Attachments to Accompany
Application for Temporary Water Right Permit for Groundwater Recharge of Eastside Water District
Sand Creek Managed Aquifer Recharge Project

ATTACHMENT 1

3. Project Description

Eastside Water District (EWD), located near the community of Denair in the San Joaquin Valley, is in the process of designing and constructing pilot facilities to demonstrate Managed Aquifer Recharge (MAR) concepts to help achieve a long-term sustainable groundwater supply for over 62,000 acres of prime farmland.

EWD is located in Stanislaus and Merced Counties within the Turlock Groundwater Subbasin (Subbasin) of the San Joaquin Valley Groundwater Basin (DWR Bulletin 118 Subbasin No. 5-22.03), as shown in **Attachment 4**. Groundwater levels within EWD have experienced significant declines over a 50-year period of record from the mid 1960's through 2014. Groundwater levels have declined 50 to 70 feet in the western and central portions of the EWD. Water level declines have been more severe in the eastern portion, with declines of up to 85 feet. The average annual rate of groundwater decline from wells located in the western and central portion have been observed to be between 1 and 2 feet per year. In the eastern portion, the annual rate of groundwater decline has been estimated recently at 3.8 feet per year. More detailed information on the groundwater conditions in the Subbasin is provided in the letter-report by ePUR and Wood Rogers, "Eastside Water District – Geologic, Hydrologic, and Hydrogeologic Characterizations for Potential Managed Aquifer Recharge of Diffused Stormwater", dated November 6, 2014, and attached to the Underground Storage Supplement accompanying this application.

Sand Creek is an ephemeral stream that flows seasonally in most winter periods through the EWD before being truncated by the Turlock Irrigation District (TID) Main Canal where it then discharges. The TID Main Canal supplies a system of distribution laterals that ultimately discharge to the main stem San Joaquin River and to the Merced River. The drainage area of Sand Creek upstream of its confluence with TID's Highline Canal is approximately 8,000 acres.

Sand Creek does not have any existing major flood control structures, however, flooding does occur in several areas. The Sand Creek Flood Control District was established in 1968 to provide maintenance of existing flood control facilities within the District boundaries. Diverting stormwater from Sand Creek for groundwater recharge projects has the potential to reduce downstream flooding.

The location and principal features of the Sand Creek MAR Project are depicted on **Attachment 4**. The Sand Creek MAR Project is located downstream of the Montpelier Road crossing, approximately 5 miles east of Denair, CA. The project is located in a reach of the creek that has been realigned from its natural alignment, and involves widening and deepening 280 lineal feet of the realigned watercourse. The watercourse would be deepened over this reach to below the indurated sediment horizons (e.g. duripan) thereby increasing the permeability of

the stream bed and banks to percolate water. The watercourse would be widened to 75 feet over this 280-foot reach, creating an approximate half-acre infiltration basin within the watercourse. The depth of excavation through the creek bed is expected to be approximately 15 feet. Excavated soil materials will be stockpiled on-site on fallowed agricultural land. There are no diverters of record downstream of the Sand Creek MAR Project to its discharge point into the TID Main Canal.

The drainage area of Sand Creek above the project location is about 5,000 acres. Due to the ephemeral nature of Sand Creek, project construction can be completed during the dry season with no incremental concern regarding sediment erosion into the creek during and after construction. The Sand Creek MAR Project is designed to artificially enhance percolation from the creek bed itself by reducing creek flow velocity and exposing the creek bottom and side slopes to higher head.

6. Water Availability

There is a reasonable likelihood that unappropriated water is available for the proposed appropriation since diversion of water would only occur during high flow events in the Sand Creek watershed. Eastside Water District consultants have prepared rainfall-runoff analyses for water projects within the district and have estimated a yield of about 2,400 acre-feet of runoff in an average year in the Sand Creek watershed. The subject pilot project estimates a projected maximum diversion to underground storage of about 720 acre-feet. The proposed diversion would be less than a third of the total estimated runoff and would potentially minimize problems of flooding downstream.

7. Place of Use

Infiltrated water will accrue to the Turlock Groundwater Basin and will be commingled with other sources of water that contribute to the basin. Groundwater will be withdrawn by existing wells owned and operated by agricultural water users within the boundaries of EWD as shown on the map accompanying this application (**Attachment 4**).

10. Diversion and Distribution Method

Flows diverted to groundwater storage are unknown but are anticipated to range from 0.5 cfs to a high of 2 cfs given the limited footprint of this pilot project and manner of recharge via enhanced percolation through an ephemeral creek bed. Flow rates and volumes actually diverted by the Sand Creek MAR Project will be measured by rehabilitating and modifying two existing instream concrete flow control structures located upstream and downstream of the infiltration

basin. The concrete bottom and sides of each structure will be rebuilt to a known aperture and an open-bottom PVC standpipe will be installed to house an electronic pressure transducer. The rating curve for each structure will be used to calculate the loss in flow (i.e. estimated infiltration) between the upstream structure and the downstream structure. The upstream structure is located approximately 30 feet upstream of the Sand Creek MAR Project, and the downstream structure is located approximately 1,750 feet downstream of the Project. Their close proximity will provide fairly accurate measurement of the change in creek discharge although additional accretionary flow may occur over this roughly 2,000-foot reach (separation plus 280-foot project length). The relatively low rate of infiltration will be make accurate quantification of the diversion imprecise during high flow periods. Quantification of diversion during high flow periods will be estimated from antecedent diversion rates and descendant diversion rates during more quiescent flows in Sand Creek.

SAND CREEK SITE MAP

E. . SIDE WATER DISTRICT

STANISLAUS COUNTY, CA

APRIL, 2016

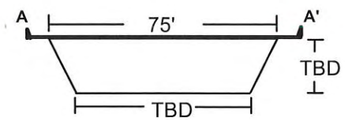
NORTH

0 25 50

FEET

- Trench/Basin
- Sand Creek
- Water Flow Direction
- Cross-Section Line

Cross-Section View



EPUR Safe Water for All

WOOD RODGERS

ATTACHMENT 2

State Water Resources Control Board

Division of Water Rights

1001 I Street • Sacramento, California 95814• (916) 341-5300
Mailing Address: P.O. Box 2000 • Sacramento, California • 95812-2000
FAX (916) 341-5400 • http://www.waterboards.ca.gov/waterrights

Linda S. Adams
Acting Secretary for Environmental Protection

Edmund G. Brown Jr.
Governor

APPLICATION NO. _____
(Leave blank)

UNDERGROUND STORAGE SUPPLEMENT TO APPLICATION TO APPROPRIATE WATER BY PERMIT

1. State amount of water to be diverted to underground storage from each point of diversion in item 3b of form APP.

a. Maximum Rate of diversions (1) 2 (2) _____ (3) _____ cfs
b. Maximum Annual Amount (1) 720 (2) _____ (3) _____ acre-feet

2. Describe any works used to divert to offstream spreading grounds or injection wells not identified in item 7 of form APP.

All works used divert to offstream spreading grounds are identified in Attachment 1 in response to Item 3 of the Application form.

3. Describe spreading grounds and identify its location and number of acres or location of upstream and downstream limits if onstream.

The spreading grounds consist of a 280 foot reach of the existing water course, widened to 75 feet, creating roughly a 0.5 acre area.

4. State depth of groundwater table in spreading grounds or immediate vicinity:
202.6 feet below ground surface on 10/20/2014 19XX measured at a point located within the SW ¼ of SE ¼ of Section 6, T 5S, R 12E, MD B&M

5. Give any historic maximum and or minimum depths to the groundwater table in the area.

Location 5S/12E-6Q1 Maximum 210 feet below ground surface on 11/26/2012 (date)
Location 5S/12E-6Q1 Maximum 143 feet below ground surface on 3/8/2001 (date)

6. Describe proposed spreading operation.

See Attachment 1 response to Item 3 of the Application form.

ATTACHMENT 3

7. Describe location, capacity and features of proposed pretreatment facilities and/or injected wells.

NA

8. Reference any available engineering reports, studies, or data on the aquifer involved.

California Department of Water Resources (CA DWR) Bulletin 118. Groundwater Basin Number 5-22.03, San Joaquin Valley Groundwater Basin, Turlock Subbasin. Also see letter-report by ePUR and Wood Rogers "Eastside Water District - Geologic, Hydrologic, and Hydrogeologic Characterizations for Potential Managed Aquifer Recharge of Diffused Stormwater", 11/6/2014 (attached hereto).

9. Describe underground reservoir and attach a map or sketch of its location.

See Map, Attachment 4 to the Application form. Also see letter-report by ePUR and Wood Rogers "Eastside Water District - Geologic, Hydrologic, and Hydrogeologic Characterizations for Potential Managed Aquifer Recharge of Diffused Stormwater", 11/6/2014 (attached hereto).

10. State estimated storage capacity of underground reservoir.

Per CA DWR Bulletin 118, the total storage capacity of the Turlock Subbasin is estimated to be 30,000,000 acre-feet to the base of fresh groundwater.

11. Describe existing use of the underground storage reservoir and any proposed change in its use.

The underground storage reservoir is currently used for municipal, domestic, commercial, industrial, stockwatering, and irrigation purposes. Eastside Water District users primarily use water from the underground storage reservoir for irrigation purposes. Change in use will be minimal because this is a pilot project.

12. Describe the proposed method and location of measurement of water placed into and withdrawn from underground storage.

See Attachments 1 and 4 to Application form for measurement of water placed into underground storage. Water withdrawn from storage will be measured based on changes in groundwater level as determined from 16 monitoring wells, 5 of which are CASGEM wells (see Attachment 4 for monitoring well locations).

Additional copies of this form and water right information can be obtained at www.waterrights.ca.gov.

November 6, 2014

Kevin M. Kauffman, P.E.
Eastside Water District, Acting General Manager
P.O. Box 692632
Stockton, California 95269-2632

Dear Mr. Kauffman:

Subject: Eastside Water District – Geologic, Hydrologic, and Hydrogeologic Characterizations for Potential Managed Aquifer Recharge of Diffused Stormwater

In accordance with our Contract, Wood Rodgers, Inc. (Wood Rodgers) is pleased to submit this letter report that details our Geologic, Hydrologic, and Hydrogeologic Characterizations for Potential Managed Aquifer Recharge (MAR) of Diffused Stormwater. This report is the major deliverable for this project.

Introduction

Eastside Water District (EWD) solicited qualifications in April 2014 for a design effort to develop MAR for what has been identified as up to 60 cfs' of inflow into the Highline Canal. This specific stormwater is considered runoff, or "diffused" overland flow, that has not or will not gather to a natural watercourse. Turlock Irrigation District (TID) operates 49 inlets into its Highline Canal, which passively allows this diffused overland flow to enter the canal in order to protect its levees from erosion or damage. EWD has conducted four earlier studies on the development of groundwater recharge via MAR in: 1990 (Boyle Engineering Initial Site Identification), 1995-1996 (Boyle Engineering and Ken Schmidt), 2003 (Joe Marcotte and Ken Schmidt), and aspects of an October 2003 study by Psomas.

Wood Rodgers and E-PUR LLC (Project Hydrogeologists) collaborated to provide EWD with hydrologic, geologic, and hydrogeologic site characterization. The objective of this study was to identify suitable locations for intercepting diffused stormwater and direct it to potential MAR facilities. One of the objectives of this project was to develop data and information needed to support Provost & Pritchard (Project Engineer) in completing a 30% design of MAR facilities across EWD and also areas within TID and the Ballico-Cortez Water District (Study Area). This letter report summarizes work efforts of the Project Hydrogeologists. Electronic files of our data

will be sent to EWD for the design effort currently being conducted by the Project Engineer and for future projects.

The Project Hydrogeologists provided a proposal to EWD to complete six tasks to characterize the hydrologic, geologic, and hydrogeologic potential for MAR sites, particularly in the area of the Highline Canal. These tasks are detailed below:

Task 1 – Groundwater Elevation Contour and Depth Maps

Task 2 – Evaluate Diffused Stormwater Flow to TID Canals and Existing Ponding Areas

Task 3 – Subsurface Sediment Texture Analysis and Estimated Hydraulic Conductivity

Task 4 – Geologic Cross-Sections of Eastside Water District and Adjoining Regions

Task 5 – Surface and Shallow Subsurface Soil Mapping of Area

Task 6 – Develop MAR Site Selection Criteria and Prospective MAR Site Locations

The methods, analyses, and recommendations for each task is reported in the following sections, followed by a section of Recommendations of additional steps anticipated for final design in the areas of geologic, hydrologic and hydrogeologic assessment.

Task 1 – Groundwater Elevation Contour and Depth Maps

The Project Hydrogeologists assessed data to evaluate groundwater elevations over time and current depth to groundwater. The Project Hydrogeologists developed time-series plots of groundwater elevations (hydrographs), groundwater elevation contour maps, and a map of depth to groundwater in 2014 for the Study Area.

