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File No. 030137-0012

January 24, 2008

VIA FEDEX

DOCKET
07-AFC-3
DATE JAN 24 2008
RECD. JAN 24 2008

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 07-AFC-3
1516 Ninth Street, MS-4
Sacramento, California 95814-5512

Re: CPV Sentinel Energy Project: Docket No. 07-AFC-3

Dear Sir/Madam:

Pursuant to California Code of Regulations, title 20, sections 1209, 1209.5, and 1210, enclosed herewith for filing please find a letter from Dale Shileikis to the CEC regarding Appendix C and associated replacement pages to Applicant's responses to CEC Data Requests 35, 38, 43, 50, 60, and 62 through 65.

Please note that the enclosed submittal was also filed today via electronic mail to your attention.

Very truly yours,

Paul E. Kihm
Senior Paralegal

Enclosure

cc: Michael J. Carroll, Esq. (w/ encl.)

OC\933446.1

URS

January 24, 2008

Dockets Unit
California Energy Commission
1516 Ninth Street, MS 4
Sacramento, CA 95814

RE: CPV Sentinel Energy Project
Application for Certification 07-AFC-3

On behalf of CPV Sentinel, LLC, a limited liability company and the Applicant for the above-referenced CPV Sentinel Energy Project, we are pleased to submit the enclosed document:

- Appendix C and associated replacement pages to the *CPV Sentinel Energy Project Response to Data Requests (35, 38, 43, 50, 60, and 62 through 65)* that was docketed on January 22, 2008

This appendix was inadvertently left out of the previous submittal. This document is being submitted to the CEC for docketing.

URS Corporation

Dale Shileikis
Vice President

Enclosure

URS Corporation
221 Main Street, Suite 600
San Francisco, CA 94105
Tel: 415.896.5858
Fax: 415.882.9261
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TABLES

Revised Table 38-4 Expected Annual Emissions (All Operating Units)

FIGURES

Figure 50-1 Existing Wastewater Collection System
Figure 50-2 Proposed Future Wastewater Collection System
Figure 50-3 Horton Wastewater Treatment Plant Location
Figure 50-4 Horton Wastewater Treatment Plant Percolation Basins
Figure 50-5 Aquifer Formations and Groundwater Barriers
Figure 50-6 Indicated Depth to Crystalline Bedrock

APPENDICES

Appendix A Draft Erosion Control Plan
Appendix B Technical Memorandum: Additional Groundwater Flow Model Scenarios, Proposed CPV Sentinel Energy Project
Appendix C Extract from Harding Lawson Associates Report: Geothermal Resource Assessment and Exploration, Desert Hot Springs, California

BACKGROUND

Data Request 38 was only party answered in the "Reponses to Data Requests" dated October 4, 2007. Data Request 38 asked for a detailed discussion and analysis of the proposed use of groundwater for power plant cooling and a comparison with other options/alternatives. There were three subparts to this data request. Subparts (a) and (c) to this data request focused on air-cooling, and subpart (b) focused on the use of groundwater for power plant cooling. A detailed discussion and analysis of power plant cooling options/alternatives, other than air-cooling, was not provided.

65. Please provide a detailed discussion and analysis of alternative power plant cooling options. This discussion and analysis should focus on the economic feasibility and environmental soundness of the cooling options, and include those listed below. The applicant may be aware of options other than those listed below that are equally or more feasible and sound; if so, please provide an analysis of these alternatives.

- ***Use of the Desert Hot Springs Sub-Basin groundwater as a source of lower quality, high total dissolved solids (TDS) groundwater water.***
- ***Use of a different inlet and intercooling method, such as a mechanical air-chiller with air-cooling, instead of using a wet cooling tower.***

RESPONSE

DESERT HOT SPRINGS SUB-BASIN GROUNDWATER

The potential to use groundwater from the Desert Hot Springs Subbasin was evaluated in Section 8.6.2 of the AFC and determined to be infeasible. As requested, the Applicant is providing additional support for this conclusion with a focus on economic feasibility and environmental soundness.

Economic Feasibility

Groundwater in the Desert Hot Springs Subbasin has relatively poor water quality (highly mineralized and high temperatures). Water quality data for eighteen private wells within the Subbasin are summarized in a report prepared by Harding Lawson Associates (see Appendix C). In particular, the water quality of the groundwater in this subbasin is high in TDS, chloride, and pH. The water quality of this groundwater is significantly worse than the quality of reclaimed water that would be produced by the Horton WWTP. In addition, water temperatures in 34 wells studied by the DWR in the early 1960s ranged from 82 degrees Fahrenheit (°F) to 200°F, with an average temperature of approximately 118°F (URS, 2005).

The use of groundwater from the Desert Hot Springs Subbasin would have significant cost implications to the proposed CPVS project. It is anticipated that significant treatment of the water would be required to reduce the levels of TDS (on the order of 1,000 to 1,500 milligrams per liter [mg/L]) to meet the cooling tower design levels (approximately 500 mg/L). This would require a much larger makeup water treatment system or a reduction in the cooling tower cycles (from approximately six or seven cycles to approximately three cycles). In addition, the higher values of pH of this groundwater (pH values range from approximately 8.5 to 9.0) would increase the acid consumption used to maintain the circulating water pH at a lower range and increase the use of dispersant chemicals.

APPENDIX C

EXTRACT FROM HARDING LAWSON ASSOCIATES REPORT: GEOTHERMAL RESOURCE ASSESSMENT AND EXPLORATION, DESERT HOT SPRINGS, CALIFORNIA

A Report Prepared for

City of Desert Hot Springs
11-711 West Drive
Desert Hot Springs, California 92240

COPY

GEOTHERMAL RESOURCE ASSESSMENT AND EXPLORATION DESERT HOT SPRINGS, CALIFORNIA

HLA Job No. 17,319,001.01

by

Roy C. Skinner,
Senior Geologist

John G. Catts,
Associate Geochemist

Robert F. Corwin,
Associate Geophysicist

Harding Lawson Associates
7655 Redwood Boulevard, P.O. Box 578
Novato, California 94948
415/892-0821

October 18, 1985

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Appendix A - GEOCHEMISTRY

DISTRIBUTION

Appendix A

GEOCHEMISTRY

GEOCHEMISTRY

A. General Ground-Water Chemistry

The concentrations of aqueous constituents determined by the project laboratory and aqueous properties determined in the field by instrumental measurement are compiled in Table 1. The locations of the sampled wells are shown on Plate 3. Ground water in all PW series wells is relatively similar in composition with dominant sodium and sulfate. These waters have specific conductivities ranging from 1500 to 2200 μmhos/cm with the exception of water from well P-9 which had significantly lower total dissolved solids (SC = 830 μmhos/cm). Ground-water pH in the PW series wells ranges from 8.3 to 9.0.

A trilinear Piper Diagram was constructed as a method of graphically presenting ground-water quality data. Before constructing this diagram individual ground-water samples were evaluated for charge balance. By this process charge equivalents of major cationic components are summed and compared with the sum of major anionic components. This calculation was necessary for construction of the trilinear diagram but is also an independent check on laboratory quality control. Water samples with charge balances differing by more than 10 percent for cations versus anions are suspect. All samples generated from this study showed less than 5 percent deviation and in most cases less than 2 percent.

