.8. Model Calibration Results

Model calibration was achieved through comparison of observed groundwater levels and measured stream flows to model results. Observations used to constrain aquifer parameter values included approximately 7,900 groundwater level observations from 93 wells. Observations used to constrain stream bed parameters included approximately 3,900 stream flow measurements from 12 gage stations.

Calibration quality quantifies the ability of the groundwater model to simulate observed groundwater levels. These results are evaluated with respect to fit statistics outlined by Anderson and Woessner (2002). More qualitative measures of model fit are also commonly used to evaluate model calibration quality and included in the model results.

4.8.1. Statistical Measures of Model Fit

Model calibration was evaluated through five common residual error statistics used to characterize model fit. These include the mean of residual error (ME), mean of absolute residual error (MAE), root mean of squared residual error ($RMSE$), Normalized RMSE ($NRMSE$), and linear correlation coefficient (R). The residual error here is calculated by subtracting the observed value from the simulated value at a specific physical location and time.

The mean of residual error (ME) is a measure of the general model tendency to overestimate (+) or underestimate (-) measured values. In general, it is a quantification of the model bias given by:

$$ME = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)$$

Where: N is the total number of observations

y_i is the ith observed value

$\hat{y}_i$ is the ith simulated value of a model dependent variable

The mean absolute residual errors (MAE) is more robust to represent the goodness of fit as no individual errors will be canceled in the estimation as ME. The MAE estimates the average magnitude of the error between modeled and observed values and is defined as:

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|(y_i - \hat{y}_i)|$$

The root mean of squared residual error ($RMSE$) is defined as the square root of the second moment of the differences between observed and simulated error. Since the error between each observed and simulated value is squared, larger errors tend to have a greater impact on the value of the $RMSE$, therefore RMSE is generally more sensitive to outliers than the MAE.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^{2}}$$

The normalized root mean squared error ($NRMSE)$ is calculated to account for the scale dependency of the $RMSE$ and is a measure of the $RMSE$ divided by the range of observations (Anderson and Woessner, 2002).

The linear correlation coefficient (R) is defined in the following equations:

$$R = \frac{COV(y,\hat{y})}{\sigma_y.\sigma_{\hat{y}}}$$

Where: $COV(y,\hat{y}_i)$ is the covariance between the observed (y) and simulated ($\hat{y}$) values

σ_y is the standard deviation of the observed values

$\sigma_{\hat{y}}$ is the standard deviation of the simulated values

The value of R lies between 1 (perfect linear correlation) and -1 (perfect linear correlation in the opposite direction). Usually, simulated and observed quantity is plotted in a scatter diagram to represent the model calibration results graphically with associated linear correlation coefficient R.

There are no uniform calibration standards used to determine an acceptable calibration of a groundwater flow model (Anderson and Woessner, 2002; Anderson et al., 2015). Summary statistics, such as those discussed in this section, should be used to evaluate the fit of simulated values to observed data and to minimize the error between these values (Murray-Darling Basin Commission, 2001; ASTM, 2008). For the purposes of calibrating Tehama IHM, calibration targets were set to minimize the model error to within 10% of the range of observed values.

4.8.2. Groundwater Level Calibration

A subset of the approximately 2,400 wells that have observed groundwater levels in the study area was selected for model calibration. Wells were selected to provide a broad representation of the model domain based on the spatial distribution, availability of associated well construction information, depth zone of well completion, and period of record of available water level data. A total of 93 wells were selected to be used in calibration of Tehama IHM with a total of 7,913 water level observations during the calibration period. Simulated and observed groundwater elevations were compared over the 1990 through 2018 calibration period. To summarize calibration results, a single model layer was selected to compare to observed water levels. In some cases, a well is constructed across multiple model layers, or no construction details were available to determine where the well was screened. In these cases, a single model layer was chosen for each well based on a qualitative review of the hydrograph.

Groundwater level calibration statistics are presented in **Table 4-41**. As stated in **Section 4.7.1**, the calibration targets for Solano IHM were set to minimize the model error to within 10% of the range of observed values. Observed groundwater level measurements used for calibration range from 44 to 499 feet, therefore an acceptable *RMSE* for Solano IHM would be 45 feet.

