

AN EVALUATION OF GEOLOGIC CONDITIONS
EAST CONTRA COSTA COUNTY

Prepared for:

East Contra Costa County Agencies

Prepared by:

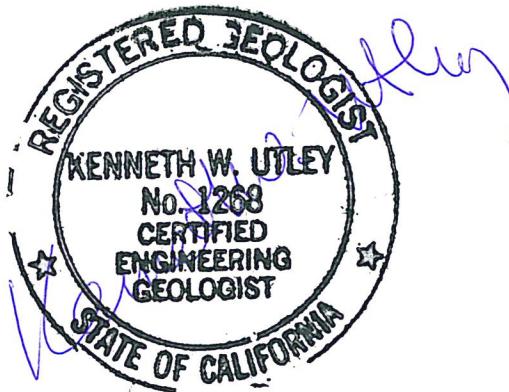
Luhdorff & Scalmanini, Consulting Engineers, Inc.

March 29, 2016

AN EVALUATION OF GEOLOGIC CONDITIONS
EAST CONTRA COSTA COUNTY

Prepared by:
Luhdorff & Scalmanini, Consulting Engineers, Inc.

March 28, 2016



Kenneth W. Utley

TABLE OF CONTENTS

1. INTRODUCTION	1
2. GEOLOGY	2
2.1 Coast Ranges Geology.....	2
2.2 Mesozoic Great Valley Sequence	2
2.3 Tertiary-Paleogene Sedimentary Rocks	3
2.4 Late Tertiary-Neogene Units.....	3
3. QUATERNARY GEOLOGIC HISTORY	4
4. GROUNDWATER HYDROLOGY	5
4.1 Brentwood Area	7
4.2 Tracy Area	7
4.3 Clifton Court Area	7
5. CONCLUSIONS	7
6. REFERENCES	8

1. INTRODUCTION

This report was prepared for the following local agencies located within the eastern portion of Contra Costa County:

- Byron-Bethany Irrigation District
- City of Brentwood
- Contra Costa County
- Diablo Water District
- East Contra Costa Irrigation District
- Town of Discovery Bay

These agencies authorized and funded the work to develop a fuller understanding of the geologic setting underlying the Contra Costa County portion of the Tracy Groundwater Subbasin (DWR 5-22.15). Other cooperating agencies included Contra Costa Water District and City of Antioch. The location of the Tracy Subbasin is shown on **Figure 1**.

The work described in this report was also undertaken to better understand differences among three subareas within the Tracy Subbasin, which are shown on **Figure 2**. The subareas are as follows:

1. The portion of the subbasin that occurs within Contra Costa County.
2. The portion of the subbasin that occurs within San Joaquin County north of Old River.
3. The portion of the subbasin that occurs within San Joaquin and Alameda counties south of Old River.

Local agencies in the Tracy Subbasin have engaged in efforts to comply with the 2014 Sustainable Groundwater Management Act (SGMA). The above subareas have been discussed among local agencies as potential boundaries for formation of Groundwater Sustainability Agencies and Groundwater Sustainability Plans. They also represent divisions in previous general water resource planning, including AB3030 Groundwater Management Plans, reflective of variations in groundwater occurrence and availability, and jurisdictional considerations. This report focuses on the geologic history of freshwater sediments from which groundwater is extracted for beneficial uses as defined and regulated under SGMA. The work is intended to provide a basis for hydrogeologic conceptualization of the subbasin and, through its design and approach, to identify connections or distinctions that will aid in the development of Groundwater Sustainability Plans. In accordance with the objectives of the funding agencies, the work was also undertaken to assess any basis for modifying the Tracy Subbasin boundaries to enable more local control over groundwater resources.

2. GEOLOGY

The study area for this report is the northwestern portion of the San Joaquin Valley where it merges in the Delta area with the Sacramento Valley of the larger geologic province of the Great Valley (see **Figure 3**). The study area encompasses the eastern portion of the Contra Costa County and western San Joaquin County to south of the City of Tracy. Fresh groundwater is produced for municipal, domestic, and irrigation from underlying unconsolidated alluvial fan and fluvial sedimentary deposits. Much irrigation water is also supplied by surface water from various sloughs and ditches, particularly in the eastern portion of the study area.

