Tehama County:
A Small Water Systems
Drought Vulnerability Study

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ESRI 2005

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Abstract

Previous droughts have prompted water supply concerns for small, rural communities' ability to maintain water supplies for sanitation, drinking, and fire fighting needs. Funded by the Department of Water Resources, the Tehama County Flood Control and Water Conservation District (District) initiated a small water systems (SWS) drought vulnerability study. The study inventoried locations of SWS and evaluated the relative degree to which SWS, reliant primarily on groundwater, may be at risk of supply shortages or impacts during droughts. ArcView 8.3 and the ArcView Spatial Analyst extension were used to analyze drought vulnerability factors including future water demands associated with agricultural and urban growth. These tools were also used to estimate drought groundwater levels, as well as graphically represent the SWS drought vulnerability findings. The District will use the GIS project as a planning and management tool to help lessen the likelihood of drought susceptibility for existing and future SWS. A comprehensive project report was completed for the SWS project by Camp Dresser and McKee consulting firm for the District and the Executive Summary is available in Appendix A.

Introduction

Drought and water supply shortages are an ever-present concern in California. Common problems during drought periods include a lack of drinking water, sanitation issues, increased risk of fire, and increased challenges suppressing fires once they start.

Tehama County is a rural county, located at the north end of the Sacramento Valley in California. The valley is bound on the east by the Sierra Nevada range and to the west by the Cascade range. The Sacramento River and Interstate Highway 5 bisect the county. There are three incorporated cities within the county: Red Bluff, Corning, and Tehama. The primary economy is agriculture including ranching, farming and timber industries, however, the county is experiencing large scale development for the first time in recent years.

In response to the potential for critical water shortages within the state of California, the CALFED Record of Decision (ROD) directed the Governor to create a panel to develop a contingency plan for reducing water shortage impacts. The ROD charged the Governor's Advisory Drought Planning Panel (Panel) with identifying available resources and funding mechanisms to reduce the impacts of such shortages. The Panel's contingency plan recognized water shortage management challenges, which includes rural, self-supplied water users. Small Water Systems (SWS) are one such self-supplied user. SWS are independent water conveyance systems that supply water to a select group of users, and are not associated with a larger, municipal system.

In 2003, the Tehama County Flood Control and Water Conservation District (District), funded by a grant from the California Department of Water Resources (DWR), engaged in an inventory and investigation of the SWS in Tehama County, in order to determine their relative degree of risk in the event of drought, using GIS as the tool to compile, model, analyze, and share the results. The following discussion focus's on the use of GIS to complete the study.

Background

The District is actively involved in many interrelated groundwater management activities. Prior to undertaking the SWS study, an in depth, countywide water inventory and analysis was completed (CDM 2003). Tehama County participates in groundwater management practices and has an adopted groundwater management plan, consistent with AB 3030. Groundwater levels are monitored in cooperation with DWR Northern District and local property owners.

In Tehama County all SWS are monitored for water quality by the Tehama County Department of Environmental Health (TCEH) or by the State of California Department of Health Services (DHS). Prior to 2002 the systems were all monitored for water quality by DHS. DHS currently monitors only systems with more than 200 users. As such, each agency maintains a database and archival information for the systems they monitor. Additionally, DWR maintains well log and groundwater monitoring databases. The well log database contains the physical attributes of all recorded well sites in the county, based on information submitted by the well driller. Well logs have controlled use in California and access is restricted by legislation. The groundwater monitoring database compiles current and historic groundwater levels. It is use to observe and predict changes in groundwater resources within the county.

SWS in Tehama County fall under five broad categories. The first four utilize groundwater resources to provide water; the fifth utilizes surface water resources. A system may have more than one well associated with it. In the county there are 149 systems made up of a total of 176 wells, springs or surface water sources:

1. State Small Water System: A residential system consisting of 5-14 service connections or serving less than 25 persons year round. Examples include small apartment complexes and rural subdivisions.

2. Community Water System: A residential system consisting of 15 or more service connections or 25 or more persons. Examples include apartment complexes and mobile home parks.

3. Non-Transient Non-Community Water System: A system serving non-residential areas, but routinely serving the same population of 25 or more persons, or 15 or more connections. Examples include schools, workplaces.

4. Transient Non-Community Water System: A system serving non-residential areas with a changing population and serving 25 or more persons, or 15 or more connections. Examples include freeway traveler rest stops and campgrounds.

5. Surface Water System: Any SWS that utilizes surface water sources as the water supply.

Data Collection

Camp Dresser and McKee (CDM) developed a Technical Memorandum on Methodology prior to commencing the data collection. The memorandum set the parameters for the project and reflected extensive coordination efforts and the input of numerous parties including the District management and GIS staff, DWR Groundwater staff, DWR Land and Water Use staff, and CDM management and GIS, Geology, and other technical staff. Numerous technical sessions were conducted prior to developing the methods in order to produce a sound process to proceed with both the data collection and analysis. This methodology was used first in the data collection and proved invaluable throughout the project.

The project had three components of research prior to the data compilation: agency archival and database research, field research and collecting GPS coordinates, and conducting stakeholder interviews. Groundwater and drought data was provided by DWR Northern District, and used to model potential drought conditions for the study area and the individual systems in the later phases of the investigation.

The first step was to compile a comprehensive list of existing systems. This was accomplished by querying the TCEH, DHS, and DWR databases and compiling them. The resulting table provided the names, locations and contact information for each system and the number of wells associated with each system as well as well construction and performance attributes.

The second step was to review the individual system file archives at the TCEH office and DHS office. The system permit application and well log are the primary documents in the archives and provides information about the type and extent of the system, such as number of connections, size of population served, and storage capacity. Other information regarding water quality testing and results was reviewed but not compiled. As one might expect, some files were incomplete or did not have current information. For example, state well log reports were not available for all systems or change of ownership was not recorded.

A letter of introduction and sample interview form was distributed to all stakeholders prior to contacting them to schedule an interview (Appendix B). The interview form served two purposes. It captured the personal knowledge and experiences of system stakeholders, and it allowed us to share the data we had compiled with them. The interview forms were filled out as completely as possible prior to the interview and stakeholders were asked to verify the existing information and complete the missing information. Examples of personal knowledge are prior water supply shortages, information about well deepening or changes in the depth to the pump bowls, not recorded by the State or County.

GPS coordinates were collected during the interview using a Trimble GeoExplorer XT. In the event GPS coordinates were not collected site addresses were geocoded instead, and the source of the coordinates was identified in the final database so the user would be able to distinguish between real and addressed locations. System operators were interviewed on site whenever possible, otherwise telephone interviews were held and coordinates were collected separately. The GPS coordinates, archival and field research, along with the information collected during the interview process were added to the table of existing systems. Elevations were extracted from the USGS National Elevation Dataset (NED) and appended to the table, resulting in the base SWS layer. Please refer to Appendix C for the data dictionary, which includes data sources.

Classifying Risk Factors

In order to determine the drought vulnerability of the SWS inventoried it was first necessary to model anticipated drought conditions for the study area. Tehama County experienced a severe drought from 1987 through 1994. The county has experienced other periods of drought, but this period was chosen because it resulted in the most serious impacts on water supplies.

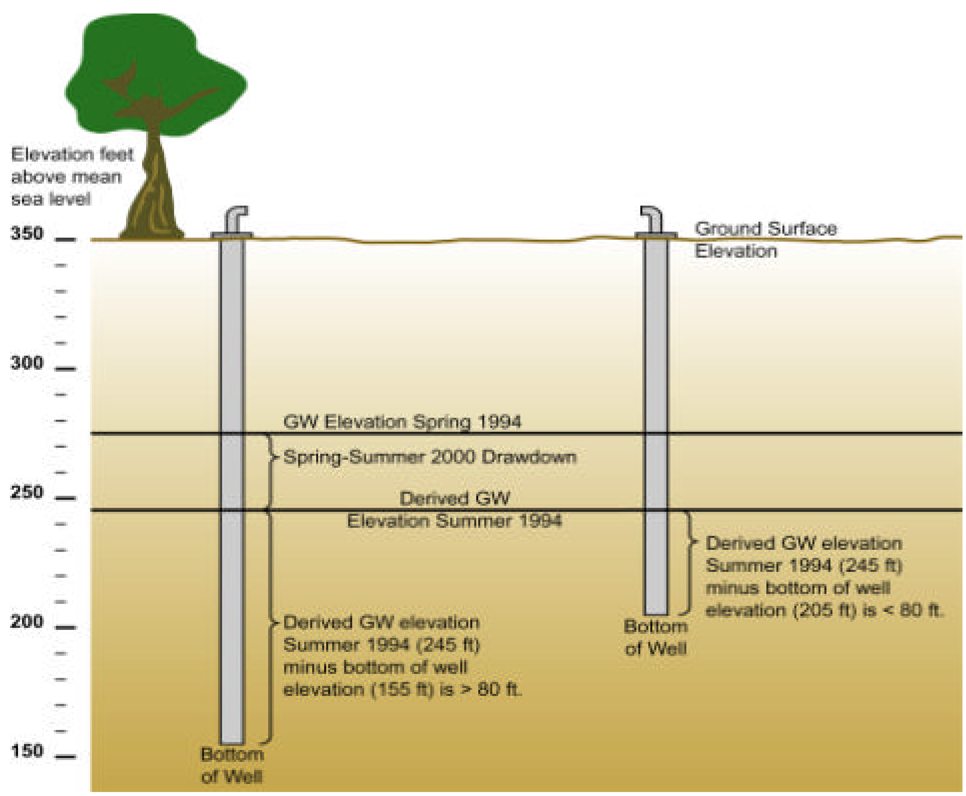


Figure 1.
Methods for Determining the Derived Drought Groundwater Elevation

A drought scenario was developed by subtracting year 2000 groundwater demands, from the 1994 drought elevations, provided by DWR Northern District, resulting in the derived drought groundwater elevation. Wells with less than 80 ft. between the bottom of the well and the derived groundwater elevation were determined to be at risk. The graphic above (Figure 1.) illustrates the scenario developed to determine the likelihood of each SWS being adversely affected during a drought, based primarily on depth and seasonal draw down.

Additional analytical factors were examined to determine vulnerability, including a history of water supply shortages in previous droughts, areas with excessive seasonal draw-down or decreasing groundwater storage trends (based on DWR groundwater monitoring), geologic factors such as construction in a fractured rock aquifer, and areas with anticipated urban or agricultural growth.