The trilinear diagram is shown as Figure 2. Percent distribution of major cations are plotted in the lower left triangle and percent distribution of major anions are plotted in the lower right triangle. Data is

Sample Number	pH	S.C.	T°C	δ^2H	$\delta^{18}O$	Na	K	Ca	Mg	Cl	F	SO_4	PO_4	NO_3	HCO_3	Ag	Al	As*	B	Ba	Co	Cr	Cu	Fe	Mn	Si	Sr	Th	V	Zn
PW-1	9.00	1600	55	-92	-11.20	280	8	34.0	.08	106	9.5	491	0.75	-	32	-	.06	75	1.3	.006	.07	-	.010	.01	-	26.1	1.1	.07	.012	-
PW-2	8.80	1810	46	-92	-10.98	312	9	44.5	.13	156	8.3	518	-	11.9	32	-	.08	50	1.2	-	.07	-	.013	.05	-	24.2	1.4	.07	.012	.11
PW-3	8.87	1680	71	-93	-11.36	275	7	35.3	-	106	10.1	500	0.70	-	30	-	.03	82	1.4	-	-	-	-	-	-	30.0	1.2	-	-	-
PW-4	8.68	2000	52	-95	-11.13	338	4	54.4	.27	162	7.4	617	-	-	26	-	.05	8	1.5	.029	-	-	-	.03	-	11.8	0.50	-	.010	.07
PW-5	8.54	1705	39	-86	-10.31	288	4	41.2	1.45	127	4.6	521	-	-	28	-	.05	1	0.67	.028	-	-	-	.02	-	8.25	0.40	-	.012	-
PW-6	8.51	1730	33	-85	-10.20	308	5	42.1	.53	142	4.1	512	-	9.1	41	-	.07	1	1.2	.024	-	-	.009	.09	-	8.91	0.28	-	.029	.06
PW-7	8.93	1700	62	-92	-11.31	269	8	31.6	-	99.8	9.3	475	0.87	-	28	-	.06	43	1.2	-	-	-	-	.05	-	30.0	1.04	-	.005	-
PW-8	8.87	1720	55	-90	-11.02	285	5	35.9	.13	124	6.6	484	-	-	28	-	.07	6	1.1	.034	-	-	-	.08	-	13.2	0.24	-	.023	-
PW-9	8.74	830	32	-84	11.18	116	5	12.5	.96	35.5	3.2	184	0.85	-	46	-	.01	1	0.20	-	-	-	-	.10	-	8.31	0.14	-	.032	-
PW-10	8.41	1955	37	-85	-9.85	329	6	65.4	1.73	207	5.9	503	-	30.6	44	-	.04	37	1.2	.011	-	-	-	.03	-	12.9	1.5	-	.008	-
PW-11	8.64	1670	50	-88	-10.90	269	8	33.7	.08	116	7.5	422	1.61	11.6	57	-	.07	25	1.1	.012	-	-	-	.35	-	25.2	1.2	-	.008	.21
PW-12	8.65	1520	48	-94	-11.54	244	6	23.1	.08	84.5	8.2	418	0.72	-	30	-	.04	40	0.99	.012	-	-	-	.44	-	20.5	0.71	-	.008	-
PW-13	8.78	1820	37	-86	-10.19	337	7	50.0	.11	189	7.5	527	-	33.2	27	-	.08	34	1.4	.006	-	-	-	.02	-	16.5	1.2	-	.007	-
PW-14	8.54	2200	60	-91	-10.88	410	13	112	.47	275	8.3	722	-	20.1	32	.011	.09	29	2.1	.015	.05	-	.014	.09	-	256	3.8	.07	.005	-
PW-15	8.64	2100	52	-88	-9.97	399	9	79.2	.67	223	7.0	694	-	23.9	41	-	.02	5	1.9	.021	-	-	.018	.03	-	18.2	2.8	-	.006	-
PW-16	8.27	1900	45	-88	-10.58	358	9	69.6	1.02	230	7.2	557	-	33.8	48	-	.03	9	1.7	.030	-	-	-	.01	-	12.7	1.3	-	.033	-
PW-17	8.31	1755	59	-93	-11.22	310	8	42.5	.78	136	8.6	526	-	-	41	-	.05	18	1.5	.030	-	-	-	.01	-	15.7	0.54	-	.067	-
PW-18	8.80	2000	58	-88	-10.72	367	12	60.9	.12	208	8.9	624	-	32.7	24	-	.03	71	2.0	.013	-	-	-	.02	-	30.2	2.6	-	-	-
SW-1	8.60	635	13	-80	-10.62	30	8	52.9	27.7	6.9	1.0	108	0.95	-	209	.012	.09	-	0.02	.039	-	-	-	.03	-	9.02	0.49	.07	.054	-
WD-8	7.72	1520	29	-79	10.21	140	12	128	36.1	107	1.7	445	-	34.5	138	.006	.04	-	0.13	.024	-	.01	-	.09	-	13.4	0.88	.05	.080	-
WD-24	7.75	870	26	-82	-10.95	60	10	60.9	19.2	16.4	1.2	174	0.85	-	174	.009	.09	-	0.04	.034	.06	.02	-	.09	-	10.3	0.32	.09	.058	-
WD-27	8.08	570	27	-75	-9.86	49	8	37.4	5.81	26.7	0.8	61.5	1.05	4.61	129	.010	.06	-	0.02	.040	.06	.02	-	.02	-	9.58	0.24	.12	.030	-
Detection Limit	-	-	-	-	-		1		.01							.005	.01	1.0		.005	.05	.01	.008	.01	.01			.05	.005	.05

* Concentration in µg/l

Note: All concentrations of Be (0.0005 mg/l), Cd (0.01 mg/l), Mo (0.2 mg/l), Ni (0.05 mg/l), Pb (0.05 mg/l), Ti (0.005 mg/l), and Zr (0.05 mg/l) were below their respective detection limit.

Harding Lawson Associates
Engineers, Geologists & Geophysicists

Geochemistry Table
City of Desert Hot Springs
Riverside County, California

FIGURE **1**

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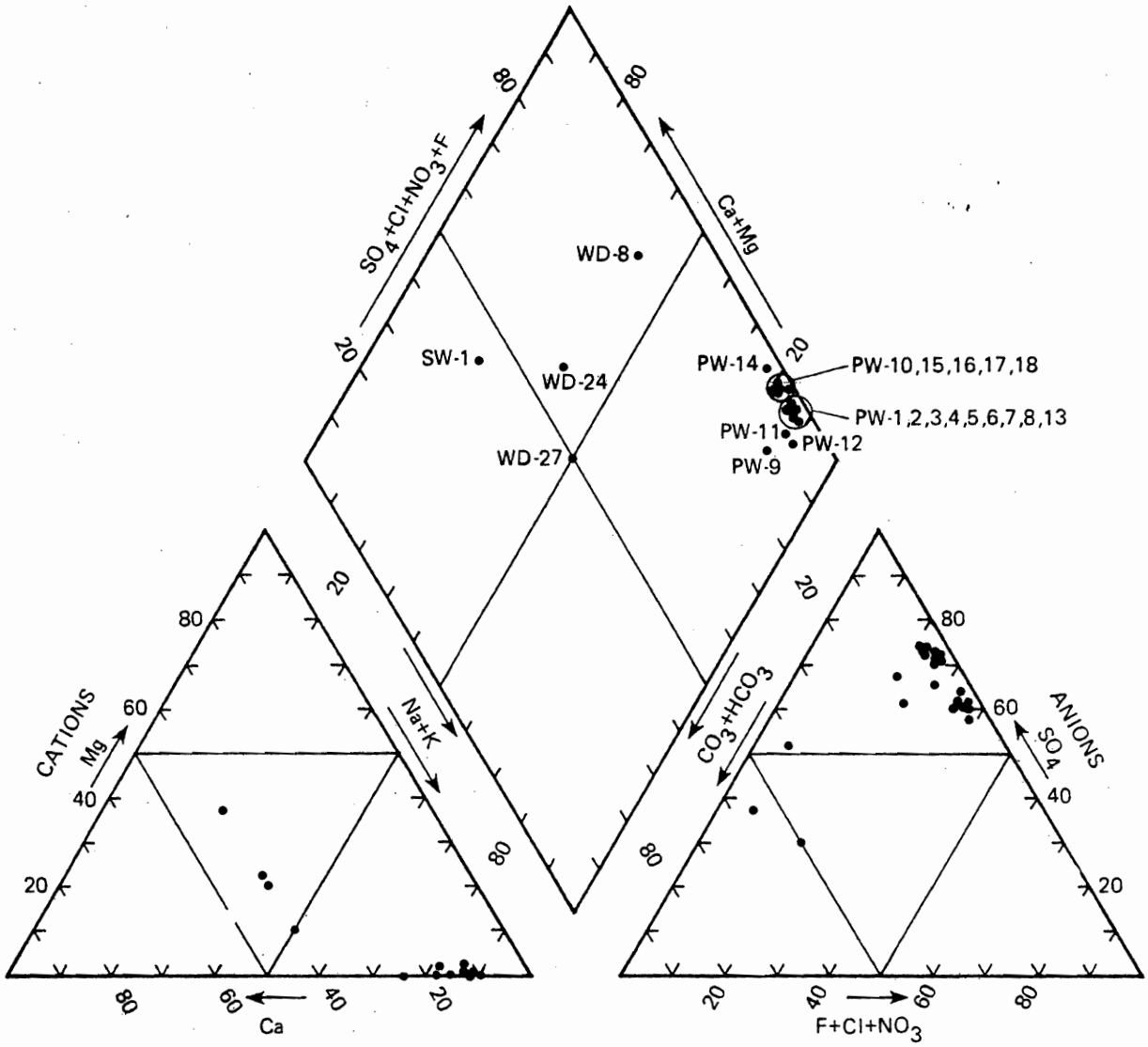
JG	17,319,001.01	RCS	10/85		



