URS

Technical Memorandum
Panoche Energy Center (PEC)

Water Quality Evaluation
April 24, 2007

Introduction

In earlier technical memorandums on the subject of water use for the proposed Panoche Energy Center (PEC) project, it was presented that the groundwater from confined aquifers would be the most appropriate water supply source for the project. This technical memorandum has been developed in response to questions raised in previous technical memorandums and to address the comments and questions generated by California Energy Commission (CEC) staff. The questions relate to whether the water from confined aquifers below the Corcoran Clay should be considered *inland waters that are suitable for use as sources of domestic, municipal, or agricultural water supply* and whether *it could be considered fresh inland waters.* These issues could raise questions regarding PEC's conformance with SWRCB Policy 75-58.

Degraded Water Quality

Degraded groundwater within the lower confined aquifers was selected to meet the PEC process water needs based on a comprehensive review of available sources of water supply and a decision analysis as described in the Application for Certification (AFC), where all potential available water sources were considered. The water in confined aquifers below the Corcoran Clay is considered to be a degraded water supply in accordance with the CEC definition of degraded water *as surface water, groundwater, treated municipal effluent or industrial process water which is not suitable for potable use because of natural or manmade contamination*. Degraded water includes *naturally occurring brackish water deemed too salty for human consumption or irrigation* (CEC, 2003[a])

Water for Domestic or Municipal Use
It is our opinion that the potential source of water for the PEC project complies with CEC policy. Because of the degraded nature of the water under consideration, there is minimum competition for an alternative use of the proposed water as there are no known domestic or municipal uses of groundwater within several miles of the PEC.

Groundwater is not typically considered a source of drinking water locally due to high specific conductance, sulfate, and total dissolved solids (TDS) as well as elevated levels of other parameters and constituents.

[a] California Energy Commission. 2003. Use of Degraded Water Sources as Cooling Water in Power Plants, P500-03-110.

- The water in the confined aquifer below Corcoran Clay contains high turbidity levels which are 10 to 50 times over the state and federal secondary limitations.
- The concentrations of some of the metal ions also exceed both state and federal secondary maximum contaminant levels (MCLs).
- High concentrations of boron are present in the local groundwater. Boron has been identified to have adverse effect on human health and is listed as a contaminant candidate by the U.S. Environmental Protection Agency (US EPA), although it is not regulated by the current drinking water standards due to its low natural occurrence. The boron health reference level has been calculated by US EPA at 1.4 milligrams per liter (mg/L) (US EPA, 2006[b]) whereas water samples from the confined aquifer indicate a boron concentration range from 1.6 to 3.0 mg/L.

The table below lists the parameters and constituents in the confined aquifer that exceed the MCLs set by the California Department of Health Service and US EPA.

Parameters	PEC Area Confined Aquifer Water Quality Data	California Department of Health Services[1]		U.S. Environmental Protection Agency	
		Primary MCL	Secondary MCL	Primary MCL	Secondary MCL
Specific Conductance	1,100-1,500 µS/cm		900 µS/cm		
Sulfate as SO4	370-440 ppm		250 ppm	500 ppm	250 ppm
TDS	820-1,100 ppm		500 ppm		500 ppm
Turbidity	45-260 NTU		5 NTU		
Manganese	0.026-0.36 ppm		0.05 ppm		0.05 ppm
Iron	0.14-45 ppm		0.3 ppm		0.3 ppm

µS/cm = microsiemens per centimeter

ppm = parts per million (equivalent to mg/L)

[1] Title 22 California Code of Regulations

Water for Irrigation Use

While groundwater has been used for irrigation of land surrounding the PEC in the past, it has been replaced by higher quality surface water under normal conditions. Past usage of the groundwater for irrigation was generally limited to more salt tolerant crops (e.g., cotton and grain) than those prevalent in the surrounding area today. Information presented in Section 5.5.1.7.1 of the AFC describes the following changes in local irrigation practices:

> *Early farmers in the Westlands Sub-basin made use of groundwater for irrigation. In 1968, the delivery of surface water with low levels of dissolved solids from the San Luis Unit of the federal Central Valley Project (CVP) largely replaced the use of groundwater containing elevated levels of dissolved solids for irrigation. However, in response to drought conditions and other surface water shortfalls beginning in 1988, farmers reactivated old wells and constructed new wells in order to pump groundwater to irrigate their crops.*

[b] U.S. Environmental Protection Agency Office of Water, 2006. Health Effects Support Document for Boron.