2.1 Coast Ranges Geology

West of the San Joaquin Valley lies the Coast Ranges geologic province of uplifted, older, highly deformed, and well-consolidated geologic units. The immediate range is termed the Diablo Mountains, but is subdivided here as the Mt. Diablo area north of Livermore Valley, and the southern Diablo range to the south. These areas have had a long history of sedimentary deposition, deformation, and uplift. The geologic units are a record of the plate tectonic evolution of California. The units exposed in the Mt. Diablo Mountains extend eastward below the San Joaquin valley at great depths. These units are divided into three broad categories: the Mesozoic Great Valley Sequence, the Tertiary (Paleogene) sedimentary rocks, and the late Tertiary (Neogene) sedimentary rocks. These exposures in the Diablo Mountains are shown on **Plate 1**.

Regional geologic relationships are best seen on the San Francisco-San Jose Quadrangle map (Wagner and others, 1990). Numerous more detailed geologic maps and reports cover the area. The most accessible detailed maps are by T.W. Dibble, Jr. from the Dibblee Foundation series and which were used in preparing this report. Reports summarizing the geologic history include the classic Hackel (1966), and the more recent Bartow (1991), which is the main source for this report.

2.2 Mesozoic Great Valley Sequence

The Mesozoic (pre-65 million years (m.y.)) Great Valley Sequence consists of deep water marine sedimentary deposits grading eastward into shallow marine and deltaic deposits. These units were deposited in the forearc basin in the convergent plate tectonic setting of the subduction of the Pacific Plate below the North American Plate. The Andes-like volcanics to the east in the Sierra Nevada area was the source of the sediment carried into the forearc basin. The Great Valley Sequence occurs in the Mt. Diablo area and the southern Diablo range, and underlies younger deposits below the San Joaquin Valley.

In the Mesozoic of the northwestern San Joaquin Valley area, a structural element formed that influenced depositional patterns for a long period of geologic time. The Stockton Fault appears to be initially a down-thrown to the south normal fault with greater thickness of the Great Valley Sequence to the south. The cause of the Stockton Fault is not clear from a tectonic framework, and different theories have been

proposed (Bartow, 1991). Subsequent activity on the fault shows opposite movement as a reverse fault with down to the north relative motions.

2.3 Tertiary-Paleogene Sedimentary Rocks

Beginning in the early Tertiary, the plate tectonic configuration began to change as plate subduction angles altered, and the change to a transform boundary of the ultimate San Andreas Fault system began to evolve. During much of the Paleogene (about 59 to 23 m.y.), the San Joaquin Valley and Coast Ranges were dominated by alternating sequences of marine inundations of shallow marine deposits and periods of non-marine sequences (Bartow, 1991). Even during deposition of non-marine sequences, marine deposition continued north of the Stockton Fault and in the southern San Joaquin Valley.

The Paleogene sedimentary rocks are exposed on the northern edge of the Mt. Diablo area, west of the City of Brentwood (see **Plate 1**). These deposits are largely marine sandstones and shales, and their exposure pattern may reflect the Sherman Island and Midlands Faults. The units extend below the Valley floor north of the Stockton Fault.

During the Tertiary Period, the Stockton Fault assumed a down to the north reverse fault movement. On the uplifted southern side of the fault, the Paleogene sedimentary units are absent for 20 miles or more to the south (Bartow, 1985; 1991). This area is identified as the Stockton Arch where the Paleogene rocks were never deposited or removed by erosion. South of the Stockton Arch, marine conditions also continued interrupted by non-marine periods. By the end of the Paleogene, the marine conditions persisted in the south valley. Drainage from the Sierra region appears to be to the south (Bartow, 1991). Exposures of the Paleogene rocks are not present to south of the southern Diablo range, along the western San Joaquin Valley, but are present below the valley south of the Stockton Arch.

