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Chemistry of spring and well waters on Kilauea Volcano, Hawaii, and vicinity

by

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ABSTRACT

Published and new data for chemical and isotopic samples from wells and springs on Kilauea Volcano and vicinity are presented. These data are used to understand processes that determine the chemistry of dilute meteoric water, mixtures with sea water, and thermal water. Data for well and spring samples of non-thermal water indicate that mixing with sea water and dissolution of rock from weathering are the major processes that determine the composition of dissolved constituents in water. Data from coastal springs demonstrate that there is a large thermal system south of the lower east rift of Kilauea. Samples of thermal water from shallow wells in the lower east rift and vicinity have rather variable chemistry indicating that a number of processes operate in the near surface. Water sampled from the available deep wells is different in composition from the shallow thermal water, indicating that generally there is not a significant component of deep water in the shallow wells. Data for samples from available deep wells show significant gradients in chemistry and steam content of the reservoir fluid. These gradients are interpreted to indicate that the reservoir tapped by the existing wells is an evolving vapor-dominated system.

INTRODUCTION

The purpose of this study is to use chemical and isotopic data to identify processes that determine the chemistry of well and spring samples (Figure 1) across the wide spectrum of water compositions found on Kilauea Volcano and vicinity. This information was developed for use by the U.S. Department of Energy in its preparation of an Environmental Impact Statement for the Hawaii Geothermal Project. Water chemistry on Kilauea is determined by multiple processes starting with those that occur as a result of the normal island hydrologic cycle (Sorey and Colvard, 1994; Takasaki, 1994). Near the shore, wells tap a basal fresh-water zone overlying sea water intruded from the ocean. The fresh water is from precipitation that infiltrates the land. At the interface between the fresh water and sea water, there is a zone that is a mixture of fresh and saline water. Because fresh water is less dense than sea water, the first order theory relating the thickness of the fresh water lens to the height of the water table above sea level is given by the Ghyben-Herzberg formula for a hydraulic balance between sea water and fresh water. Fresh water is also found at high elevations as perched water along low-permeability geologic contacts or as dike-impounded water.

The chemistry of the dilute meteoric water is determined in part by the composition of precipitation, and in part by water-rock interaction. Precipitation carries dissolved atmospheric gases (particularly carbon dioxide) and small amounts of salts (mostly as ions of sodium, chloride, and some sulfate) from sea spray, and this is generally the source of these constituents in dilute meteoric water. Locally, precipitation may also carry elevated sulfate derived from oxidation of gaseous emissions from Kilauea Volcano (Scholl and Ingebritsen, 1994). Upon infiltrating the land, additional carbon dioxide from the soil zone dissolves in the water and raises its acidity. This slightly acid water reacts with the minerals in volcanic rock to form bicarbonate and to dissolve sodium, magnesium, calcium, and silica (e.g. Feth and others, 1964; Garrels and MacKenzie, 1967; Nathenson and Thompson, 1990). This dilute meteoric water will be referred to in this report as dilute water. The dilute water produced by this process may also mix with sea water. The chemistry of a mixed water containing even a small fraction of sea water is mostly determined by the constituents in sea water because of the high salinity of sea water.

In addition to the normal processes of island hydrology, thermal processes also affect the chemistry of water. Magma intrudes at shallow levels and is erupted at the surface within Kilauea's rift zones and summit caldera. The interaction of magma and hot rock with water and the addition of gases released from the magma to the water produces a large range of water compositions. Since sea water makes up much of the source water for this system in the lower east rift zone, the starting composition is saline rather than dilute. Reactions of fluid and rock at elevated temperature, of a fluid that is initially saline, causes some constituents to precipitate, some to increase by dissolution of minerals in the rock, and has almost no effect on other constituents.