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Trilinear Piper Diagram
City of Desert Hot Springs
Riverside County, California

FIGURE
2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JG	17,319,001.01	RCS	10/85		

then extrapolated into the central trapezoid for comparison of water qualities. This diagram does not plot data with respect to total dissolved constituents but as percent distributions of equivalents. Therefore, waters that have undergone evaporation should plot in the same location as parent waters. Such a diagram is an excellent mechanism for evaluating mixing effects of ground waters, because the two ground-water end members will plot as separate points, with all mixed waters falling on a line segment joining the two end-members.

As shown in Figure 2, all PW series wells plot in a very small area of the diagram, suggesting similar origin and hydrochemical history. However, ground water from Wells WD-8, WD-24, and WD-27 are all distinctly unique, as is the composition of surface water SW-1. Mixing relationships between ground water in the vicinity of the City of Desert Hot Springs and wells of the WD series are not apparent.

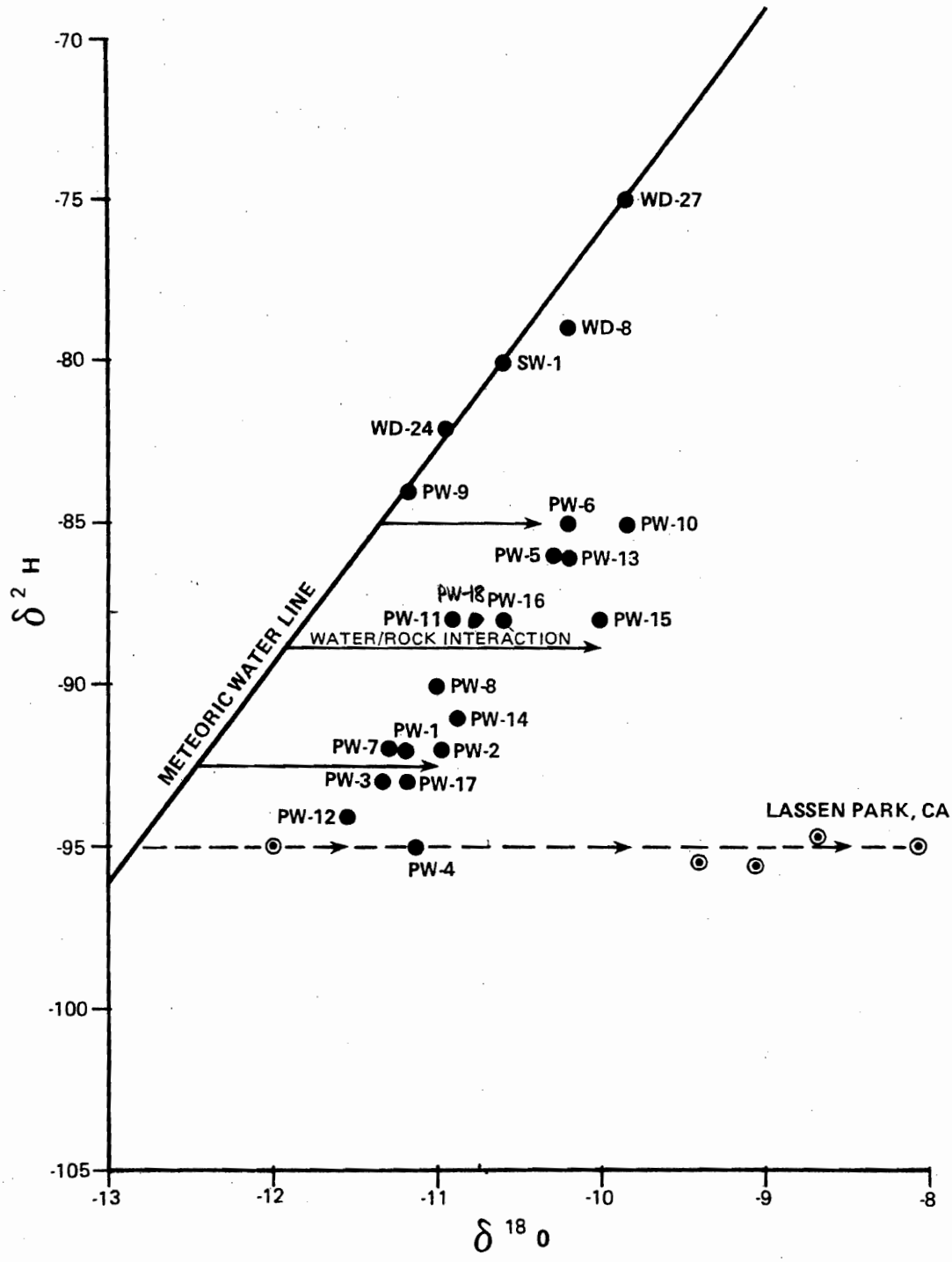
In general, ground waters from WD series wells are of lower dissolved solids as seen in specific conductivity values. Water from WD-8 is Na-Ca-Cl-SO_4-HCO_3 in composition, water from WD-24 is Na-Ca-SO_4-HCO_3 in nature, and WD-27 is predominantly Na-Ca-HCO_3 in composition. Surface water from SW-1 is most similar to water from well WD-24 which is in closest proximity. It appears from the diversity of composition in WD series wells and the large areal distribution of these wells (Plate 3) that recharge/discharge relationships as well as aquifer mineralogy may be diverse in these areas.

Upon final examination of Figure 2 it is apparent that these sodium sulfate ground waters from PW series wells have undergone a very similar hydrochemical history and are closely related in spite of the difference in spatial grouping of these wells. Shallow ground waters are more typically calcium rich; deeper ground waters, which have undergone more water/rock interaction, are more sodium rich. Therefore, it is reasonable that ground waters from PW series wells which are from greater depths would have significantly longer residence time.

B. Isotope Geochemistry

All 21 ground-water samples and the single surface water sample collected for this project were analyzed for isotopic abundances of oxygen and hydrogen. As stated previously, relative isotopic abundances for these stable isotopes are expressed as a percentage of deviation from Standard Mean Ocean Water (SMOW) (e.g., $\delta^{18}O = 50‰$). Results of mass spectral analysis are presented in Table 1.