The final calibrated *RMSE* was 21.6 feet, resulting in a *NRMSE* of 5%, well within acceptable limits. The calculated *MAE* is 13.6 ft, a small value when compared to the range of observed groundwater levels in the model domain (**Figure 4-1**). The calculated *ME* (-0.97 ft) indicates that the model tends to simulate slightly lower groundwater levels than observed (under-predict) by an average of about 1 foot. The relation between observed and simulated groundwater elevations is shown by layer in **Figure 4-2**. Points plotting above 1-to-1 correlation line represent observations where Tehama IHM is simulating higher than observed groundwater elevations, while points plotting below the 1-to-1 correlation line represent observations where Tehama IHM simulating lower than observed groundwater elevations. In general, while points are plotting close to the 1-to-1 correlation line (R = 0.98), the model tends to under simulate water levels at higher observed groundwater elevations. Groundwater hydrographs of simulated and observed groundwater elevations used for model calibration are included in **Appendix H.**

Table 4-41. Groundwater Level Calibration Statistics

Calibration Statistic	Result	Target
Mean of Residual Error (ME)	-0.97 feet	-
Mean Absolute Residual Error (MAE)	13.6 feet	-
Root Mean of Squared Residual Error (RMSE)	21.6 feet	45 feet
Normalized Root Mean of Squared Residual Error (NRMSE)	5%	10%
Linear Correlation Coefficient (R)	0.98	1

The spatial distribution of residual errors in the simulated levels are presented in **Figure 4-3**. Tehama IHM is generally well calibrated. Residuals tend to be randomly distributed, indicating no clear bias in the model. The spatial distribution of residual errors in the simulated levels by layer are presented in **Figure 4-4**. Residuals are randomly distributed by layer, indicating no clear vertical bias in the model.

4.8.3. Streamflow Calibration

Observed stream flow was compared to simulated stream flow at 12 locations. Observed stream flow data were available from the California Data Exchange Center (CDEC) and the USGS. Hydrographs of observed versus simulated stream flows are available in **Appendix I**. In general, simulated stream flows generally match observed stream flows, where data are available. Streambed parameters were adjusted during the calibration process. The final streambed conductance values, by node, are shown in **Figure 4-5.**

4.9. Aquifer Parameters

Initial aquifer parameter values assigned to each aquifer parameter zone were based on reported literature values. These values were further refined and adjusted during the calibration process. Final calibrated values for each of the parameter zones are presented in **Table 4-42**. These parameter values were applied to the percent coarse textural model to generate aquifer parameter values for each model node in each model layer.

Table 4-42. Summary of Tehama IHM Calibrated Aquifer Parameters

		Horizontal Hydraulic Conductivity (feet/day)	Vertical Hydraulic Conductivity (feet/day)	Specific Yield (-)	Specific Storage (feet^{-1})	Anisotropy Ratio (Kv/Kh)
Percent Coarse End Member Values	Fine	5	-	0.01	1.00E-04	0.25
	Coarse	550	-	0.2	1.00E-06	
Zone Multipliers	Alluvium	1	1	1	1	
	Tuscan Formation	0.6	0.75	0.6	0.6	
	Tehama Formation	0.35	0.15	0.25	0.25	
	Non-Tuscan/Non-Tehama Zone	0.5	0.4	0.5	0.5	

NOTE: Power law empirical parameter for KH (pKh) = 1.00; for KV (pKv) = -0.62

4.9.1. Hydraulic Conductivity

The calibrated horizontal hydraulic conductivity (Kh) values range from 3.66 feet per day (ft/d) in layer 4 to 446.45 ft/d in layer 2 (**Table 4-43**). The final Kh values in the calibrated model area shown by model layer in **Figures 4-6** through **4-14**. Calibrated vertical hydraulic conductivity (Kv) values range from 0.19 ft/d in layer 4 to 13.02 ft/d in layer 2 (**Table 4-43**). The Kv values in the calibrated model are shown by model layer in **Figures 4-15** through **4-23**.