The organization in this report for discussing samples from wells and springs is from shallow to deep and from non-thermal to thermal. First, data for spring and shallow well samples of dilute water and mixtures of dilute and sea water are discussed. In the following sections, data on thermal water from shallow wells and springs are discussed. Particular wells and springs are chosen to represent trends that are confirmed by samples from nearby locations, and particular samples are chosen based on quality, representativeness, and completeness of analysis. In a few cases, isotopic data from one sample are used with chemical data from another sample, because only silica and salinity were determined for some isotope samples. The concluding section discusses data from deep wells that sample the geothermal reservoir.

Data obtained in this study and from available literature are given in Tables 1-5. The shallow well data have been divided according to temperature (greater than or less than 30°C); however, detailed considerations below show that some wells with temperatures less than 30°C actually contain water that has been part of the thermal system. Some published analyses that have significant quality problems (e.g. poor balances or notably anomalous values of some constituents) have been included in the tables for completeness. The column Data Source includes the primary source first (or primary sources first and second), and repeat publications of the same analysis are listed as additional references. Differences between values reported in primary references and subsequent publications are resolved by taking values listed in primary references. Data are reported in the literature in units of mg/L and mg/kg or ppm. For waters with significant total dissolved solids, the amounts reported in different units are not the same. Most laboratory procedures involve measurements in units of mass per unit volume (Hem, 1985, p. 55). The expression of analyses with high total dissolved solids in units of mass per unit mass then requires a measurement of solution density. Some people apparently decided that mg/kg or ppm are more appropriate units than mg/L and have simply reported data that were obtained in mg/L as mg/kg; e.g. McMurtry and others (1977) reproduce Swain's (1973) data with units given as ppm when the data were originally published as mg/L. Given the ambiguities of reporting, we have chosen to assume that all analyses are in mg/L. Thus, analyses that have total dissolved solids similar to that of sea water at 34,500 mg/L can have a systematic bias of 3 % in dissolved constituents. The new analyses reported in this study are in mg/L.

CHEMISTRY OF SHALLOW WATER SAMPLES

Shallow well and spring samples of dilute meteoric water and mixtures with sea water are discussed by groups for the area of Hilo and vicinity and the area from Ka Lae to Pahala (Figure 1). Discussion of various groups is necessary to illustrate the range of effects on water chemistry because no one data set shows all characteristics. Coastal springs south of Kilauea Crater and near the lower east rift are discussed next. Some of these springs are thermal and others not, but they all show significant mixture with sea water. The chemical composition of shallow well waters within the east rift and between the east rift and the coast are discussed last.

Hilo to Keaau area

The chemical data for samples from the Hilo to Keaau area (Figure 2) show the full range of behavior for non-thermal waters (Figure 3). The modified Schoeller diagrams used in this report utilize meq/L for dissolved species and mmol/L for silica. The advantage of this presentation is that it shows both relative and absolute amounts available for reactions. The dilute waters (3603-01, 3702-01, and 3804-01) have chloride concentrations that range from 1.6 to 7.3 mg/L, about what one finds in rain water (0.8 - 10.7 mg/L, Table 2; see also Scholl and Ingebritsen, 1994). Two analyses are shown for Waiakea 4 (4203-04); one (1972) with chloride concentration of 6.5 mg/L and the other (1978) with 39.8 mg/L. The 1972 analysis has similar chemistry to the dilute waters. The 1978 analysis is enriched in Na, Cl, and Mg, elements that are most concentrated in sea water. Thus, this well appears to be able to tap dilute water or a mixture with some added sea water. All of the other samples shown on Figure 3 have as their major determinant of chemistry the dilution of sea water as shown by the join lines being parallel to the lines for the analysis for sea water. Two samples from Keaau Orchard 2 (3900-02) show varying amounts of dilution of sea water, except silica and bicarbonate concentrations which are nearly the same in both samples.