2.4 Late Tertiary-Neogene Units

In the Neogene, plate tectonics evolution was dominated by the northward migration of the triple junction plate boundary as the strike-slip fault system of San Andreas Fault zone formed. East of the fault zone, elements of the Coast Range were deformed and uplifted to positive elements. At times, these deformations yielded sediment into the San Joaquin Valley. The Stockton Fault movement appears to have ended in the early Neogene with total reverse offset of about 10,000 feet. The Stockton Arch may have acted as a positive element as Bartow (1991) shows the area as a divide between drainage to the Sacramento Valley to the north and to the south to the marine embayment in the San Joaquin Valley. North of the Stockton Arch, shallow marine conditions also persisted, including at times, across the Mt. Diablo area, until at least 9 m.y.

The earliest Neogene (Miocene 23 to 5.3 m.y.) units exposed along the northern edge of Mt. Diablo area are shallow marine transitioning to non-marine. Further south, exposures are more limited until a larger area wraps around south of Mt. Diablo area towards the Livermore valley (see **Plate 1**). The units tend to be predominated by sandstone to pebbly sandstones.

In the younger Neogene (Pliocene 5.3 to 2.5 m.y.), the San Andreas Fault system was well established and deformation and uplift of the Coast Range to the east was occurring. Sierra Nevada drainages appear to continue to the remaining southern San Joaquin Valley marine embayment (Bartow, 1991). The exposures of these younger Neogene units overlie the older Neogene units around the Mt. Diablo area and southern Diablo range. Where exposed, the unit is dominated by pebbly sandstone to the north and conglomerate/sandstones to the south. These appear to be sourced from the uplifted Coast Range elements and deposited by alluvial fans.

Both the older and younger Neogene units extend eastward beneath the northern San Joaquin Valley, but are poorly understood even from deep oil and gas well logs. Part of the cause of this is that the state Division of Oil and Gas field classification designates post-Paleogene units as undifferentiated non-marine units. Gas fields in western San Joaquin County indicate 3,000 to 4,000 feet of post-Paleogene units, but includes younger Quaternary units. Electric logs tend to show the Neogene units are dominated by monotonous sequence of fine-grained sediment of sandy claystones and mudstones with few sand beds. The units also appear to contain at best brackish to saline water, although it is difficult to define base of fresh water without interbedded sand beds.

By the end of the Neogene, movement along the San Andreas Fault system had isolated the southern San Joaquin marine embayment from the ocean (Bartow, 1991). The impounded water probably transformed into brackish- to fresh-water lakes. Drainage in the San Joaquin Valley continued to flow southward towards the subsiding lake basin area. Drainage from the lakes appears to have flowed from the basin across the San Andreas Fault to the Salinas Valley and Monterey Bay area. To the north of the Stockton Arch, area drainage in the Sacramento Valley appears to continue to drainage westward north of the Mt. Diablo area.

3. QUATERNARY GEOLOGIC HISTORY

The youngest geologic unit in the San Joaquin Valley area is the Quaternary (2.5 m.y. to present) unconsolidated sedimentary units of sand, gravel, silt and clay that cover the valley floor. Most of these deposits are probably of the longer, older Pleistocene Epoch (2.5 to 0.01 m.y.), the Great ice Age when alpine ice fields and glaciers occurred along the summit of the Sierra Nevada. High runoff and sediment yield from the Sierra Nevada appears to continue to largely drain to the lakes in southern San Joaquin Valley. Drainage out of the lakes may have persisted across the San Andreas Fault system to the Salinas valley for at least the older Pleistocene.

The plate tectonic configuration of the San Andreas Fault was well formed in the Pleistocene. The Diablo ranges continued to be uplifted as shown by the deformed Neogene units around the Mt. Diablo area (see **Plate 1**). The westward tilting of the Sierra Nevada block begun in the Pliocene also continued in the Quaternary. From these uplifted areas, smaller stream drainages formed alluvial fans off the Diablo Mountains into the valley. Larger drainages from the Sierra Nevada formed broad alluvial-fluvial plains

from the east. In the center of the valley, low gradient stream channels and flood plains were formed, flowing southward to the southern lakes.