Surface water delivered by the Westlands Water District is generally used rather than groundwater wells, and many wells in the area have collapsed or are abandoned.

A few functional irrigation wells are still present within the surrounding area but are rarely used because the groundwater they produce is not suitable for irrigation of most of the crops that are presently grown in the area and can be damaging to the soil. Farmers in the area typically purchase surface water from the Westlands water district at a higher cost than pumping groundwater underlying their property. Acceptance of this cost penalty indicates that the local farmers consider usage of groundwater as the sole source of irrigation water to be undesirable.

Typically, the following basic criteria are used to evaluate water quality for irrigation purposes (Follett and Soltanpour, 1999[c]):

- Total soluble salt content (salinity hazard)
- Relative proportion of sodium cations to other cations (sodium hazard)
- Excessive concentration of toxic elements (e.g., chloride, boron)
- Bicarbonate anion concentrations related to calcium and magnesium cations

Groundwater within the confined aquifers underlying the site presents threats to crops and soils including salinity, sodium, and boron hazards. The effect of the hazard of water quality on irrigation by individual properties is presented in an attachment to this memorandum.

Conclusion

The information presented though this memorandum clearly demonstrates that the competitive uses of the water supply selected for PEC are insignificant. Groundwater supplies within the confined aquifers underlying the site are not known to be used for domestic or municipal supply in the surrounding area and may only be used for agricultural supply on a short-term basis if surface water is unavailable. The groundwater presents a high sodium hazard and is generally unsuitable for continuous use as a sole source water supply. In addition, the groundwater is unsuitable for irrigation of crops sensitive to boron and usage on crops semi-tolerant to boron ranges from permissible to unsuitable depending on the crop. High sulfate concentrations in the groundwater also present a hazard of foliar leaf burn when sprinklers are used for irrigation. It is not beneficial to use groundwater within the confined aquifers for either domestic and municipal supply purposes or agricultural irrigation purposes. Based on these usage limitations, it appears that groundwater meets the degraded water criteria presented through the "Use of Degraded Water Sources As Cooling Water in Power Plants" CEC Consultant Report (CEC, 2003) guidance, and is therefore an appropriate water supply for the PEC project.

[c] Follett, R.H., and P.N. Soltanpour. 1999. Irrigation Water Quality Criteria, Colorado State University Cooperative Extension.

Attachment: Hazardous Effect of Water Quality on Agricultural Irrigation Uses

Typically, the following basic criteria are used to evaluate water quality for irrigation purposes (Follett and Soltanpour, 1999):

- Total soluble salt content (salinity hazard)
- Relative proportion of sodium cations to other cations (sodium hazard)
- Excessive concentration of toxic elements (e.g., chloride, boron)
- Bicarbonate anion concentrations related to calcium and magnesium cations

The following evaluation evaluates irrigation water quality hazards presented by groundwater within the confined aquifers based on recent sampling of monitoring wells at the Panoche Energy Center (PEC). Groundwater data for these samples are summarized on Tables 1 and 2.

Salinity Hazard

Excess salt increases the osmotic pressure in the soil that can result in a physiological drought condition. While the soil can appear to contain sufficient moisture for the crop, plants will wilt because their roots cannot absorb enough water to replace that lost by transpiration. The total soluble salt content of irrigation water is generally measured by determining its electrical conductivity (EC) or by determining the actual salt content [measured as total dissolved solids (TDS)] (Follett and Soltanpour, 1999). Based on recent sampling of monitoring wells at the PEC, the EC in confined aquifer groundwater underlying the site ranges from about 1,100 to 1,500 microsiemens per centimeter (μS/cm) and the TDS range from about 820 to 1,100 milligrams per liter (mg/L). Usage of irrigation water within this range is permissible from an agricultural standpoint if leaching for salinity management is practiced. This technique requires excess water to be applied keep the salts in solution and flush them below the root zone (Fipps, 2003).