Risk was examined at the individual system and regionally as well in order to assist in

Table 1.
Tehama County Regions and Inventory Units

Regions	**Inventory Units**
Sacramento Valley GW Basin	1. Red Bluff East
	2. Red Bluff West
	3. Corning East
	4. Corning West
	5. Bend
	6. Antelope
	7. Dye Creek
	8. Los Molinos
	9. Vina
Redding GW Basin	10. Bowman
	11. Rosewood
	12. South Battle Creek
West Mountain	13. West Mountain
East Mountain	14. East Mountain

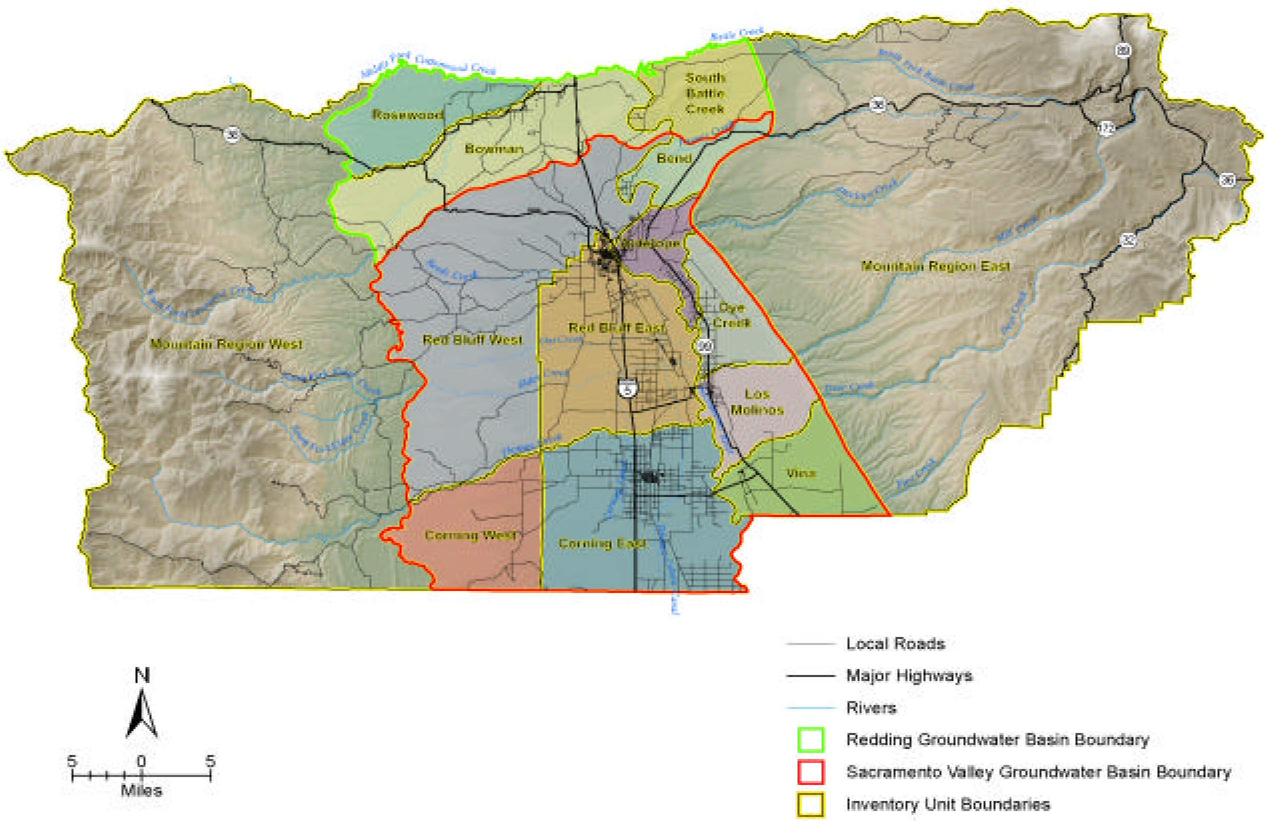
future planning and development in the County. The areas were defined using the inventory units developed during the 2003 Tehama County Water Inventory and Analysis (CDM) to provide continuity between the studies and resulting reports. As such, the county is divided into four primary regions, based on groundwater basins and the mountainous areas. The inventory units are subsets of these regions. The four regions of Tehama County are: the Sacramento Valley Groundwater Basin, Redding Groundwater Basin, Mountain Region West, and Mountain Region East. Table 1 lists the regions and their associated inventory units. Figure 2 illustrates their locations within the county.

Table 2

TIER 1	**TIER 2**		**TIER 3**			
SWS Interview	Geology	Derived Drought Groundwater Elevation	Spring-Summer 2000 GW Level Draw Down	GW in storage/ GW monitoring well hydrographs	Change in Source Water	Future Ag/Urban Growth

Individual systems were classified as unlikely vulnerable or potentially vulnerable based on the factors listed in Table 2. Those systems determined to be potentially vulnerable in any category were divided into three (3) weighted tiers. Tier 1 systems are those that have already experienced water supply shortages during past droughts and have not performed any corrective actions, such as deepening the wells, or lowering their pumps. Tier 2 systems are those that have known geologic restrictions, such as wells developed in fractured rock aquifers, or exceed the parameters of the derived groundwater elevation calculations. Tier 3 factors including excessive spring/summer 2000 groundwater level draw down, changes in groundwater storage and monitoring well hydrographs, changes in source water, and anticipated urban or agricultural growth do not forecast vulnerability by themselves, but significantly increase the likelihood of vulnerability when combined with Tier 1or 2 factors.

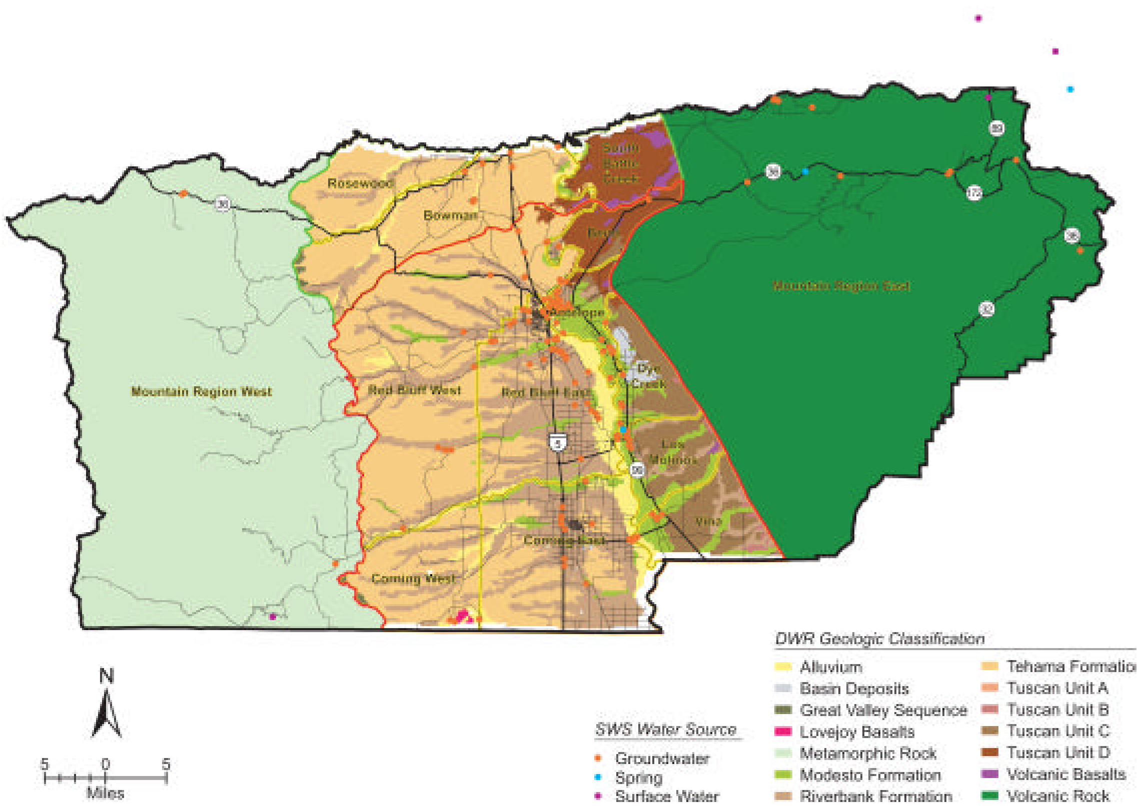
Figure 2 Tehama County SWS Inventory Units



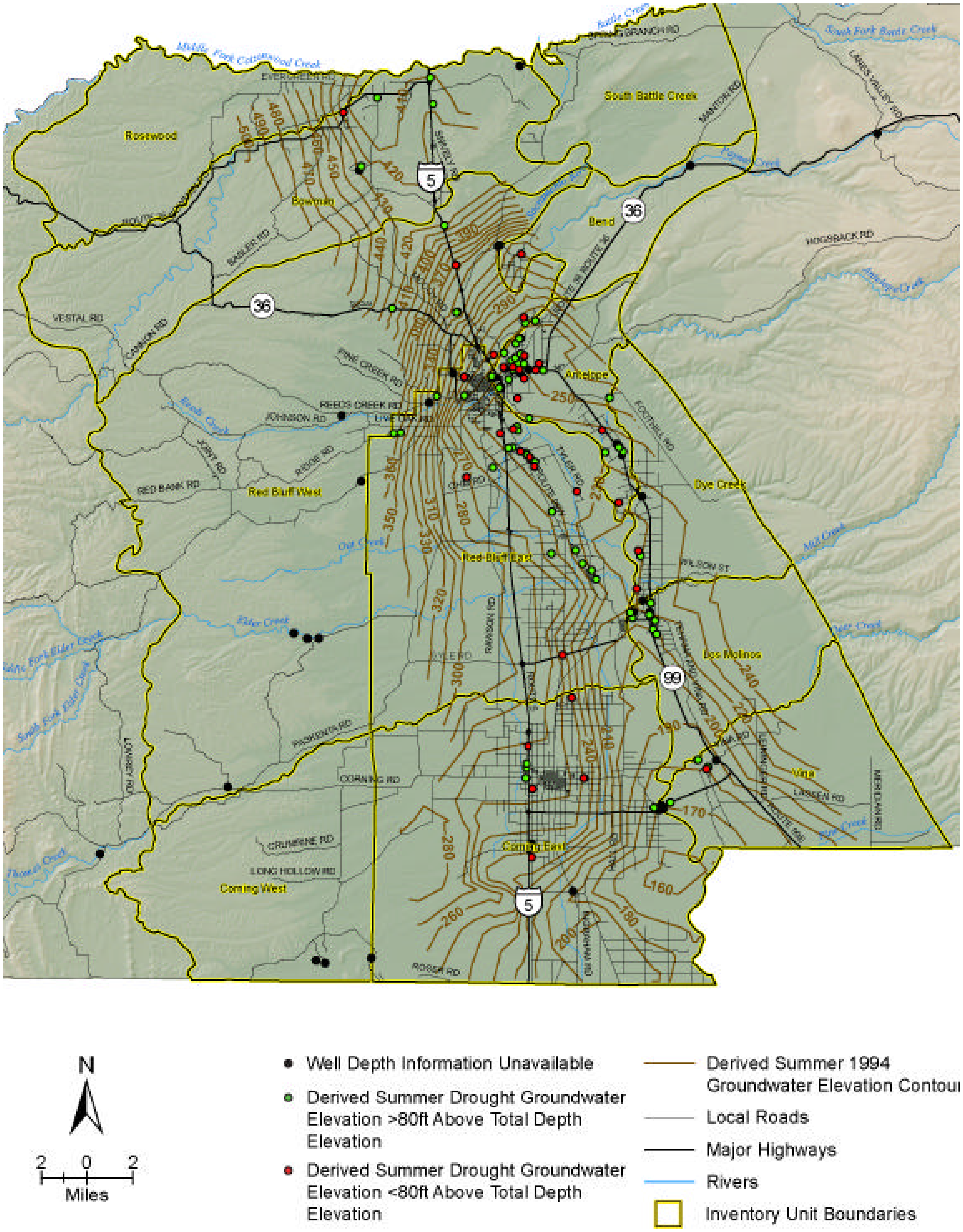
The following excerpt from the SWS Executive Summary (CDM 2005) briefly summarizes each of the drought vulnerability factors in the three tiers and the threshold, if any, for carrying the system forward in the analysis.