Just prior to about 600,000 years before present, a large lake termed the Corcoran Lake flooded nearly all the San Joaquin Valley northward to the Tracy area. A widespread blue lake clay was deposited across the San Joaquin Valley known as the Corcoran Clay, or E-clay. This clay has not been identified further north into the Delta area of Contra Costa County, or in the Sacramento Valley. The cause of the formation of the Corcoran Lake, and smaller subsequent lakes, is not clear. Possibilities include that the San Andreas Fault system blocked the western drainage outlet of the lakes in the south, at least for brief periods. Alternatively, higher runoff due to climatic conditions may have been the principal cause that formed the lakes.

The northern extent of the Corcoran Lake, including the deposition of the E-Clay, appears to have been in the Stockton-Tracy area. The cause of this is not clear. An alluvial fan dam across the valley (Atwater, 1986) or a structural-caused drainage divide by differential subsidence between the north and south across the Stockton Arch may explain the northernmost extent. Other possible causes could be structural blockage of the drainage out of the Sacramento Valley or regional tilting of the northern San Joaquin Valley.

It is tempting to suggest that the high base-level of the Corcoran Lake disrupted drainage patterns in the San Joaquin Valley. Possible subsequent opening of a shorter drainage pattern of the Sacramento River across the San Francisco Bay area, caused San Joaquin drainage to be diverted to the Delta area, until the drainage pattern of northward flowing San Joaquin River developed through the remainder of the Pleistocene.

4. GROUNDWATER HYDROLOGY

The groundwater hydrology of the northwestern San Joaquin Valley area that is the focus of this report is relatively poorly known. The reasons of this are multifold. Groundwater usage is limited to eastern Contra Costa County and the Tracy area to the south. Under most of western San Joaquin County in the Delta, few groundwater wells exist as surface water is the source for irrigation use within delta islands. Fresh groundwater aquifers are limited to relatively shallow depths of 500 to 700 feet in the Contra Costa County area, and to 1,600 feet in the Tracy area. Oil and gas electric logs indicate that at greater depths fine-grained clays and mudstones with very few sand beds occur, and contain saline to brackish water. Some saline waters at shallow depths above the fresh water bearing sands have been found along the trend of the Old River channel.

Hydrogeologic studies have tended to cover areas in the Sacramento Valley north or east of the Delta area. In the San Joaquin Valley, studies have covered areas on the west side of the valley studies have covered areas from Tracy south (Hotchkiss and Balding, 1971) and on the east side of the valley south of

the Stanislaus River (Page and Balding, 1973). Even regional studies tend to have little information for the northwestern San Joaquin Valley area (Page, 1986).

Luhdorff & Scalmanini (1999) performed a study of eastern Contra Costa County groundwater for five local water agencies. The focus of the study was the uppermost 500 feet in which most water wells were completed. A depositional facies model was developed from examination of over 500 well logs that were used to assess sand bed characteristics and their extent. The facies consisted of a fluvial plain grading into a delta island area in the north. This was bound to the west by a marginal delta dunes area. An alluvial plain area extends and thins westward to the older geologic units exposed in the Mt. Diablo area. This depositional model was incorporated into an AB3030 Groundwater Management Plan covering the sphere of influence for Diablo Water District, an Environmental Impact Report for conjunctive use wells by Diablo Water District, and a water master plan for Town of Discovery Bay.

Electric logs from Oil and Gas were also examined for the nature of geologic units at greater depths. The top of the electric logs tend to be at 800 feet or greater depths. These logs generally show fine-grained geologic units with few sand beds. The depth to base of fresh water is difficult to discern in available electric logs because of the lack of sand beds. In the 1999 study of groundwater hydrology in eastern Contra Costa County, the base of fresh water was not systematically mapped. The base of freshwater has been mapped previously in the general area by Page (1971) and Berkstresser (1973).

Most groundwater studies in the westerns San Joaquin County have been centered on the Tracy area. The Tracy Regional Groundwater Management Plan (GEI, 2007) and a related hydrogeologic assessment (GEI, 2007) were reviewed for the geologic cross-sections and interpretations. These reports characterized groundwater wells in the immediate Tracy area, and additional review of these wells was not attempted for the present study.