EWD is located within the Turlock Groundwater Subbasin (Subbasin) of the San Joaquin Valley Groundwater Basin. The Turlock Groundwater Basin Association (TGBA) maintains a database of wells throughout the Subbasin to monitor groundwater elevation changes and for California Statewide Groundwater Elevation Monitoring (CASGEM) compliance. The TGBA database is managed and maintained by TID. The Project Hydrogeologists acquired this database from TID at the request of EWD and also obtained data from the Modesto Irrigation District and the City of Modesto on select groups of wells along and near the north side of the Tuolumne River. The Project Hydrogeologists also acquired CASGEM data for wells located throughout the Subbasin from the California Department of Water Resources (DWR) Water Data Library (WDL) online database.

A number of CASGEM monitored wells were selected throughout the EWD study area to assess historic and current groundwater elevations. The locations of these wells, along with their historic groundwater levels, are shown in Figure 1A. Groundwater levels within EWD (and within TID) have experienced significant declines over a 50-year period of record from the mid 1960's through 2014. Groundwater levels have declined 50 to 70 feet in the western and central portions of the EWD. Water level declines have been more severe in the eastern portion, with declines of up to 85 feet. The average annual rate of groundwater decline from wells located in the western and central portion have been observed to be between 1 and 2 feet per year. In the eastern portion, the annual rate of groundwater decline has been estimated at 1.5 feet per year from 1971 to 2000, and 3.8 feet per year from 2000 to 2011, as illustrated within the hydrographs shown on Figure 1A.

For analysis of area-wide historic groundwater elevations, Steven Phillips of the United States Geological Survey (USGS) was consulted regarding his groundwater modeling efforts in the region (Phillips, 2007). Mr. Phillips noted that groundwater elevations have been in continuous decline through 2004 (the period of record). The USGS groundwater model was initiated on groundwater elevations observed and interpreted for the year 2000. These groundwater elevations are a good representation of historic groundwater elevations for the Subbasin. Figure 1B depicts the groundwater elevations contoured from the groundwater model data-set for the year 2000. Groundwater elevations in 2000 indicate a depression in groundwater beneath EWD that extends westward under TID. The groundwater elevations indicate a groundwater mound around Delhi that may be a result of canal leakage in the area. The groundwater contours also indicate that the Merced River is generally discharging to groundwater but with a reversal to a gaining stream southwest of the EWD associated with the mounding near Delhi. This groundwater mound and the associated groundwater movement toward EWD and the Merced River, demonstrated by Figure 1B, is a key feature for the MAR project. Our assessment of groundwater movement is discussed further under Task 6 in the evaluations for site identification and site selection.

To analyze historic lows for groundwater elevations, the historic trends indicated that the most recent data collected under CASGEM and other Subbasin monitoring efforts represent the historic low. Thus, spring 2014 data were used to evaluate groundwater elevations and depths to groundwater. From the groundwater elevation data acquired for this study, a subset of wells were selected for analysis. Contouring of groundwater elevations from April and March 2014 data was accomplished using natural-neighbor interpolation for the wells depicted on Figure 1C; natural neighbor interpolation uses only local data points and thereby does not overestimate or underestimate the interpolated values. Figure 1C depicts spring 2014 groundwater elevation data beneath the Study Area. Groundwater elevations in spring 2014 indicate two groundwater depressions, one beneath EWD and one beneath TID and the City of Turlock. Similar to the 2000 contours, the groundwater elevations in 2014 indicate a groundwater mound around Delhi. The

dataset of groundwater elevations and wells for this study does not extend to the Merced River and thus a data gap exists as to whether the Merced River is discharging to groundwater or gaining from groundwater south of EWD (for example, where the Highline Canal turns at South Avenue).

The depth to groundwater is a critical consideration for artificial recharge projects. If there is no room for additional groundwater storage, recharge projects are not needed and could be detrimental. Groundwater recharge projects have the potential to bring the groundwater table to near the land surface, which can cause a variety of problems to infrastructure and crops. To evaluate the depth to groundwater, the data from the field measurements in spring 2014 were contoured directly rather than subtracting groundwater elevations from land surface elevations. Land surface elevations are usually taken from a digital elevation model (DEM) and the field data were of higher precision than a DEM, even though the heights of some of the measurement points above land surface are unknown. Figure 1D provides contouring of the depth to water measurements. The potential to have groundwater mounding near the land surface does not appear likely along the Highline Canal, as depths to groundwater is greater than 70 feet as compared to Delhi, where groundwater is approximately 20 feet below land surface. This assessment does not take into consideration the potential to create perched water on top of impermeable or very low permeable formations. Soil assessments with exploration drilling will be imperative to characterize the potential to create perched water layers.

Task 2 - Evaluate Diffused Stormwater Flow to TID Canals and Existing Ponding Areas

The ground surface that slopes toward the Highline Canal within the EWD boundary was modeled in GIS using the National Elevation Dataset 1/3 arc second (10 meter) grid. The grid was projected from the horizontal datum NAD83 (North American Datum 1983) in meters to NAD83 in feet, which converted the grid size to approximately 33 feet by 33 feet. The elevation values of the grid were converted from vertical datum NAVD88 (North American Vertical Datum of 1988) in meters to NAVD88 in feet and presented in Figure 2A (located as a plate in the Appendix). The Highline Canal alignment and inlet gate locations were provided by TID in the AutoCAD drawing file format and were converted to GIS Shapefiles for this analysis.

The watersheds that drain from east to west were analyzed using the converted elevation data set above to determine the watershed extents and the breaks between watersheds that flow to the existing inlet gates along the Highline Canal, as shown in Figure 2B (located as a plate and table in the Appendix). The ESRI ArcHydro data model and tools were implemented to automate the delineation of the watersheds. The 33 foot grid resolution was too coarse to depict the high ground of the canal banks that would impound runoff flowing west, so a visual inspection was conducted to refine the watershed boundaries at the canal alignment location. Aerial imagery was used to identify open, unplanted locations, adjacent to the existing inlet gates that could serve as potential MAR pond sites. The pond sites were delineated in GIS based on the extents of the

unplanted areas in the aerial imagery. These ponds or existing detention areas are also shown in Figure 2B.

Task 3 – Subsurface Sediment Texture Analysis and Estimated Hydraulic Conductivity

The Project Hydrogeologists developed a detailed hydrogeologic evaluation of the ground beneath EWD using sediment-texture analysis. Sediment-texture analysis was developed as a scientific and engineering methodology by the USGS and researchers at the University of California at Davis in the 1990s. It was subsequently used on a wide scale by the USGS for estimating hydraulic conductivity of geologic layers in their 2009 Central Valley Hydrologic Model (CVHM). From that study and others, there is a large set of existing Percent-Coarse data points in the region.

The Project Hydrogeologists set out to augment the existing Percent-Coarse data of the Modesto to Turlock area with areas close to EWD that needed more data for estimating purposes. To accomplish this, the Project Hydrogeologists acquired DWR Well Completion Reports (WCRs) in the area of interest via a letter request for those confidential records. Where there were apparent data gaps within and near EWD, the WCRs were carefully vetted for those that could be precisely located (i.e. within a quarter of a quarter Section) and those with higher quality lithologic logs. This was done over an area roughly 10 miles by 10 miles in size. In addition to the WCRs, EWD provided 29 boring logs from testing it had conducted in 1996 and 2003 within and just south of EWD. The locations of the lithologic data beneath and around EWD are shown on Figure 3A, both those created for this study and those obtained from the USGS CVHM study.

EWD logs and the higher quality WCR lithologic data were located laterally and reduced into a database with the lithologic data classified via the USGS method. The lithologic data was then reduced to sequential vertical packets of estimated Percent-Coarse over 15-foot intervals. These newly generated Percent-Coarse data developed by the Project Hydrogeologists were combined with the previously existent USGS Percent-Coarse data throughout the region provided by the USGS at 50-foot vertical intervals. From this more comprehensive data, we applied geostatistical analysis of the coarse- and fine-grained sediment textures to assess the patterns and spatial trends within the data. The sediment-texture modeling was to have been done using the Stanford Geostatistical Modeling Software (SGeMS) for geospatial modeling; however, it was found that SGeMS was unable to perform ordinary block-kriging, the type of geospatial modeling called for by the trends in the data, on the grid size selected for horizontal resolution. The geostatistician working with the Project Hydrogeologists, Dr. Bill Huber, developed and tested a software program that performed ordinary block-kriging for the geospatial estimates of Percent-Coarse throughout a roughly 40 mile by 40 mile area. The geospatial data model utilized both vertical samplings of lithologic data at 15-foot and 50-foot to arrive at a sediment-texture model in three dimensions that estimates the Percent-Coarse.

Ground surface elevations were incorporated into the sediment-texture model from a DEM of the area. Other vertical controls applied to the sediment-texture model were the groundwater elevations in the year 2000 (Phillips, 2007), the regional depth to the top of the Corcoran Clay as the first group of water bearing intervals or similar depth where the Corcoran Clay is not present such as beneath EWD, and the estimated bottom of the sedimentary aquifer in the region as the second group of water bearing intervals.

The sediment-texture model provides a semi-continuous estimate of regions with the highest probability of good connection to the water bearing zones at and near ground surface.

A probable hydraulic-conductivity value was then assigned to the Percent-Coarse estimates for three depth-based intervals to aid in site selection and characterization: (1) just below land surface (e.g. 7.5-feet), (2) the unsaturated zone, and (3) the interval of the first groundwater bearing zone. Using the vertical controls of depth to groundwater and the depth of the first water-bearing intervals, hydraulic conductivity of the subsurface and near surface was then estimated from the sediment-texture model.

Horizontal hydraulic conductivity, represented as K_h, was estimated using methodology developed by the USGS in CVHM (Faunt, 2009). Relative values of horizontal hydraulic conductivity for different sediment textures were calculated across EWD for each cell within the Percent-Coarse texture model.

$$K_h = K_c F_c + K_f F_f$$

where: K_h *represents the horizontal hydraulic conductivity for the Geolayer*

K_c *represents the hydraulic conductivity of the end member for coarse − grained sediments; value of* 820 $^{ft}/_{day}$ *used (Faunt, 2009)*

K_f *represents the hydraulic conductivity of the end member for fine − grained sediments; value of* 0.24 $^{ft}/_{day}$ *used (Faunt, 2009)*

F_c *represents the Percent Coarse as a fraction*

F_f *represents the Percent Fine as a fraction*

For horizontal hydraulic conductivity of the subsurface, Percent-Coarse estimates were averaged arithmetically over the unsaturated zone and over the first water-bearing intervals weighted by the layer thickness in the texture model using published methods (Maasland, 1957).

$$K_h = \frac{\sum_{i=1}^{n} K_i * d_i}{D}$$

where: K_h *represents the horizontal hydraulic conductivity for the Geolayer*
D *represents the GeoLayer thickness*
d_i *represents the cell thickness*
K_i *represents the celll horizontal hydraulic conductivity*

For example, there are 44 layers in the unsaturated zone of the texture model and the K_h for each layer was computed and then the thickness-weighted arithmetic average was calculated. The resulting estimates of K_h across EWD and the surrounding area are provided in GIS Shapefiles accompanying this report.

For vertical hydraulic conductivity, represented as K_v, the estimating method developed by the USGS in CVHM (Faunt 2009) was utilized to calculate relative vertical hydraulic conductivity across EWD. This was done for each cell within the Percent-Coarse texture model via the following formula.

$$K_v = \left[K_c^p F_c + K_f^p F_f\right]^{\frac{1}{p}}$$

where: K_v *represents the vertical hydraulic conductivity*
p *represents the averaging power mean exponent*
[*for the San Joaquin Valley, this value was given as* (-0.8)]
and K_c, K_f, F_c, F_f *as previously defined*

For vertical hydraulic conductivity of the subsurface, Percent-Coarse estimates were averaged following the equation for an averaging power mean exponent between that of a harmonic mean (conventional at p= -1.0) and a geometric mean (p = 0) for each individual layer in the texture model. The resulting value of K_v is calculated by taking a weighted harmonic mean of the individual values where the weighting was again the individual layer thickness.

$$K_v = \frac{D}{\sum_{i=1}^{n} {d_i}/{K_i}}$$

where: K_v *represents the vertical hydraulic conductivity for the Geolayer*
D *represents the GeoLayer thickness*
d_i *represents the cell thickness*
K_i *represents the cell vertical hydraulic conductivity*

For example, there are 44 layers in the unsaturated zone of the texture model and the K_v for each layer was computed and then the layer-thickness-weighted harmonic mean calculated. The resulting estimates of K_v across EWD and the surrounding area are depicted on Figures 3B and 3C for the near surface and unsaturated zone, respectively.