SWS literature review and stakeholder interview results: Systems that experienced water supply problems in the past are likely to experience similar problems in future droughts. This factor is described only for individual systems. Systems that experienced water supply reliability problems in the past were carried forward in the analysis as potentially vulnerable.

Geology: The geologic formation that a well is producing water from influences the rate of water production and reliability of the water supply. Groundwater wells completed in the valley are generally producing from basin deposits and are more able to support the volume of water required for SWS. Wells completed in the mountainous areas of Tehama County are usually producing water from fractures. Fractured rock aquifers have limited water in storage and limited extent due to the lack of interconnectedness of the fractures. These qualities of fractured rock aquifers can significantly limit the volume and rate of groundwater production. Systems overlying fractured rock aquifers were carried forward in the analysis as potentially vulnerable.

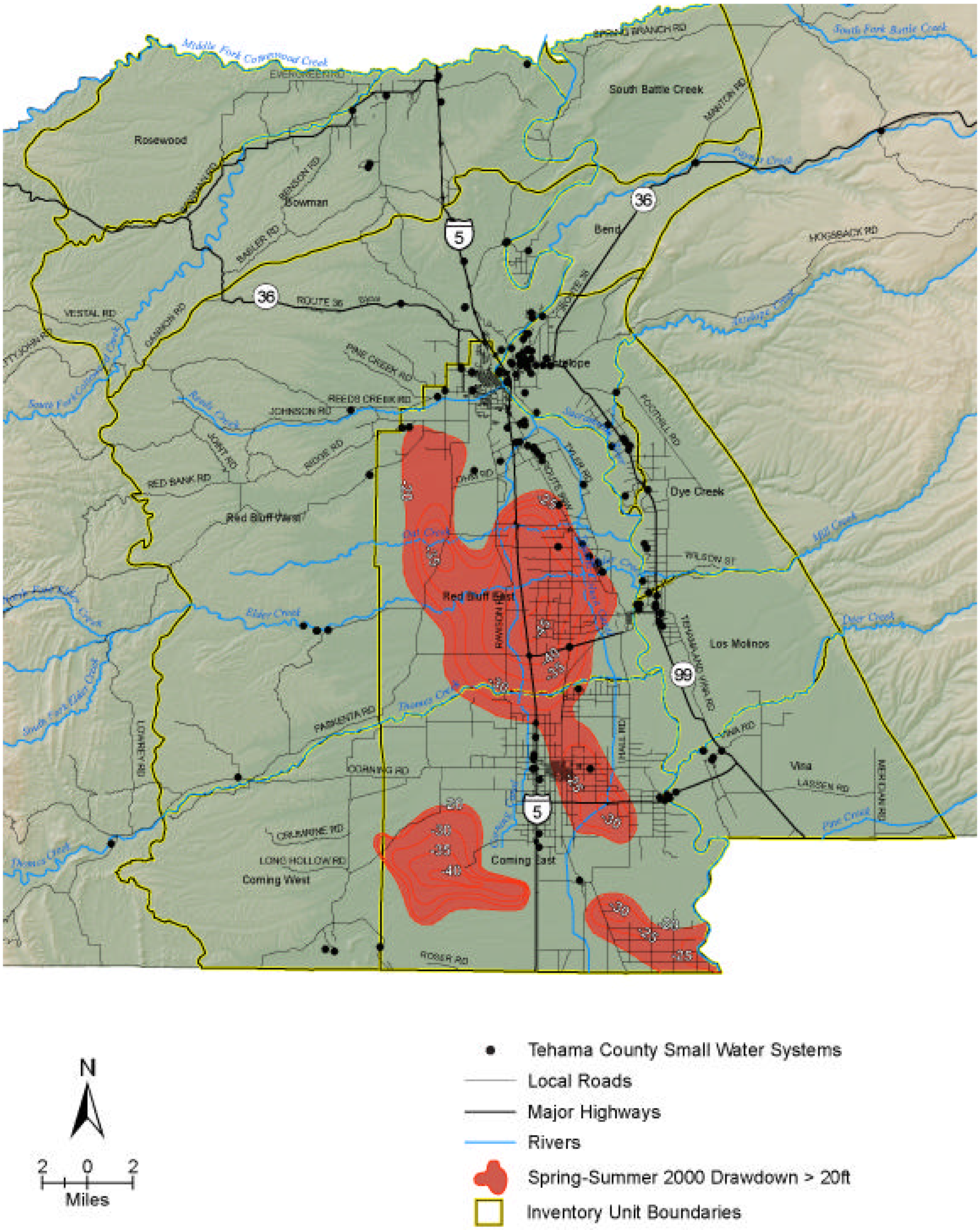


Derived Drought Groundwater Elevation: SWS having less than 80 feet between the derived drought groundwater elevation and the bottom of their well are likely to experience water supply shortages in the event of a drought and were carried forward in the analysis as potentially vulnerable.

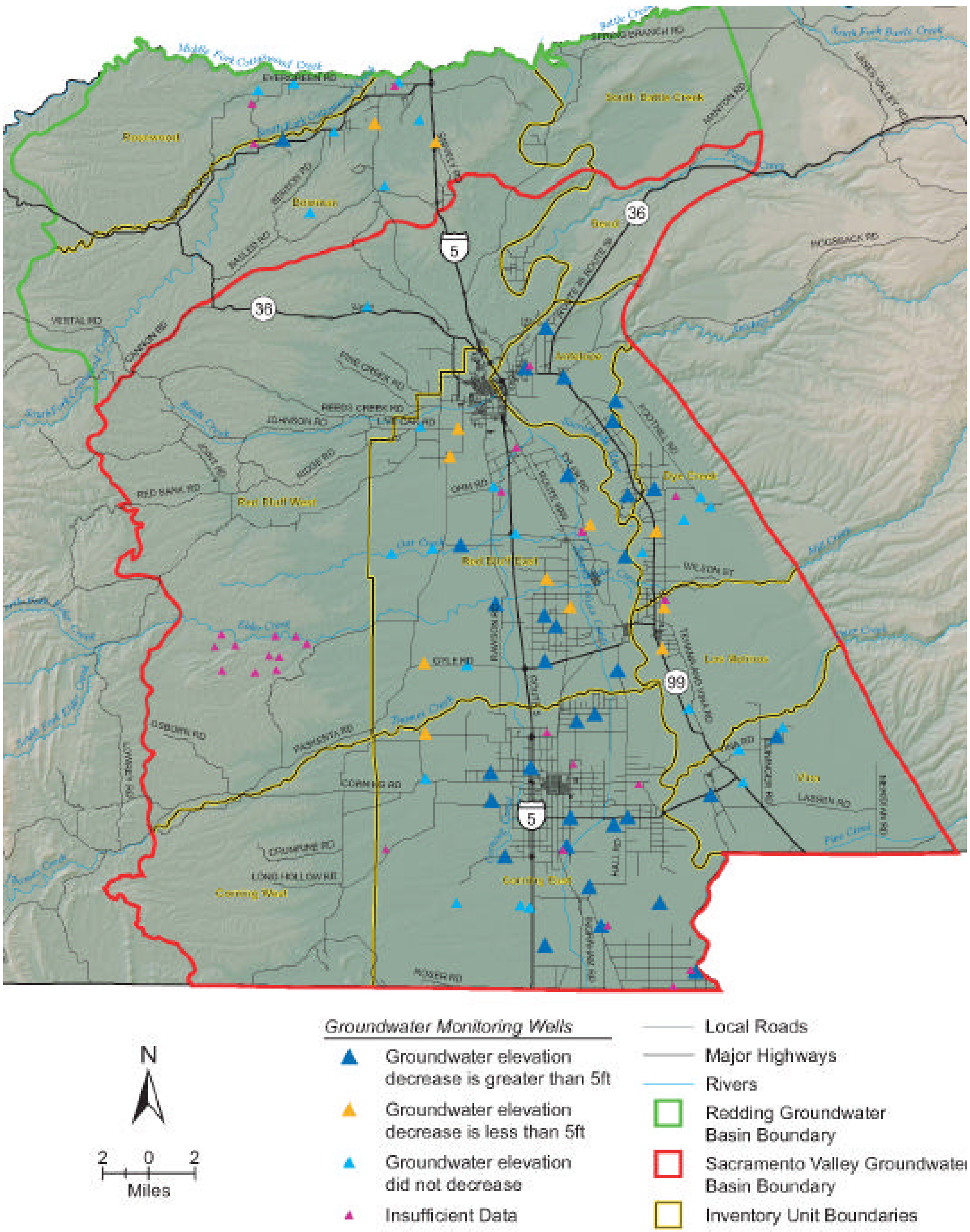


Spring to Summer Groundwater Level Draw Down: A large decrease in the groundwater level between spring and summer results when the rate of groundwater extraction exceeds the ability of the aquifer to recharge groundwater removed from storage. Recharge will generally exceed demand during the winter months, resulting in recharge of the aquifer to levels that are generally consistent from spring to spring.

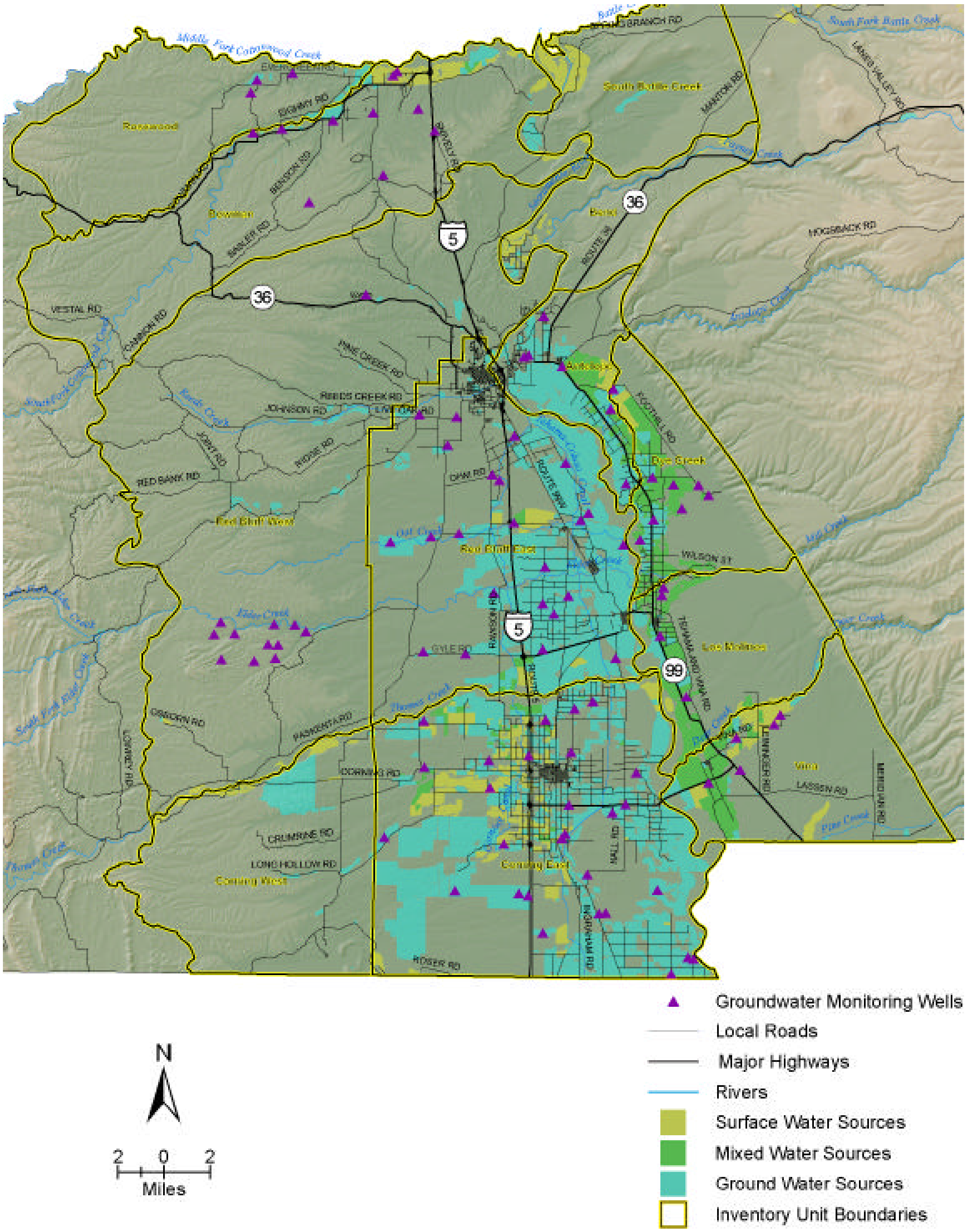
Seasonal draw down of the groundwater aquifer may impact groundwater wells completed at shallow depths. Systems in areas of the county with 20 feet or more seasonal draw down were carried forward in the analysis as potentially vulnerable.