For the present study, a systematic map of the base fresh water aquifers in the area using electric logs for oil and gas wells obtained through the state Division of Oil, Gas & Geothermal Resources website was developed (see **Plate 1**). As mentioned previously, depths to the top of most logs and the fine-grained character of the sedimentary units below 700 feet were limitations in the north. Selection of logs to review was based on the top of the log being less than 1,000 feet in depth. Base of fresh water aquifers was based on thick sand beds with high resistivity values and the character of the self-potential response on the electric logs. Deeper sandy units, probably sandy clays or mudstones, with low resistivity values and indeterminable self-potential characteristics were considered to be non-viable as aquifers.

The elevation of the base of freshwater aquifers determined from oil and gas logs were plotted on a base map (see **Plate 1**) and manually contoured. Contour lines of one hundred feet were drawn, but is variable based on well control. The resulting map is a hydrostratigraphic map based on the nature of the bed (sand and/or gravel) and containing fresh water. The determined beds at each location should not be considered, in general, as lithostratigraphic equivalent (i.e., connected to other beds in different wells

across the map), or necessarily time-stratigraphic equivalent (i.e., of the same geologic age). For example, the beds defining the deepest areas on the map are probably not connected or time equivalent to beds at much shallower depths to the east or west. The resultant map represents the most detailed examination of base of fresh water in the north San Joaquin Valley study area.

4.1 Brentwood Area

In the Brentwood area, the depth of freshwater aquifer descends eastward from the edge of the valley. The deepest area occurs near the Contra Costa County line to -1,200 feet. Further east the depth of freshwater aquifer rises to -600 feet. Several gas fields are shown further east (see **Plate 1**) which show base of fresh water as 100 feet depth or less (California Division of Oil & Gas, April 1983). However it is not known exactly how these values were determined.

4.2 Tracy Area

In the Tracy area, the depth of freshwater aquifer descends eastward from the edge of the valley. A larger, deeper depression occurs beneath the City of Tracy to depths of -1,600 feet. This depression appears to bend and extend eastward roughly along the trend of the Stockton Fault (see **Plate 1**). Further east the depth of freshwater aquifer rises to -500 to -600 feet elevation. The Lathrop Gas field lists the base of freshwater at a depth of 300 feet, though the method of determination is not evident.

4.3 Clifton Court Area

The base of freshwater determined for the Brentwood and Tracy areas are generally are similar to published base of fresh water by Page (1971) and Berkstresser (1973). Between these two areas, is termed the Clifton Court area. Although well control is relatively sparse in this area, anomalously shallow elevations of base of freshwater occur further east. Contouring of the area shows a possible ridge-like extension eastward from the edge of the valley. Further eastward, depths of the base of freshwater decline to -800 feet to -900 feet elevation and extend eastward, then rises to the east to -600 feet elevation. The maximum low across the Clifton Court area appears to be 300 feet shallower in the Brentwood area (-1,200 feet elevation), and possibly 700 feet shallower than in the Tracy area (-1,600 feet elevation). If this interpretation of a ridge-like feature is correct, the cause is not clear. It may be a possible fault uplift or deformation on the south side of the Vernalis fault. The age of the Vernalis Fault is not well known (Bartow, 1991), but it is at least Neogene (Miocene to Pliocene?) and may be younger (Quaternary?). No surface expression has been noted to the fault and if this configuration exists, it may influence groundwater flow around the ridge, or at least impede any northwest flow from the south at depths below -400 feet elevation.

5. CONCLUSIONS

The geologic history of the northwestern San Joaquin Valley as described in this report provides a framework for hydrogeologic conceptualization of the Tracy Groundwater Subbasin. Key features of the

geologic history are reflected in exposures of Mesozoic Great Valley Sequence, and Tertiary and late Tertiary sedimentary rocks in the Diablo Mountains. These rocks represent the western boundary of the Tracy Subbasin.

While the interpreted geologic history consists of multiple possible explanations for certain features, the rocks in the Mt. Diablo range north of Livermore Valley and the southern Diablo range reflect distinctions between the northern and southern portions of the groundwater subbasin including variations in the base of fresh water. Additionally, the apparent northern extent of the Quaternary Corcoran Lake has implications in groundwater hydrology, particularly through the occurrence of the Corcoran Clay. The Corcoran Clay is prominent as a demarcation between the primary upper and lower freshwater aquifer sequences of the San Joaquin Valley and affects vertical groundwater movement including recharge, demarcates water quality boundaries, and it is an important factor in well construction standards throughout the San Joaquin Valley. The absence of the Corcoran Clay in the Contra Costa County subarea reflects a distinction in the hydrogeology across the Tracy Subbasin that is recognized locally and should be reflected in the development of groundwater conceptualizations for the subbasin.

