SEEKING AN UNDERSTANDING OF THE GROUNDWATER AQUIFER SYSTEMS IN THE NORTHERN SACRAMENTO VALLEY

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SOUND CONCEPT OR MISCONCEPTION

To many people, the Sacramento Valley appears as an expansive groundwater basin filled with freshwater. It is also common to conceptualize the groundwater basin as an underground lake or a series of underground rivers that provide water to wells. Are these sound concepts or misconceptions? Recent interpretation of over 150 down-hole electrical resistivity logs from widely scattered locations throughout much of the northern Sacramento Valley has revealed that these simplistic concepts are incorrect. This pamphlet provides a glimpse of ongoing studies of the aquifer systems in the northern Sacramento Valley. The findings are preliminary and will likely improve as further information is gathered. Comprehensive reports of these studies should be available later in 2004.

KNOWLEDGE GAPS AND NEW INVESTIGATIONS

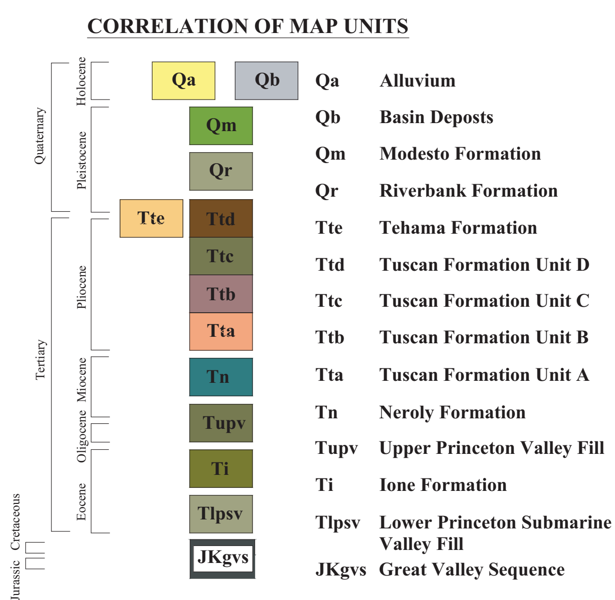
Concepts are easily formed and rationalized and can appear to be factual without sufficient field research to validate them. Until recently, only three regional investigations of the aquifer systems in the Sacramento Valley had been completed in the past 80 years and none were conducted since the mid 1970's.

Since 1997, the California Department of Water Resources, Northern District, Groundwater Section, headquartered in Red Bluff, California, has been conducting new investigations into the saline and freshwater aquifer systems in the northern Sacramento Valley. Findings from their investigations offer a greater understanding of the geology and hydrogeology in the northern Sacramento Valley.

METHODS USED IN RECENT GROUNDWATER INVESTIGATIONS

Geologic cross-sections have been and are currently being developed to help understand the sub-surface hydrogeology of the northern Sacramento Valley. Figure 1 shows the surface geology of the northern Sacramento Valley and location of six geologic cross-sections created during these studies. Four of the cross-sections trend west to east. The northernmost cross-section line, A-A' runs from Flournoy to Vina. The cross-section line B-B' ranges from Chrome to Chico. Line C-C' transects the area midway between Artois and Willows and extends east to the area between Durham and Richvale. Line D-D' follows the Glenn-Colusa County line through Princeton and extends east into the area north of Gridley. Two north-south cross-section lines run down each side of the valley. Line E-E' represents an eastside transect that extends from the foothills southeast of Vina to the Sutter Butte mountain range in the south. Line F-F represents a west side transect that parallels I-5 near Red Bluff in the north and ends midway between Maxwell and Williams in the south.

Figure 1. Northern Sacramento Valley Geologic Map. Red lines illustrate geologic cross-sections used in investigations of the northern Sacramento Valley aquifer systems since 1997. The legend of corresponding geologic map units and names is below.



Electrical resistivity logs from natural gas and water wells were used to develop these sections. Resistivity surveys were performed in these wells before the casing and pump were installed. A probe consisting of paired electrodes was lowered into a borehole and an electrical current of a known voltage was sent from one electrode through the geological formation surrounding the borehole. The second electrode detected the drop in electrical current after it had been conducted through the formation. Formations with coarse gravel and sand have greater resistance to electrical current while fine grain formations such as clay have less resistance. Formations that contain saline water have even less resistance. Electrical resistivity data, portrayed on an electrical log, or e-log, was recorded continuously throughout the depth of the borehole and graphically displayed with computer software. The data were then used to determine the depth of various geologic formations. Geologic formations that have similar resistivity patterns or "signatures" allow correlation of these formations between various wells.