The estimates of vertical hydraulic conductivity for the unsaturated zone do not represent rates of percolation, but rather they represent the relative ability of different areas to percolate water. On Figures 3B and 3C, the blue coloring represents areas where water will percolate more rapidly than the brown areas. The estimates of hydraulic conductivity are modeled on a relative basis and likely do not represent the absolute values. It is anticipated that clay and duripan areas will have even lower values than estimated here and that areas with coarse sand to gravel near the surface will have higher values. It is our professional judgment that in utilizing the calibrated values of vertical hydraulic conductivity from CVHM textural modeling, that the hydraulic conductivity for soils and sediments between the high and low values for Percent-Coarse are well represented. Comparison of the regional model hydraulic conductivity values derived in this study using CVHM (Faunt 2009) and those hydraulic conductivity values resulting from USGS local textural model (Phillips 2007) are favorable, 0.24 feet/day vs. 0.46 feet/day for vertical conductivity of the fine-grained end member (meaning only silt and clay with no sand). These estimates of vertical hydraulic conductivity are shown in Figure 3C in particular have been utilized in Task 6 to identify the locations for MAR facilities that are best suited to conveying water more rapidly into the subsurface.

Each of these K_v estimates has a projected estimation error associated with it from the geospatial modeling; the smaller that estimation error the more confidence we have in the prediction. Figure 3D depicts the estimation error for K_v in the unsaturated zone via transparency; the more visible the K_v estimate the lower the error, and the darker the background the higher the uncertainty in the predicted values. These vertical hydraulic conductivity estimates were generated as GIS Shapefiles along with the K_v for the first-water bearing interval and are attached to this report.

Task 4 – Geologic Cross-Sections of Eastside Water District and Adjoining Regions

The Great Valley of California is an asymmetrical trough filled with Mesozoic (deposited 248 million years ago [mya] to 99 mya) and Cenozoic (65 mya to present) sediments that reach a thickness of approximately 30,000 feet. The Great Valley consists of the Sacramento Valley in the north and the larger San Joaquin Valley in the south. The San Joaquin Valley represents the lower two thirds of the Great Valley and is approximately 200 miles long and up to 70 miles wide, bound on the north by the Sacramento-San Joaquin Delta, the Sierra Nevada mountains on the east, the Coast Range Mountains on the west, and the Tehachapi and San Emigdio mountains to the south.

The geologic formations that make up the freshwater-bearing groundwater system underlying EWD include (from youngest to oldest): the Modesto Formation, Riverbank Formation, Turlock Lake Formation, and Mehrten Formation. The surface exposures of each of these formations are shown in Figure 4A. Each of these units is summarized below.

Within EWD, the strike and dip of the formations are generally northwest to southeast, with a dip of approximately 1 to 3 degrees to the southwest. The geologic formations form a wedge shaped geometry, which increases in thickness from east to west.

Modesto Formation

The Modesto Formation is of late Pleistocene age (about 1 mya to recent). The formation consists of mostly sand, gravel, silt, and contains some silt and clay units. A majority of the Modesto Formation is observed to outcrop to the west of EWD; however, smaller outcrops of the formation are observed along low lying drainage areas and river channels throughout the study area. There does not appear to be much saturated thickness of the Modesto Formation within EWD.

Riverbank Formation

The Riverbank Formation, which is of middle Pleistocene age (about 1.5 mya to 1 mya), underlies the extent of the Modesto Formation. The thickness of the formation increases westward, with a thickness of generally less than 200 feet. The formation consists primarily of sand with scattered gravel and silt lenses. A majority of the Riverbank Formation outcrops west of EWD, between the TID Main Canal and the TID Highline Canal. However, smaller portions of the formation are observed to outcrop along low-lying drainage areas and river channels throughout the study area. There does not appear to be much saturated thickness of the Riverbank Formation within EWD.

Turlock Lake Formation

The Turlock Lake Formation, which is of early Pleistocene and late Pliocene age (2.5 mya 1.5 mya), underlies the Riverbank Formation. The thickness of the unit increases westward, but the thickness is generally less than 600 feet. The formation consists of mostly fine sand and silt (Marchand and Allwardt, 1981). The Corcoran Clay member of the Turlock Lake Formation ranges in thickness from 10 to 100 feet. The Corcoran Clay is generally dark greenish-gray in color, but is commonly referred to as "the blue clay". The Corcoran Clay lies in the upper part of the Turlock Lake Formation; however, the extent of the Corcoran Clay which has been locally mapped in the subsurface (by others) along and west of North Santa Fe Avenue was not observed during this investigation and is not thought to be present in the subsurface underlying EWD. The Turlock Lake Formation is the primary aquifer for shallow wells within EWD and also along the majority of the Highline Canal. This formation would be the primary target of MAR projects

within the study area near the Highline Canal. While the Turlock Lake Formation contains significant layers of sandy material, it also contains highly cemented sandstone layers (duripan) that are thought to have low permeability.

Deposition of the Turlock Lake Formation appears to have eroded portions of the Mehrten Formation, which suggests that there is an erosional unconformity between these formations within portions of the Study Area.

Mehrten Formation

The Mehrten Formation is Miocene to late Pliocene in age (5 mya 2.5 mya) and consists of a sequence of volcaniclastic and volcanic rocks. The Mehrten Formation is comprised of two distinct geologic units: the Upper Mehrten Formation and the Lower Mehrten Formation. The Upper Mehrten Formation consists of gravels, well sorted black andesitic sands (reported by well drillers as "black sands") and interbedded blue to brown silts and clays (DWR 1974). The Lower Mehrten Formation consists of dense volcanic flows of tuff breccias with interbedded conglomerates and sandstones. This unit acts as a confining layer between sand intervals. In the vicinity of EWD, the Mehrten Formation ranges in thickness from 200 feet along the eastern portions of the study area, to over 600 feet west of the TID Main Canal. While the Mehrten Formation contains significant layers of sandy material, the location and depth of the deposits in relation to the potential MAR sites more than likely precludes these deposits from directly benefiting the project.

Geologic Cross-Section

A geologic cross section was prepared with existing data from EWD, DWR, and the California Department of Conservation Division of Oil, Gas, and Geothermal Resources (DOGGR) geophysical logs. The available lithologic data and geophysical logs were used to prepare geologic cross section A-A', as shown in Figure 4B. The geologic cross section depicts the general elevation (relative to mean sea level) that each geologic formation is anticipated to exist within the EWD study area.

One prominent feature identified while correlating the geologic units was vertical offset of the formations traversing west to east along the cross section line. This suggests faulting has occurred, with apparent vertical upward movement on the west side relative to the east side. The exact location of the fault is unknown, but has been referred to in previous work conducted in the area. To the east of the fault, a prominent erosional contact was identified between the top of the Mehrten Formation and the bottom of the Turlock Lake Formation, as discussed briefly above. The data suggest that prior to the deposition of the Turlock Lake Formation, the deposits of the Mehrten Formation were disrupted by deformational stresses that enhanced erosion of the existing sediments.

The surface exposures of the geologic formations relative to the potential surface water available near the Highline Canal indicate that the deposits of the Turlock Lake Formation would be the primary target for the percolation of diffused stormwater flows for aquifer recharge to meet the project objectives.

Task 5 – Surface and Shallow Subsurface Soil Mapping of Area

The Project Hydrogeologists reviewed Soil Survey Geographical (SSURGO) datasets for EWD gathered in parts of Stanislaus County and Merced County from the Natural Resources Conservation Service (NRCS) online sources. The SSURGO soil data was reviewed for key data including rated depth of soil and the presence of hardpan layers for the area soil types. A GIS shapefile was generated from SSURGO data tables to provide useful data regarding surface soils, including: vertical hydraulic conductivity, hydrologic soil type, and depth of soil.

The SSURGO data gathered was representative of the EWD, and was drawn from SSURGO studies in both Stanislaus and Merced Counties. SSURGO soil data was associated with location data through database queries. Additional queries converted SSURGO soil data units into project appropriate units of feet per day. Additionally, the data reported as saturated hydraulic conductivity was confirmed to be saturated vertical hydraulic conductivity through a phone conversation with NRCS staff.

Spatially-located SSURGO data was provided to the Project Hydrogeologists as a GIS Shapefile and depicted as Figure 5A. The saturated vertical hydraulic conductivity and hydrologic soil types displayed in Figure 5A provide insight as to the location within the study area where surface soils may be sufficient to meet project goals as well as areas where duripan soil layers can be expected and must be accounted for in site evaluation and design to achieve project goals. Saturated vertical conductivities are described in Figure 5A as minimum and maximum values for the soil column, as well as a NRCS-defined representative value. Hydrologic soil types A and B (depicted in blues) are considered to be soils with high drainage capacity, whereas types C and D (shown in yellows and reds) have very little drainage capacity. Soil depths were also provided to the Project Hydrogeologists in a GIS Shapefile to assist in estimating depth of excavations needed for design locations.

Task 6 – Develop MAR Site Selection Criteria and Prospective MAR Site Locations

The Project Hydrogeologists collaborated closely with the Project Engineer to develop MAR Site-Identification Criterion and MAR site suitability. Subsequently, the Project Hydrogeologists and the Project Engineer met with Kevin Kauffman (District representative) on September 24, 2014 and selected the following five (5) criteria to be used to select potential MAR locations. They are ranked below in relative order of importance, as determined by the Project Hydrogeologists and Engineer.

Prospective MAR Site Identification Criteria:

1) Best Unsaturated Zone Relative Hydraulic Conductivity (K_v) for Percolation

2) Potential to Replenish Groundwater within Eastside Water District, "Fill the Hole"

3) Potential Basin Size for Percolation

4) Size of Watershed Above Site

5) Capability of Percolation Site for Multi-Use (Flood Control and Percolation) and Multi-Water Source (Sand Creek, Mustang Creek, and Dry Creek in addition to Diffused Flow in Highline Canal)

The Project Hydrogeologists and Engineer utilized the project information developed in Tasks 1 through 5 to identify prospective site locations adjacent to, or near the TID Highline Canal, and other areas within EWD with good MAR potential. To evaluate criteria No. 1 and 2, the Project Hydrogeologists created a map depicting the vertical hydraulic conductivity of the unsaturated zone combined with the interpreted groundwater elevation contours from April 2014 data. Figure 6A displays vertical hydraulic conductivity and groundwater elevation contours together with probable groundwater flow directions. Areas with a vertical hydraulic conductivity of greater than 0.5 feet/day were rated as favorable and evaluated further against the other site identification criteria. It should be noted that the site identification criteria will not exactly match the criteria matrix that the Project Engineer is developing for the selection of three sites to be brought to 30% design during the second phase of the project.

For criterion No. 3, the Project Hydrogeologists performed a preliminary visual examination of land use near inlet structures to assess land parcel sizes and areas that might be available and suitable for gravity fed percolation features. A secondary visual examination was made in the September 24th meeting of areas with suitable adjoining land uses and potential land parcels available of greater than 10 acres. Percolation areas of 10 acres or more were judged to be capable of providing meaningful capture and infiltration capacity (for example more than 750 acre-feet per year of aquifer recharge at a site).

The watershed areas above select inlets of Figure 2A were compared against criterion No. 4. Significant inflow to the Highline Canal is available at TID Inlet F-1 near the northern upstream end of the Highline Canal. Locations south of TID Inlet F-1 were judged to have water available for diversion from the Highline Canal during "significant rainfall events". Data from TID on the flow in the Highline Canal during episodic rainstorms was sought during the site identification phase but was not immediately available. The return frequency of these "significant rainfall events" is to be assessed during the preliminary 30% design phase to guide design decisions on the size of groundwater recharge facilities to be built.

A preliminary list of 13 sites that satisfied Site Identification Criteria Nos. 1 through 4 was developed in the September 24, 2014 collaborative meeting. Those sites are identified as Preliminary Sites 1 through 11 in the accompanying Figure 6B. An additional two Preliminary Sites, Sites 12 and 13, that satisfy Site Identification Criteria Nos. 1 through 5 were identified and are also shown in Figure 6B.

Criterion No. 5 was used to assess potential recharge sites for multi-use as a flood control feature and as a percolation facility. This criterion is best satisfied in the watercourses of Sand Creek and Mustang Creek, since other drainages when flooding are currently controlled into the Highline Canal. The water in Sand Creek and Mustang Creek is not considered diffused stormwater; however, the stormwater flow in a Sand Creek or Mustang Creek location can conceptually be intercepted and percolated without a water right permit, if an equivalent rate and duration of stormwater flow in the Highline Canal is conveyed downstream. This flow interception in the drainage course could act as a flood control feature and thus be a dual purpose facility. Subsequently, a surface water right may be obtained for unclaimed excess stormwater flow in these natural watercourses. If a subsequent surface water right is obtained for excess stormwater flow, then additional diffused flow would be available to take at these sites or it could be taken to other groundwater recharge sites instead of Sites 12 and 13, depending on economic as well as technical considerations.