Analytical results are also presented graphically in Figure 3 as a plot of $\delta^{2}H$ versus $\delta^{18}O$. Isotopic fractionation occurs during evaporation from the world's oceans and also during condensation. Evaporation selectively concentrates lighter isotopes (^{16}O, ^{1}H) of oxygen and hydrogen. Condensation within clouds selectively precipitates heavy isotopes (^{18}O, ^{2}H). Fractionation during condensation is extremely temperature dependent, and precipitation at cooler temperatures is



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Plot of δ^2H versus δ^{18}O
City of Desert Hot Springs
Riverside County, California

FIGURE
3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
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more depleted in ^{18}O and ^{2}H than precipitation that has occurred at lower elevations and warmer ambient temperatures.

Relationships between the abundances of ^{18}O, ^{2}H, and temperature have been established. These relationships differ depending on distance from an ocean, latitude, and altitude. The global relationship for isotopic abundances in precipitation has also been established as

$$\delta^{2}H = (8\ \delta^{18}O + 10)‰$$

This function plots as a straight line on Figure 3 and is termed the Meteoric Water Line. The slope and intercept of this line changes slightly with specific site conditions. From isotope abundances measured in the surface water sample (SW-1) and comparison with shallow ground-water samples from PW-9, WD-8, WD-24, and WD-27, the $^{18}O/^{2}H$ precipitation relationship for Desert Hot Springs conforms to the function

$$\delta^{2}H = (8\ \delta^{18}O + 5)‰$$

which is extremely close to the average global trend. Precipitation under warmer conditions would plot along this line but to the upper right. Precipitation under cooler conditions or higher elevation would plot along this same line but fall to the lower left.

Ground-water contact with aquifer minerals results in significant isotopic exchange for oxygen isotopes only. This exchange results in an enrichment in ^{18}O in the ground water, and therefore water/rock reactions should cause deviations from the meteoric water line to the right, towards more positive $\delta^{18}O$ values. This enrichment in ^{18}O of ground waters in

contact with aquifer minerals is a very slow process and occurs in measurable increments for extremely old (100,000 years) ground waters or for ground-water systems that exhibit temperatures of 80°C or above (geothermal).

Figure 3 in addition to showing Desert Hot Springs data, also shows ground-water isotope data for the Lassen Park geothermal area. This documented geothermal resource area has ground water that, from contact with the geothermal source area, shows $\delta^{18}O$ deviations of up to +5‰ from meteoric isotopic content. Shifts of oxygen isotopes from documented geothermal areas may exceed +10‰.

Isotopic abundances from PW series Desert Hot Springs ground-water wells show significant displacement from the meteoric water line. Because no natural process would cause a depletion of ^{2}H with no change in the ^{18}O content, it has been assumed that waters from the PW series wells were recharged to the ground-water system at cooler ambient temperatures or higher elevations. Therefore, enrichment in ^{18}O abundances due to water/rock interaction has occurred for these waters in a relatively consistent fashion, with deviations of approximately +1‰ to 1.5 ‰. It should be noted that isotopic data indicate that for ground waters from wells PW-5, PW-6, PW-10, and PW-13, recharge occurred at warmer temperatures or lower elevations than recharge from other PW series wells. Sampling temperatures from these lower elevation wells were generally less than 40°C while sampling temperatures from wells recharged at cooler temperatures reach values of 60°C. However, $\delta^{18}O$ shifts for both populations of

wells are similar at +1.0 to 1.5 ‰, with a noted anomaly at well PW-15, which showed the largest $\delta^{18}O$ shift of +1.8‰.

The areal distribution of the ground-water wells sampled is such that the two populations of ground waters discussed above do not occur in a separate area. PW series wells 14, 15, 16, 17, and 18 are several miles to the southeast of the City of Desert Hot Springs, while other PW series wells are located near the city (Plate 3). Although these wells are in two distinct spatial groups, variations in isotopic abundances do not correspond with these two physical groupings. For example, PW-14 and PW-17 are in the cooler recharge, higher temperature group, yet wells PW-16 and 18 are part of the warmer recharge lower temperature wells. Nevertheless, all these wells are physically spaced within 1 mile of each other. Ground water from well PW-15 appears to have been recharged under warmer conditions but had a sampling temperature of 52°C. These unlikely recharge characteristics may be the result of varying degrees of mixing or due to relationships of the wells to the recharge source.

C. Interpretive Geochemistry

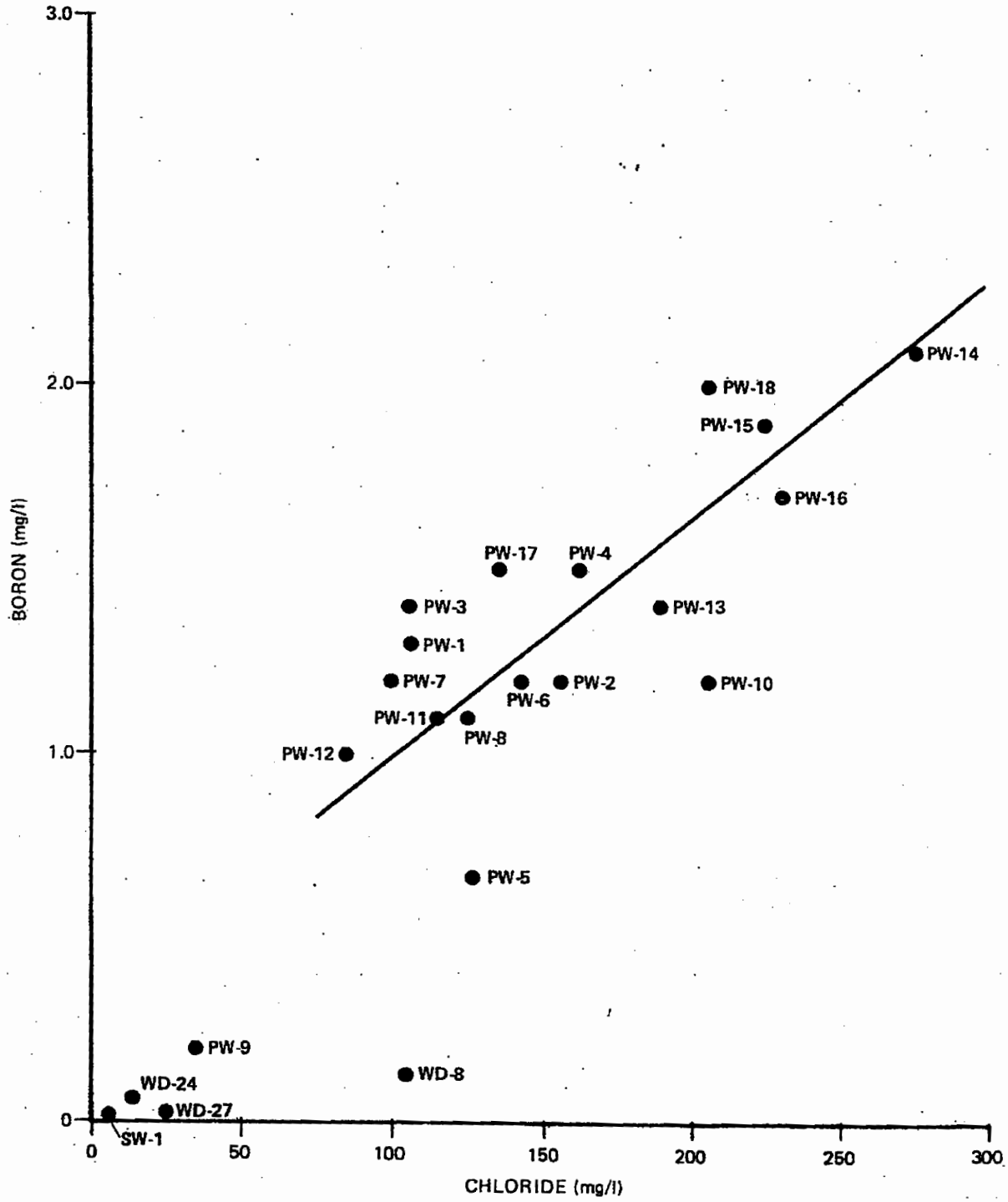
Additional interpretation of the geochemical data presented in Table 1 was performed to evaluate evidence for origin and mixing of ground waters. Ground waters of the PW series wells have very similar aqueous chemistry with respect to general ground-water quality characteristics. The trilinear diagram (Figure 2) shows that with respect to common cations and anions all

waters plot within a very small field. Other graphical techniques have also been used to assist in interpretation of aqueous geochemistry. These techniques include primarily concentration-concentration plots for a variety of aqueous constituents.