Silica in the mixed waters is much higher than in sea water and shows no relationship to chloride concentration. Silica is also relatively uncorrelated with bicarbonate concentration (Figure 4), even though the latter varies by a factor of two. The high-concentration sample of Waiakea 4 (4203-04) shows a significantly lower silica for the same bicarbonate concentration (Figure 4). The samples from Waiakea (4304-02 and -03) have chloride concentrations of 12,500 and 6,250 mg/L compared to 19,000 mg/L for sea water. For the silica versus bicarbonate behavior to be explained as a mixing relationship between dilute water and sea water, the dilute water would have to have a higher silica concentration than has been found. This indicates that carbon dioxide is available to continue the dissolution of minerals after mixing. Silica concentrations are not particularly high, and there is no indication of a thermal anomaly from the silica data.

In addition, magnesium data can be used to assess the thermal characteristics of water in Hawaii. In most thermal waters, magnesium is very low or absent, and a plot of magnesium versus chloride can be useful for understanding geochemical processes involving mixing and thermal modifications (Cox and Thomas, 1979). The data are shown in Figure 5 along with a dilution line calculated from values for sea water. On a log-log plot, a dilution line is straight whereas a mixing line is a curve at small amounts of the high-concentration end member. The advantage of a dilution model is that it explains most of the behavior of water containing varying amounts of sea water without having to make any assumptions concerning the dilute end member. Down to a chloride concentration of 81 mg/L, the high-concentration samples follow the dilution line for sea water on the magnesium versus chloride plot (Figure 5). The lack of deviation from a simple dilution relationship indicates that dissolution of minerals in rock is not sufficient to noticeably affect the magnesium concentration. This is not the case for samples from wells at Pearl Harbor, Oahu that interact with marine calcareous deposits in the cap rock to add magnesium (Visher and Mink, 1964). The two samples for Waiakea 4 (4203-04) show the effect of mixing where the concentration of the dilute end member becomes important.

Limited isotopic data are available for this area (Figure 6). Sea water as represented by Standard Mean Ocean Water (SMOW) would be at (0,0) in Figure 6 (Craig, 1961). Values for a sea-water sample collected at Isaac Hale Park are slightly heavier than SMOW possibly because of higher evaporation in summer, but the sample contains less chloride than normal sea water and may also be somewhat diluted by fresh water. Values for a sample from the southern edge of Hilo Bay are within analytical uncertainty for defined values for SMOW. For comparison purposes, we will use the ocean water of Hem (1985) for dissolved constituents and SMOW for isotopes. Lower deuterium values for Haena spring (3889-S2) suggest that some of the recharge comes from higher elevation water such as that found in one dilute sample from Keaau (Shipman) well (3804-01), and this interpretation can be established more clearly in other areas.

Pahoa area and Hawaiian Paradise well

Wells in the Pahoa area are close to the east rift of Kilauea Volcano (Figure 7), and waters from these wells are generally quite dilute (Figure 8). Water samples from Hawaiian Shores 1 and 2 (3185-01 and 02) contain a slight amount of sea water as shown from the pattern in Figure 8. Hawaiian Paradise well (3588-01) is 9 km north of the most northerly Pahoa area well (Figure 2), and its chemistry shows a clear signature of added sea water. Chloride values for the Hawaiian Shores wells are intermediate between the more dilute waters and the sea-water dilution line, and data for the Hawaiian Paradise well are nearly on the dilution line (Figure 9). Silica is independent of bicarbonate concentration (Figure 10). There is a suggestion of an increase in silica with temperature (Figure 11), although the relationship is weak. Temperature does not show any relationship with chloride concentration. It may be that the increase in temperature and silica reflects some conductive and/or convective heating from the thermal anomaly on the east rift. Pahoa Battery 2A and 2B (2986-01 and 02) are closest to the east rift and have slightly anomalous sulfate concentrations (Figure 12) suggesting the possible addition of sulfate from oxidation of sulfur-rich gases associated with magmatic volatiles. Deuterium isotopes are generally in the range of -14 to -18 ‰, although one sample from Keonepoko Nui (3188-01) is -22 ‰ (Figure 13).