Table 4-43. Summary of Tehama IHM Calibrated Hydraulic Conductivity

	Horizontal Hydraulic Conductivity (feet/day)			Vertical Hydraulic Conductivity (feet/day)		
Model Layer	Minimum	Maximum	Average	Minimum	Maximum	Average
1	13.20	419.20	159.43	0.21	9.67	2.22
2	5.57	446.45	130.07	0.19	13.02	1.99
3	9.38	222.09	79.01	0.20	4.74	1.02
4	3.66	166.50	75.63	0.19	2.63	0.89
5	11.29	199.20	66.32	0.20	3.62	0.82
6	11.29	199.20	61.01	0.20	3.62	0.77
7	15.10	225.36	84.07	0.21	4.94	1.07
8	24.64	228.63	73.27	0.23	5.16	0.90
9	9.38	107.64	39.00	0.20	1.68	0.62
Total	**3.66**	**446.45**	**85.31**	**0.19**	**13.02**	**1.14**

4.9.2. Storage Coefficients

Final calibrated specific yield (Sy) values range from 0.003 in layers 2 and 4 to 0.164 in layer 2 (**Table 4-44**). The final Sy values in the calibrated model area shown by model layer in **Figures 4-24** through **4-32**. Calibrated specific storage (Ss) values range from 6.69E-06 ft^{-1} in layer 2 to 9.70E-05 ft^{-1} in layer 2 (**Table 4-44**). The Ss values in the calibrated model are shown by model layer in **Figures 4-33** through **4-41**.

Table 4-44. Summary of Tehama IHM Calibrated Storage Coefficients

	Specific Yield (-)			Specific Storage ($feet^{-1}$)		
Model Layer	Minimum	Maximum	Average	Minimum	Maximum	Average
1	0.005	0.154	0.059	7.68E-06	9.21E-05	3.67E-05
2	0.003	0.164	0.049	6.69E-06	9.70E-05	4.19E-05
3	0.004	0.082	0.029	8.42E-06	5.41E-05	2.69E-05
4	0.003	0.063	0.027	1.02E-05	5.47E-05	2.77E-05
5	0.005	0.074	0.024	1.39E-05	5.64E-05	2.92E-05
6	0.005	0.074	0.022	1.44E-05	5.64E-05	3.01E-05
7	0.006	0.084	0.030	1.04E-05	5.52E-05	2.62E-05
8	0.008	0.085	0.026	9.41E-06	4.87E-05	2.82E-05
9	0.004	0.042	0.015	1.71E-05	5.70E-05	3.40E-05
Total	**0.003**	**0.164**	**0.031**	**6.69E-06**	**9.70E-05**	**3.12E-05**

5. SENSITIVITY ANALYSIS AND MODEL UNCERTAINTY

5.1. Sensitivity Analysis

A model response or prediction depends on the governing equations it solves, the mechanisms and structure of the model, and the values of the model parameters. Sensitivity analysis is a means of evaluating model uncertainty due to parameter estimates by systematically altering one of the model parameters and examining the associated change in the model response. After the groundwater flow model was calibrated, a quantitative sensitivity analysis was performed using the flow model parameters that were most uncertain and likely to affect the flow simulation results. The calibrated flow model was used as the baseline simulation and sensitivity simulations were compared with those of the baseline simulation at all observation points. Model sensitivity was evaluated for model parameters using UCODE-2014. The basis of a model parameters sensitivity was based on groundwater elevation observations given a 1% parameter value perturbation. Sensitivity was evaluated through the Composite Scaled Sensitivity (CSS) statistic described by Hill and Tiedman (2007).

Sensitivity of simulated groundwater elevations to parameter perturbation are presented in **Figure 5-1**. The CSS statistic shows the model is most sensitive to the Horizontal Hydraulic Conductivity of Coarse Materials (KHC) parameter within the aquifer system defined in **Table 4-43**.

5.2. Model Uncertainty and Limitations

All groundwater flow models are a simplification of the natural environment, and therefore have uncertainty and limitations that are important to recognize. For this reason, uncertainty exists in the ability of any numerical model to completely represent groundwater flow. Some of the uncertainty is associated with limitations in available data. Considerable effort was made to reduce model uncertainty by using measured values as model inputs whenever available, and by conducting quality assurance and quality control assessments of data that were obtained. Where limited data exist to develop input values for parameters or other inputs with high uncertainty, a conservative approach to assigning input values was followed.