Geothermal waters are commonly identified by compositional equilibrium between dissolved constituents and alteration minerals. This assumption of the presence of equilibrium conditions is critical to the use of geothermometers but is also important in evaluating mixing of geothermal waters with cooler near-surface ground water. Mixed waters tend to acquire characteristics intermediate between the quality of the geothermal and shallow ground waters.

Chemical characteristics of cooling geothermal waters may produce waters similar in composition to those generated by mineral leaching following the mixing process, making interpretation difficult. However, several major trends are common for mixed waters of geothermal origin. In general, such waters contain high concentrations of silica in relation to sample temperatures, high total carbonate, and low pH (6-7) for waters with less than 100 ppm chloride.

Waters derived from geothermal systems generally have high concentrations of both chloride and boron because these elements are not readily incorporated into geothermal minerals. Therefore, a specific geothermal source area should generate waters with relatively constant boron/chloride ratios. Figure 4 is a plot of boron versus chloride



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Plot of Boron versus Chloride
City of Desert Hot Springs
Riverside County, California

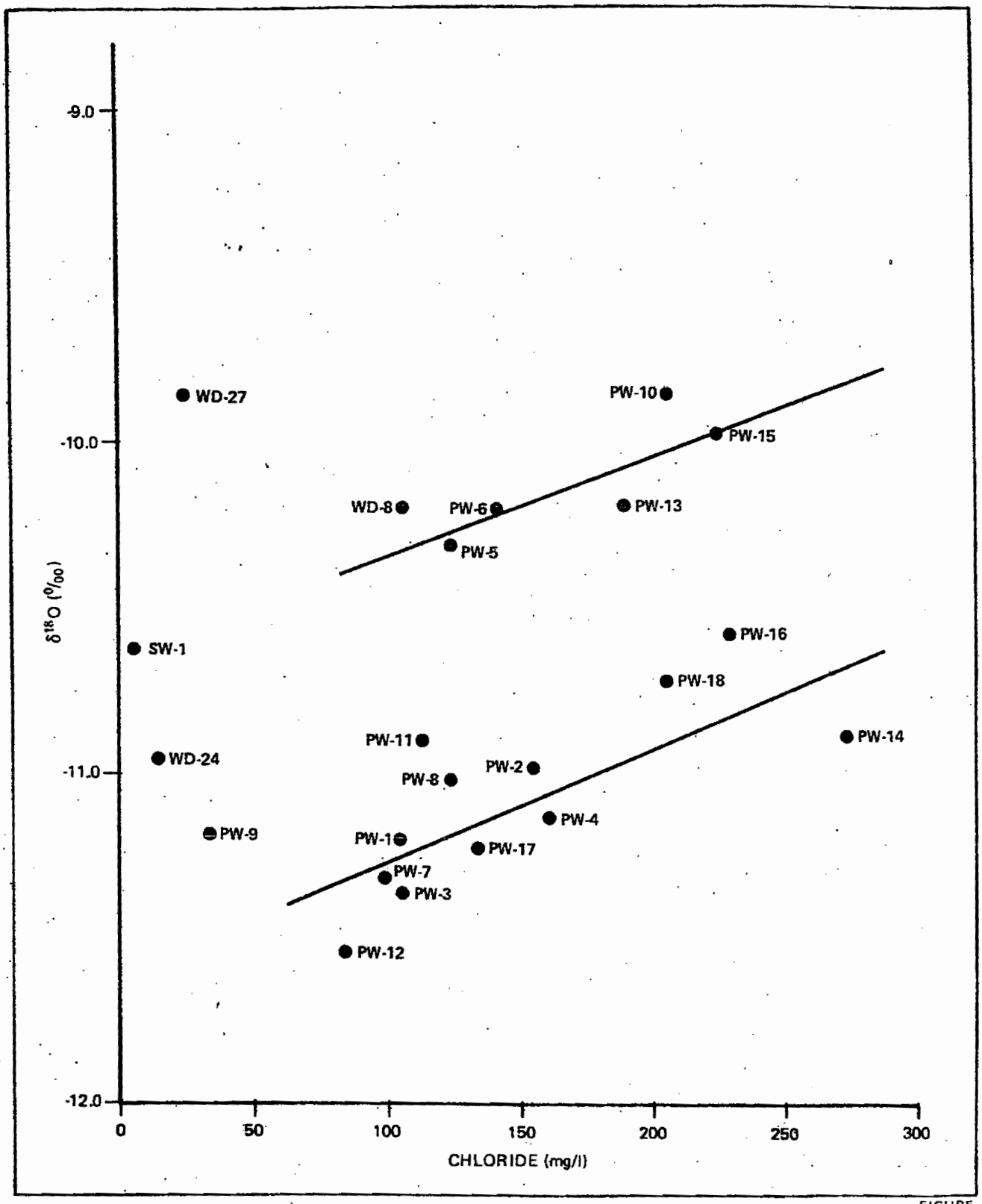
4

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JG	17,319,001.01	RCS	10/85		

concentration. The best fit of the data for PW series wells is also shown. Boron/chloride ratios are not constant for all data but fall within a range of .01 to .005. The trends observed in this plot are either those of mixing or increasing geothermal temperature to the upper right. It should be noted that wells PW 14, 15, 16, and 18 show highest concentrations of both boron and chloride and therefore best represent geothermally derived end member waters. It should also be noted that all four of these wells exist in close proximity to each other several miles to the southeast of town.

The composition of cooler shallow ground waters should plot near zero boron concentration and up to 25 mg/l chloride as do data from WD-24 and WD-27. Wells WD-8 and PW-9, although they may be from a geothermal source, have apparently undergone considerable mixing based on their plot on the diagram.

Mixing of geothermal waters with cold waters can also be evaluated by examining relationships of $\delta^{18}O$ and chloride. Figure 5 is such a plot. Shifts in $\delta^{18}O$ values are a result of water/rock interaction (section A.4.2). Upon consideration of data from PW series wells, it appears that two data populations exist. Best fits of the trends for each population are shown as line segments. The two line segments may represent mixing of geothermally derived waters with two cooler shallow ground waters of different $\delta^{18}O$ composition. The two cooler ground waters may have variable compositions due solely to differences in recharge areas because the $\delta^{18}O$ differences are less than 1‰. It should be noted that data



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Plot of $\delta^{18}O$ versus Chloride
City of Desert Hot Springs
Riverside County, California

FIGURE **5**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JG	17,319,001.01	RCS	10/85		