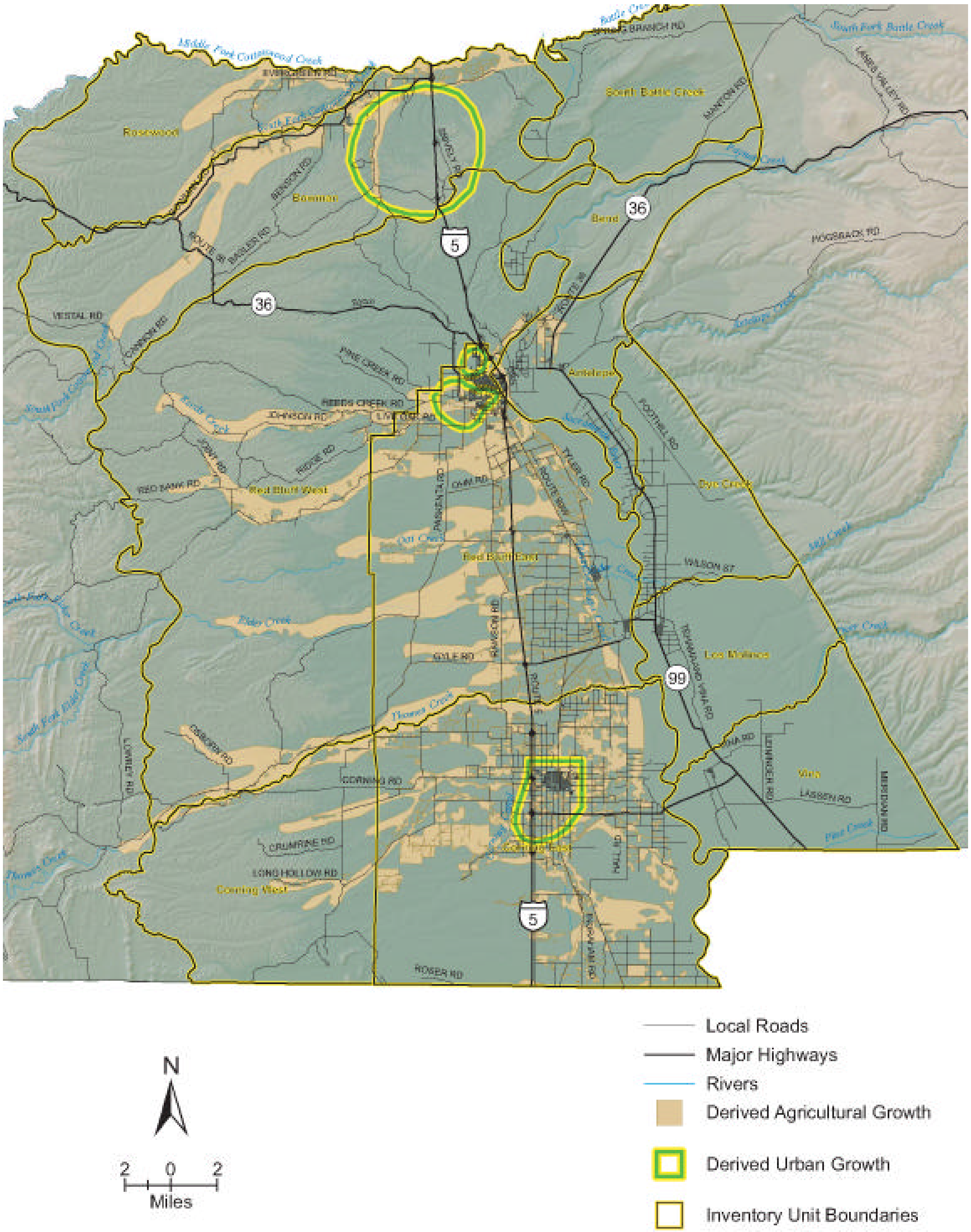
Groundwater in Storage/Monitoring Well Hydrographs: The District and DWR Northern District jointly monitor and maintain a network of wells for the purpose of monitoring seasonal groundwater levels. The level at each well is measured and recorded in the spring, summer and fall. Comparison of spring-to-spring measurements provides the best indication of current groundwater level trends because the aquifer is not extensively used for agriculture during the winter months, and the majority of groundwater recharge occurs during this time period. Areas with decreasing groundwater level trends were carried forward in the analysis as potentially vulnerable. Additionally, systems within areas to monitoring wells with hydrographs that indicate greater than 5 foot decreases in groundwater elevations between 1998 and 2003 were carried forward in the analysis as potentially vulnerable.



Changes in Source Water: Areas that have access to both surface water and groundwater (agricultural water users) could shift to increased groundwater use; especially in drought conditions as surface water allocations are reduced. Systems in proximity to areas with a mixed-use water supply source were carried forward in the analysis as potentially vulnerable.



Potential Urban and Agricultural Growth Areas: Regional growth patterns that indicate an anticipated increased demand will put more pressure on a fixed water supply source, such as a SWS. Areas that have been identified as anticipating significant development or have the potential for additional agricultural development were carried forward in the analysis as potentially vulnerable.



GIS Project Development and Methods

The GIS project development for the SWS inventory and investigation had three components. The first was to compile all the existing archival data available regarding SWS in to a single database. The second was to model a reasonable countywide drought scenario (derived drought groundwater elevations) in order to determine the likelihood of the individual systems to be adversely affected during a future drought. The third component was to explore other issues affecting groundwater supply that could impact these systems in the event of drought.

The base SWS layer, consisting of the GPS coordinates combined with the archival and field interview data, resulted in a point layer containing all existing institutional data. The information resulting from the derived drought groundwater elevations was then added to the SWS layer. Results of the stakeholder interview, indicating past water supply problems during either of the last two drought periods was included in the SWS base layer.

ArcGIS and Spatial Analyst were enlisted to create the derived drought elevations. Specific data was extracted from various layers in order to calculate likely groundwater elevations in the event of a drought.

The first phase of analysis was to determine if the wells were deep enough to perform under anticipated drought conditions. Systems having less than 80 feet from the bottom of the well to the derived drought groundwater elevation were determined to be at risk as a Tier 2 factor. The distance of 80 feet was determined to be reasonable, based on input from District management, CDM geologists, and DWR Northern District Groundwater Section staff. The derived drought groundwater elevation uses year 2000 groundwater demand and applies 1994 drought elevations to model likely groundwater elevations under today's conditions in the event of a prolonged drought. Data from a variety of sources was sought out to perform the calculations needed to determine likely water supply shortage conditions including:

- Groundwater well log database (DWR Northern District Groundwater Section)
- Digital Elevation Model (USGS DEM)
- Spring 1994 groundwater elevation contours (DWR Northern District Groundwater Section)
- Spring-Summer 2000 groundwater draw down data (DWR Northern District Groundwater Section)

The calculations performed to determine the derived groundwater elevations are as follows:

- Ground surface elevations above sea level were extracted from the USGS DEMs and converted to feet.
- Well depth (distance from the ground surface to the bottom of the well) was acquired from well logs and confirmed or corrected during stakeholder

interviews. The well bottom was calculated by subtracting the total well depth from DEM elevation at the well site.

- The derived groundwater surface elevation in feet above mean sea level was calculated by subtracting the spring-summer 2000 draw down data from the spring 1994 drought groundwater surface elevation.
- The distance in feet between the well bottom elevation and derived groundwater elevation by subtracting.
- The results of the last calculation were divided into three categories; no data, greater than 80 feet, or less than 80 feet and added to the SWS layer.

Tier 2 risk factors also included known geologic limitations, specifically the occurrence of systems in fractured rock aquifers in the mountainous areas of the county. Regional surface geology mapped by Harwood and Helley and converted to GIS by DWR Northern District Groundwater Section was used to identify systems constructed in areas with geologic limitations.

Tier 3 risk factors were analyzed in conjunction with Tier 1 and Tier 2 risk factors. Tier 3 risk factors alone were not compelling enough to indicate drought vulnerability, but are considered contributing factors. Tier 3 indicators were not analyzed using GIS technology. CDM geologists and other staff investigated the occurrences of Tier 3 issues both regionally and individually.

Regional Results

The Small Water Systems Drought Vulnerability Assessment (District/CDM) published February 2005 includes the analysis of individual systems. The individual results were included in the final report but are excluded from this presentation because law in California protects well log information. The Executive Summary section of the final report is provided in Appendix A. Countywide results for the four primary areas: Mountain Region West, the Sacramento Valley basin, and the Mountain Region East are discussed below.

The most significant indicator of drought vulnerability was past experience. Six system operators within the county communicated the Tier 1 factor, prior water supply shortages during prior droughts. All six systems were located on the west side of the Sacramento River. All of the systems located in the valley area have taken measures to upgrade their wells. The sixth system, located just inside the southern half of the Mountain Region West has not upgraded its system and was carried forward as potentially drought vulnerable.

The Mountain Region West contains three SWS, including the system discussed in the previous paragraph, which experienced shortages during prior droughts. Although the two remaining systems investigated do have geologic limitations, it was determined they are not likely to experience water supply shortages, based on data collected during the interview process. It should be noted limited historic or archival data is available for the mountain regions, as they are outside the extents of the DWR groundwater monitoring grid; therefore they were analyzed based on interviews and geology only. Urban or agricultural growth is not anticipated for these areas in the near future and was not considered a factor.

Mountain Region East is the only area in the study that included spring water or surface water supply sources as well as groundwater wells. As with the Mountain Region West, the 20 systems in this area are constructed in fractured rock, but these systems did not exceed any other factors, making them unlikely to be drought vulnerable at their present use.