Kaalualu to Punaluu area

The chemical data for the samples from Kaalualu to Punaluu area (Figure 14) show patterns similar to the Hilo area group (Figure 15). Data for four coastal springs are shown on Figure 15 with broken lines, and they show a considerable range for dilution of sea water. Repeat samplings a year apart for Kamehame Hill crack (0829-S1) and Kawa Spring (0631-S1) have quite similar chemistries (Table 2). Data for higher-elevation dilute waters from Haao Tunnel (0537-01) and New Mountain House Tunnel (0936-01) have no sea-water signature. Maximum measured chloride concentration of Haao Tunnel (0537-01) is 8.55 mg/L, within the range to be expected for rain water. The sulfate concentration of 16.3 mg/L is high, and this may indicate some addition of a sulfur compound beyond that in rain water.

Silica and bicarbonate concentrations are remarkably similar for the concentrated waters (Figure 16), and this constancy indicates continued reaction after mixing with sea water. The magnesium concentration once again follows the dilution line (Figure 17), indicating no noticeable effect on magnesium concentration from reaction with minerals in rock.

Isotopic data for the samples containing diluted sea water span a broader range of values than has been measured on samples of the higher-elevation dilute waters (0537-01 and 0936-01) immediately upslope (Figure 18). This can be seen more clearly in a plot of deuterium versus chloride (Figure 19). Sea water (assumed 0 ‰ deuterium, 19,000 mg/L chloride) can mix with dilute water with isotopic values shown on Figure 19 to produce the values found in 0631-S1, 0831-03, and 0830-S1. The isotopes for Kamehame Hill crack (0829-S1) and for Kaalualu Spring 1 (8836-S1) require dilute waters with deuterium values of -29 and -33 ‰ (Figure 19), lighter than found in the low-elevation (700 to 1000 m) dilute water. Average deuterium compositions of rainfall versus elevation suggest that such light isotopes come from rain water at higher elevations (Scholl and others, 1993).

Pahala area

The four wells in the Pahala area are nearly on a straight line above the group of three springs along the coast (Figure 14). The pattern of water chemistry is similar to that for other areas (Figure 20). The data for the sample from the Palima well (1128-02) indicates a small amount of sea water based on the elevated amounts of Na and Cl and the slightly elevated Mg concentration compared to the dilute samples (Figure 20). Two samplings for Pueo Spring (0926-S1) show a range of concentrations (Figure 20), but repeat samplings for Waiapele crack (0926-S2) and Waioala Spring (0927-S1) have similar chemistries. Silica concentrations are relatively constant, but bicarbonate concentrations have a wider range than for the last group of springs (Figure 21). Magnesium concentrations follow the dilution trend for the spring samples, with the sample for the Palima well (1128-02) being intermediate between the low- and high- concentration waters

(Figure 22). The diluted sea water shows a somewhat narrow range of calcium (Figure 20), and the variation of calcium with chloride (Figures 23) deviates from the dilution line at higher chloride concentrations than was found in the magnesium versus chloride trends for these waters (Figure 22) and for the previous group (Figure 17). This deviation is probably related to the higher bicarbonate concentrations being balanced by increased calcium concentrations compared to the dilution trend.

Isotope values for the spring samples are uniformly lower than those for the dilute waters (Figure 24), indicating recharge at higher elevations. The value for the Palima well (1128-02) is at low end of the range. The isotopic data for the Palima well are from a 1974 sample in McMurtry and others (1977), and the chemistry is from a 1974 sample from Thomas and others (1979). The reported salinity for the isotope sample was 0.01 per cent, which is similar to the measured dissolved solids for the chemistry sample of 110 mg/L. Assuming that the chemistry was similar, the low values for the isotopes in the Palima well coupled with its small sea water content indicate that this well samples a water that is dominantly dilute and originated as precipitation at a higher elevation than the waters sampled by wells 1128-01 and 1229-01 (Scholl and others, 1993).