The goal for each of these sites is to be able to divert diffused stormwater that enters the Highline Canal during rainfall events into a designed groundwater recharge facility nearby using gravity flow. Site ranking criteria in addition to these site identification criteria were discussed and developed among the Project Hydrogeologists and Project Engineer during August and early September 2014. The site ranking criteria are to be further developed during the design phase to provide a reasonably objective analysis of the relative merits among the thirteen sites identified. There are criteria to be further evaluated in the design, such as recharged water outflowing to nearby watercourses and rivers such as the Merced River; there is a data gap for groundwater elevations and probable flow in the south as noted in Figure 6A. There is also a need to assess the potential for percolating recharge water to impact nearby-crop root-zones. Water quality concerns with regard to nitrate contamination from dairy operations were discussed, but not assessed, as part of this project. Site-specific groundwater quality characterization for select potential MAR sites may be warranted during site exploration (as discussed in Task 1).

The September 24, 2014 meeting served as a handoff meeting from the Project Hydrogeologists to the Project Engineer. It is anticipated that after ranking, three (3) sites will be selected by the Project Engineer and then taken to a 30%- complete engineering design. It is anticipated that the Project Hydrogeologists may be asked by EWD to review additional site ranking criteria developed and their application to the thirteen sites identified herein. The electronic files of technical criteria from hydrologic and hydrogeologic assessments done by the Project Hydrogeologists are provided herein for use by EWD.

Conclusions

- There appears to be sufficient unsaturated sediments along the Highline Canal that would benefit from groundwater recharge projects.
- Thirteen sites (eleven near the Highline Canal) were identified to have favorable conditions to warrant consideration as MAR locations for diffused stormwater.
- The soil texture analysis suggests that areas in the northern portion of the Highline Canal may not be good candidates for spreading basins. Dry wells in this area may be better suited to develop MAR projects in that area.

Recommendations

- Site exploration to identify the site specific soil texture and permeability is recommended for all sites to be developed into MAR locations.
- Sonic drilling through the unsaturated sediments should be used to provide continuous soil samples.
- Test holes should be converted into monitoring wells to help track the effectiveness of MAR operations on the unsaturated sediments and to enable passive air pressure testing for hydraulic conductivity.
- A groundwater monitoring well network should also be developed to track water levels in the aquifers near the MAR locations and to establish a pre-project baseline water quality conditions near the MAR locations.

If you have any questions or require additional information, please call us at (916) 341-7447 (Wood Rodgers) or (209) 451-5933 (E-PUR).

Sincerely,

Lawrence H. Ernst

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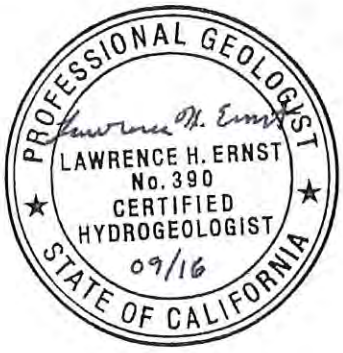
Principal Hydrogeologist
Wood Rodgers, Inc.

John M. Lambie

John Lambie, CA PE, PG, CEG
Principal Groundwater Hydrologist
E-PUR, LLC



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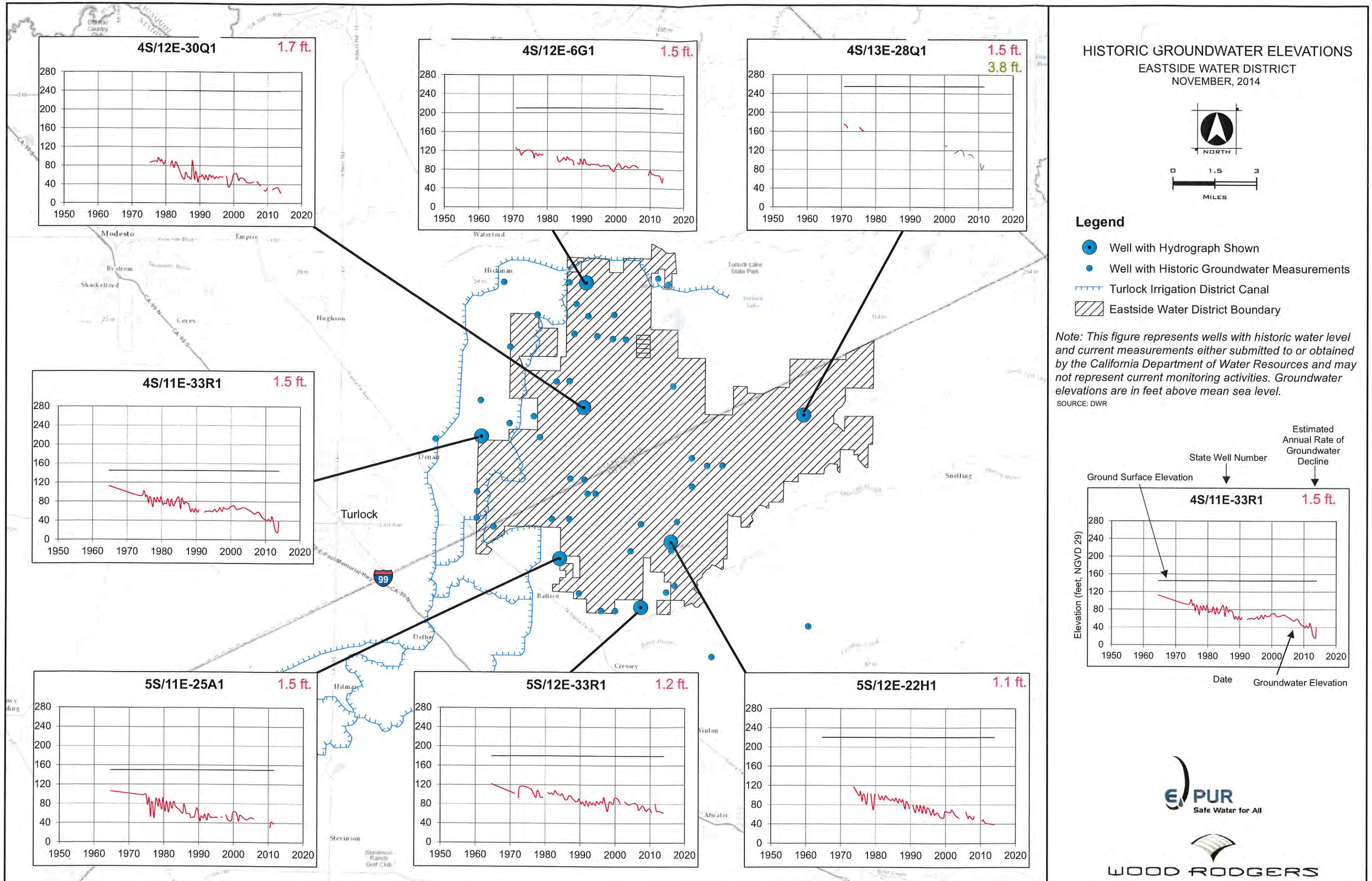

HISTORIC GROUNDWATER ELEVATIONS
EASTSIDE WATER DISTRICT
NOVEMBER, 2014
NORTH
0 1.5 3
MILES
Legend
Well with Hydrograph Shown
Well with Historic Groundwater Measurements
Turlock Irrigation District Canal
Eastside Water District Boundary
Note: This figure represents wells with historic water level and current measurements either submitted to or obtained by the California Department of Water Resources and may not represent current monitoring activities. Groundwater elevations are in feet above mean sea level.
SOURCE: DWR
4S/12E-30Q1 1.7 ft.
4S/12E-6G1 1.5 ft.
4S/13E-28Q1 1.5 ft. 3.8 ft.
4S/11E-33R1 1.5 ft.
5S/11E-25A1 1.5 ft.
5S/12E-33R1 1.2 ft.
5S/12E-22H1 1.1 ft.
Modesto
Empire
Bystrom
Shackelford
Ceres
Hughson
Waterford
Hickman
Turlock Lake State Park
Denair
Turlock
Ballico
Delhi
Cressey
Hilmar
Stevinson
Atwater
Snelling
Ground Surface Elevation
State Well Number
Estimated Annual Rate of Groundwater Decline
Elevation (feet, NGVD 29)
Date
Groundwater Elevation
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FIGURE 1A

GROUNDWATER ELEVATION CONTOURS
WATER YEAR 2000

EASTSIDE WATER DISTRICT
NOVEMBER, 2014

NORTH

0 1 2
Miles

Legend

- GW Elevation Water Year 2000 (ft above MSL)
- Turlock Irrigation District Canals

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FIGURE 1B

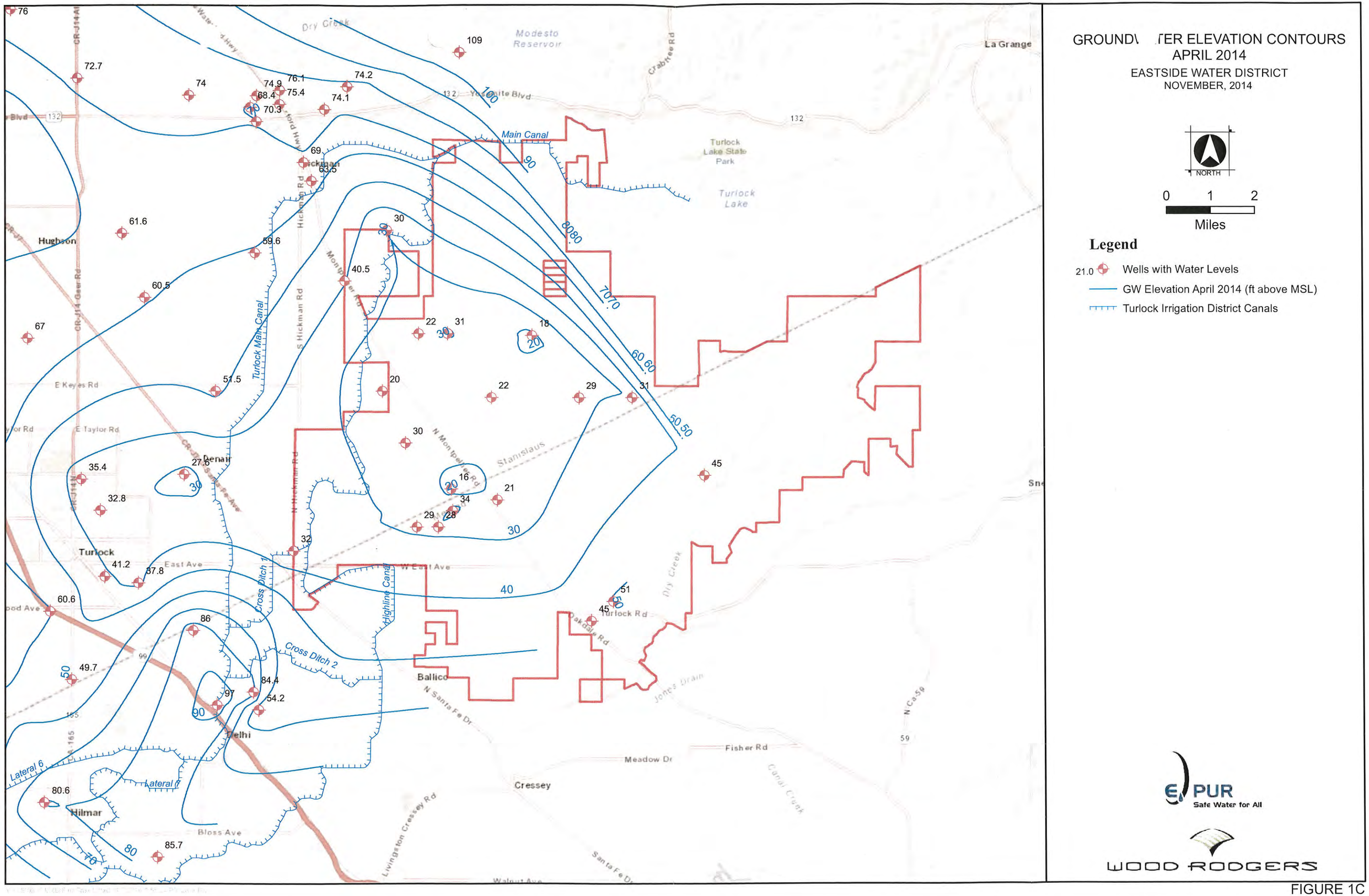
GROUNDWATER ELEVATION CONTOURS
APRIL 2014
EASTSIDE WATER DISTRICT
NOVEMBER, 2014
NORTH
0 1 2
Miles
Legend
21.0 Wells with Water Levels
GW Elevation April 2014 (ft above MSL)
Turlock Irrigation District Canals
Modesto Reservoir
Turlock Lake State Park
Turlock Lake
Main Canal
Turlock Main Canal
Cross Ditch 1
Cross Ditch 2
Highline Canal
Lateral 6
Lateral 7
Hughson
Denair
Turlock
Ballico
Delhi
Hilmar
Cressey
La Grange
Stanislaus
Dry Creek
Jones Drain
Canal Creek
Yosemite Blvd
Hickman Rd
S Hickman Rd
N Hickman Rd
N Montpelier Rd
Montpelier Rd
E Keyes Rd
E Taylor Rd
East Ave
W East Ave
Turlock Rd
Oakdale Rd
N Santa Fe Dr
Meadow Dr
Fisher Rd
Bloss Ave
Livingston Cressey Rd
Santa Fe Dr
Walnut Ave
Crabtree Rd
CR-J14 Geer Rd
CR-J14 N
CR-J14 Santa Fe Ave
Hickman Rd
Santa Fe Dr
N Ca-59
Dry Creek
Jones Drain
Canal Creek
100
90
80
70
60
50
40
30
20
10
76
72.7
74
74.9
76.1
74.2
68.4
75.4
74.1
70.3
69
63.5
61.6
59.6
60.5
67
51.5
30
40.5
22
31
18
20
22
29
31
30
45
35.4
27.6
32.8
16
34
21
29
28
32
41.2
37.8
60.6
86
49.7
84.4
97
54.2
51
45
80.6
85.7
109
74
74.9
76.1
74.2
68.4
75.4
74.1
70.3
69
63.5
61.6
59.6
60.5
67
51.5
30
40.5
22
31
18
20
22
29
31
30
45
35.4
27.6
32.8
16
34
21
29
28
32
41.2
37.8
60.6
86
49.7
84.4
97
54.2
51
45
80.6
85.7
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FIGURE 1C