6. REFERENCES

- Atwater, Brian F.; Adam, David P.; Bradbury, J. Platt; Forester, Richard M.; Mark, Robert K.; Lettis, William R.; Fisher, G. Reid; Gobalet, Kenneth W.; Robinson, Stephen W. 1986. *A fan dam for Tulare Lake, California, and implications for the Wisconsin glacial history of the Sierra Nevada*. Geological Society of America Bulletin, Volume: 97 Issue: 1
- Bartow, J.A. 1985. *Map showing Tertiary stratigraphy and structure of the Northern San Joaquin Valley, California*, Field Studies Map MF-1761, Scale 1:250,000.
- Bartow, J.A. 1991. *The Cenozoic Evaluation of the San Joaquin Valley, California*. U.S. Geological Survey, Professional Paper 1501.
- Berkstersser, Jr., C.F. 1973. *Base of fresh ground water approximately 3,000 micromhos in the Sacramento Valley and Sacramento-San Joaquin Delta, California*. U.S. Geological Survey, Water-Resources Investigations Report 73-40.
- California Division of Oil & Gas. 1982. *California Oil and Gas Fields*. Northern California, Volume 3.
- Dibblee, Jr., T.W. 2006. *Geologic Map of the Antioch South and Brentwood Quadrangles, Contra Costa County, California*. Dibblee Geology Center Map DF-193, Scale 1:24,000.
- Dibblee, Jr., T.W. 2006. *Geologic Map of the Byron Hot Springs and Clifton Court Forebay Quadrangles, Contra Costa, Alameda, and San Joaquin Counties, California*. Dibblee Geology Center Map DF-195, Scale 1:24,000.

Dibblee, Jr., T.W. 2006. *Geologic Map of the Midway and Tracy Quadrangles, Alameda and San Joaquin Counties, California*. Dibblee Geology Center Map DF-243, Scale 1:24,000.

GEI Consultants. 2007. *Hydrogeologic Assessment Report for the Tracy Subbasin*. Prepared for City of Tracy. January.

GEI Consultants. 2007. *Tracy Regional Groundwater Management Plan*. Submitted to City of Tracy. March.

Hackel, O. 1966. *Summary of the Geology of the Great Valley*. In *Geology of Northern California*, Bulletin 190, E.H. Bailey, ed. San Francisco, California: United States Geological Survey, California Division of Mines and Geology.

Hackel, O. 1966. *Summary of the Geology of the Great Valley*. In *Geology of Northern California*, Bulletin 190, E.H. Bailey, ed. San Francisco, California: United States Geological Survey, California Division of Mines and Geology.

Hotchkiss, W.R. and Balding, G.O. 1971. *Geology, hydrology, and water quality of the Tracy-Dos Palos area, San Joaquin, California*. U.S. Geological Survey. Open-File Report 72-169.

Luhdorff & Scalmanini Consulting Engineers. 1999. *Investigation of Groundwater Resources in the East Contra Costa Area*. Prepared for five water agencies. March.