In this groundwater investigation, e-logs were gathered from numerous wells along the section lines shown in Figure 1. Resistivity data for each well were digitized and placed in the correct location along the cross-section line.

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Figure 2 illustrates how e-log data were compared to one another to identify similarities between boreholes and to develop a geological cross-section for each of the section lines shown in Figure 2.

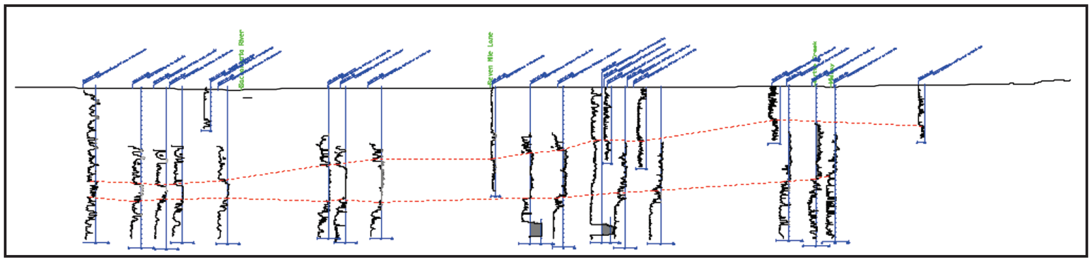


Figure 2. Illustration showing how electrical logs (e-logs) are used to correlate formations and develop geologic cross-sections.

FINDINGS FROM INVESTIGATIONS

Hydrogeology

Most people do not realize that the Sacramento Valley is primarily a saline water aquifer system, and that fresh groundwater is only found in the upper formations. Marine formations, such as the **Great Valley Sequence** and the **Lower Princeton Submarine Valley Fill** deposits, labeled in red in Figure 3, are the primary saline water aquifer systems in the northern Sacramento Valley. The groundwater from these aquifer systems is highly saline and unsuitable for either domestic or agricultural use. Transitional aquifer systems such as the **Neroly Formation, Ione Formation,** and **Upper Princeton Valley Fill** tend to contain a mixture of saline and fresh groundwater. These units are also labeled in red in Figure 3 and contain groundwater that may or may not be suitable for various uses depending on location.

Four major freshwater, or non-marine, formations exist in the northern Sacramento Valley. They are the **Alluvial** deposits, the **Tuscan Formation**, units A and B, the **Tuscan Formation**, unit C, and the **Tehama Formation**. These deposits overlie the marine, or saline, formations and are the major source of fresh groundwater to wells. These formations are shown in Figure 3, labeled in blue. The thin red line in Figure 3 below the Tuscan Formation and the Tehama Formation, and above the Great Valley Sequence, Neroly Formation, and Ione Formation represents the approximate contact between fresh and saline groundwater, occurring at a depth ranging from 1500 to 3000 feet below ground surface.