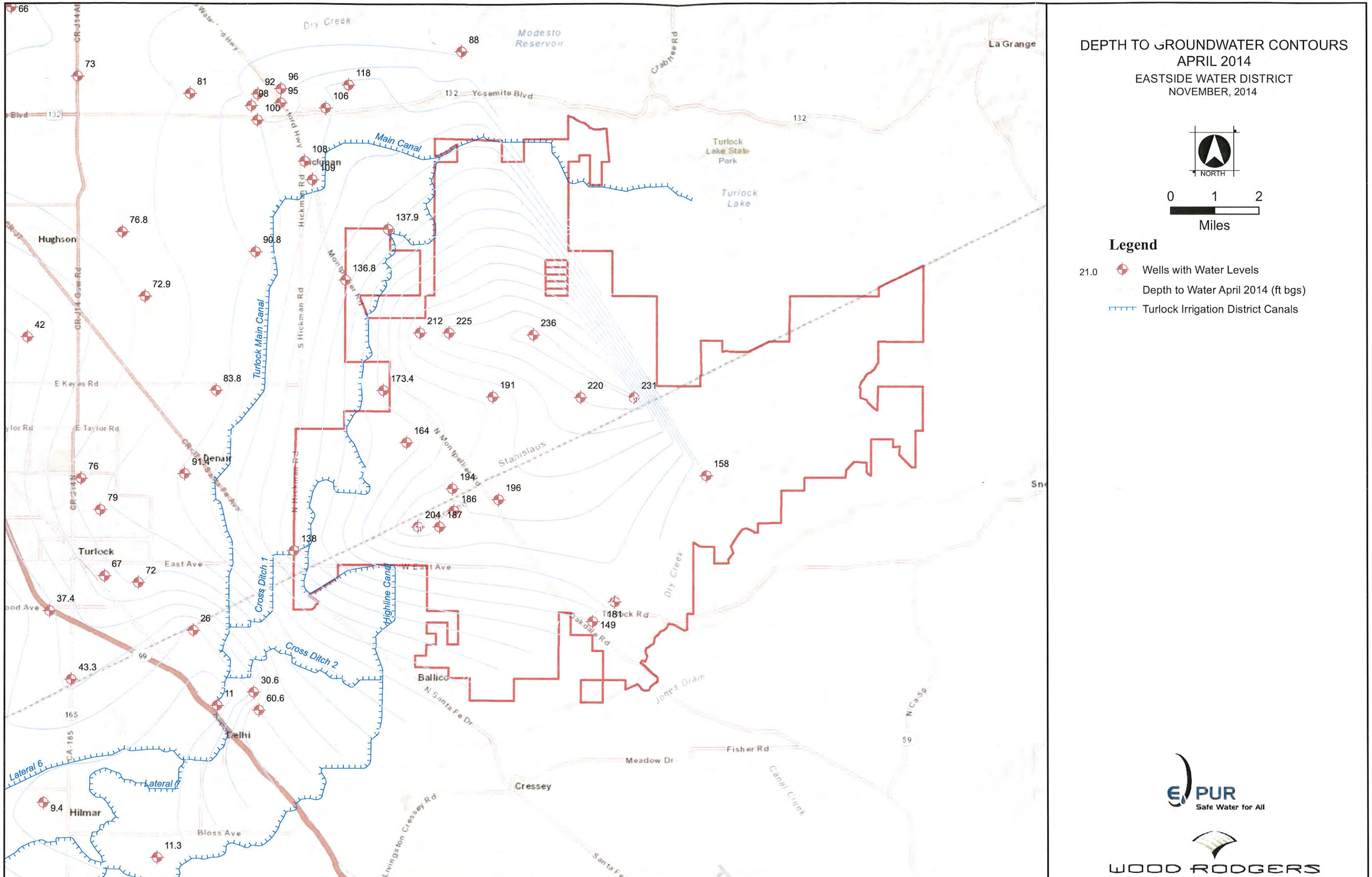
DEPTH TO GROUNDWATER CONTOURS
APRIL 2014
EASTSIDE WATER DISTRICT
NOVEMBER, 2014
NORTH
0 1 2
Miles
Legend
21.0 Wells with Water Levels
Depth to Water April 2014 (ft bgs)
Turlock Irrigation District Canals
Main Canal
Turlock Main Canal
Cross Ditch 1
Cross Ditch 2
Highline Canal
Lateral 6
Lateral 7
Modesto Reservoir
Turlock Lake State Park
Turlock Lake
Hughson
Denair
Turlock
Delhi
Hilmar
Ballico
Cressey
La Grange
Yosemite Blvd
Hickman Rd
S Hickman Rd
E Keyes Rd
E Taylor Rd
East Ave
W East Ave
Bloss Ave
Fisher Rd
Meadow Dr
Livingston Cressey Rd
Stanislaus
Dry Creek
Jones Drain
Canal Creek
66
73
81
92
96
98
95
100
118
106
88
108
109
76.8
90.8
137.9
136.8
72.9
42
212
225
236
83.8
173.4
191
220
231
164
158
91.4
76
194
196
186
79
204
187
138
67
72
37.4
26
181
149
43.3
30.6
11
60.6
9.4
11.3
132
99
165
59
CR-J14 Over Rd
CR-J14 Alt
CR-J7
CR-J14 N
CA-165
N Hickman Rd
N Montpellier Rd
N Santa Fe Dr
Santa Fe Dr
Walnut Ave
Crabtree Rd
Oakdale Rd
N Ca-59
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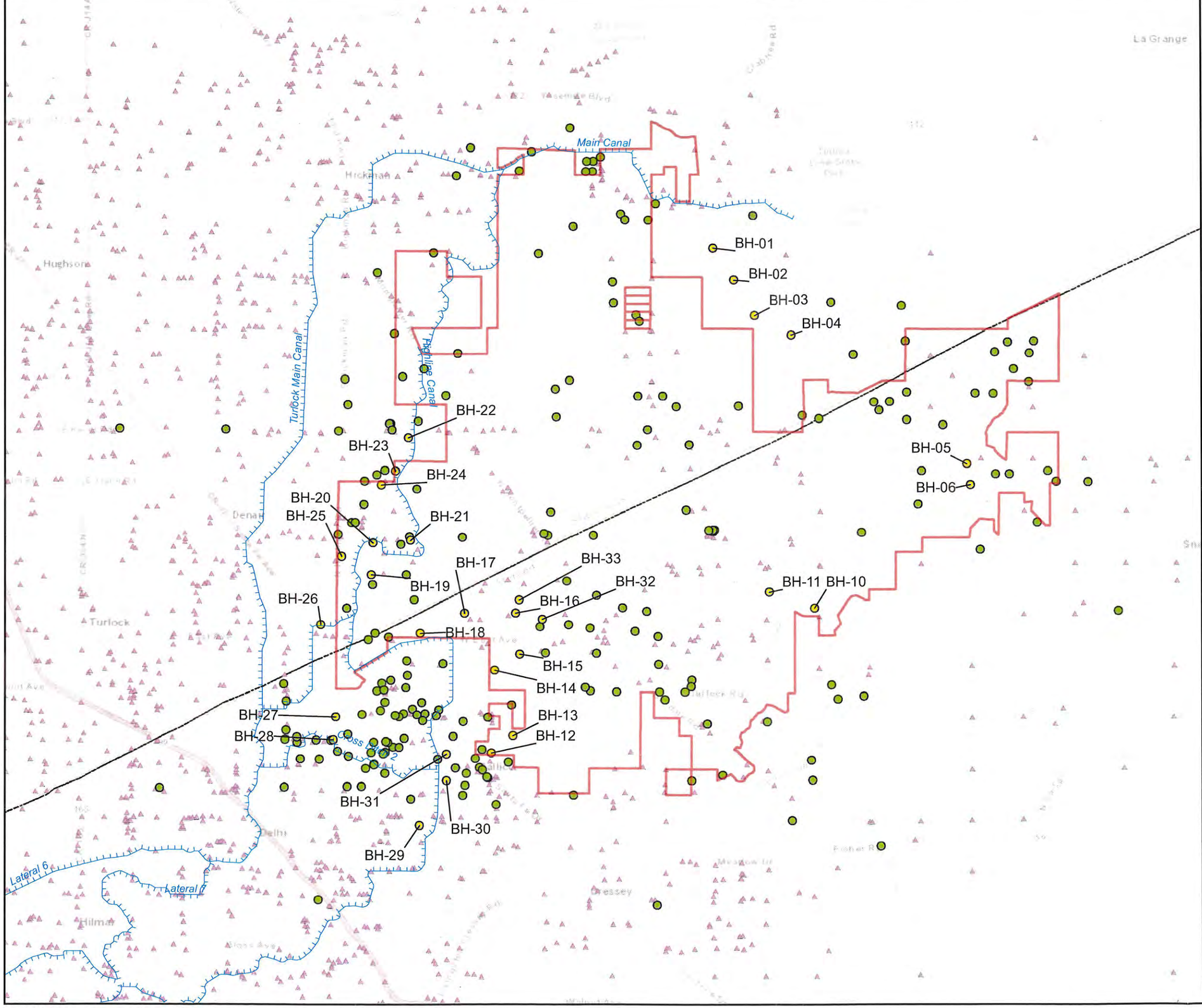
FIGURE 1D

TEXTURE MODEL LITHOLOGIC LOCATIONS

EASTSIDE WATER DISTRICT
NOVEMBER, 2014



NORTH

0 1 2

Miles

Legend

- Good Quality Well Completion Reports
- BH-01 Previous Project Boreholes
- Previous USGS Textural Study
- Turlock Irrigation District Canals

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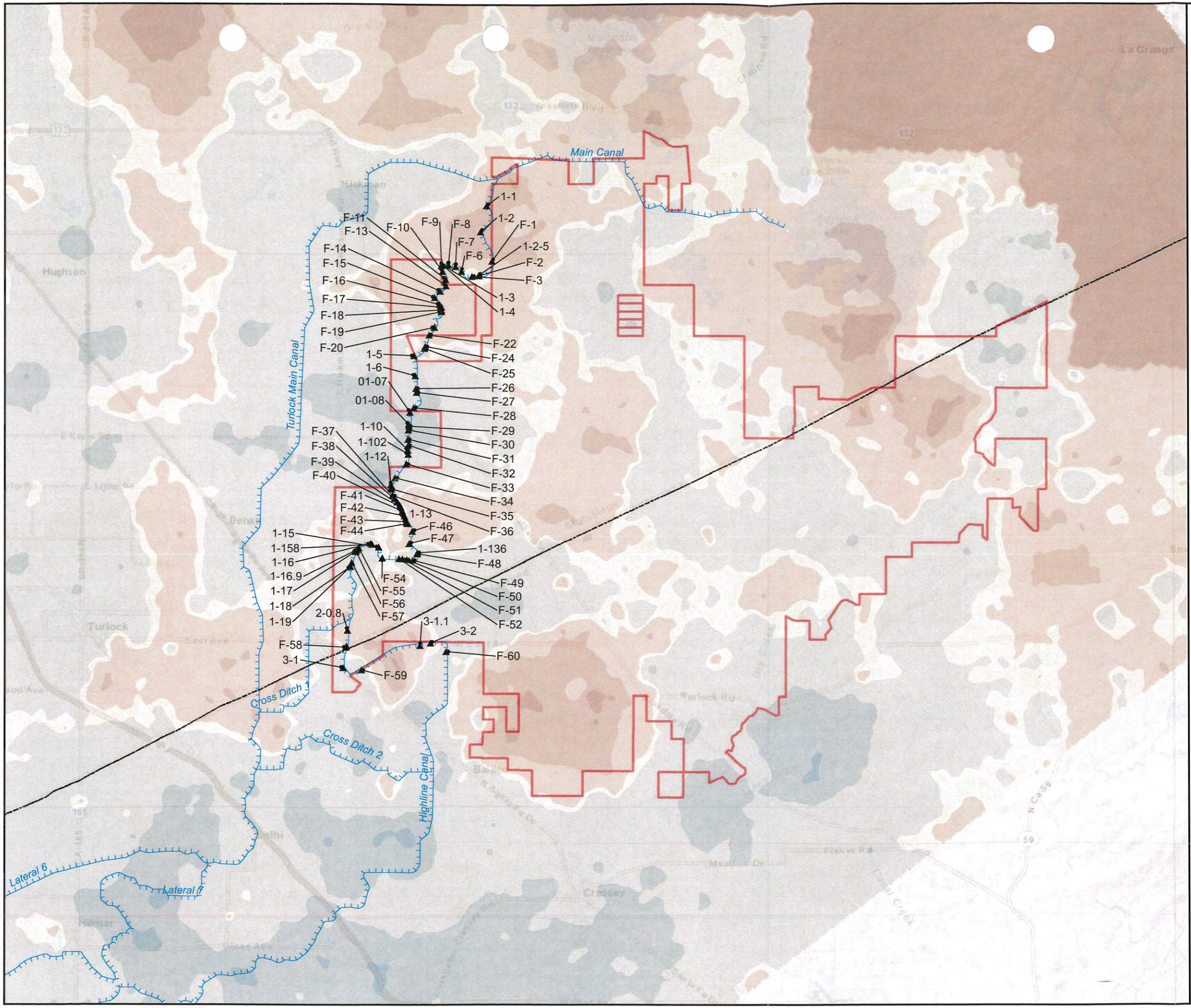
FIGURE 3A