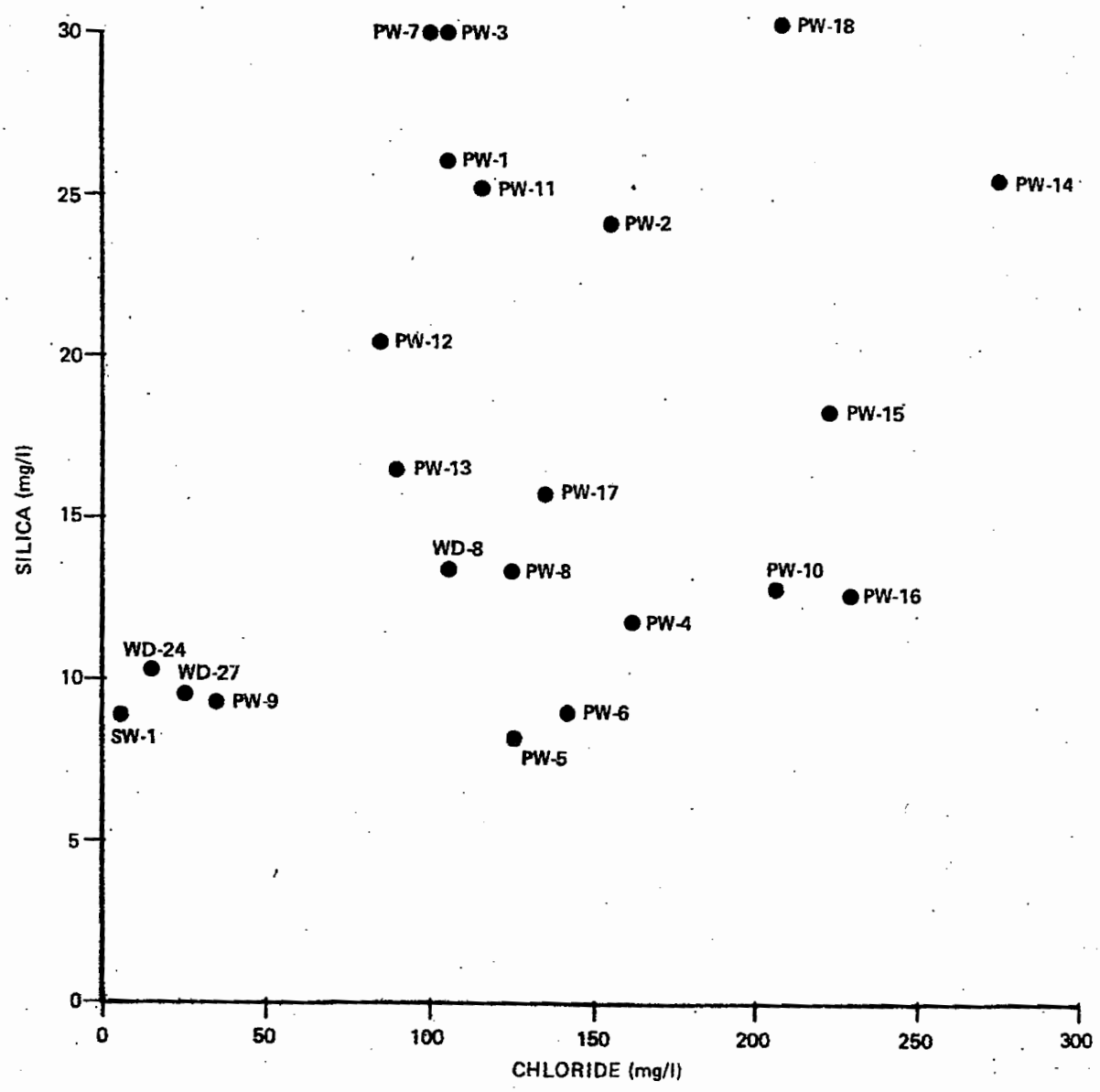
falling along respective line segments are not spatially grouped on the site location map. Mixing trends do exhibit similar slopes on the ^{18}O versus chloride plot. Wells PW-14, 16, and 18, previously cited for high boron and chloride, do occur grouped on the plot. This grouping of wells into populations may be a result of the depth of the aquifer that is sampled by each well.

Geothermal waters that have not reequilibrated with respect to silica solubility typically yield a linear plot of silica versus chloride. Figure 6 is such a plot for Desert Hot Springs data. It is evident from these data that silica concentrations are random with respect to chloride content, indicating that if these waters had equilibrated with silica at higher temperatures, precipitation of a silica phase has occurred. Concentrations of dissolved silica in documented geothermal areas are typically from 200 to 600 mg/kg. Concentrations for Desert Hot Springs wells are very low (<30 mg/kg) indicating that either silica precipitation has occurred, ground waters have had a relatively short retention time at low temperatures, or dilution of geothermal water has occurred to a significant degree.

Because of the presence of high concentrations of aqueous sulfate, a plot of chloride versus sulfate was developed (Figure 7). The linear relationship of sulfate/chloride concentrations is obvious. Highest concentrations of both aqueous constituents were found in wells PW-14, 15, 16, and 18, similar to the trend observed for boron. This indicates that

from PW series wells consistently have R values less than 5 and, therefore, for these wells the correction is zero. Corrections to the WD series wells are significant, with corrections up to 35°C as shown in Table 8.

In conclusion, ground waters sampled from the Desert Hot Springs area indicate that significant geothermal activity is present. This conclusion is based on $\delta^{18}O$ deviations, geochemical relationships of dissolved constituents, and geothermometry. From ground waters sampled and interpretive geochemistry, the geothermal activity at the depths sampled does not appear to be of the magnitude of other known high temperature geothermal areas. This assumption has resulted from one of several factors, including low dissolved silica concentrations, low geothermometer temperatures, and moderate $\delta^{18}O$ isotopic deviations. These characteristics exist because the source is not as strong as other active areas, or mixing with shallow ground waters have made less clear the definition and intensity of the source area. Of all wells sampled, the area to the southeast of the town (Wells PW-14, 15, 16, 17, 18) appears to be most promising.



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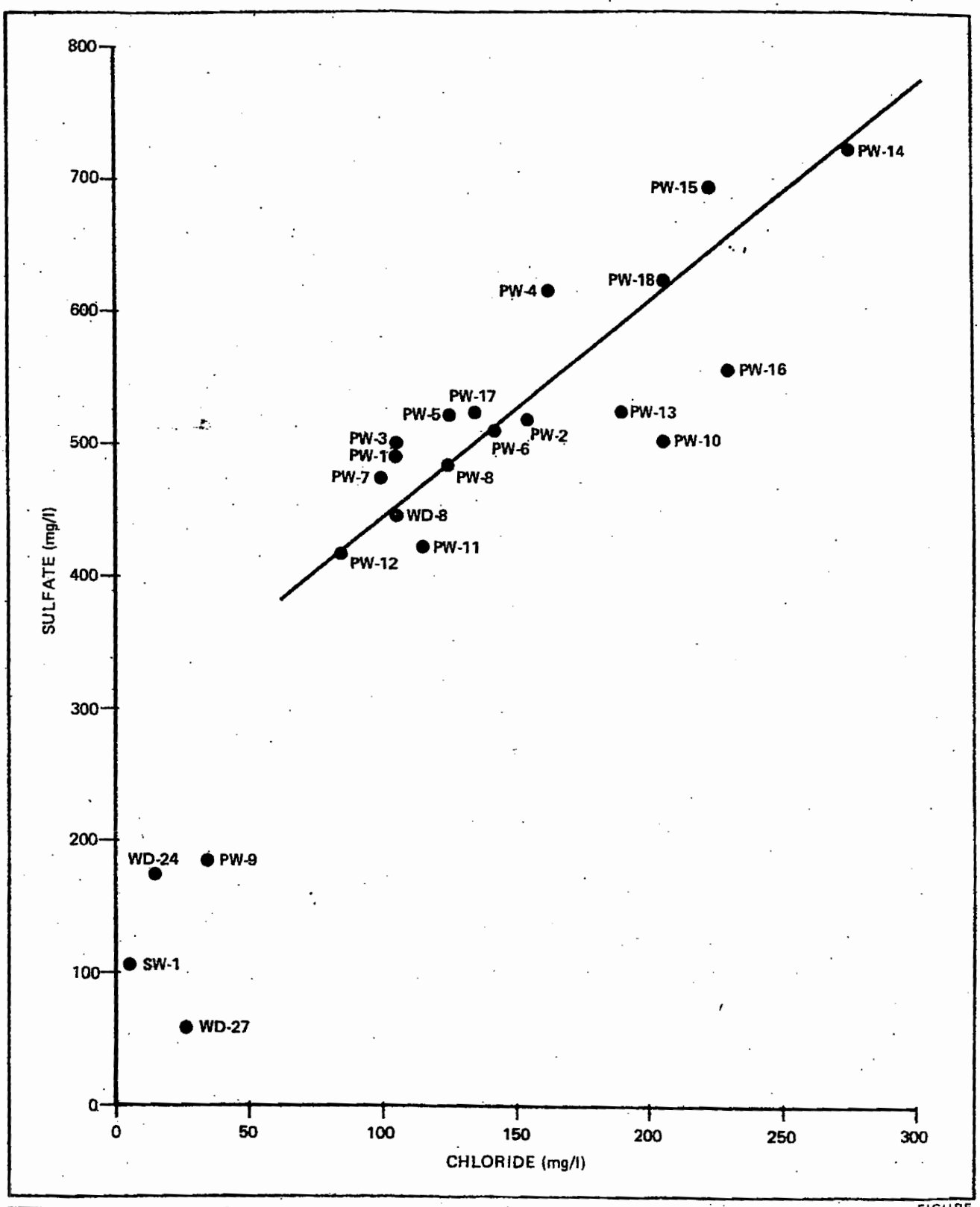
Plot of Silica versus Chloride
City of Desert Hot Springs
Riverside County, California