Puu Elemakule to Apua Point area

The springs in this area are generally south of Kilauea Crater (Figure 25) and include the thermal spring (42°C, 1420-S1) Puu Elemakule (Na Puu o na Elemakule on topographic maps). Chemistry data for the springs generally follow the sea water dilution trend for major elements other than silica and bicarbonate (Figure 26). Magnesium and bromide versus chloride follow the dilution trend (Figures 27 and 28) even though Puu Elemakule (1420-S1) is a thermal spring, and magnesium content should be reduced at high temperature. Sulfate data for Kaaha, West crack (1518-S1) and Kaaha, East crack (1617-S1) north east along the coast from Puu Elemakule show that sulfate is higher than expected from the dilution trend for these two springs (Figure 29). Calcium is also higher than the dilution trend for most of the springs (Figure 30). Measured spring temperature versus silica shows that only Puu Elemakule (1420-S1) is clearly thermal (Figure 31), but some other springs could also be anomalous based on silica (Figure 32) and their slightly higher temperatures than expected for non-thermal springs issuing at sea level (generally around 18-22°C). Silica versus bicarbonate shows that higher silica concentrations tend to correlate with higher bicarbonate and that bicarbonate concentrations are above 100 mg/L for a number of springs (Figure 32).

Isotopic data allow grouping among these springs. Deuterium versus oxygen-18 shows that isotopes are shifted from the meteoric water line, with Puu Elemakule showing the largest shift (Figure 33). Deuterium versus chloride clarifies this relationship by showing how mixing with sea water affects the isotopes (Figure 34). Apua Point crack (1511-S1) appears to have an isotopic content of dilute water that is different from all other springs in this area, though the heaviest value is suspect. Halape crack (1615-S1) and Halape Iki spring (1615-S2) appear to have the same and lighter diluting water than for Apua Point crack (solid line). A still lighter diluting water (broken line) is found for Kalue crack (1617-S2), Kaaha, East crack (1617-S1), and Kaaha, West crack (1518-S1). The range in isotope values for the dilute water, though not as large as for the springs in the Pahala area (Figure 24), indicates that some of the flow paths are longer than others. The longer flow paths would permit the addition of thermal energy and carbon dioxide to these waters.

The data for Puu Elemakule (1420-S1) can be interpreted in two ways. The mixing line (shown as a broken line) of Figure 34 passes through the data point with heavier isotopes. Assuming that the lighter data point should be heavier, Puu Elemakule is then on the same mixing trend as the Kalue and Kaaha crack samples. Alternatively, giving equal weight to the two data points would make the mixing line pass through a deuterium value of -35 ‰ at zero chloride. Using the equation for the global meteoric water line relating deuterium (δD) and oxygen-18 ($\delta^{18}O$) compositions ($\delta D = 8\ \delta^{18}O + 10‰$; Craig, 1961), the value of oxygen-18 for zero chloride can be calculated from the deuterium values at zero chloride in Figure 34. Using these values, the mixing lines on Figure 35 have been drawn. The calculated mixing line for Halape crack and Halape Iki spring (solid line in Figure 35) passes through the data and indicates that the isotopes of the dilute water are on the meteoric water line. The isotope values for Puu Elemakule, Kalue, and Kaaha are all slightly shifted to heavier values from the mixing line (broken line in Figure 35), although the difference is within analytical uncertainty. If we use the alternative mixing line for Puu Elemakule, the measured values for this spring are shifted by 0.5 ‰ from the calculated mixing line. This amount of shift would tend to indicate that the water has undergone high-temperature reaction with rock, although this interpretation is tenuous based on the lack of any noticeable change in magnesium concentration from that produced by diluting sea water. These differing interpretations can only be resolved with more precise isotopic data.

Springs from Pohoiki to Cape Kumukahi area

Springs along the coast from Pohoiki to Cape Kumukahi (Figure 7 and Figure 36) are a significant thermal anomaly with a surprising coherence that indicates there is a significant regional flow of thermal water that discharges along the coast (Iovenitti, 1990). Chemical data for the springs follow a sea-water dilution trend except for silica and bicarbonate (Figure 37). Magnesium versus chloride shows slight depletion from the sea-water dilution trend (Figure 38) even though spring temperatures range to 37°C. Calcium is slightly enriched compared to the sea-water dilution trend (Figure 39). Silica concentrations range to a high value of 98 mg/L and are independent of bicarbonate concentration (Figure 40).