ESTIMATED VE CAL HYDRAULIC CONDUCTIVITY IN THE NEAR SURFACE SEDIMENTS BENEATH EASTSIDE WATER DISTRICT

EASTSIDE WATER DISTRICT
NOVEMBER, 2014



NORTH

0 1 2
Miles

Legend

Upper Unsaturated Zone - Kv

- 0.00 - 0.30 ft/d
- 0.30 - 0.35 ft/d
- 0.35 - 0.45 ft/d
- 0.45 - 0.50 ft/d
- 0.50 - 1.00 ft/d
- 1.00 - 2.00 ft/d
- 2.00 - 2.89 ft/d
- Turlock Irrigation District Canals
- Highline Canal Inlets

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FIGURE 3B

ESTIMATED V[illegible]ICAL HYDRAULIC CONDUCTIVITY
OF THE UNSATURATED ZONE
BENEATH EASTSIDE WATER DISTRICT

EASTSIDE WATER DISTRICT
NOVEMBER, 2014

NORTH

0 1 2
Miles

Legend

Unsaturated Zone - Kv

- 0.25 - 0.30 ft/d
- 0.30 - 0.35 ft/d
- 0.35 - 0.45 ft/d
- 0.45 - 0.50 ft/d
- 0.50 - 1.00 ft/d
- 1.00 - 2.00 ft/d
- 2.00 - 19.4 ft/d
- Turlock Irrigation District Canals
- Highline Canal Inlets

Main Canal
Turlock Main Canal
Cross Ditch
Cross Ditch 2
Highline Canal
Lateral 6
Lateral 7
1-1
1-2
1-2-5
1-3
1-4
1-5
1-6
01-07
01-08
1-10
1-102
1-12
1-13
1-15
1-158
1-16
1-16.9
1-17
1-18
1-19
1-136
2-0.8
3-1
3-1.1
3-2
F-1
F-2
F-3
F-6
F-7
F-8
F-9
F-10
F-11
F-13
F-14
F-15
F-16
F-17
F-18
F-19
F-20
F-22
F-24
F-25
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F-60

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FIGURE 3C

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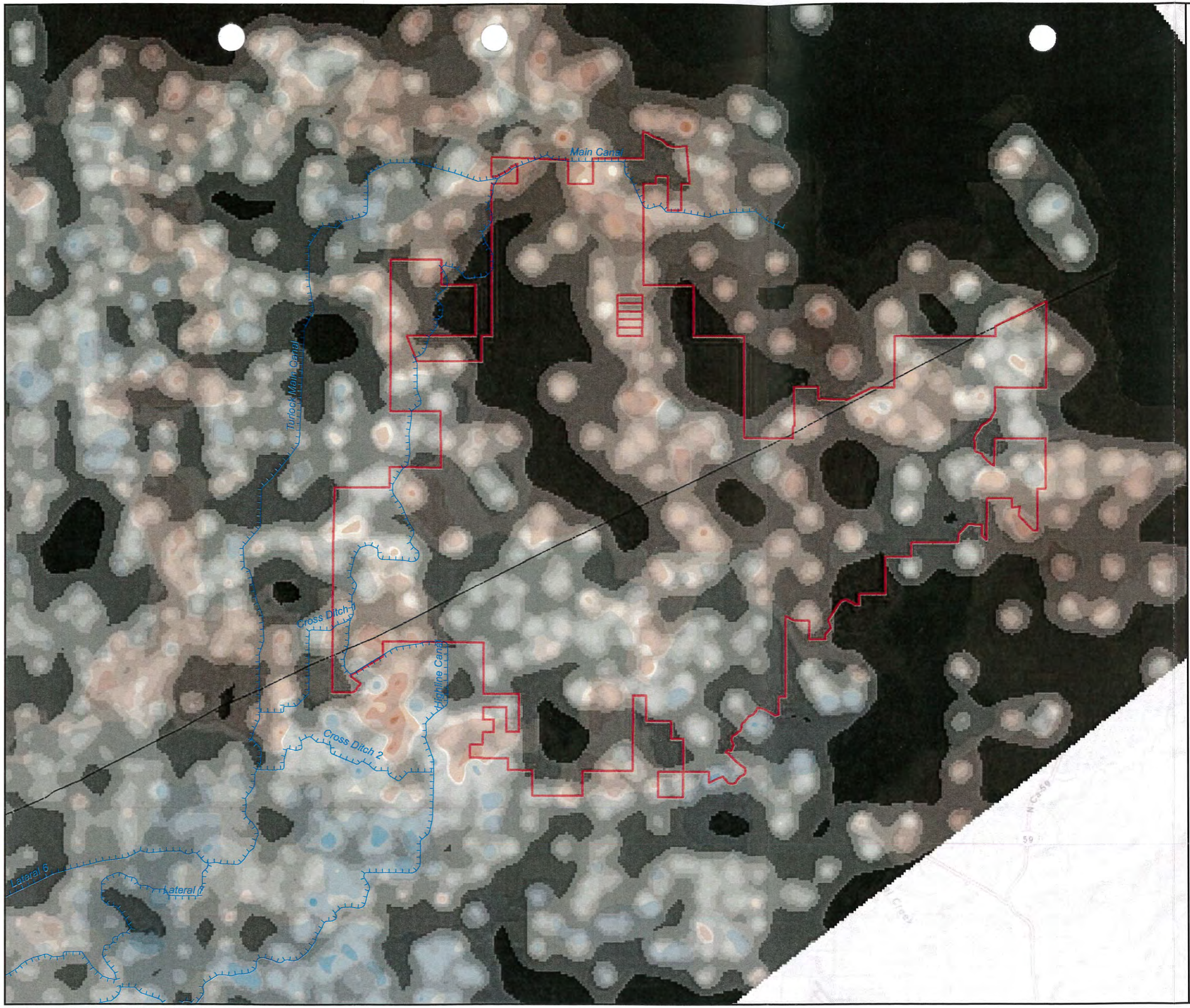

OVER[illegible] OF PREDICITION ERROR
FOR VERTICAL HYDRAULIC CONDUCTIVITY
OF THE UNSATURATED ZONE
EASTSIDE WATER DISTRICT
NOVEMBER, 2014

NORTH

0 1 2
Miles

Legend

Unsaturated Zone - Kv

- 0.25 - 0.30 ft/d
- 0.30 - 0.35 ft/d
- 0.35 - 0.45 ft/d
- 0.45 - 0.50 ft/d
- 0.50 - 1.00 ft/d
- 1.00 - 2.00 ft/d
- 2.00 - 19.4 ft/d
- Turlock Irrigation District Canals

NOTES: Estimation error is shown as transperancy of the layer overlying the Unsaturated Kv field. The more visible the Kv estimate the lower the error and the darker the overlay the higher the uncertainty in the predicted values

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FIGURE 3D

GEOLOGIC MAP

EASTSIDE WATER DISTRICT
NOVEMBER, 2014

NORTH

0 1.5 3
MILES

Map Symbols

- DWR Wells
- DOGGR Wells
- Private Well
- Turlock Irrigation District Canal
- Eastside Water District Boundary
- Cross Section Line

Geologic Units

Quaternary 2 Ma - Recent

- Qm — Modesto Formation
- Qr — Riverbank Formation
- Qtl — Turlock Lake Formation

Tertiary 65 - 2 Ma

- Tm — Mehrten Formation
- Tvs — Valley Springs Formation
- Ei — Ione Formation

Notes: Only the geologic units present in the cross section are displayed.

Geologic Map Source:
Wagner, D.L., Bortugno, E.J., and McJunking, R.D., 1991, Geologic Map of the San Francisco-San Jose Quadrangle, California, Map No. 5A (Geology), 1:250,000.

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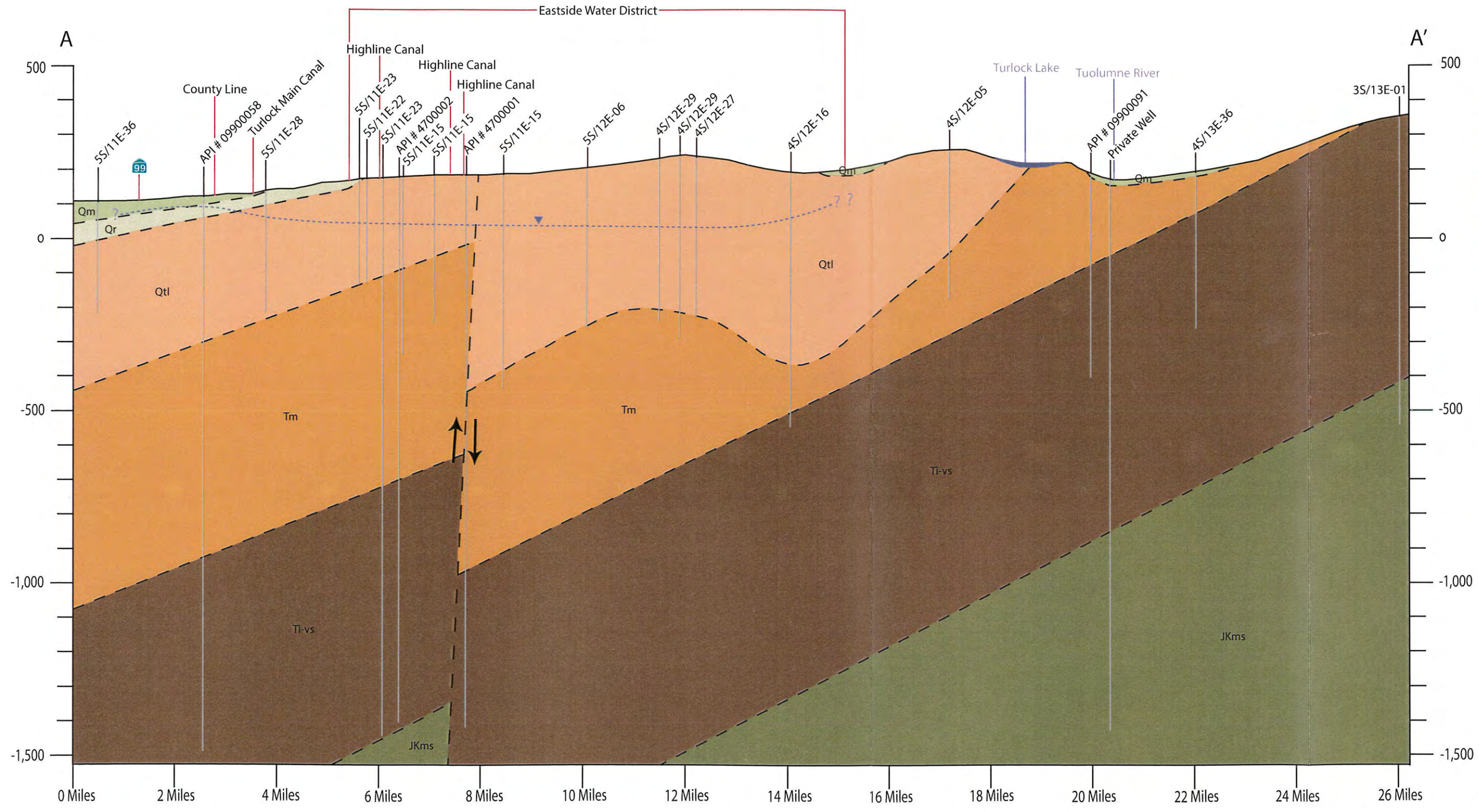
FIGURE 4A

