DEEP WELL FEASIBILITY ASSESSMENT

Panoche Energy Center

Feasibility of Wastewater Disposal

by

Deep Injection Wells

1. BACKGROUND

Duke Energy Services are preparing a Class I Injection Well Permit Application to install and operate a total of 4 Class I Deep Injection Wells for the disposal of wastewater.

The PEC property is located approximately one (1) mile south of the abandoned Cheney Ranch Gas Field (Figure 1).

2. CHENEY RANCH GAS FIELD WELL LOGS

Based on an analysis of the Cheney Ranch Gas Field E-logs, it appears that successful injection wells can be installed south of the Cheney Ranch Gas Field on the PEC property (Figure 2). The E-Logs of wells in the Cheney Gas Field show sedimentary sequences can be correlated over distances of up to 2 miles (Figure 2). By extrapolation, the E-logs indicate approximately 500 feet of permeable sands beneath the PEC property.

Calculations based on regional Eocene sands, indicate that an injection well of approximately 5,700 feet deep, would intersect more than 500 feet of permeable sands (Figure 3). The estimated injection rates for the proposed wells at PEC are shown in Section 3.

The Kreyenhagen Shale appears to be present beneath the PEC property in the depth interval 3,300 and 4,200 feet bgs. This impermeable sequence of shale should form a substantial confining zone, and prevent the migration of injected wastewater towards the overlying aquifers and underground sources of drinking water (USDW).

The feasibility of installing a successful injection wells at the proposed Panoche Site is based primarily on the presence of substantial thicknesses of permeable sands and 900 feet of impermeable Kreyenhagen Shale, that would protect the regional USDW.

A list of the wells located in the Cheney Ranch Gas Field is shown on Table 1.

TABLE 1. Cheney Gas Field Wells, Fresno County, California

	API NUMBER	OPERATOR	LEASE	WELL N0.
1	01920736	Cencal Drilling, Inc.	Silver Creek	57X
2	01920711	Cencal Drilling, Inc.	Silver Creek	73X
3	01920687	Cencal Drilling, Inc.	Silver Creek	77X
4	01900191	Exxon Corporation	Cheney Ranch	2
5	01920712	Cencal Drilling, Inc.	Silver Creek	14X
6	01920726	Cencal Drilling, Inc.	Silver Creek	27X
7	01920830	Cencal Drilling, Inc.	Silver Creek	22X
8	01921446	Cencal Drilling, Inc.	Cheney Ranch	15X
9	01900190	Exxon Corporation	Cheney Ranch	1
10	01920710	E.A. Bender, Operator	Silver Creek	72X
11	01923117	Nahama & Weagant Energy	Cheney Ranch	81X-30
12	01900192	Exxon Corporation	Cheney Ranch	3
13	01920758	E.A. Bender, Operator	Silver Creek	54X
14	01900193	L.M. Lockhart	England	1-31
15	01920776	E.A. Bender, Operator	Silver Creek	32X
16		Atlantic Richfield Co.	Roberts	1
17		E.A. Bender, Operator	Silver Creek	18

3. HYDROGEOLOGY

Confining Zone

The Eocene Kreyenhagen Shale is a relatively impervious sequence that overlies the proposed injection zone. Beneath the PEC property, the Kreyenhagen shale could be between 800 and 900 feet thick. The maximum thickness attained by this sequence in the Central Valley is 900 feet. The Kreyenhagen Shale is reportedly laterally and vertically extensive.

Hydrogeologic parameters of the confining zone:

The Kreyenhagen shale normally exhibits a "baseline" shale response on the spontaneous potential (SP) log because of positive millivolt deflection by saline formations in low-salinity drilling fluids. This characteristic is consistent with rocks having negligible porosity and permeability and generally considered as evidence that they are impermeable. Gas-charged sands of the Cheney Ranch Gas Field indicate the Kreyenhagen shale has a hydraulic conductivity low enough to confine even gaseous substances over geologic time.

The permeability of the confining zone was estimated to be 1 millidarcy (md) based on the intrinsic permeabilities for clay, silt, sandy silts, and clayey sands given in Fetter

(1994, p. 98). The estimated hydraulic conductivity for the Kreyenhagen shale is 1.08 x 10^{-06} cm/s, or 3.06 x $l0^{-03}$ ft/day.