The character of the thermal water is shown by plots of temperature versus silica and chloride (Figures 41 and 42). Increasing temperature correlates with increasing silica indicating a hot end-member with high silica. Temperature also shows a correlation with increasing chloride indicating that the hot end-member is a saline water. The consistency of both trends indicates that there is a single end-member with high temperature and high silica and chloride concentrations that mixes with cold, dilute water. Surprisingly, the most concentrated sample of this end-member does not seem to differ in any significant way from diluted sea water in the major element concentrations except for silica and bicarbonate (Figure 37).

The consistency of the proposed mixing process also appears in the stable isotope data (Figures 43, 44, and 45). Assuming that the high-salinity water is isotopically-unshifted ideal sea water (0 ‰ deuterium and oxygen-18), the deuterium versus chloride plot permits the extrapolation to zero chloride to find the deuterium isotope composition of the cold, dilute water (Figure 44). Using the equation for the meteoric water line, the deuterium value obtained permits the oxygen-18 versus chloride mixing line to be calculated (Figure 45). The oxygen-18 data have less scatter than the deuterium data, and both lines are consistent with mixing a dilute meteoric water with sea water. The same mixing line is also shown on the deuterium versus oxygen-18 plot (Figure 43). Although these mixing lines are consistent with the saline end-member being isotopically unshifted sea water, they do not rule out the possibility of a shift either by high-temperature reaction with rock or by boiling (see below). If the saline end-member is much more concentrated than the most concentrated spring sample obtained, there could easily be an isotopic shift that could not be detected with the existing data. However, the lack of any noticeable effect on major-ion chemistry other than silica and bicarbonate tends to indicate that temperatures are not very high.

The systematic variations of chloride and silica with temperature (Figures 41 and 42) indicate that it should be possible to use the spring data to estimate reservoir temperature from the warm-spring or boiling-spring mixing models (Truesdell and Fournier, 1977; Fournier, 1981). McMurtry and others (1977) also applied these mixing models to some thermal waters on the east rift and to Pohoiki and Allison springs. Figure 46 shows silica versus enthalpy along with a mixing line assuming a cold water at 22°C and 50 mg/L silica. Figure 47 shows the extrapolation of this mixing line. For the warm-springs mixing model, the enthalpy of the reservoir fluid would be determined by the intersection with the curve for the quartz-conductive geothermometer of Fournier and Potter (1982a). The point of closest approach to the curve is at point C. The silica at point C for warm-spring mixing is around 720 mg/L with a corresponding reservoir temperature of 314°C. However, the mixing relation for silica versus chloride (Figure 48) indicates that silica calculated at the chloride concentration of sea water (19,000 mg/L) would only be 240 mg/L. Although there is considerable uncertainty in the slopes from Figures 47 and 48, the high value of silica required by the point of closest approach in Figure 47 compared to what would be available based on sea-water chloride in the reservoir fluid makes the warm springs mixing model unlikely. The failure of the mixing line to intersect the quartz geothermometer curve makes this a doubly unlikely solution.

A more reasonable solution is obtained from the boiling-spring mixing model. For the boiling springs mixing model, the spring is assumed to have mixed with cold water after having boiled to 100°C at point E on Figure 47. The original enthalpy of the boiled water is derived from the quartz-adiabatic geothermometer relation at point F. The silica concentration at an enthalpy of 419.0 j/g (100°C) at point E in Figure 47 is 245 mg/L with a corresponding enthalpy at point F of 773.4 j/g for a calculated source fluid temperature of 182°C. The steam fraction for boiling from 182°C to 100°C is 0.157, and the chloride concentration in such a boiled fluid starting sea-water chloride of 19,000 mg/L would be 22,500 mg/L. Based on the silica versus chloride mixing relation in Figure 48, the corresponding silica concentration is 275 mg/L compared to the inferred concentration in the boiled fluid of 245 mg/L. These two methods of calculating silica concentration give similar results, and their agreement indicates that this is a reasonable model.