GEOLOGIC CROSS SECTION A TO A'
EASTSIDE WATER DISTRICT
NOVEMBER 2014



Geologic Legend

- Qm — Modesto Formation
- Qr — Riverbank Formation
- Qtl — Turlock Lake Formation
- Tm — Mehrten Formation
- Ti-vs — Undifferentiated Valley Springs and Ione Formations
- JKms — Undifferentiated Marine Sediments

Map Symbols

- Geologic Contact - Dashed Where Inferred
- Approximate Location of Fault
- Well Used for Geologic Correlation
- Groundwater Elevation (Spring 2014

Vertical Scale In Feet (msl): 300', 200', 100', 0'

Horizontal Scale In Miles: 0, 1, 2

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DEVELOPING INNOVATIVE DESIGN SOLUTIONS

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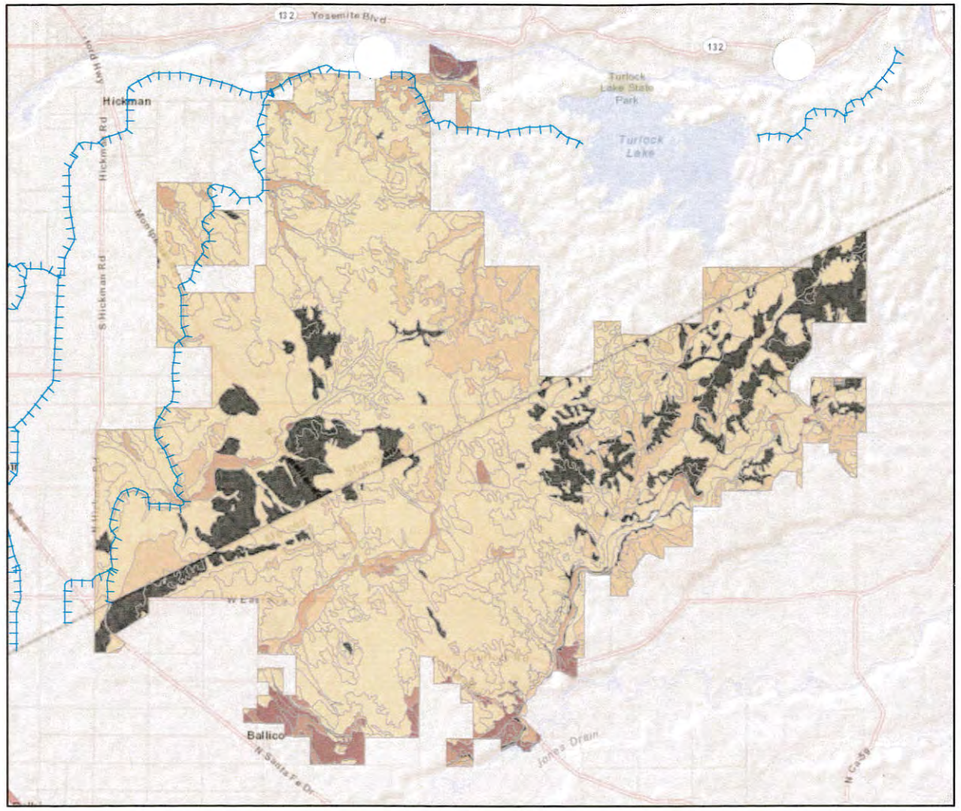
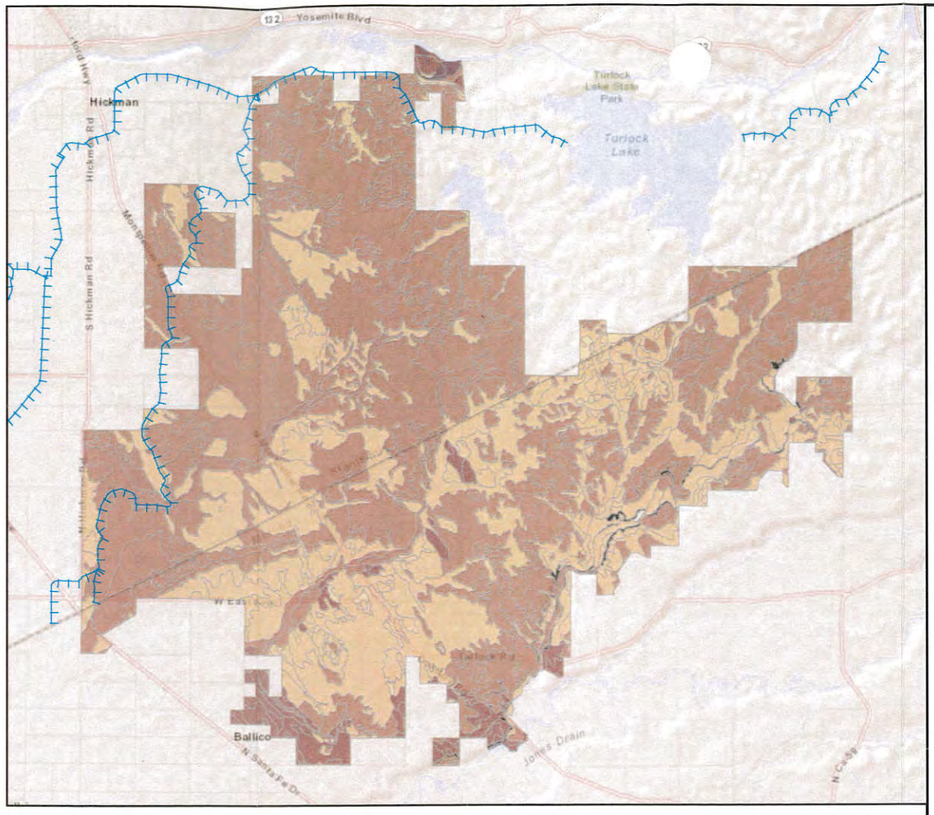
FIGURE 4B

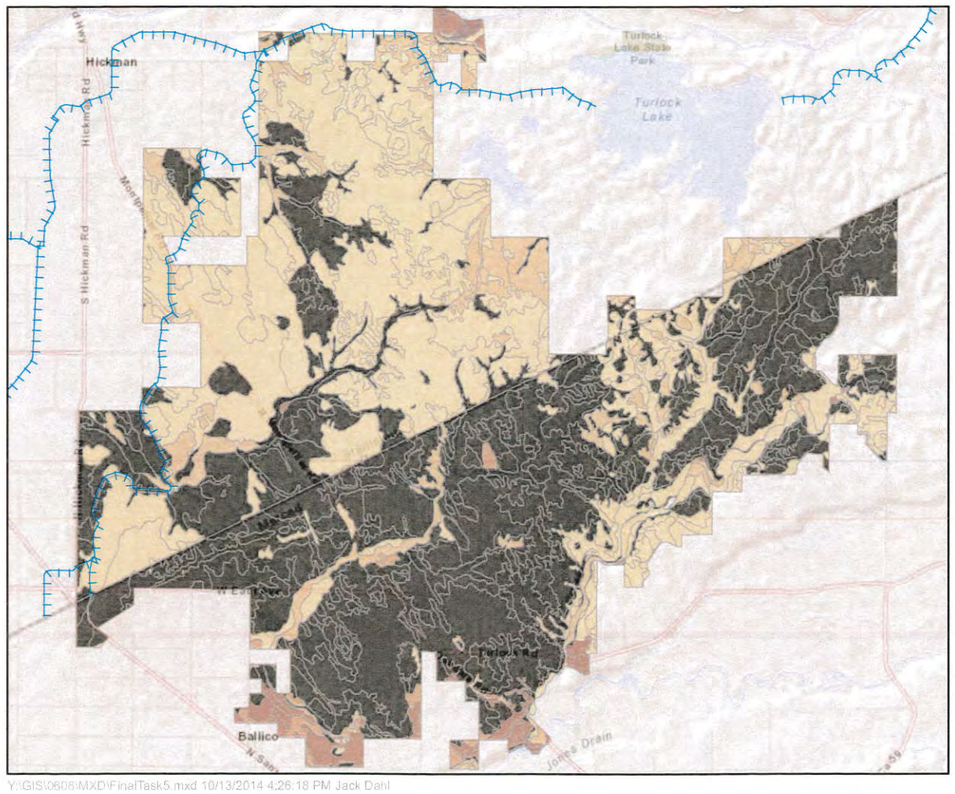
AREA VERTIC . HYDRAULIC CONDUCTIVITY AND HYDROLOGIC SOIL GROUP FROM NRCS

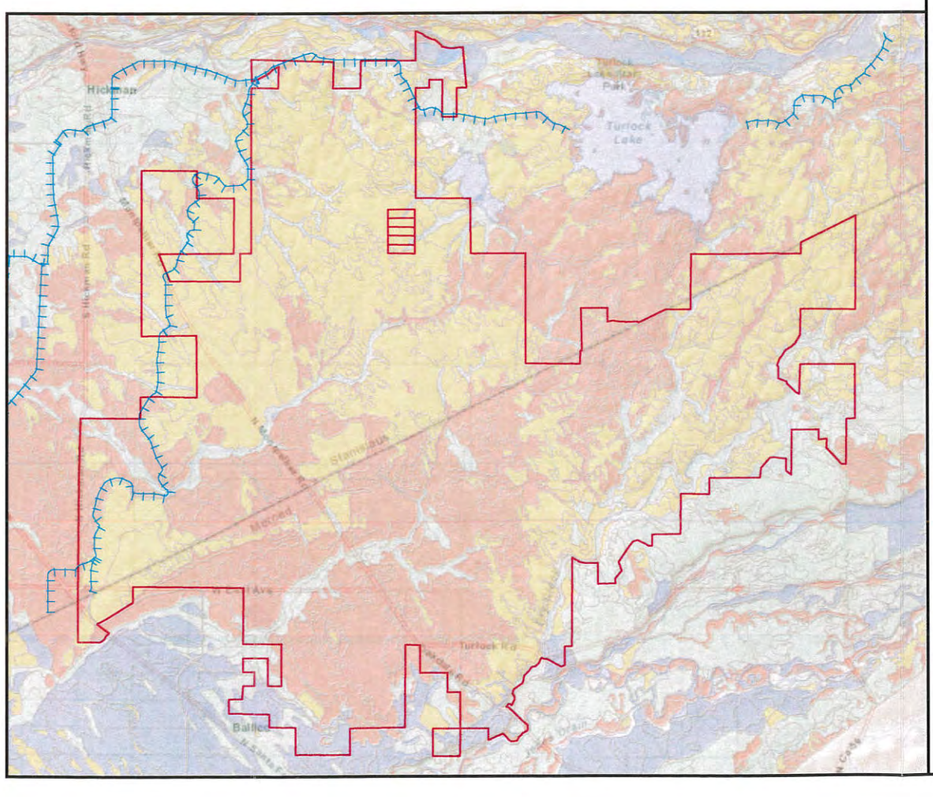
EASTSIDE WATER DISTRICT

OCTOBER, 2014









NORTH

0 2 4

Miles

Legend

SSURGO Hydro Soil

Hydrologic Soil Group

- A
- B
- C
- C/D
- D

SSURGO Hydraulic Conductivity

Kv Value

- 0
- 0 to 1 ft/d
- 1 to 5 ft/d
- 5 to 10 ft/d
- 10 to 25 ft/d
- 25 to 40 ft/d
- Turlock Irrigation District Canals

EPUR Safe Water for All

WOOD RODGERS

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FIGURE 5A

ESTIMATED V[illegible]TICAL HYDRAULIC CONDUCTIVITY OF THE UNSATURATED ZONE WITH GROUNDWATER ELEVATION CONTOURS

APRIL 2014

EASTSIDE WATER DISTRICT

NOVEMBER, 2014

NORTH

0 1 2

Miles

Legend

- Wells with Water Levels

Unsaturated Zone - Kv

- 0.25 - 0.30 ft/d
- 0.30 - 0.35 ft/d
- 0.35 - 0.45 ft/d
- 0.45 - 0.50 ft/d
- 0.50 - 1.00 ft/d
- 1.00 - 2.00 ft/d
- 2.00 - 19.4 ft/d
- GW Elevation April 2014 (ft above MSL)
- Turlock Irrigation District Canals
- Highline Canal Inlets

EPUR Safe Water for All

WOOD RODGERS

FIGURE 6A

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Site Number	County	Parcel Size (ac)
1	Stanislaus	40
		40
		40
		40
2 & 3	Stanislaus	54
		41
		307
4 & 5	Stanislaus	104
		76
		40
		40
		40
6	Stanislaus	81
7	Stanislaus	142
8	Merced	21
9	Merced	38
		42
10	Merced	24.8
11	Merced	31.5
12	Merced	206
		403
13	Stanislaus	15