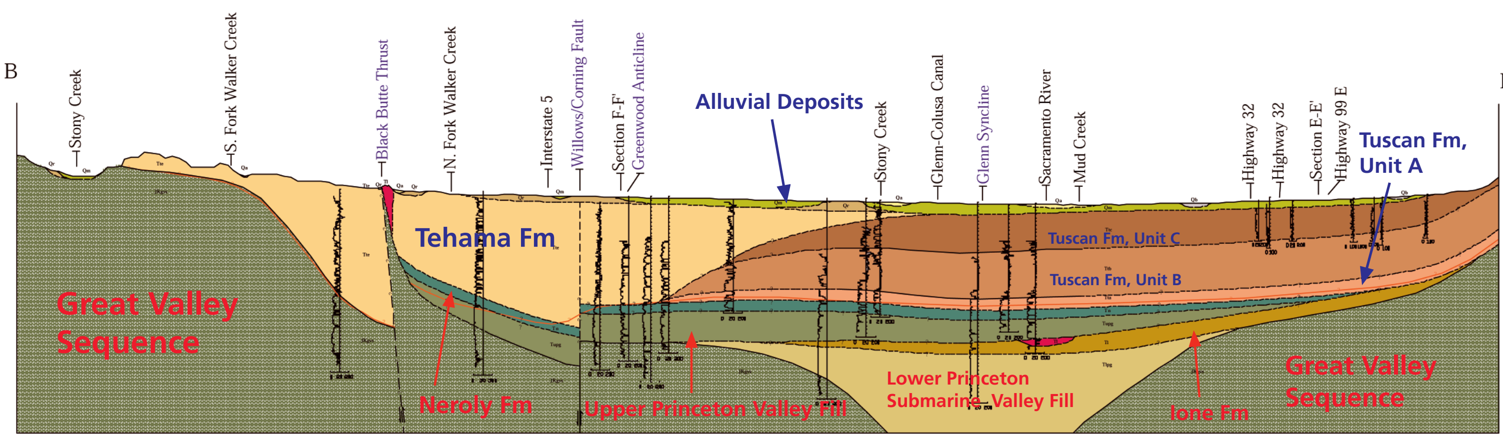


Figure 3. Geologic formations identified for cross-section line B-B' (refer to Figure 1) between Chrome on the west side of the Sacramento Valley and Chico on the east side to a depth of about 3000 feet. Surface landmarks provide orientation across the valley. The Tuscan Formation, unit D is illustrated in the surface geology (figure 1) near Red Bluff, However, it was not encountered in this cross-section or any of the other sections south of Red Bluff.

Freshwater Aquifer Systems

The **Alluvial aquifer system** is the uppermost groundwater bearing unit, reaching from ground surface to maximum depth of about 200 feet. Many domestic wells draw water from this aquifer system. In the northern Sacramento Valley, the Alluvial aquifer system is comprised of four different subgroups, according to geologic material, location and age of the geologic material, and the different rates each of the subgroups yield groundwater. The Alluvium, the Modesto and Riverbank Formations, and the Basin deposits are identified as Qa, Qm, Qr, and Qb, respectively, in Figure 1.

The Alluvium is composed of gravel, sand and silt deposited along active rivers and their tributaries. Groundwater yields can be productive from these deposits. The active gravel deposits found along Stony Creek and Thomes Creek are examples of Alluvial deposits. The Modesto Formation consists of gravel, sand, silt and clay deposits that border existing streams on both sides of the valley. The Riverbank Formation is composed of older gravel, sand and silt, and was deposited mainly on the west side of the valley. Groundwater yields in the Modesto and Riverbank Formations are also productive. Basin deposits consist of low permeable clays that usually produce little water to wells. The Butte Basin is an example of where Basin deposits occur.

The **Upper Tuscan** aquifer system is exposed on the east side of the valley along the foothills and is found at a depth of about 800 feet in the central portion of the valley. This aquifer system extends west past the Sacramento River under the surface, and underlies the Alluvial aquifer system. It consists of consolidated rocks and finer grained silts and clays formed from volcanic mud flows and yields various rates of groundwater. Along the eastern margin of the valley, well yields in the Upper Tuscan are low. Moving westward across the valley, the character of the Upper Tuscan changes to a more permeable water-bearing zone with groundwater production up to 6,000 gpm (gallons per minute). The Upper Tuscan aquifer system corresponds to the Tuscan Formation, units C and D, as shown in Figure 1.

The **Lower Tuscan** aquifer system is also exposed on the east side of the valley. In the central portion of the valley, it is found at a depth of about 1000 feet below ground surface. It lies beneath the Upper Tuscan aquifer system beginning at the eastern foothills and extends westward past the Sacramento River approaching Interstate 5 (see Figure 4). This aquifer system consists of gravels, sands, and silts that typically yield high flows (2000 to 3000 gpm). Artesian wells have been observed on the west side of this aquifer system due to the hydrostatic pressure from up gradient recharge areas to the east. The Lower Tuscan aquifer system corresponds to the Tuscan Formation, units A and B, as shown in Figure 1.

The **Tehama Formation** aquifer system is exposed on the west side of the Sacramento Valley, at a depth ranging from the ground surface to about 1000 feet. This formation underlies the Alluvial aquifer system to the east. The Willows-Corning Fault and the Black Butte Thrust Fault disrupt the continuity of the aquifer system. The Tehama Formation aquifer system was formed from the uplifting and erosion of the Coast Ranges and consists primarily of clay, sand and gravel. Groundwater is pumped from wells in this aquifer system but well yields and specific capacities (gpm per foot of drawdown in the well) are typically less than those in the Tuscan aquifer systems.