Uncertainty associated with water budget results estimated using the Tehama IHM depends in part on the model inputs relating to the surface water system with additional sources of uncertainty associated with model inputs relating to the groundwater system, including aquifer and streambed properties, specification of boundary conditions, and other factors. The uncertainty estimates associated with surface water system water budget components that are also inputs or outputs of the groundwater system water budget are noted in **Section 2.3 of the GSPs**. Recognizing the uncertainty of the surface water system water budget components, the overall uncertainty of other water budget components simulated for the groundwater system, including subsurface flows, groundwater discharging to surface water, and change in groundwater storage are estimated to be in the range of 10 to 30 percent. These groundwater system water budget components are subject to slightly higher uncertainty as they incorporate uncertainty in the surface water system water inflows and outflows with additional uncertainty resulting from limitations in available input data and simplification required in modeling of the subsurface heterogeneity. However, the uncertainty in the groundwater system water budget derived from a numerical model such as the Tehama IHM depends to a considerable degree on the calibration of the model and can vary by location and depth within the Subbasin. The Tehama IHM is a product of local refinement and improvements made to the SVSim model. The Tehama IHM simulates the integrated groundwater and surface water systems and metrics relating to the calibration of the model indicate the model is reasonably well calibrated in accordance with generally accepted professional guidelines and is sufficient for GSP-related applications.

The finding and conclusions of this study are focused on a Subbasin scale and use of the model for site-specific analysis should be conducted with an understanding that representation of local site-specific conditions may be approximate and should be verified with local site-specific investigations. The flow model was developed in a manner consistent with the level of care and skill normally exercised by professionals practicing under similar conditions in the area. There is no warranty, expressed or implied, that this modeling study has considered or addresses all hydrogeological, hydrological, environmental, geotechnical, or other characteristics and properties associated with the subject model domain and the simulated system.

6. CONCLUSIONS

Based on the calibration of Tehama IHM using historical conditions over the calibration period from water year 1990 to 2018 and accompanying assessment of model sensitivity, the Tehama IHM groundwater flow model is suitable for use as a tool for analyses to support development and implementation of the Tehama County Subbasins' GSP and other water resource management interests within the Tehama County Subbasins.

Tehama IHM provides a useful tool for evaluating a wide variety of future scenarios and inform the decision-making process to achieve and maintain sustainable groundwater management in the Tehama County subbasins. A numerical model can be a convenient and cost-efficient tool for providing insights into groundwater responses to various perturbations including natural variability and change, and also changes associated with management decisions or other humanmade conditions. However, as with any other modeling tool, information obtained from a numerical model also has a level of uncertainty, especially for long-term predictions or forecasts. The level of uncertainty associated with model simulations likely increases the more the scenarios extend beyond the range of historical conditions and processes over which the model was calibrated, such as for long-term predictive scenarios or predictive scenarios with extreme alterations to the hydrologic conditions.

Future and ongoing updates to Tehama IHM will be valuable for improving the model performance and evaluating the accuracy of the model predictions. Using data from the ongoing historical monitoring efforts and forthcoming GSP monitoring, Tehama IHM should be updated periodically, including through extending of the model period and associated inputs. Although the frequency of conducting model updates may depend on a variety of factors, including evaluation of the model performance in predicting future conditions, trends in projected hydrology, and intended model applications, such an update could initially be considered every five years. This frequency of model update should be adequate and cost effective to test and improve Tehama IHM periodically with new site-specific and monitoring information. In accordance with monitoring and reporting requirements associated with the GSP, high-quality groundwater elevation, pumping, surface water deliveries, ET, and stream discharge data will especially benefit the future improvement of the model. New groundwater observation data should be compared with simulated model results to assess the performance of the model in predictive applications. If the differences between the measured groundwater data and Tehama IHM's predicted results are significant, adjustment and modification may be applied to the model input parameters.

Further refinement to Tehama IHM should be made by addressing key data gaps. Upon release of a calibrated SVSim model, an evaluation should be done to consider the benefits of incorporating any relevant aspects from the calibrated SVSim into the Tehama IHM. Through upcoming GSP-related monitoring, additional groundwater level data can be used to refine boundary condition water levels and improve model calibration. Additional improvements to model calibration can be made by the potential linking of additional well construction information to calibration wells, incorporation of additional stream flow data on ungaged streams, and refinements to the simulation of surface water distribution systems. Further refinements to Solano IHM can be made by keeping the historical model simulations current through periodic updating of the model and review of model calibration in preparation for 5-year GSP update reports. Additional model revisions should be conducted in areas outside the Tehama County Subbasins as such data are obtained from adjacent Subbasins and determined to be beneficial in the evaluation of conditions within the Tehama County Subbasins.

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Appendix 2-K

Detailed Water Budget Details

Bowman Subbasin

Sustainable Groundwater Management Act

Groundwater Sustainability Plan Appendix 2K – Detailed Water Budget Results

January 2022

Prepared For:

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