Chalcedony controls silica solubility at temperatures below 200°C, and the temperature of 182°C is low enough that chalcedony is the most likely phase controlling silica solubility in these springs. A diagram similar to Figure 47 can be prepared based on chalcedony solubility (Fournier, 1981). The warm-springs mixing model does not apply in this case, because the possible intercept would be much greater than 200°C. The solution for the boiling springs mixing model using chalcedony yields a calculated source fluid temperature of 165°C. The steam fraction for boiling from 165°C to 100°C is 0.123, and the chloride concentration in such a boiled fluid starting at sea-water chloride of 19,000 mg/L would be 21,700 mg/L. Based on the silica versus chloride mixing relation in Figure 48, the corresponding silica concentration is 267 mg/L compared to the inferred concentration in the boiled fluid of 245 mg/L. The comparison for the chalcedony calculation is slightly better than for quartz, and the lower temperature of 165°C from chalcedony solubility seems more compatible with the nearly unmodified chemistry of the fluids compared to the composition of their sea-water source. The probable sequence is that a source fluid at 165°C could supply water near sea water composition that boils to 100°C and loses its steam. This boiled water then mixes with dilute water to produce the compositions found in the springs.

The isotopic and chloride composition of sea water at 165°C that boils to 100°C can be calculated using the methods in Truesdell and others (1977). Mixing lines for this high-chloride boiled end-member are shown as the upper lines on the isotope diagrams (Figures 43, 44, and 45), and they are consistent with the proposed process. The 165°C temperature of this source fluid is low enough to explain the lack of significant modification of the major element compositions of this fluid from that of sea water. An additional factor may be that, because of the large scale of the flow system, the rocks have lost their capacity for affecting anything other than the silica in the resulting fluid. The low temperature of the source fluid compared to temperatures at great depth in some east rift drill holes indicates that the flow system operates on the periphery of the geothermal reservoir rather than interacting with the deeper reservoir. The springs occur over a distance of 7 km along the coast, indicating that the 165°C source must be a relatively large volume. Because of the large extrapolations involved from the measured enthalpy and silica to the inferred conditions for the source fluid, this interpretation should be regarded with caution until confirmed by further drilling. If the silica concentration is determined by some other process than equilibrium with a pure silica phase (e.g., Nathenson and Thompson, 1990), the extrapolation to intercept the chalcedony curve with the boiling-springs mixing model would not be valid, and the entire system could be much lower in temperature but would still be extensive.

Wells within the east rift zone between the east rift zone and the coast

Samples from wells within and south of the east rift zone (Figure 7 and Figure 36) show minor to major amounts of sea water addition and minor to major modifications of sea water chemistry. The only consistent characteristic of thermal waters beyond measured temperature are high amounts of dissolved silica. Most other constituents show extremely variable relationships. Similarities in chemical patterns serve to divide these well waters into two groups, each with similar chemical patterns, and other waters with different patterns. The first group with similar chemical patterns is Malama Ki (2783-01), Allison (2881-01), and Pulama (2102-01). Malama Ki and Allison are located south of the lower east rift (Figure 36), and Pulama is located south of the middle east rift (Figure 7). Chemical data for samples from these wells show a pretty close correspondence with diluted sea water, except for silica and bicarbonate (Figure 49). The two samples for Allison (2881-01) show significant increase in the saline component from 1975 to 1982. The sulfate in the 1982 sampling is the same as in 1975, and it seems likely that the 1982 value is incorrect. Magnesium is close to the sea-water dilution line, but it appears to be somewhat depleted for Malama Ki and Allison and somewhat enriched for Pulama (Figure 50). Water from Pulama and the 1975-sample from Allison contain only a small component of sea water and are dominantly dilute water. Calcium is enriched for all three wells (Figure 51), and this may reflect ion exchange of magnesium for calcium in water-rock reaction. Potassium is also enriched compared to sea-water dilution for Malama Ki and Allison (Figure 52).