Injection Zone

The proposed injection zones for the proposed PEC injection wells, are the undifferentiated Eocene sands, the Laguna and Cima Sands (Figure 2). The Paleocene and Lower Eocene sands below the Kreyenhagen shale and above the Upper Cretaceous Panoche Group shales have been selected as the primary injection zones, as they appear to be laterally continuous and sufficiently thick (Figure 2). Thinner sand sequences such as the Domengine sandstones and Moreno Formation Sands may be included as part of the injection zone.

The Eocene sands, Laguna and Cima, in the proposed injection zone shown in the nearest well to the site, the England well No. 1-31, have a total gross thickness of about 566 ft and an estimated net sand thickness of about 500 ft. The injection interval beneath the PEC property is expected to be at least 500 feet thick, as there appears to be a thickening of these sequences from north to south across the Cheney Ranch Gas Field (Figure 2).

Using E-logs, the Eocene sands beneath the Cheney Ranch Gas Field can be correlated. The strong correlation of the sand and shale between wells indicates that the sedimentary sequences can be extended from the Cheney Ranch Gas Field to the south, beneath the PEC property (Figure 2).

Hydrogeologic parameters of injection zone

Hydraulic conductivity and permeability

The permeability of the Paleocene sand in the proposed injection zone is estimated to be 500 md based on the permeabilities in producing zones in the surrounding oil and gas fields (California Department of Conservation, 1998; California Department of conservation, 1981). The hydraulic conductivity of the proposed injection zone is estimated to be 0.00054 cm/sec, or 1.53 ft/day.

Porosity

Porosity is estimated to be at least 25%, based on similar Eocene sand sequences in the San Joaquin Basin.

Transmissivity

Using a minimum injection zone thickness of 500 ft: The estimated transmissivity is 1.53 ft/d * 500 ft = 765 ft2/d = 5,721 gal/d/ft

Injection Zones

The proposed injection zones are located in the approximate depth ranges 4,800 to 5,200 and 5,400 to 5,700 feet bgs.

Average and Maximum Injection Pressure

The maximum injection pressure is calculated based on a pressure gradient of 0.8 psi/foot, a maximum top perforation depth of 4,800 feet, and injection fluid assumed to have a specific weight of 62.4 lb/ft^3, and thus a gradient of 0.433 psi/foot.

Maximum injection pressure: (0.8 psi/foot – 0.433 psi/foot) x 4,800 feet = 1,764 psi.

Injection Rates

Based on the transmissivity of the sands in the proposed injection zone, injection rates greater than 400 gal/minute are anticipated for the proposed injection wells (Figure 3).

5. OPERATION OF INJECTION WELLS

Above Ground System

The combined PEC process wastewater will be pumped at between 375 and 514 gallons per minute via an underground pipeline to an elevated 20,000 gallons wastewater holding tank. The 20,000 gallons holding tank will also act as a reservoir to moderate the injection flow rate.

Hydrochloric acid and bio-growth retardants will be added to the wastewater in the elevated holding tank prior to injection. Details of the preparation of the pre-injection wastewater will be provided on completion of an assessment of the chemical compatibility of the anticipated wastewater and formation water.

From the elevated holding tank, the wastewater will be gravity fed by two eight-inch diameter pipelines to two centrifugal pumps, connected separately to two primary injection wells (Well Nos. 1 and 2). The injection rate to each of the two wells will range between 350 to 1,000 gallons per minute (gpm). The estimated injection pressure range for both wells is 50 to 150 pounds per square inch (psi). A flow control valve will allow PEC to divert the wastewater into either one or two of the backup wells (Well Nos. 3 and 4), during maintenance and other outages of the primary Wells, 1 or 2.

Injection Well Design

A preliminary well design that would apply to all the proposed injection wells is shown on Figure 3. Multiple layers of casing and cement in the design are to protect underground sources of drinking water (USDW), determined as groundwater with a TDS of less than 10,000 gm/L. The ‘longstring’ casing is extended beyond a thick sequence of Kreyenhagen Shales, to a depth of approximately 4,240 feet bgs.