County wide, only six systems were identified as potentially drought vulnerable, with five of the six being located in the valley basin. Two of the systems identified were in the Red Bluff East inventory unit, located in the center of the county, and the remaining three were in the Corning East inventory unit, located in the south central county.

Both SWS in Red Bluff East had much less than 80 feet from the bottom of the well to the derived drought levels. The first system had less than 40 feet and the second had less than 5 feet. The first system also failed the spring to summer draw down and the storage/hydrograph criteria. The second system did not fail any other criteria but the shallowness of the well was compelling enough to consider it vulnerable.

Each of the three Corning West systems failed to meet the derived groundwater elevation criteria and the storage/hydrograph criteria. Additionally, one of the systems indicated a supply problem in previous drought, another is expected to be impacted by urban or agricultural growth, and the third demonstrated excessive draw down during the spring to summer monitoring.

Public Outreach

One objective of this project was to engage the stakeholders and community and encourage them to participate in water resource management. As such, outreach, education, counseling were included in the final phase of the project. A comprehensive public presentation was agendized and conducted as part of a regularly scheduled Tehama County AB 3030 Groundwater Management Technical Advisory Committee (TAC) Meeting. The results were also agendized and presented at a regularly scheduled Tehama County Flood Control and Water Conservation District Board Meeting. Both meetings are noticed in the local newspaper and had agendas posted in public places prior to the meeting. A press release was submitted and published by the local newspaper to announce the conclusion of the project and encourage the public to attend the TAC meeting to learn more.

Prior to the presentation letters were mailed to all the stakeholders inviting them to attend the presentation. The systems determined to be at risk were informed of the findings and provided contact information to discuss their systems prior to the presentations. The draft Executive Summary section of the report was provided to the TAC members, Flood Control Board and attendees of the presentations. Following the publishing of the final project report the Executive Summary, a copy of the individual state well log (where available), and individual results of each SWS were mailed to the system operators, including systems that declined to participate in the study.

Challenges

Like any major undertaking, this project was not without its challenges. People and data were the two areas were challenges arose. There was a very high level of cooperation between agencies during this investigation, but convincing system operators to participate was more difficult. Some system operators were either unresponsive or simple refused to participate. Others agreed to be interviewed but would not allow the locations of their wells to be GPS'ed. While researching archival data the biggest challenge turned out to be obtaining hard copies of the state well logs. This data is also available in the DWR well log database, but there are wells with incomplete data.

Conclusions and Recommendations

Prior to performing this study little was known about SWS in Tehama County other than the water quality findings of individual systems. The District wished to be proactive in their approach to managing water resources. Drought is always a concern in this region and can have serious impacts. This project provided the opportunity to compile and analyze data prior to the next drought emergency. It also provided an opportunity for SWS operators to learn more about their own systems, and interact with the District.

The District was pleased to discover only a few (six) SWS are likely to be at risk in the event of drought. It should be noted, however, almost all of the systems investigated had at least one of the risk factors associated with Tier 1, 2 and 3, but not to the extent to consider it at risk at this time.

The ongoing value of this project is the tool it provides and the means to share and further explore the data. The GIS companion project was distributed to the Tehama County Planning Department and Tehama County Environmental Health Department (TCEH). TCEH was a primary source of the archival data, however, GIS provides them with a new and versatile method of exploring their data. TCEH collects water quality data that could now easily be appended to the SWS layer for additional analysis. The District is incorporating GIS into its Groundwater Management Plan and this new data will help guide the Plans actions in the future. The same is expected of the Planning Department, which is undertaking a General Plan update at this time and is using GIS analysis for the first time in the Department's history. This tool can be used by the County Planners to guide decisions regarding new development that includes a SWS. Additionally, it can guide future land use planning by considering potential drought vulnerability.

As a result of this project the District is purchasing six In-Situ data loggers to improve groundwater monitoring data collection and analysis in the county.

There are nearly 10,000 groundwater wells in Tehama County. The majority of these wells are privately owned domestic wells or agriculture wells. The methods used to determine if the SWS were sufficiently deep to perform under drought conditions could be recreated using domestic or agricultural wells data.

Appendix A

Executive Summary

Executive Summary

ES.1 Introduction

In response to the potential for critical water shortages within the State of California, the CALFED Record of Decision (ROD) directed the Governor to create a panel to develop a contingency plan for reducing water shortage impacts. The ROD charged the Governor's Advisory Drought Planning Panel (Panel) with identifying available resources and funding mechanisms to reduce the impacts of such shortages. The Panel's contingency plan recognized water shortage management challenges, which included rural self-supplied water users.

Previous droughts have prompted health and safety concerns for small, rural communities' ability to maintain water supplies for sanitation, drinking, and fire fighting. The Panel expressed a need for contingency planning by State and local governments to assist rural water users without adequate water sources.

The Tehama County Flood Control and Water Conservation District (District) is undertaking a small water systems (SWS) drought vulnerability study consistent with the Panel's recommendations for Implementation Action B – Assistance to Small Water Systems and Homeowners in Rural Counties. The purpose of this countywide Small Water System Drought Vulnerability Study (funded by the Department of Water Resources) is to inventory locations and extent of systems and evaluate the relative degree to which SWS, reliant primarily on groundwater, may be at risk of supply shortages or impacts during droughts.

SWS in this report include the following water system types:

- State Small Water System: System consists of 5-14 service connections or serves less than 25 persons year round. (Apartment, subdivision)

- Community Water System: System serves residential areas with 15 or more service connections or 25 or more persons. (Apartment, mobile home park)

- Non-Transient Non-Community Water System: System serves non-residential areas, but routinely serves the same population for 25 or more persons, or 15 or more connections. (Schools, workplaces)

- Transient Non-Community Water Systems: System serves 25 or more persons, or 15 or more connections for non-residential areas with a changing population. (Rest stops, campgrounds)

- Surface Water System: Small water system or community water system that utilizes surface water for water supply serving 25 or more persons, or 15 or more connections.

ES.1.1 Tehama County

Tehama County encompasses roughly 3,000 square miles and 1.9 million acres in northern central California. The county's economy is based on agriculture, including ranching, farming, and timber production (Tehama County 2004). Agriculture is the largest user of water in the County, approximately 80 percent of total water demand. Groundwater represents the majority of supply, approximately 46 percent of the total County supply (DWR, as cited in CDM 2003). Other water supplies include local stream diversions, CVP contractor's water delivered from the Tehama Colusa and Corning Canals, Sacramento River riparian users, reclaimed wastewater, and surface water reuse.

The Sacramento River is the largest river in the county, into which drain many important tributary streams. At Red Bluff, a portion of the river's flow is diverted into the Tehama-Colusa Canal, a Reclamation irrigation facility stretching 100 miles south to serve agricultural land. The Corning Canal is used to supply surface water diverted from the Sacramento River to districts in Tehama County, such as the Corning Water District. Tributaries of the Sacramento River that flow from the mountains and across the valley floor before reaching the Sacramento River provide much of the local surface water supply within Tehama County. These tributary streams also significantly contribute to the groundwater recharge in the basin.

ES.1.2 Role of the Flood Control and Water Conservation District

The District is actively involved in many interrelated groundwater management activities; this study will further the District's effort to identify areas of the county where unmet local needs exist, specifically in relation to the drought vulnerability of SWS. Several efforts have been undertaken both locally by the District and statewide to better characterize water resources including a water resources inventory, groundwater level monitoring, and groundwater quality projects.

ES.1.3 SWS Drought Vulnerability Project Goals and Objectives

The purpose of this study is to evaluate the relative degree to which SWS, reliant primarily on groundwater, are at risk of supply shortages or impacts during droughts. By developing a better understanding of the potential drought impacts to individual SWS, the District will be better situated to manage water resources in the county. The primary objective of the study is to inventory the SWS within the county and determine the likelihood of vulnerability of these systems. Given this objective, project goals include:

- Engaging SWS operators to participate in the study;
- Obtaining a well log for each well;
- Mapping the coordinates of each system;
- Creating a GIS companion project including a SWS data layer;

- Comparing SWS well depth to estimated groundwater levels during a past drought period; and
- Developing recommendations for further evaluation and analysis.

ES.1.4 Project Approach

Los Molinos Community Services District Small Water System Well and Storage

The project approach encompasses archival research, field research, and analysis using GIS. The Department of Water Resources (Northern District) and the AB3030 Technical Advisory Committee participated in the project and document development by providing insight, guidance, and review. Compiling both archival and field data provides the District with physical system information as well as the SWS operators' knowledge of system performance during past droughts. GIS is used to compare, and subsequently graphically illustrate, the system data with groundwater levels and drought contour mapping to determine each system's likelihood of drought vulnerability. Additional variables are also evaluated qualitatively: SWS operator experience, surrounding land uses, anticipated land use changes, and groundwater level trends in nearby monitoring wells. The study output includes an identification of systems that are potentially drought vulnerable or unlikely drought vulnerable.

ES.1.5 Document Development and Potential Uses

SWS data was obtained from databases at the California Department of Health Services - Redding and the Tehama County Environmental Health Department. Data obtained from these agencies was confirmed during interviews with SWS operators. Additional information regarding the history of the system and system coordinates were also collected during the interviews. Well logs were obtained at the agencies and from the Department of Water Resources.

The results of the SWS drought vulnerability study are important to Tehama County's water supply planning efforts because they enable the District to focus support for implementation of actions that can lessen the likelihood of drought vulnerability. Additionally, through identification of county areas that are potentially drought vulnerable, the District can undertake additional actions to monitor those areas and provide planning guidance for any future development.

ES.2 Data Collection

The archival research was the initial data gathering step to compile existing information, specifically system location and status. The data collected from the CA Department of Health Services and Tehama County Environmental Health Department also served as a starting point for discussions during the field interviews.

Introductory materials were sent to each SWS operator informing them of the project goals and requesting an interview. The purpose of the interview was to confirm data on file at the agencies, collect additional information including the SWS operators' experience during drought conditions, and GPS the well coordinates. An interview form was completed during each interview and permission to publish the system coordinates was also requested. (Appendix A contains a sample interview form.)

ES.2.1 Data Collection Results

Three SWS were labeled as SWS within the agencies' databases but have subsequently converted to receiving municipal water supplies. These systems no longer fall under the SWS heading and are removed from the study. Table ES-1 summarizes the archival and field data collection results. Well logs were obtained during the archival research; however, only 63 out of a total of 158 well logs were in the files. An additional 11 well logs were obtained from DWR and a DWR database supplied additional well information. The remaining well logs could not be located. Approximately 70 percent of the SWS operators granted interviews, but less (55 percent) of the GPS coordinates were obtained. Many of the SWS operators participated in the interview but requested the coordinates of their system not be published in this report for security or privacy reasons.

Table ES-1. Archival and Field Data Collection Results

	Archive Data	Field Data	
	Well Logs	**Interview with SWS operator**	**GPS coordinates**
Percentage Obtained	47% 74/158[1]	72% 126/176[2]	55% 96/176

[1] Total wells logs are 158 rather than 176 (total for field data collection) because some systems use surface water or springs, which do not have well logs.
[2] SWS total (176) includes the number of individual wells, springs, or surface water intakes. In some cases, one SWS operator may have more than one water source (e.g., well).

Approximately 30 percent of the SWS operators either declined an interview or were not available for interviews as described in Table ES-2.