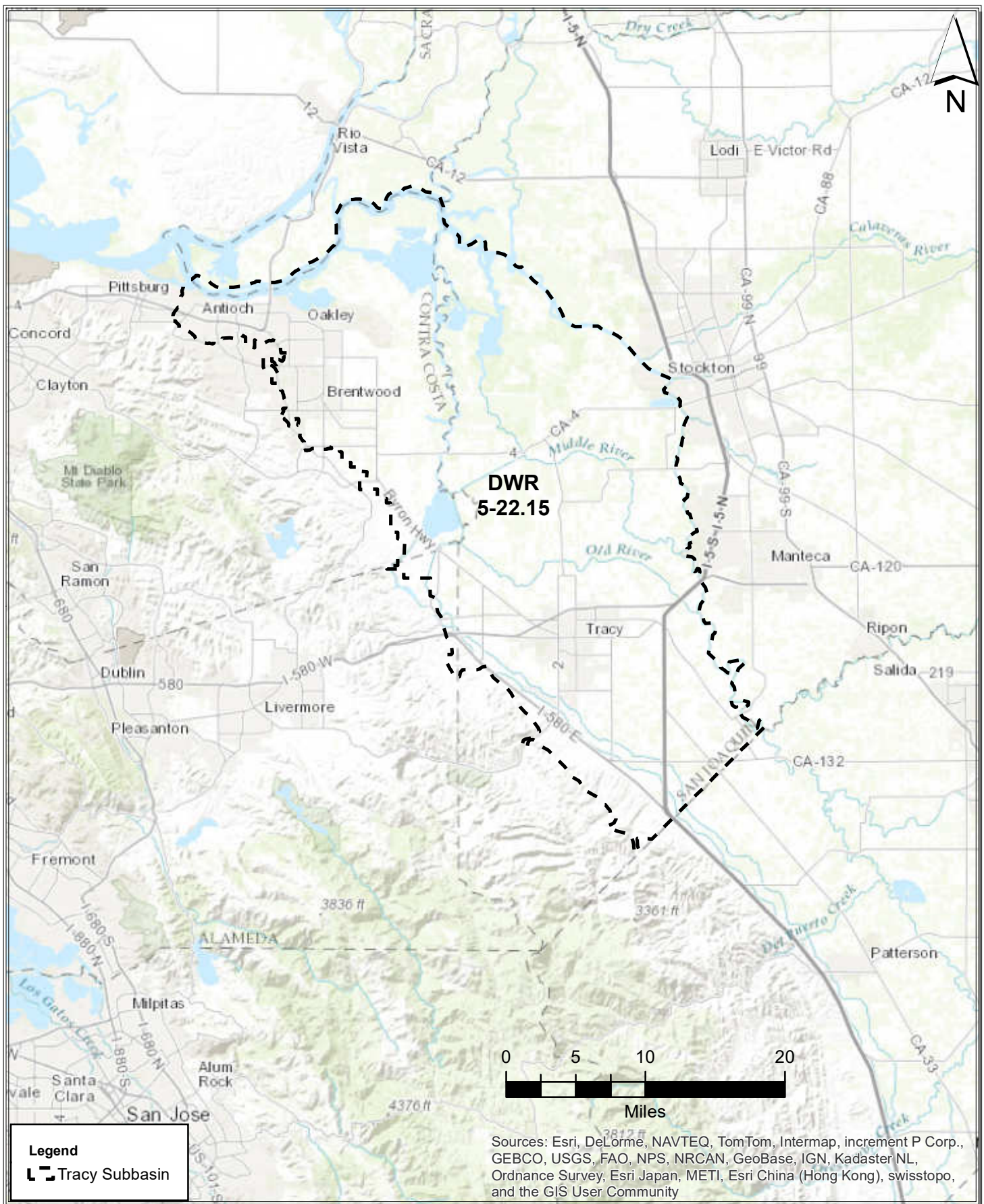
Page, R.W. 1973. *Base of fresh ground water (approximately 3,000 micromhos) in the San Joaquin Valley, California*. Hydrologic Atlas 489.

Page, R.W. 1986. *Geology of the fresh ground-water basin of the Central Valley, California, with texture maps and sections*. Professional Paper 1401-C.

Page, R.W. and Balding, G.O. 1973. *Geology and quality of water in the Modesto-Merced area, San Joaquin Valley, California, with a brief section on hydrology*. Water-Resources Investigations Report 73-6.