By extrapolation of the lithostratigraphic sequences identified in the Cheney Ranch Gas Field well logs, thick sequences of permeable sand layers are anticipated beneath the PEC property from approximately 4,200 to 5,600 feet bgs (Figure 2). The proposed injection wells are to be installed with two sections of louvred screens through the sand intersections between approximately 4,800 to 5,700 feet bgs.

Proposed Injection Well Locations

The location of the four (4) proposed deep injection wells is shown on Figure 4. Well Nos. 1 and 2 will be the primary injection wells, whilst Wells 3 and 4 will be ancillary wells, operated during periods of maintenance or primary well failure.

Well Operation

The maximum injection rate is expected to be 750,000 gallons per day. The average injection rate is expected to be 540,000 gallons per day. The injection rate will be measured continuously in the supply line immediately before the wellhead, and the total volume will be recorded.

Based on the low total suspended solids (TSS) content of the wastewater streams at operating power generating plants that add flocculants to the water system, pre-injection filtration to remove TSS may not be required. Normally, wastewater with TSS levels above 5 ppm would be filtered prior to injection.

An automatic electronic injection system control and recording unit will be stationed in an office of the PEC for monitoring of the injection pressure and flow rate. The electronic control system will be connected by overhead cables to the injection well pumps, holding tank9s) and inline pressure and flow rate gauges.

Contingency Plan for Well Failures

The injection pumping system could be shutdown for a total of 2 days, for pump repairs or maintenance. During this period, an onsite 2 million gallon steel tank could provide sufficient holding capacity until the IW pumping system is back up and running. An alternative to storing the wastewater, during periods of injection system pump repair, would be to install a third wastewater pumping unit.

Plugging and Abandonment Plan

Proposed disposal wells will be abandoned in accordance with EPA, DOGGR, and other applicable requirements in force at the time wells are abandoned. The EPA, DOGGR, and other applicable requirements in force at the time wells are abandoned will approve the cementing program. Wells will be cemented from the bottom of the well to the surface. A steel cap will be welded on and an abandonment marker will be installed.

Monitoring

USEPA regulations governing disposal of wastewater into deep injection wells require regular tests for monitoring the formation water's hydraulic property changes in the vicinity of the well. PEC will perform mechanical integrity tests (MIT) every five years, as prescribed by the USEPA Injection Well Permit. The MIT is a shut-in test, which requires the PEC facility to not inject any wastewater into the IW while the test is being performed PEC has assumed that the MIT would be performed during routine outages.

6. CONCLUSION

Based on the analysis of the Cheney Ranch Gas Field E-logs, and the reported transmissivity values for similar San Joaquin Basin strata, the sand sequences in the depth interval 4,200 to 5,700 feet bgs beneath the PEC property contain adequate permeable sand layers for the installation of successful deep injection wells.

The proposed PEC injection wells, pumping at 100 psi are expected to inject approximately 600,000 gal/day of Panoche Energy Center wastewater.