Table ES-2. Breakdown of Interviews not Conducted with SWS Operators

Description	Percentage of Total
Declined to participate in study	7% (13/176)
Unresponsive	13% (23/176)
No contact available	8% (14/176)
Total	28% (50/176)

- Declined to participate in study – A dozen SWS operators (13 water sources) did not wish to participate in the study and did not provide responses to the interview form.

- Unresponsive – Several contact attempts were made with the SWS operators via letters and phone calls. Many SWS operators did not respond to the contact attempts.

- No contact available – In many cases, the contact information on file at the agencies was no longer valid. Attempts were made to locate a forwarding address or a new contact. In some cases, the SWS may not be in use (e.g., a restaurant that has been shut down) and there is no available contact.

ES.3 Methodology

The drought vulnerability methodology focuses on identifying vulnerable SWS based on potential source water limitations during hydrologic drought. The methodology includes an approach to identify both (1) county areas that are potentially drought vulnerable (2) and individual SWS that are potentially drought vulnerable. The rationale for this dual approach results from the various types of information available to complete the assessment. Additionally, the identification of areas as well as individual SWS provides the District with information that can be used in future planning efforts. Potentially drought vulnerable areas of the county are identified using criteria such as spring to summer groundwater level drawdown, source water information, and anticipated growth-related increase in water demand information. Criteria including SWS interview results and summer drought groundwater elevation are added to the analysis to identify potentially vulnerable individual SWS.

- **SWS literature review and interview results:** SWS that experienced water supply problems in the past are likely to experience similar problems in future droughts. This factor is described only for individual SWS and not in the Inventory Unit results discussion.

    - SWS that experienced water supply reliability difficulties during past droughts and have not remedied the problem are carried forward in the analysis as potentially drought vulnerable SWS.

- **Tehama County surficial geologic map:** The geologic formation that a well is producing water from influences the rate of water production and reliability of the water supply. Groundwater wells completed in the Sacramento Valley or Redding groundwater basins are producing groundwater from basin deposits, which generally support development of the volume of water required for the specified use. Groundwater wells completed in mountainous areas are usually producing water from fractures. Fractured rock aquifers generally have limited water in storage and limited extent (due to the lack of interconnectedness of the fractures). Within Tehama County, volcanic rock and metamorphic rock (areas outside of the valley) can significantly limit the volume and rate of groundwater production.

    - Areas of the county outside of the valley are carried forward in the analysis as potentially drought vulnerable areas.

- **Spring-to-summer 2000 groundwater level drawdown:** A large decrease in groundwater level between spring and summer results when the rate of groundwater extraction exceeds the ability of the aquifer to recharge groundwater removed from storage. Recharge will generally exceed demand during the winter months, resulting in recharge of the aquifer to levels that are generally consistent from spring-to-spring. Seasonal drawdown of the groundwater aquifer may impact groundwater wells completed at shallow depths.

  - Areas of the county with 20 feet or more seasonal drawdown are carried forward in the analysis as potentially drought vulnerable areas.

- **Derived summer 1994 drought groundwater elevation:** SWS operators without a substantial elevation distance between the derived summer 1994 drought groundwater elevation and the bottom of well elevation could experience water supply problems during future droughts. This factor is described only for individual SWS and not in the Inventory Unit results discussion. (Inventory Units are described in Section ES.3.2.)

  - SWS with less than 80 feet between the derived summer 1994 drought groundwater elevation and the bottom of the well are carried forward in the analysis as potentially drought vulnerable.

- **Groundwater in storage/groundwater monitoring well hydrographs:** The District and DWR Northern District jointly monitor and maintain a network of wells for the purpose of monitoring seasonal groundwater levels. The groundwater level at each well is measured and recorded in the spring, summer, and fall. Comparison of spring-to-spring measurements provides the best indication of current groundwater level trends because the aquifer is not extensively used for agricultural irrigation during the winter months and the majority of groundwater recharge occurs during this time period. SWS, reliant on groundwater, located in proximity to areas with observed declining groundwater trends may have increased vulnerability during future drought based on observed groundwater trends.

  - Areas with decreasing groundwater level trends are carried forward in the analysis as potentially drought vulnerable areas.

  - SWS in proximity to groundwater monitoring wells that indicate groundwater elevation decreases of greater than 5 feet during 1998 – 2003 are carried forward in the analysis as potentially drought vulnerable.

- **Changes in source water:** Areas that have access to both surface water and groundwater (agricultural water users) could shift to increased groundwater use, especially in drought conditions as surface water allocations are reduced.

  - SWS in proximity to areas that include a mixed-use water supply source are carried forward in the analysis as potentially drought vulnerable.

- **Future increase in water demand associated with urban and agricultural growth:** Regional growth patterns that indicate an anticipated increased demand will put more pressure on a fixed supply source.
  - Areas that are anticipating significant urbanization growth or have the potential for additional agricultural development are carried forward in the analysis as potentially drought vulnerable areas.

ES.3.1 Drought Vulnerability Factor Classification

The drought vulnerability factors are categorized into Tier 1, Tier 2, and Tier 3, which represents confidence in the degree to which the factor can forecast vulnerability. The factors within each tier have an equal weight. The Tier 1 factor, SWS interview results, is assigned the greatest ability to forecast because SWS with recorded past water supply problems would be likely to experience future water supply problems. Tier 2 factors: geology and derived summer 1994 drought groundwater elevation, have a moderate ability to forecast future vulnerability. Tier 3 factors: spring-summer 2000 groundwater level drawdown, groundwater in storage/groundwater monitoring well hydrographs, change in source water, and future agricultural or urban growth, do not forecast future vulnerability by themselves, but add to the ability to forecast vulnerability of SWS that have positive Tier 1 or Tier 2 factors.

TIER 1	TIER 2		TIER 3			
SWS Interview	Geology	Derived Summer 1994 Drought GW Elevation	Spring-Summer 2000 GW Level Drawdown	GW in storage/ GW monitoring well hydrographs	Change in Source Water	Future Ag/Urban Growth

The SWS are classified as “potentially vulnerable” or “unlikely vulnerable” based on exceedances of the drought vulnerability factor thresholds. The number of exceedances and whether the exceedances are for a Tier 1, Tier 2, or Tier 3 factor are included in the SWS vulnerability determination.

SWS are classified as “potentially vulnerable” if”

- The SWS have an exceedance of a Tier 1 factor (SWS interview); or
- The SWS have exceedances of three or more factors where one factor must be a Tier 2 factor.

ES.3.2 Drought Vulnerability Assessment Reporting

During completion of the Tehama County Water Inventory and Analysis project (2003), the county was divided into four regions based on mountainous areas and groundwater basins. Detailed reporting of the physical setting, current water sources, water supplies, and water budgets were completed for each region and for subsets of each region, referred to as “Inventory Units”. In an effort to maintain consistency, the same regions and associated Inventory Units are used for reporting of SWS’ drought vulnerability.

The four regions of Tehama County are as follows:

- Mountain Region West;
- Mountain Region East;
- Redding groundwater basin; and
- Sacramento Valley groundwater basin.

The regions are subdivided into Inventory Units based on groundwater sub-basin boundaries, as shown on Figure ES-1 (at end of Executive Summary). Tehama County includes 10 groundwater sub-basins, in addition to the Mountain Region West and Mountain Region East. A list of regions and associated Inventory Units is included in Table ES-3.

Table ES-3. Tehama County Regions and Inventory Units

Regions	**Inventory Units**
Sacramento Valley GW Basin	1. Red Bluff East
	2. Red Bluff West
	3. Corning East
	4. Corning West
	5. Bend
	6. Antelope
	7. Dye Creek
	8. Los Molinos
	9. Vina
Redding GW Basin	10. Bowman
	11. Rosewood
	12. South Battle Creek
West Mountain	13. West Mountain
East Mountain	14. East Mountain

ES.4 Geographic Information System

Geographic Information System (GIS) is used in the SWS project as an analysis tool and as a method of graphically representing the SWS drought vulnerability findings.

The District will use the GIS project in the future as a management tool to aid identification and prioritization of actions to help lessen the likelihood of SWS drought susceptibility.

ES.4.1 GIS Database and GIS Layer

During field data collection, SWS well points were collected using a Trimble GeoXT GPS system, and corrected using base station data files. SWS well points not collected using the GPS system were estimated using the SWS' address using the website: http://www.geocode.com/, a GPS coordinate estimator (Tele Atlas 2003).

The archival and field data collection findings were compiled into a GIS database. The database includes results from the archival research, field surveys, field interviews, and

SWS GPS coordinates. A GIS layer was developed using ArcGIS 8.3 that incorporates the attribute data with the SWS locations. The database is linked to the GIS layer such that the attributes in the database are associated with the SWS points.

ES.4.2 Companion Project

The companion project combines the SWS locations with relevant GIS basemap data layers, including water bodies, roadways, groundwater levels, and drought contours. The companion project uses GIS to store and represent information collected during archival and field research. A basemap was created using the following layers:

- Roads (Tehama County Public Works 2004)
- Surface hydrology (CaSIL 2003)
- County boundary (CaSIL 2003)
- Inventory unit (DWR, as cited in CDM 2003)

The information contained in these layers provides reference points, natural features, and infrastructure locations. Additional GIS layers were used during the analysis and to represent the findings graphically:

- Surficial geology map (DWR, as cited in CDM 2003)
- 2000 spring-summer drawdown (DWR, as cited in CDM 2003)
- Land use data (DWR, as cited in CDM 2003) sorted by water source
- Groundwater basins (DWR, as cited in CDM 2003)
- Urban area boundaries (Tehama County Public Works 2004)
- Surface Elevation Model (USGS)
- DWR Tehama County Groundwater Monitoring Grid (DWR, as cited in CDM 2003)

ES.4.3 Future Uses

As new information becomes available, Tehama County is able to update the GIS project. The GIS output is a result of available data and queries of that data. GIS is a tool that can be used in the future as more data is available or as assumptions change. The GIS database will be valuable in future development countywide. County Environmental Health will also be able to use the database to update and track SWS status.

ES.5 Analysis Results

ES.5.1 Countywide Results

The following subsections present an overview of the occurrence and magnitude of the drought vulnerability factors within Tehama County. The purpose of the discussion is to provide a general description of the drought vulnerability factors at a county level; a discussion of the factors at an Inventory Unit level and SWS level follows.

ES.5.1.1 SWS Literature Review and Interview Results

Tehama County has a total of 149 SWS with 176 wells, springs, or surface water intakes. (Some systems have more than one well.) Based on interview results, six SWS operators identified water supply problems. These SWS are all west of the Sacramento River and extend from central Tehama County to the Mountain Region West Inventory Unit: Caltrans Red Bluff rest stop southbound, Caltrans Corning rest stop northbound and southbound (single well on southbound I-5), Paskenta Community Services District (CSD), R-Wild Horse Ranch, Rancho Tehama Association Rec Hall, and Tehama County Ridgeway Park. Each of the SWS operators has remedied the water supply problem by upgrading their wells except the Paskenta CSD, which is carried forward as potentially drought vulnerable.

ES.5.1.2 Hydrogeologic and Geologic Data

Surficial geology

The eastern third and western third of the county (Mountain Region East and Mountain Region West Inventory Units) overlay hardrock rather than sedimentary deposits found in the valley (Figure ES-2 at end of Executive Summary). The fractured rock aquifers have a less reliable water source compared with the aquifers underlying the valley floor. The approximately two-thirds of the county that overlay hardrock have an increased susceptibility to drought given the variable nature of the water supply from this geologic formation. A total of 28 SWS are in Mountain Region East and West; the remaining SWS are within the valley, all of which are supplied by groundwater.