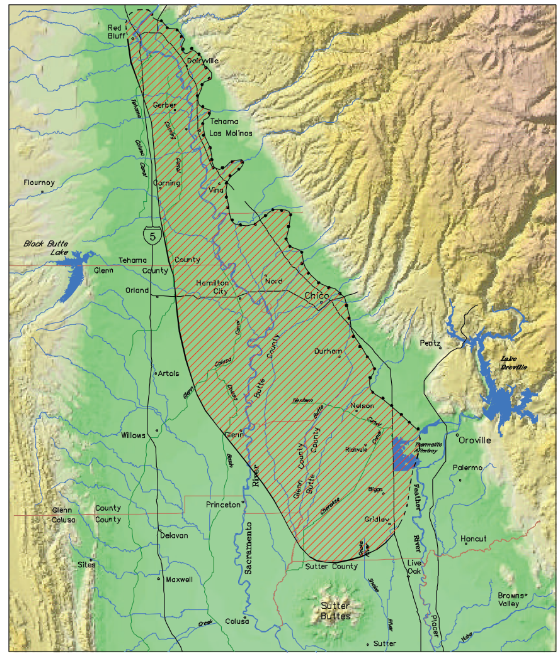


Figure 4. Buried extent of Lower Tuscan aquifer system in the northern Sacramento Valley.

The geologic cross-section (B-B) displayed in Figure 3 is representative of the other east-west cross-section lines (A-A', C-C,' and for the most part D-D'). The Tuscan aquifer systems are evident on the east side of the valley beginning near Red Bluff and extend as far south as Little Dry Creek in Butte County. Investigations along section line E-E' reveal slightly different geology, beginning at Little Dry Creek and extending south to the Sutter Buttes. Another aquifer system, the **Sutter Formation** aquifer system, overlies the Upper and Lower Tuscan aquifer systems. The Sutter formation originates at the base of the Sutter Buttes mountain range and forms an apron surrounding the Sutter Buttes that extends northward towards Little Dry Creek. On the west side of the valley, the Tehama aquifer system consistently extends from Red Bluff southward past Maxwell and Williams into the Southern Sacramento Valley.

VALUE OF UNDERSTANDING THE AQUIFER SYSTEMS

The hydrogeology illustrated in Figure 3 is complex, involving both saline and freshwater aquifer systems. These systems do not align well with county jurisdictions. As county governments and residents pursue local management to protect and manage groundwater, the geology of the aquifer systems suggests that cross-county coordination may eventually be necessary. It also suggests that groundwater monitoring should be in place for specific aquifer systems. Figure 4 illustrates the buried extent of the Lower Tuscan aquifer system. Understanding the extent of this potentially productive aquifer system is important to ensure that it is managed in the future to achieve a balance between preservation and utilization. Figure 5 shows postulated recharge areas for the Lower Tuscan aquifer system. Interestingly, some critical recharge areas appear to be along the foothills of the Cascade range. Ultimately, an improved understanding of the northern Sacramento Valley groundwater system protects against misconceptions from being taken as fact and identifies where further research is needed to continue to improve our understanding and management ability.

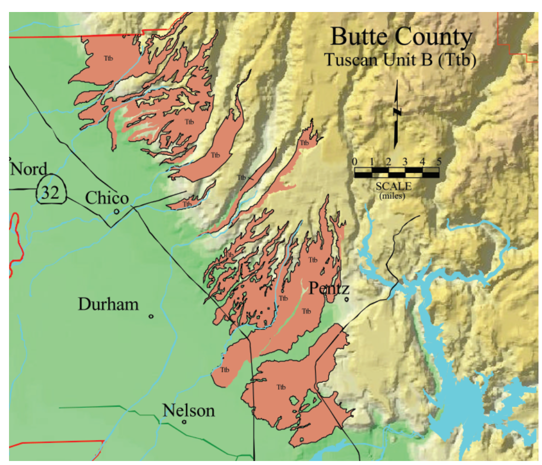
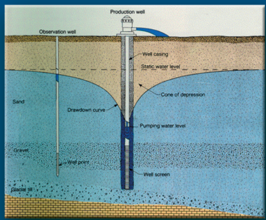


Figure 5. Some postulated recharge areas for the Lower Tuscan system.

RELATED NORTHERN SACRAMENTO VALLEY GROUNDWATER REFERENCES

- Kirk Bryan, USGS Water Supply Paper 495. Published 1923
- USGS Water Supply Paper 1497, Published 1961
- DWR Bulletin 118-6 - Evaluation of Groundwater Resources: Sacramento Valley. Published 1978



This newsletter is the first in a series of six discussing topics related to groundwater, water wells and pumping plants.

Seeking an Understanding of the Groundwater Aquifers Systems in the Northern Sacramento Valley

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