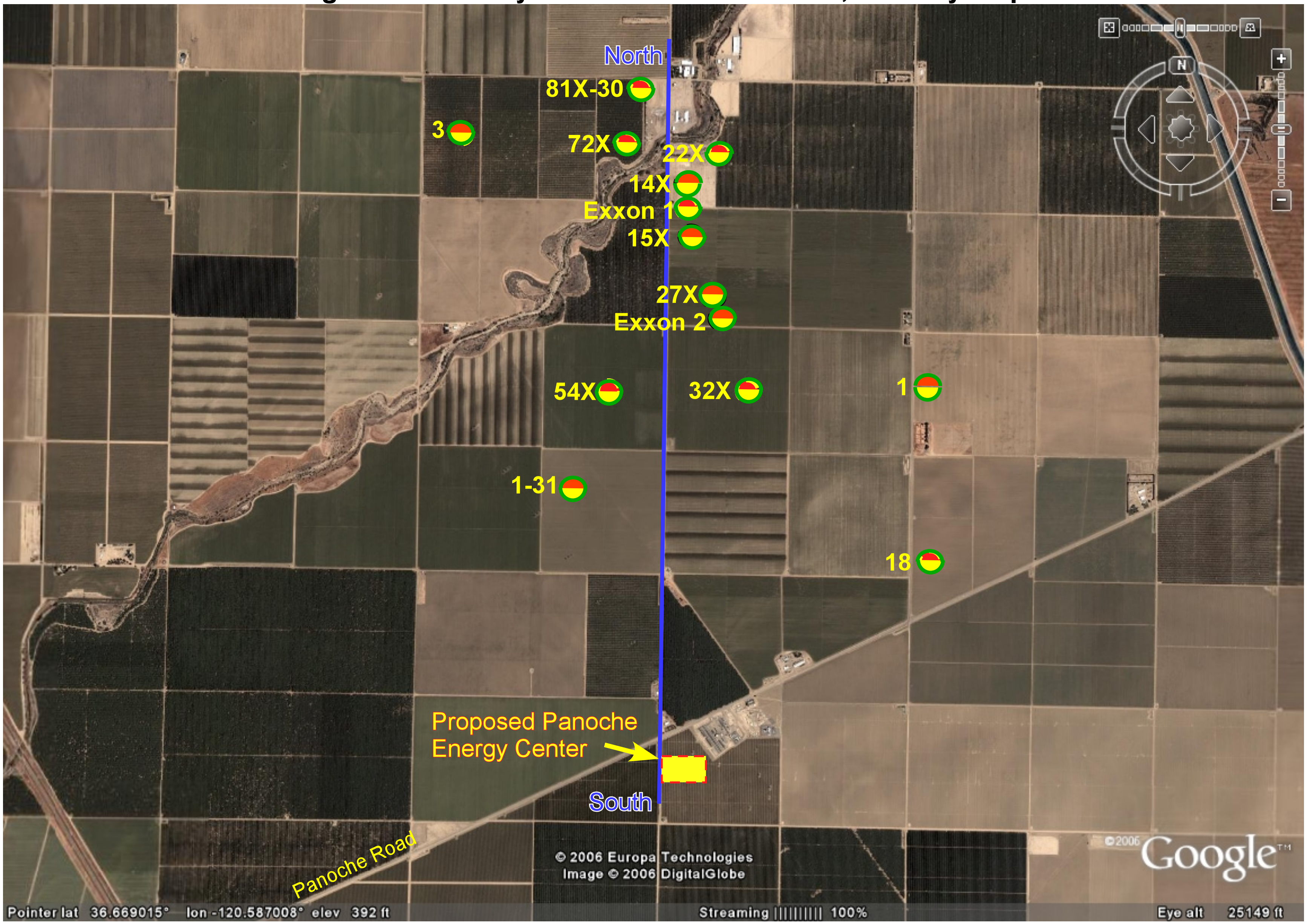
7. REFERENCES

Califomia Department of Conservation, 1998. *California Oil Fields, Central California:* Division of Oil and Gas, and Geothermal Resources, Publication TR11, vol. 1, Sacramento.

California Department of Conservation, 1981. *California Oil Fields, Northern California:* Division of Oil and Gas, and Geothermal Resources, Publication TRIO, vol. **3,** Sacramento.

Fetter, C.W., 1994. Applied Hydrogeology. (Third Edityio): Prentice Hall: Englewood Cliffs, NJ.

Figure 1 Cheney Ranch Gas Field Wells, Locality Map



Panoche Energy Center
West Panoche Road
Fresno County
California

Legend

Location of Cross Section (see Figure 2)

Plugged and Abandoned Gas Wells

Panoche Energy Center Site

Scale

1 Inch= 2,640 feet

0 2,000 4,000 feet

Figure 2   Deep Lithologic Sequences Beneath Cheney Ranch Gas Field, Extrapolated to Panoche Energy Center (PEC)