Spring-to-summer 2000 groundwater level drawdown

The magnitude of spring-summer 2000 groundwater level drawdown ranges throughout the county from zero to approximately 45 feet (Figure ES-3 at end of Executive Summary). Areas of drawdown greater than 20 feet are concentrated in three distinct areas west of the Sacramento River and south of the city of Red Bluff in the Red Bluff East and Corning East Inventory Units. These areas overlay areas that generally have groundwater as the only water source. Within two of the three distinct areas, groundwater drawdown contours extend to 40-45 feet.

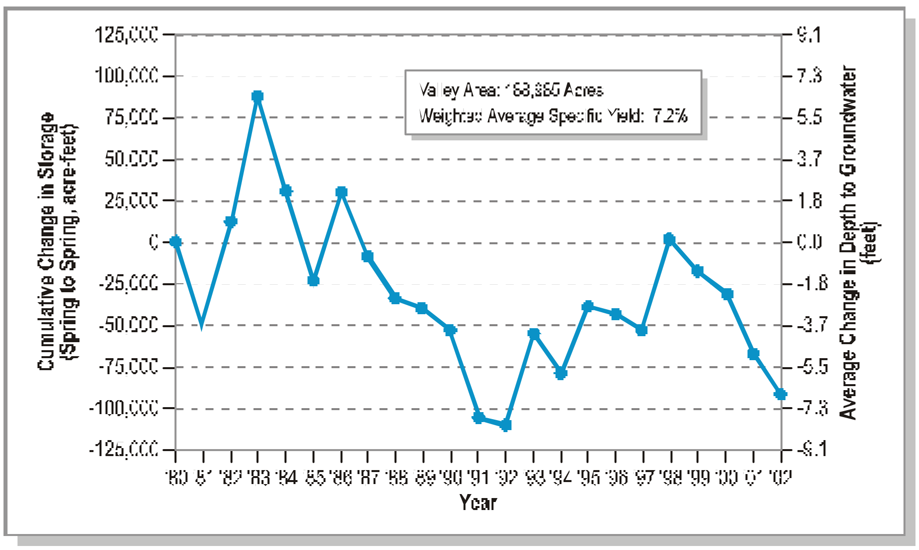
Derived summer 1994 drought groundwater elevation

A total of 30 SWS have less than 80 feet between the derived summer 1994 drought groundwater elevation and the bottom of the well. (Spring-to-summer drawdown in 2000, representing current seasonal drawdown, was subtracted from the spring 1994 groundwater elevation, representing a drought year, to derive the estimated summer 1994 drought groundwater elevation.) These SWS are generally outside the cities of Red

Bluff and Corning and along the Sacramento River (Figure ES-4 at end of Executive Summary).

Groundwater in storage/groundwater monitoring well hydrographs

The cumulative change in spring-to-spring groundwater storage for the county is generally a function of the water entering the aquifer (precipitation and natural recharge) and the water exiting the aquifer (groundwater use). Figure ES-5 shows the change in storage annually from 1980 through 2002. During the drought cycle between 1987 and 1992, groundwater levels declined approximately 7 feet with approximately 86 percent of average precipitation over the five years. Between 1998 and 2002, groundwater levels declined approximately 6.5 feet with approximately 89 percent of average precipitation over the four years (Table ES-4). Although not classified as a drought cycle, the precipitation average during 1998-2002 is close to the average during 1987-1992; during times when precipitation is less than 105 percent of average, the change in storage trend decreases within the county.



Source: California Department of Water Resources, Northern District

Figure ES-5
Estimated Cumulative
Change in Spring to Spring Storage

The change in groundwater elevation in groundwater monitoring well hydrographs (between 1998 and 2003) is used to evaluate potential drought vulnerability for SWS. Figure ES-6 (at end of Executive Summary) shows the change in groundwater elevation based on the groundwater monitoring well hydrographs. Hydrographs that show a greater than 5-foot decrease in groundwater elevation are generally west of the Sacramento River and are located around the City of Corning and to the northeast and southeast of the City of Red Bluff.

Table ES-4. Percentage of Average Precipitation	
Year	**Percent of Average**
1981	0.89
1982	1.21
1983	1.83
1984	0.97
1985	0.73
1986	1.41
1987	0.67
1988	0.91
1989	0.96
1990	0.75
1991	0.75
1992	0.91
1993	1.48
1994	0.80
1995	1.96
1996	0.95
1997	0.81
1998	2.16
1999	0.94
2000	1.00
2001	0.86
2002	0.78
2003	1.16
Data obtained from DWR. Precipitation is measured at Red Bluff, station number 7292. Percent of average is calculated based on the average precipitation for the period of record (1935-2002) at Red Bluff (23.41 inches).	

ES.5.1.3 Changes in Source Water

Mixed source water users are identified in Figure ES-7 (at end of Executive Summary). Mixed source water users occur on the east and west sides of the Sacramento River. A concentration of mixed source water users are on the eastern side of the Sacramento River and encompass parcels within the Antelope, Dye Creek, Los Molinos, and Vina Inventory Units. Mixed water source users also exist in Red Bluff East and Corning East Inventory Units.

Tehama County surface water supplies decrease in a dry year compared to an average year as shown in Table ES-5. Countywide decreases in surface water supplies correspond with an increase in groundwater use: 172,700 acre-feet in an average year and 233,000 acre-feet in a dry year (DWR, as cited in CDM 2003).

Table ES-5. Tehama County Surface Water Supplies in an Average and Dry Year			
Supply Source	**Average Year (acre-feet)**	**Dry Year (acre-feet)**	**Percent Change**
Local stream diversion	106,300	76,600	-28%
CVP (Corning and Tehama-Colusa Canal)	21,300	12,300	-42%
Sacramento River/CVP	14,400	15,100[1]	5%
Total	142,000	104,000	

[1] Sacramento River riparian users' water is not cut back.
Source: DWR, as cited in CDM 2003

ES.5.1.4 Future Increase in Water Demand Associated with Urban and Agricultural Growth

Urban Growth

Future urban growth is centered along the Interstate 5 corridor, which runs north-south through the center of the county (Figure ES-8 at end of Executive Summary). Large-scale housing developments (2,500-3,500 units) are proposed in northern central Tehama County (northern end of the Sacramento groundwater basin and in the Tehama County portion of the Redding groundwater basin). Urban growth is also expected surrounding existing urban centers including the cities of Red Bluff and Corning, including the South Avenue and Corning Road interchanges with I-5.

Agricultural Growth

Recent agricultural trends in Tehama County indicate an increase in acreage in production of tree crops (almonds, walnuts, and olives) and a decrease in livestock. Between 2001 and 2004, cattle within the county have decreased from 79,000 to 66,000 (California Agricultural Statistics Service 2004). Between 1998 and 2003, almond acreage has increased by approximately 1,500 acres and an additional 2,300 acres of walnuts have been planted (California Agricultural Statistics Service 2004a). The trend towards increased acreage in tree crops results in additional groundwater demand.

Future agricultural growth is anticipated to occur on type II soils. These soils occur primarily along stream beds beginning near the foothills on the western side of the county and extending into the center of the county up to Interstate 5 (Figure ES-8). Type II soils are also found in central and southern Tehama County east of I-5. Agricultural development on all of the areas identified in Figure ES-8 is unlikely because of the proximity to the streams and the potential for flooding.

ES.5.2 SWS Results

The following SWS (Table ES-6) are potentially vulnerable based on exceedances of the drought vulnerability factor thresholds.

Table ES-6. Potentially Drought Vulnerable SWS

Inventory Units	SWS	Drought Vulnerability Threshold Exceeded
1. Red Bluff East	Kountry Korners Mobile Home Park SWS	Derived summer 1994 drought groundwater elevation; spring-summer 2000 groundwater level drawdown; groundwater in storage/groundwater monitoring well hydrographs.
	Friendly Acres Mobile Home Park	Derived summer 1994 drought groundwater elevation
2. Red Bluff West	SWS unlikely drought vulnerable	N/A

Table ES-6 continued. Potentially Drought Vulnerable SWS		
3. Corning East	Caltrans Corning Rest Stop (NB/SB) SWS	SWS interview; derived summer 1994 drought groundwater elevation; groundwater in storage/groundwater monitoring well hydrographs.
	Lazy Corral Mobile Home Park SWS	Derived summer 1994 drought groundwater elevation; groundwater in storage/groundwater monitoring well hydrographs; future ag/urban growth.
	Jehovah's Witness Church SWS	Derived summer 1994 drought groundwater elevation; spring-summer 2000 groundwater level drawdown; groundwater in storage/groundwater monitoring well hydrographs.
4. Corning West	SWS unlikely drought vulnerable	N/A
5. Bend	SWS unlikely drought vulnerable	N/A
6. Antelope	SWS unlikely drought vulnerable	N/A
7. Dye Creek	SWS unlikely drought vulnerable	N/A
8. Los Molinos	SWS unlikely drought vulnerable	N/A
9. Vina	SWS unlikely drought vulnerable	N/A
10. Bowman	SWS unlikely drought vulnerable	N/A
11. Rosewood	There are no SWS within Rosewood	N/A
12. South Battle Creek	There are no SWS within South Battle Creek	N/A
13. West Mountain	Paskenta Community Services District SWS	SWS interview
14. East Mountain	SWS unlikely drought vulnerable	N/A

ES.6 Conclusions and Recommendations

ES.6.1 Conclusions

An exceedance of a drought vulnerability factor represents the potential for future drought vulnerability; exceedances of multiple drought vulnerability factors increase the likelihood for the potential for future drought vulnerability. The analysis identified several areas of Tehama County with exceedances of more than one drought vulnerability factor. Corning East and Red Bluff East Inventory Units contain areas with: 1) spring-summer 2000 groundwater level drawdown greater than 20 feet; 2) anticipated urban growth; and 3) groundwater monitoring well hydrographs that show a decrease in groundwater elevation of greater than 5 ft between 1998 and 2003. Interviews with SWS operators in these areas did not indicate water supply shortages during past drought periods. However, as part of future land use decisions and planning efforts, consideration should be given to the potential for drought vulnerability given an increase in demand on groundwater supply. For example, future well installation in potentially drought vulnerable areas could use the derived summer 1994 drought groundwater elevation for determining appropriate well depth.

The results of the archival and field data collection effort and subsequent analysis indicated few SWS that are potentially vulnerable (Table 6-1). Additional SWS within Tehama County may be potentially drought vulnerable; however, sufficient data was not available to determine the extent of the SWS' drought vulnerability. SWS interviews were especially helpful for characterizing past water supply impacts caused by drought. As described in Section ES.2.1, approximately 30 percent of the SWS operators either declined to participate in the study or were not available for interviews. Well logs provided some information on these SWS; however well logs were also not available for all SWS (approximately 50 percent of the well logs were obtained).

For most SWS, the location of the pump bowls was not known; therefore, the actual pumping elevation could not be used in the analysis. An approximation of 80 feet from the bottom of the well was used in determining the SWS' potential drought vulnerability relative to the derived summer 1994 groundwater elevation. Using this approximation, 30 SWS exceeded the threshold for this drought vulnerability factor. Depending on where the pump bowls are set, the number of SWS exceeding the factor could vary.