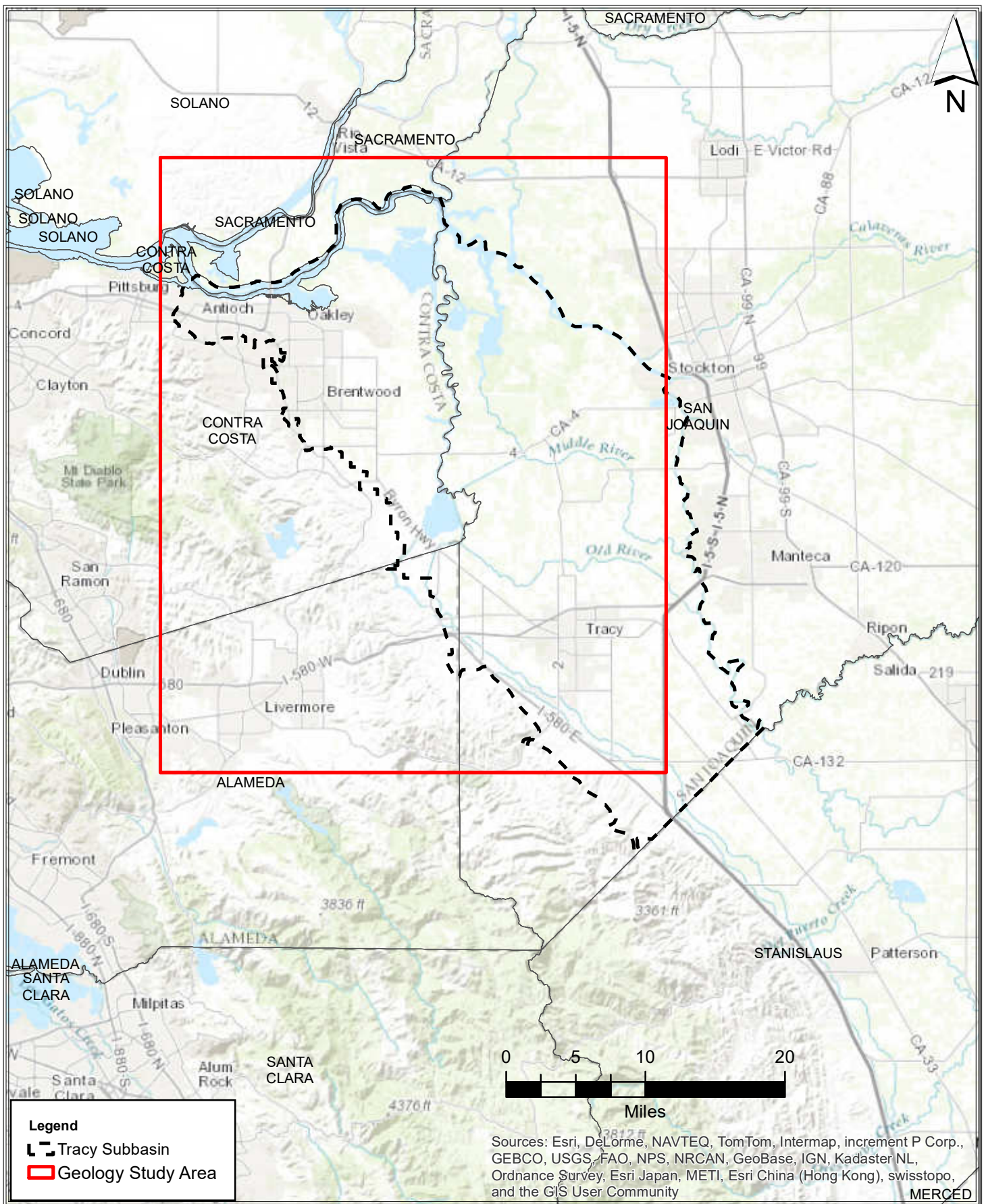
Wagner, D.L., Bortugno, E.J. and McJunkin, R.D. 1991, Compilers. *Geologic Map of the San Francisco - San Jose Quadrangle*. California Geological Survey, Regional Geologic Map No. 5A, 1:250,000 scale.

Figures



\\SERVER_PE2900\\Public\\Tom Elson\\000 Sunol ACRP rev CEQA analysis 2016feb\\GIS\\Tracy Subbasin\\Figure 1.mxd





\\SERVER_PE2900\\Public\\Tom Elson\\000 Sunol ACRP rev CEQA analysis 2016feb\\GIS\\Tracy Subbasin\\Figure 3.mxd

Plate