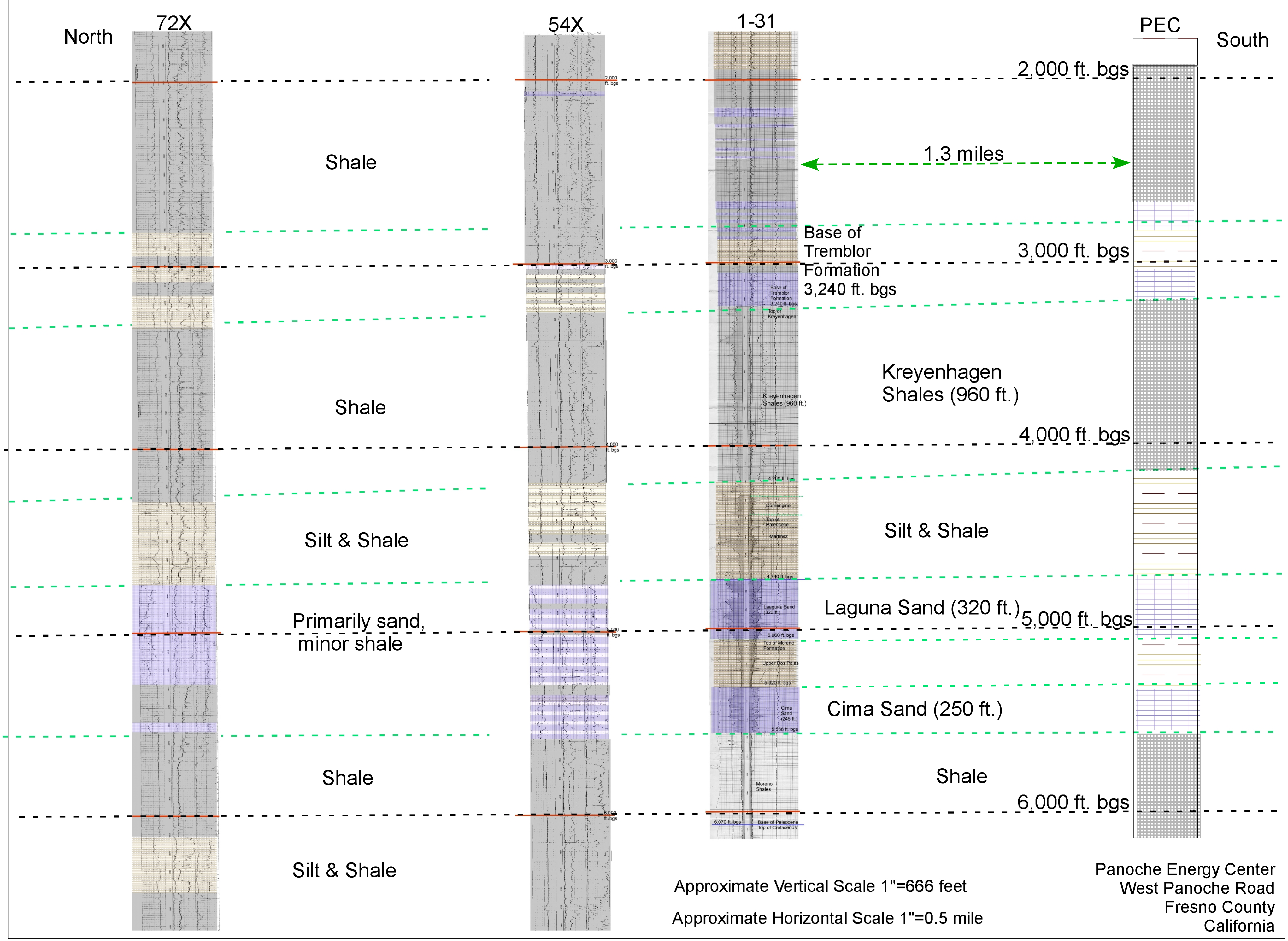