FIGURE
6

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JG	17,319,001.01	RCS	10/85		



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Plot of Sulfate versus Chloride
City of Desert Hot Springs
Riverside County, California

FIGURE
7

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JG	17,319,001.01	RCS	10/85		

sulfate minerals, such as anhydrite, may exhibit some control on ground-water composition.

Ground waters from the study area were analyzed for a large suite of trace metals, as shown on Table 1. Of the trace metals analyzed, many were not present at detectable concentrations in any samples. These metals included Be, Cd, Mo, Ni, Pb, Ti, Mn, and Zr. For several metals, a few detectable concentrations slightly above detection limits were measured (Ag, Co, Cr, Cu, Th, V, and Zn). Of the trace metals analyzed, only As, Al, B, Ba, Fe, and Sr were present in detectable concentrations for most waters. Of these elements higher than average (for this investigation) Sr values were present in samples from wells PW-14 and 15 while above average Fe concentrations were present in PW-11 and 12. Arsenic is the only trace element that appears to be present in anomalous concentrations reaching concentrations of 70 µg/l (ppb) in two wells. However, trends in arsenic and other trace metals do not appear to correlate with other observed system trends.

D. Geothermometry

The use of chemical geothermometers is based on the assumption that ground waters within the sphere of influence of a geothermal source will attain equilibrium with respect to specific minerals whose solubility is temperature dependent. For a chemical geothermometer to yield accurate temperatures, the kinetics of the controlling reaction must be fast enough

to allow equilibrium to be attained within a relatively short period of residence. However, the kinetics of the reaction must be slow enough that upward flow and cooling of waters does not cause alteration of the fluid composition.

Numerous geothermometers have been used on at least an experimental basis; however, the silica, Na/K, and Na-K-Ca geothermometers are best documented and most widely accepted. Several geothermometers were examined for Desert Hot Springs waters. These are discussed in detail below.

1. Silica Geothermometers

Silica may exist in an aquifer in a variety of mineralogic forms including amorphous silica, chalcedony, cristobalite, and quartz. Although quartz is the stable silica mineral, other silica minerals exist as intermediary forms due to reaction kinetics. The solubility of quartz is tabulated below.

Quartz Solubility

Temperature °C	SiO_2 (mg/kg)
50	13
100	46
150	126
200	271
250	471
300	660

Dependent upon system characteristics, ground waters may be in equilibrium with any of the previously mentioned minerals, all of which have

solubilities that exceed that of quartz. As equilibrium may be rather quickly attained with respect to silica mineral phases, cooling and precipitation may also occur rather rapidly, yielding artificially low silica concentrations.

As the characteristics of the Desert Hot Springs system were unknown, several silica geothermometers were used to determine the most representative technique. Calculation of temperatures using amorphous silica, chalcedony, and cristobalite geothermometers yielded artifically low equilibration temperatures. In many instances, the resultant temperatures were significantly lower than the measured sampling temperature, and in some cases negative temperature values were generated. These results are in part due to the extremely low dissolved silica concentrations for Desert Hot Springs ground water.

The quartz geothermometer yielded the only reasonable results of the silica geothermometers. The equation used for calculation of the quartz geothermometer was taken from Henly et al., 1984:

$$T(°C) = (1522/5.75 - \log SiO_2) - 273.15$$

when SiO_2 is expressed in mg/kg. Results of the quartz geothermometer calculation can be found in Figure 8 with the respective sampling temperature for each ground-water well.

Figure 8. Chemical Geothermometers

Well Number	Sampling Temperature (°C)	Geothermometers (°C)				
		Quartz*	Na/K**	Na/K***	Na-K-Ca*	Na-K-Ca w/ Mg correction
PW-1	55	75	94	129	92	97
PW-2	46	71	95	130	91	91
PW-3	71 160	79	87	122	86	86
PW-4	52	45	46	84	61	61
PW-5	39 102	33	54	91	65	65
PW-6	33	79	69	99	72	72
PW-7	62	48	97	131	93	93
PW-8	55	49	66	103	75	75
PW-9	32 90	33	122	154	88	88
PW-10	37	48	68	105	69	69
PW-11	50 122	72	97	131	91	91
PW-12	48	64	85	121	89	89
PW-13	37	56	75	111	80	80
PW-14	60 140	73	101	135	85	85
PW-15	52	60	80	116	80	80
PW-16	45	47	87	122	82	82
PW-17	59	54	88	123	87	87
PW-18	58	80	103	137	95	95
WD-8 DHS	29 84	49	179	204	78	48
WD-24 MC	26 79	40	253	265	69	34
WD-27 MC	27	38	251	263	70	65

* Henly et al., 1984
** Fournier, 1977
*** Fournier, 1981

Generally, calculated values exceed measured temperatures by 10°C to 20°C. This suggests that either one of several processes may be responsible for extremely low concentrations of dissolved silica (<30 mg/kg): 1) dissolved silica may have precipitated during upward flow and cooling; 2) ground-water residence times may have been too short in the vicinity of the

source to establish equilibrium; or 3) ground-water quality from the geothermal source area may be diluted by mixing.

2. Na/K Geothermometer

Partitioning of sodium and potassium between aluminosilicates and ground water is temperature dependent. The sodium/potassium geothermometer is controlled by mineral equilibria related to feldspar alteration. The exchange reaction involved is thought to be

$$\text{K-feldspar} + Na^{+} \leftrightarrow K^{+} + \text{Na-Feldspar}$$

This geothermometer has yielded reliable water temperatures in the presence of a wide variety of rock types up to temperatures of 350°C for near neutral pH geothermal waters. However, anomalous results are common for waters high in calcium. Since several equations for the Na/K geothermometer exist in the literature, two were selected for comparative purposes. The results are listed in Figure 8. The first Na/K geothermometer was taken from Fournier (1981) and uses the following equation:

$$T(°C) = [1217/(\log(Na/K)+1.483)] - 273.15$$

The second Na/K geothermometer was extracted from Truesdell (1975):

$$T°C = [855.6/(\log(Na/K)+0.8573)] - 273.15$$

Concentrations of both Na and K for both equations are expressed in mg/kg or ppm.

Temperatures measured with the two Na/K geothermometers differ significantly in a consistent fashion. Calculated temperatures are much higher than those derived by the quartz geothermometer. Anomalous

temperatures resulted for WD series wells, but this is a result of significant calcium concentrations which will be discussed in the section on the Na-K-Ca geothermometer.

With the exception of WD series wells, the highest Na/K derived temperature was recorded for well PW-9. However, ground water from this well showed very low dissolved solids. The artifically high temperature may be an artifact of the concentration reported for potassium (5 ppm) for which a 1 ppm error could significantly alter the calculated temperature. The potassium detection limit was 1 ppm, making analytical uncertainties in this concentration range high.