A total of 28 SWS are in Mountain Region East or Mountain Region West. Drought vulnerability assessment for these SWS was based on only two drought vulnerability factors: SWS interview and geology. Data, such as groundwater elevation, necessary for evaluating additional drought vulnerability factors is not available in Mountain Region East or Mountain Region West. The confidence in the determination that SWS in these inventory units are unlikely vulnerable is therefore not as high as the confidence in the drought vulnerability determination for SWS based on all drought vulnerability factors (i.e., SWS in the valley).

ES.6.2 Recommendations

Based on the SWS drought vulnerability assessment, the following recommendations would assist the District and SWS operators in managing existing drought vulnerability issues and reducing the potential for increased future drought vulnerability.

- Identify actions to reduce drought vulnerability for "potentially vulnerable" SWS such as deepening SWS wells and connecting SWS to municipal supplies;
- Target areas within the county for additional groundwater monitoring;
- Obtain missing well logs and add the well data into the SWS drought vulnerability assessment to better characterize the systems as potentially drought vulnerable or unlikely drought vulnerable;
- Video existing wells including where wells are screened;
- Obtain data regarding where the pump bowls are set to compare to the derived summer 1994 groundwater elevation;
- Install dataloggers to monitor groundwater levels;
- Install flow gages on supply streams to develop baseline flow data to identify and define flow trends related to hydrologic conditions;

- Identify drought vulnerability predictors, such as declines in groundwater in storage and percent of average precipitation, to aid in forecasting the onset of drought impacts;
- Use the results of this assessment to assist and guide future SWS installation. Develop a means to make the results of this report known and available to those installing SWS;
- Guide future land use planning with consideration of potentially drought vulnerable county areas; and
- Develop a countywide drought management plan.

ES.7 References

California Agricultural Statistics Service. 2004. County Estimate Reports – Livestock. Available at http://www.nass.usda.gov/ca/coest/indexce.htm. Accessed on 1 December 2004.

California Agricultural Statistics Service. 2004a. County Agricultural Commissioners' Data. Available at http://www.nass.usda.gov/ca/bul/agcom/indexcac.htm. Accessed on 1 December 2004.

CDM. 2003. Water Inventory and Analysis. Prepared for Tehama County Flood Control and Water Conservation District.

Tehama County. 2004. Available at http://co.tehama.ca.us/. Accessed on 29 November 2004.

Appendix B

Letter of Introduction and Sample Interview Form

FC-03________

Dear Small Water System Operator: August 26, 2003

Tehama County Flood Control and Water Conservation District in cooperation with the California Department of Water Resources is undertaking an inventory and investigation of small water systems within Tehama County. The purpose of this project is to identify the properties most at risk in the event of drought or other water shortages and to prepare for that event.

I will be contacting all small water system owners within the county to seek their assistance with this project. My goal is to complete a brief interview at each property to discuss any questions you have about water shortage preparedness for your system, collect data about your system, and map its location. I am including a draft of the interview form for your review.

Tehama County is proactively seeking ways to improve its drought and other water shortage preparedness and to increase its understanding of water sources within the region. An important first step to improve the response of local government to critical water supply shortages is to identify those at risk. The data collected during this investigation will be analyzed with existing data such as prior drought impacts to help predict the effect of future droughts on individual systems.

I will begin scheduling interviews in early September 2003 and look forward to meeting with you. Please call me at 530-385-1462 any time if you have any questions or comments.

Doti Watkins

GIS Project Manager
Tehama County Flood Control and
Water Conservation District

Stakeholder Interview Form
Tehama County Small Water Systems GIS Inventory

General Information

Today's Date:____________________DWR Well Log No:________________________

System Name**:** ______________________________

System Site Address: ______________________________

Cross Streets: ______________________________

System Type: ______________________________

Contact: __________________ Position: __________________________

Phone: _________________________ Email_______________________

Mailing Address: ____________________________

____

System Information

No. of Available Connections: ____________

No. of Active Connections: ____________

System Population: ________ Number of Wells in System: ____

Well #: ___________ Well Depth: ______

Does this well have a storage tank? ________

What size: _________

Pump Size: _________ Pumping Rate: _____________

# of people this well serves: ________

Current Well Depth to Water: Static: _______

Pumping: __________

What depth are the pump's bowls set at? __________

Well Location/GPS Coordinates: _______

Estimated water use: _____________

Additional Comments____

Do you have a plan of the distribution system?

Do you have an E-log of the well?

Are there other wells within the SWS boundary?

If so, what are their uses?

Does your well operate year round?

Does the system have a fire hydrant?

Has the system experienced water quality problems in the past?

Has the system experienced water supply problems in the past?

Is your water supply adequate for the intended population served?

If no, what are your projected needs?

Did you experience any water shortages during the 1976-77 drought?

Did you experience any water shortages during the 1987-92 drought?

Do you have any concerns regarding drought preparedness?

Was your well deepened or changed in response to a supply problem? If so, how?

Do you wish to be notified of public meetings regarding this project?

Would you like assistance in acquiring a meter?

Would you like us to monitor the depth to water on a regular basis?

PERMISSION TO COLLECT AND PUBLISH WELL LOCATIONS AND DATA

Signature ______________________________ **Date** ____________________

Appendix C

Data Dictionary

Appendix C - Data Dictionary

Tehama County Small Water Systems

Local Archival and Field Survey Data Collection

Attribute Field Descriptions

Name	Type	Width	Dec.	Description	Potential Entry Abbreviations	Source of info
RegAgency	text	5	0	Regulating agency:		TCEH / DHS
					TCEH-Tehama County Environmental Health	
					DHS-California Dept. of Health Services	
SysName	text	50	0	System name		TCEH / DHS
HSSystemNo	number	11	0	Health Services File number for the system		TCEH / DHS
WellLog	text	25		Does the well have a well log?		TCEH / DHS
SysAddr	text	50	0	System house number and street name		TCEH / DHS
SysCity	text	50	0	System city		TCEH / DHS
SysZip	text	50	0	System zip code		TCEH / DHS
SysContact	text	50	0	System Contact Name		TCEH / DHS
SysConPos	text	50	0	System Contact's Position		TCEH / DHS
SysConAdd	text	50	0	System Contact's House number and Street Name		TCEH / DHS
SysConCity	text	50	0	System Contact's City		TCEH / DHS
SysConSt	text	2	0	System Contact's State		TCEH / DHS
SysConZip	text	5	0	System Contact's Zip code		TCEH / DHS
SysConPhone	text	12	0	System Contact's Phone		TCEH / DHS
SysType	text	1	0	System Type:		TCEH / DHS
				Small water system		

				Community water system		
				Non-Transient Non-community water system		
				Transient Non-community water system		
				Surface Water System		
SysTypeDes	text	50				TCEH / DHS
SysPop	text	50	0	Discrete population served by system		Permit Application
ActConn	text	4	0	Discrete number of active service connections		Permit Application
AvailCon	number	19	0	Discrete number of available service connections		Permit Application
SeasBeg	text	4	0	Beginning of season of operation (mm / dd)	0101, 0115, 0428	Permit Application
SeasEnd	text	4	0	End of season of operation (mm / dd)	0920, 1231	Permit Application
LatDD	number	19	6	Latitude in decimal degrees		TCEH / DHS
LongDD	number	19	6	Longitude in decimal degrees		TCEH / DHS
UtmEast	number	8	0	Easting UTM NAD 83		Field
UtmNorth	number	8	0	Northing UTM NAD 83		Field
UtmZone	number	2	0	UTM Zone 10		Field
76-77shortage	text	3	0	Occurrence of a shortage during the 1976-77 drought		interview form
87-92shortage	text	3	0	Occurrence of a shortage during the 1987-92 drought		interview form
Adequacy	text	3	0	owner's impression about current supply's adequacy		interview form
IntDate	date	8	0	Interview Date		interview form
OtWlsInArea	text	25	0	other wells and their uses in the SWS area		interview form

Plan	text	3	0	Distribution plans available for system		interview form
Quality	text	25	0	Occurrence of owner or agency reported water quality problem		interview form
Supply	text	3	0	Occurrence of owner or agency reported water supply shortage problem		interview form
Deepened	text	25	0	Occurrence of well deepening		interview form
AmtDeepnd	text	3	0	Amount well was deepened in feet		interview form
Bowls	text	50	0	Depth from ground surface to the pump's bowls		interview form
Elog	text	3	0	E-log available for well		interview form
EstWatUse	text	25	0	Estimated Water use		interview form
HasMeter	text	3	0	Does the well have a meter?		interview form
WantsMeter	text	3	0	Does the system operator want a meter installed?		interview form
WantsMont rng	text	3	0	Doest the system operator want DWR to monitor depth to water in their well		interview form
Permission	text	3	0	Permission to publish well coordinates and data		interview form
YrRnd	text	3	0	Well operates on a year-round basis		interview form
UserWellDe	text	25	0	user assigned well designation		Permit Application
APN	text	25	0	Assessors parcel number		Permit Application
Depth2WS	numb er	19	0	Current depth to water static level		Permit Application
Depth2WP	numb er	19	0	Current depth to water pumping level		Permit Application
PumpRate	numb er	19	0	Pumping rate in GPM		Permit Application
PumpSz	numb er	19	0	Pump size (hp)		Permit Application
Pumptype	text	25	0	pump type	submersible, diesel, etc	Permit Application
StorageT	text	25	0	Presence and number of storage tanks		Permit Application
StorageCap	numb	25		Storage tank capacity (gallons)		Permit

	er					Application
SWN	text	15	0	State assigned monitoring well number		Permit Application
Depth	text	4	0	Overall depth of well at time of construction		Well Log
BotPerf	text	3	0	Bottom perforation interval of well		Well Log
TopPerf	text	3	0	Top perforation interval of well		Well Log
Const	text	25	0	Construction method of well		Well Log
PTID	number	19	0	Water level at beginning of initial pump test		Well Log
PTAD	number	19	0	Total draw down of pump test		Well Log
PTGPM	text	25	0	Gallons per minute at time of construction		Well Log
Diam	number	2	0	Diameter of well casing in inches		Well Log
DrDate	text	4	0	Construction date on well log		Well Log
LogNum	text	10	0	State assigned well log number		Well Log
GPS	text	2	0	GPS used to obtain coordinates		Field
X_Coord	number	19	5	Easting UTM NAD 83		Field
Y_Coord	number	19	5	Northing UTM NAD 83		Field
Z_Elev_m	number	19	0	Elevation extracted from NED (meters)		GIS
Z_Elev_ft	number	19	0	Elevation extracted from NED (meters) converted to feet (3.28 conversion used)		GIS
WellBottom	number	19	0	Elevation in feet above mean sea level of bottom of well. Calculated by subtracting total well depth from DEM elevation at well location		GIS
Elev_Sum94	number	19	0	Derived groundwater surface elevation in feet above mean sea level calculated using spring-summer 2000 drawdown data subtracted from spring of 1994 water surface elevation data		GIS
Bttm_Sum94	number	19	0	Distance in feet between Wellbottom elevation and Elev_Sum94 elevation in feet		GIS

Less_80ft	number	19	0	Analysis of Bttm_Sum94 into three categories; no data, greater than 80 feet, less than 80 feet		GIS
Well_Id	number	19	0			GIS
IU	text	25	0			GIS