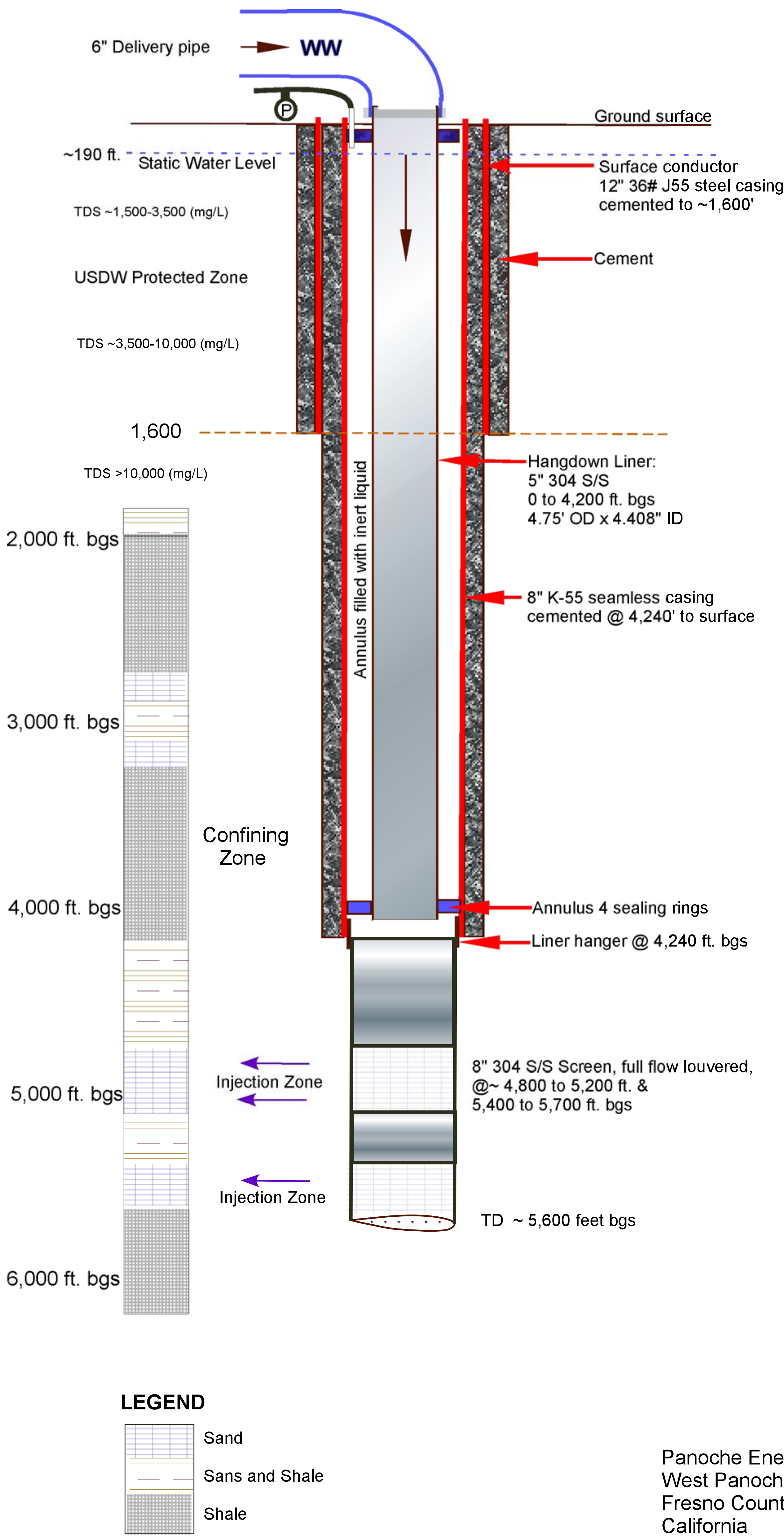