3. Na-K-Ca Geothermometer

High calculated temperatures for the Na/K geothermometer may be a result of high calcium concentrations. If calcic minerals such as plagioclase or calcite play a significant role in ground-water quality or if ion exchange reactions with calcium rich clay minerals are occurring, the Na-K-Ca geothermometer should yield more accurate and consistent temperature values. The equation used for the Na-K-Ca geothermometer was:

$$T(°C) = 1647/\log(Na/K)+\beta[\log(\sqrt{Ca}/Na)+2.06] + 2.47 - 273.15$$

Concentrations are expressed in ppm (mg/kg).

The use of this geothermometer is slightly more complicated than previous geothermometers. The value for β should be 4/3 if $T<100°C$ and $[\log(\sqrt{Ca}/Na)+2.06]>0$. However, if the calculated temperature is greater than 100°C or the above function is negative then a value of $\beta=1/3$ is used.

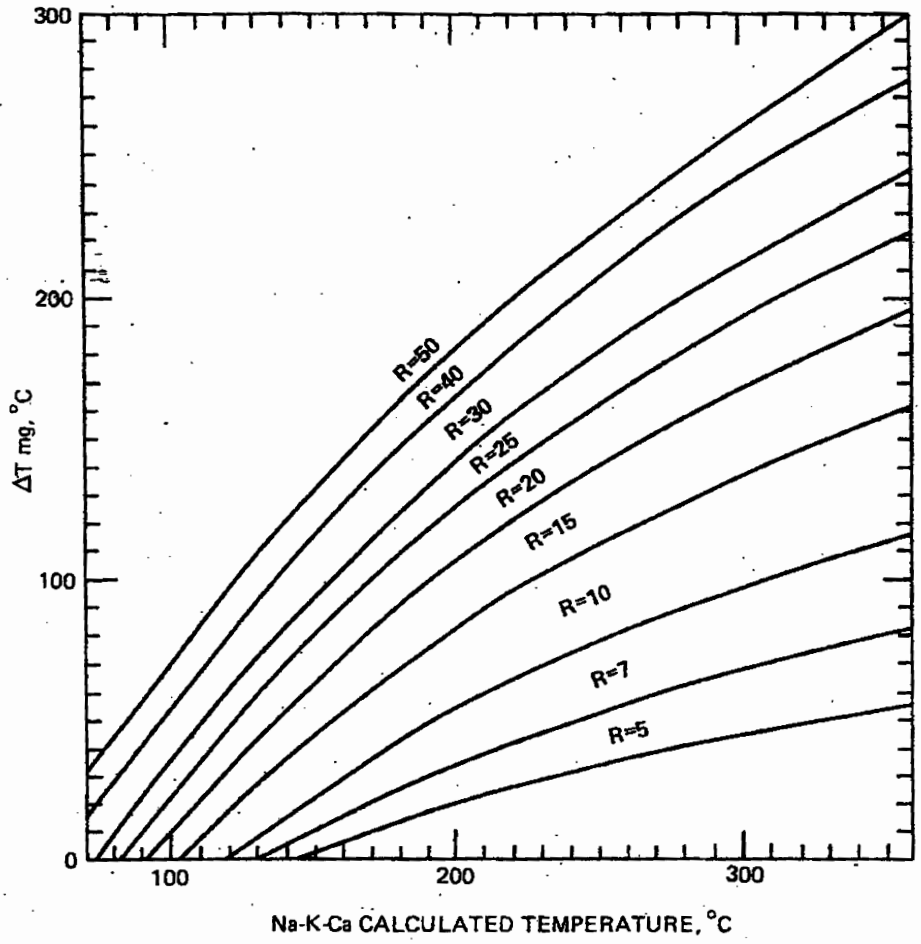
Temperatures calculated with this geothermometer are listed in Table 8. Values determined are relatively close to those determined by the Na/K geothermometer, but anomalous temperatures for WD series wells have been remedied. Calculated temperatures are consistently higher than measured sampling temperatures and appear to be the most representative temperature determined by any of the geothermometers used to this point.

High magnesium content also affects the accuracy of the geothermometers, especially at lower temperatures. This is primarily due to low solubilities of magnesium silicates at high temperatures and the potential for magnesium introduction by way of cooler near-surface waters. In general, PW series wells have relatively low magnesium content, but WD series wells do have higher magnesium. Therefore, use of the magnesium correction has been examined.

Use of the magnesium correction to the Na-K-Ca geothermometer was evaluated using information found in Fournier (1981). The correction is made by first calculating an R value:

$$R = 100\ Mg/(Mg+Ca+K)$$

with all concentrations expressed as equivalents. This R value is then used with the calculated Na-K-Ca temperature to yield a ΔT(°C) from Figure 9. This ΔT value is then subtracted from the Na-K-Ca calculated temperature. Results for this correction are shown in Figure 9. It is evident from Figure 9 that R values of at least 15 must be present to induce any temperature correction at all for waters less than 100°C. Ground waters



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Magnesium Correction Graph
City of Desert Hot Springs
Riverside County, California

FIGURE
9

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JG	17,319,001.01	RCS	10/85		

STATE OF CALIFORNIA
ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

In the Matter of:	)	Docket No. 07-AFC-3
	)	
Application for Certification, for the CPV SENTINEL ENERGY PROJECT	)	**ELECTRONIC PROOF OF SERVICE LIST**
	)	
	)	(October 15, 2007]
	)	

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DOCKET UNIT

CALIFORNIA ENERGY COMMISSION
Attn: DOCKET NO. 07-AFC-3
1516 Ninth Street, MS-4
Sacramento, California 95814-5512
docket@energy.state.ca.us

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DECLARATION OF SERVICE

I, Paul Kihm, declare that on January 24, 2008, I deposited a copy of the attached:

LETTER FROM DALE SHILEIKIS TO THE CEC REGARDING APPENDIX C AND ASSOCIATED REPLACEMENT PAGES TO APPLICANT'S RESPONSES TO CEC DATA REQUESTS 35, 38, 43, 50, 60, AND 62 THROUGH 65

with FedEx overnight mail delivery service at Costa Mesa, California with delivery fees thereon fully prepaid and addressed to the California Energy Commission. I further declare that transmission via electronic mail was consistent with the requirements of California Code of Regulations, title 20, sections 1209, 1209.5, and 1210. All electronic copies were sent to all those identified on the Proof of Service List above.

I declare under penalty of perjury that the foregoing is true and correct. Executed on January 24, 2008, at Costa Mesa, California.

Paul Kihm

OC\933442.1

Docket Optical System - 07-AFC-3_1-24-08_MCarroll_Letter from Dale Shileikis to CEC.pdf

From: <PAUL.KIHM@LW.com>
To: <docket@energy.state.ca.us>, <mturner@cpv.com>, <dale_shileikis@urscorp.com>, <Kathy_Rushmore@URSCorp.com>, <ltobias@caiso.com>, <esaltmarsh@eob.ca.gov>, <Mnazemi1@aqmd.gov>, <jboyd@energy.state.ca.us>, <jpfannen@energy.state.ca.us>, <kcelli@energy.state.ca.us>, <Bpfanner@energy.state.ca.us>, <CHolmes@energy.state.ca.us>, <pao@energy.state.ca.us>
Date: 1/24/2008 11:55 AM
Subject: 07-AFC-3_1-24-08_MCarroll_Letter from Dale Shileikis to CEC.pdf
CC: <MICHAEL.CARROLL@LW.com>
Attachments: Appendix C and Replacement Pages.pdf; Scan001.PDF; Scan001.PDF

Pursuant to California Code of Regulations, title 20, sections 1209, 1209.5, and 1210, attached please find a pdf copy of a letter from Dale Shileikis to the CEC regarding Appendix C and associated replacement pages to Applicant's responses to CEC Data Requests 35, 38, 43, 50, 60, and 62 through 65. Thank you.

<<Appendix C and Replacement Pages.pdf>> <<Scan001.PDF>> <<Scan001.PDF>>

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