POTENTIAL RECHARGE SITES MAP

EASTSIDE WATER DISTRICT
NOVEMBER, 2014

NORTH

0 0.75 1.5
MILES

Legend

- parcels_potential_recharge_anonymous
- TID Canal
- Major Roads
- Eastside Water District Boundary

#1
#2 & #3
#4 & #5
#6 & #7
#8
#9
#10
#11
#12
#13

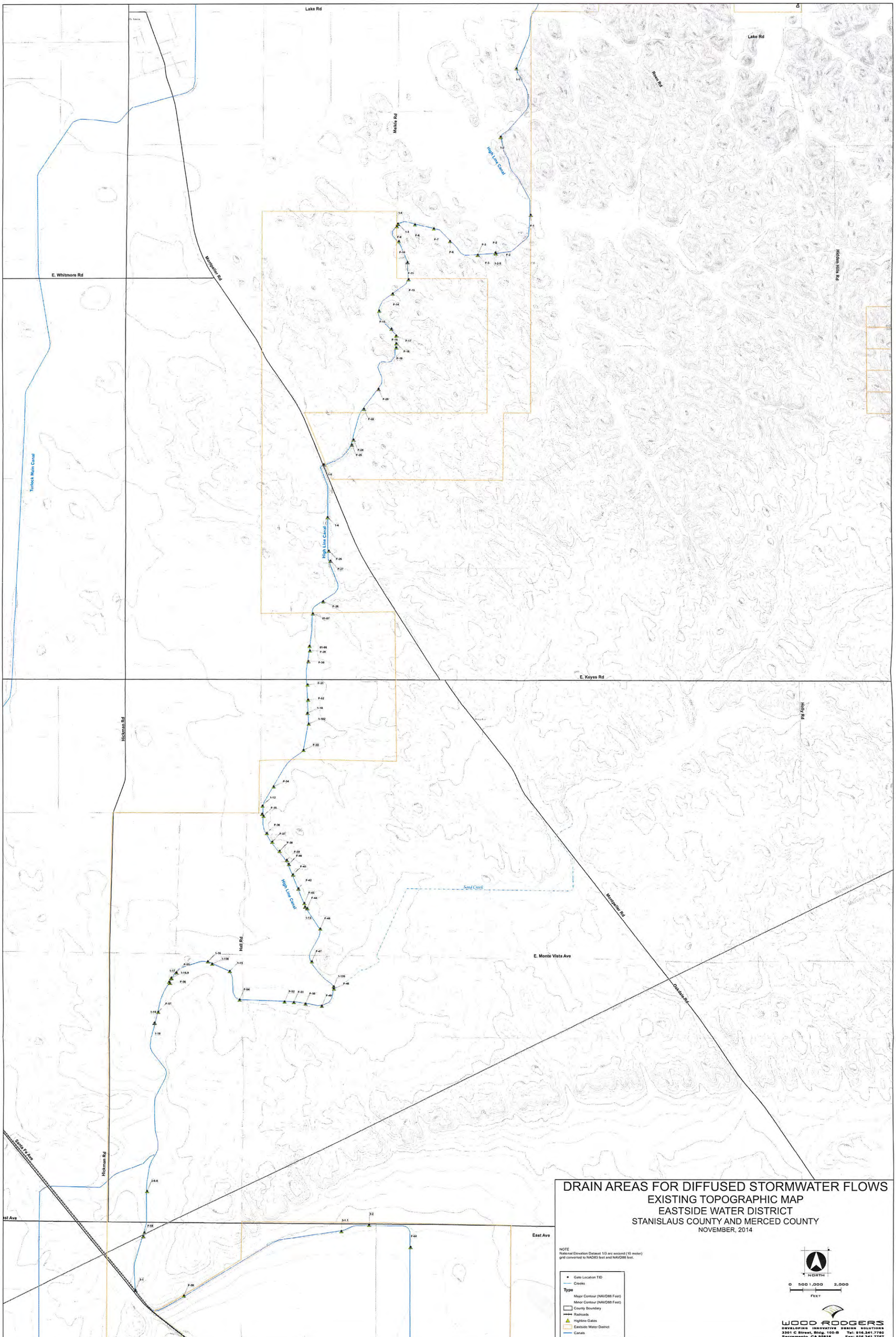
Main Canal
Turlock Main Canal
Highline Canal
Cross Ditch 1
Cross Ditch 2
Lateral 6
Lateral 7
Lateral 8
Lower Stevinson
Hickman
Vincent
Lander
Montpelier
Shaffer

Keyes
Monte Vista
Turlock
Main
East
Meadow
Oakdale
Golden State
Santa Fe
Stanislaus Co
Merced Co
99
165

J:\Jobs\8571_Eastside_WD\8571.001_MAR\GIS\Tasks\EastsideWD_Potential_Recharge_Sites_20141106.mxd 11/6/2014 12:21:40 PM sspaeth

FIGURE 6B

APPENDIX



DRAIN AREAS FOR DIFFUSED STORMWATER FLOWS

EXISTING TOPOGRAPHIC MAP

EASTSIDE WATER DISTRICT

STANISLAUS COUNTY AND MERCED COUNTY

NOVEMBER, 2014

NOTE
National Elevation Dataset 1/3 arc second (10 meter) grid converted to NAD83 feet and NAVD88 feet.

- Gate Location TID
- Creeks

Type

- Major Contour (NAVD88 Feet)
- Minor Contour (NAVD88 Feet)
- County Boundary
- Railroads
- Highline Gates
- Eastside Water District
- Canals

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS
3301 C Street, Bldg. 100-B Tel: 916.341.7760
Sacramento, CA 95816 Fax: 916.341.7767

FIGURE 2A

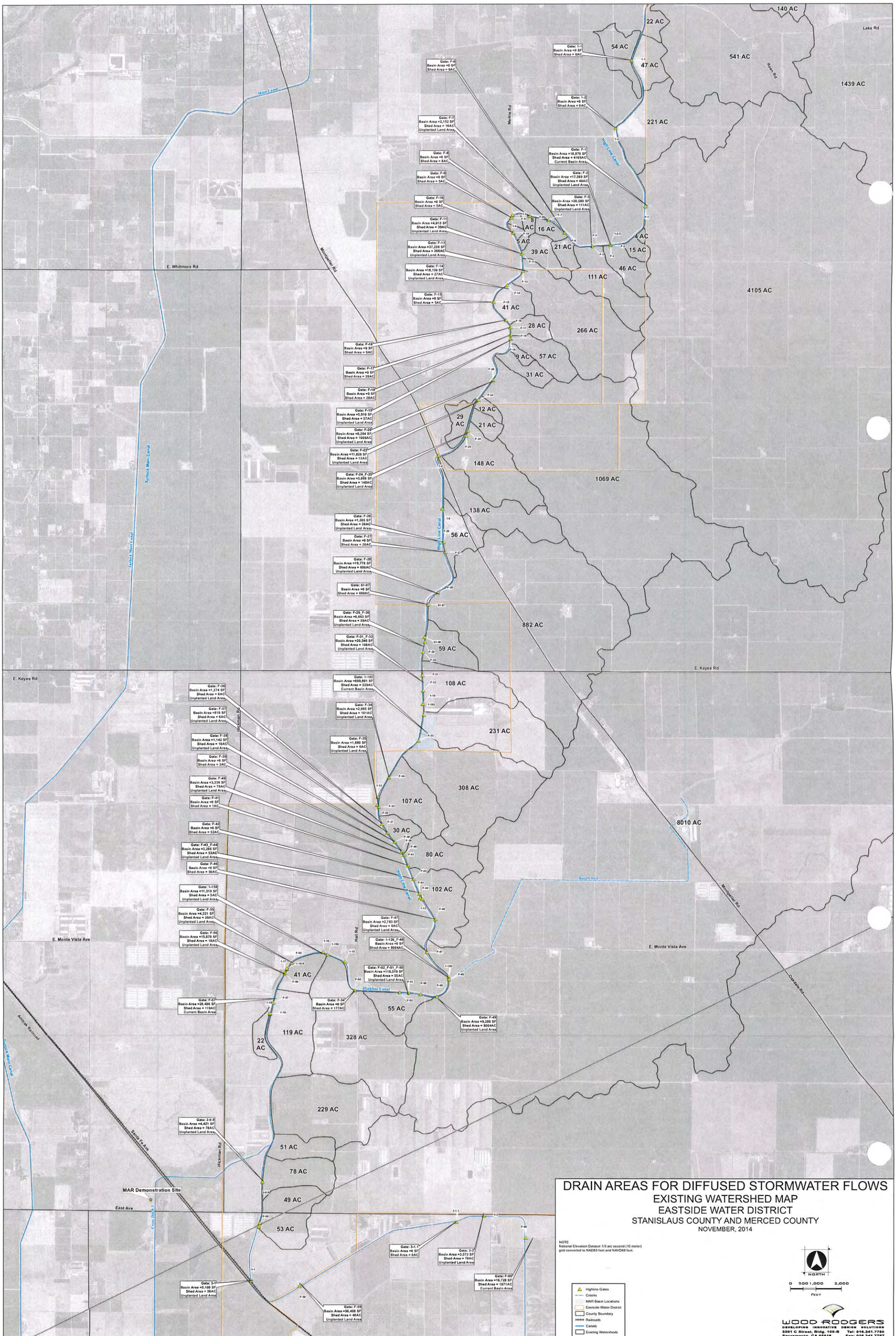

DRAIN AREAS FOR DIFFUSED STORMWATER FLOWS
EXISTING WATERSHED MAP
EASTSIDE WATER DISTRICT
STANISLAUS COUNTY AND MERCED COUNTY
NOVEMBER, 2014
NOTE
National Elevation Dataset 1/3 arc second (10 meter) grid converted to NAD83 feet and NAVD88 feet.
Highline Gates
Creeks
MAR Basin Locations
Eastside Water District
County Boundary
Railroads
Canals
Existing Watersheds
NORTH
0 500 1,000 2,000
FEET
WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS
3301 C Street, Bldg. 100-B Tel: 916.341.7760
Sacramento, CA 95816 Fax: 916.341.7767
E. Whitmore Rd
E. Keyes Rd
E. Monte Vista Ave
East Ave
Lake Rd
Rosen Rd
Mellkie Rd
Montpelier Rd
Hickman Rd
Hall Rd
Oakdale Rd
Santa Fe Ave
Amtrak Railroad
Main Canal
Turlock Main Canal
High Line Canal
Highline Canal
Sand Creek
MAR Demonstration Site
140 AC
22 AC
54 AC
47 AC
541 AC
1439 AC
221 AC
8 AC
16 AC
5 AC
39 AC
21 AC
4 AC
15 AC
46 AC
111 AC
4105 AC
41 AC
28 AC
266 AC
9 AC
57 AC
31 AC
12 AC
29 AC
21 AC
148 AC
1069 AC
138 AC
56 AC
882 AC
59 AC
108 AC
231 AC
308 AC
107 AC
30 AC
80 AC
102 AC
8010 AC
41 AC
55 AC
119 AC
22 AC
328 AC
229 AC
51 AC
78 AC
49 AC
53 AC

FIGURE 2B

Table of Inlets and Turnouts
for Figure 2B

Gate Name	Basin Landuse Description	Watershed Area (AC.)	Basin Area (S.F.)
F-57	Current Basin Area	119	28,496
F-60	Current Basin Area	1,071	16,728
1-102	Current Basin Area	539	699,801
F-1	Current Basin Area	4,105	18,879
3-1	Unplanted Land Area	56	5,108
2-0.8	Unplanted Land Area	78	4,421
F-56	Unplanted Land Area	18	15,679
F-55	Unplanted Land Area	20	4,221
1-158	Unplanted Land Area	5	11,319
F-52_F-51_F-50	Unplanted Land Area	55	118,570
F-49	Unplanted Land Area	8,004	9,286
F-47	Unplanted Land Area	6	2,783
F-43_F-44	Unplanted Land Area	52	3,266
F-31_F-32	Unplanted Land Area	108	20,540
F-29_F-30	Unplanted Land Area	59	6,663
F-24_F-25	Unplanted Land Area	148	3,869
3-2	Unplanted Land Area	78	3,573
F-2	Unplanted Land Area	46	17,569
F-3	Unplanted Land Area	111	20,589
F-13	Unplanted Land Area	266	37,256
F-20	Unplanted Land Area	1,069	8,384
F-7	Unplanted Land Area	16	2,152
F-11	Unplanted Land Area	39	4,015
F-14	Unplanted Land Area	27	18,130
F-19	Unplanted Land Area	57	5,910
F-22	Unplanted Land Area	12	11,826
F-26	Unplanted Land Area	26	1,205
F-28	Unplanted Land Area	690	19,776
F-34	Unplanted Land Area	101	2,065
F-35	Unplanted Land Area	6	1,880
F-36	Unplanted Land Area	6	1,274
F-37	Unplanted Land Area	6	819
F-38	Unplanted Land Area	16	1,142
F-40	Unplanted Land Area	79	3,236
F-59	Unplanted Land Area	48	96,408