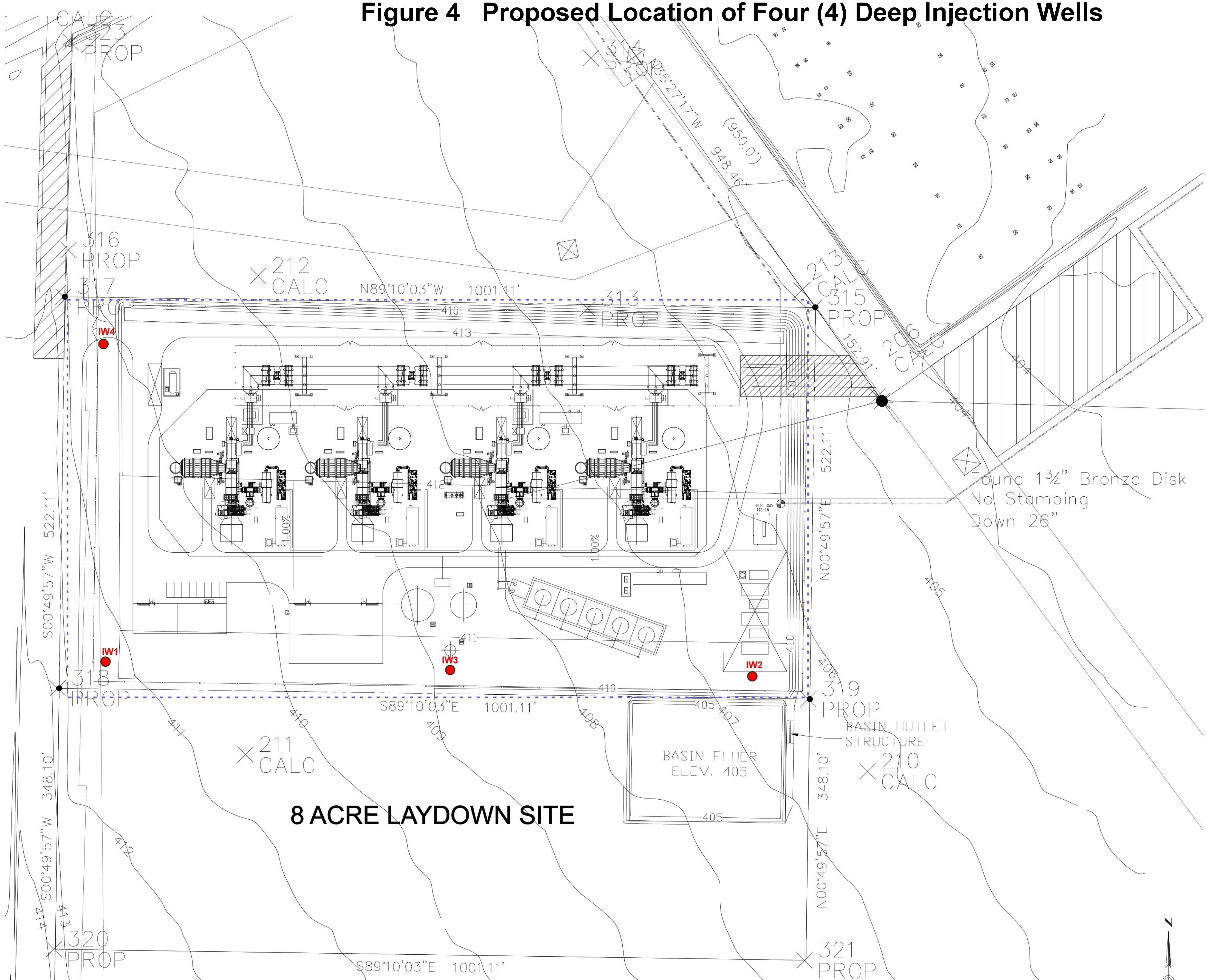
Figure 3 **Well Construction Plan**

Proposed Injection Well Schematic



Panoche Energy Center
West Panoche Road
Fresno County
California

Figure 4 Proposed Location of Four (4) Deep Injection Wells



IW2 ● Proposed location of injection well

REV	DESCRIPTION	DWN	CHK	APP	DATE
B	REVISED BASIN LOCATION	DNL	REB	SMG	07-07-06
A	ISSUE FOR AFC PERMIT	DNL	REB	SMG	06-23-06

KIEWIT INDUSTRIAL CO.
A Kiewit Company

PANOCHE ENERGY CENTER LLC

Bibb and associates
8455 Lenexa Drive
Lenexa, Kansas 66214

GRADING AND DRAINAGE PLAN
FIGURE 3.4-3

	by	date
DESIGNED	RSG	07-06-06
DRAWN	DNL	07-06-06
CHECKED	REB	07-06-06
APPROVED	SMG	07-06-06

DRAWING NUMBER
2006-027-CP-001

7/7/2006 3:38:56 PM DNL\pscomb J:\2006027\IBD\ARG\2006027-CP-001.dgn