Sodium Hazard

The sodium hazard of irrigation water usually is expressed as the sodium adsorption ratio (SAR). This is the proportion of sodium to calcium plus magnesium as milliequivalents per liter in the water ($SAR = Na/(Ca+Mg/2)^{1/2}$). Sodium contributes directly to the total salinity and may be toxic to sensitive crops such as fruit trees and grapes, but the main problem with a high sodium concentration is its effect on the physical properties of soil. Continued use of high SAR value water leads to a breakdown in the physical structure of the soil caused by excessive amounts of colloidally absorbed sodium and results in the dispersion of soil clay that causes the soil to become hard and compact when dry and increasingly impervious to water penetration due to dispersion and swelling when wet. Use of water with a SAR value greater than 10 should be avoided if it will be the only source of irrigation water for long periods even if the total salt content is relatively low (Follett and Soltanpour, 1999). Based on recent sampling of monitoring wells at the PEC, the SAR of confined aquifer groundwater ranges from about 18 to 20. The sodium hazard of this water is considered high from an agricultural standpoint, and the water is generally unsuitable for continuous use (Fipps, 2003).

Toxic Elements

Direct toxicity to crops may result from chemical elements in irrigation water. The concentration of an element in water that will cause toxic symptoms varies depending on the crop. There is a long list of elements that can cause a toxic effect on crops. After sodium, chloride and boron are of most concern. Based on recent sampling of monitoring wells at the PEC, the chloride concentrations in the confined aquifer groundwater range from about 40 to 85 mg/L. These concentrations are not likely to cause a loss in crop yield. Boron concentrations, however, ranged from about 1.6 to 3.0 mg/L. These concentrations are satisfactory only for semi-tolerant to tolerant crops (Follett and Soltanpour, 1999). While a necessary nutrient, high boron levels cause plant toxicity ranging from acute to chronic and can accumulate in the soil. Boron sensitivity of local crops ranges from sensitive (e.g., almonds, stone fruits, and grapes) to semi-tolerant (e.g., tomato) (Fipps, 2003). Local farmers reportedly do not blend groundwater with surface water for irrigation due to high boron concentrations in the groundwater that make it unsuitable for agricultural use on the crops planted in the area.

Bicarbonate Concentration

Waters high in bicarbonate tend to precipitate calcium carbonate and magnesium carbonate due to evapotranspiration. This increases the proportion of sodium ions and increases the sodium hazard of the water to a level greater than that indicated by the SAR value (Follett and Soltanpour, 1999). Concentrations of bicarbonate in confined aquifer groundwater range from about 61 to 200 mg/L based on recent sampling of monitoring wells at the PEC. The sodium adsorption ratio can be adjusted for high bicarbonate concentrations (Fipps, 2003) but that does not appear to be warranted for groundwater in the confined aquifers underlying the PEC.

Sulfate Hazard

In addition to the most of the basic criteria described previously, sulfate presents a hazard to crops irrigated using groundwater from the confined aquifers. Sulfate concentrations exceeding approximately 200 mg/L can cause foliar leaf burn when using sprinkler irrigation. Concentrations of sulfate in the confined aquifer groundwater ranged from about 370 to 440 mg/L based on recent sampling of monitoring wells at the PEC.

References

California Energy Commission. 2003. Use of Degraded Water Sources as Cooling Water in Power Plants, P500-03-110.

Fipps, G. 2003. Irrigation Water Quality Standards and Salinity Management Strategies, Texas Cooperative Extension, Texas A&M University.

Follett, R.H., and P.N. Soltanpour. 1999. Irrigation Water Quality Criteria, Colorado State University Cooperative Extension.