Silica, bicarbonate, and temperature show rather variable relations for Malama Ki and Allison (Figures 53 and 54). Unfortunately, not all analyses have all three components measured. For Malama Ki, silica ranges from 54 to 144 mg/L and bicarbonate from 128 to 262 mg/L. Temperatures range only from 52 to 56°C, not very different from temperatures measured in the well in 1974 to 1976 of 51-55°C (Epp and Halunen, 1979). If the true silica is over 100 mg/L, some of the variability in silica concentrations could be from polymerization if samples were not diluted. The low silica values for Allison of 24 and 24.1 mg/L are not easily explained, especially when the measured temperature is 38°C; however, McMurtry and others (1977) obtained a value of 53 mg/L, that seems more consistent with other data. Silica, bicarbonate, and measured temperature for Pulama are consistent with it being a slightly thermal water.

Isotopic data for these three wells are shown in Figure 55. The sample for Allison (2881-01) had a salinity of 7.5 per cent that of sea water (McMurtry and others, 1977), and its position near the meteoric water line is reasonable. The mixing line shown has been placed to pass through sea water and the sample from Allison. Salinities for McMurtry and others Malama Ki (2783-01) samples are roughly 60 per cent that of sea water, and they are consistent with the position of the Malama Ki data more than half way on the mixing line toward sea water. The most recent analysis is more dilute, but it is essentially on the same mixing line. Its chloride concentration is 25 per cent that of sea water, which is in reasonable agreement with its position at 40 per cent along the line. The cold water intercept at -19 ‰ deuterium and -3.6 ‰ oxygen-18 is quite different from the cold water intercept for the coastal springs of -13.5 ‰ and -2.9 ‰ (Figure 43). This difference indicates that these two wells intercept a flow path that is quite different from that feeding the coastal springs (Scholl and others, 1993). The higher bicarbonate contents in the well samples also indicate some difference in chemical process from the coastal springs. The isotopes for the Pulama well are also significantly different than the intercept with the meteoric water line, but that well is located quite a distance southwest (Figure 7).

Although the isotopic content of samples from Malama Ki (2783-01) and Allison (2881-01) shows that the dilute water is different from that in the springs along the coast, it is possible that the same hot, saline water feeds both the wells and the springs. The higher bicarbonate in Malama Ki and Allison would require the addition of carbon dioxide and further reaction with rock compared to the coastal springs, but this would be possible if the water sampled in the wells has a longer transit time through the flow system compared to water sampled from the coastal springs. Temperature versus chloride for the well samples is consistent with such a model (Figure 56), but it does not require that this be the case.

The second group of wells with similar chemistry is Puna Thermal TH 3 (2982-01), Puna Geothermal MW 2 (2883-07), and Keauohana 1 (2487-01). TH 3 and MW 2 are located within 1.5 km of each other (Figure 36), but Keauohana is located about 11 km west and is south of the rift (Figure 7). The distinguishing characteristic for the second group is that magnesium and calcium are nearly equal (in meq/L) instead of magnesium being much greater than calcium as in the first group (Figures 57 and 49). Correspondingly, magnesium is significantly depleted compared to the sea-water dilution line (Figure 58). Potassium is enriched compared to sea-water dilution (Figure 59), similar to the first group. Calcium is also enriched compared to sea-water dilution (Figure 60), except for the less saline sample from Puna TH 3 (2982-01). The sea water component in these fluids is confirmed by bromide versus chloride following the dilution line (Figure 61). Silica and bicarbonate values for Keauohana 1 (Figure 62) are similar to those for normal ground water, but temperature (to 28.5°C; Table 2) and magnesium depletion (Figure 58) indicate that it probably has a slight thermal signature (Iovenitti, 1990). Puna Thermal TH 3 (2982-01) has undergone significant changes in chemistry, with two representative analyses shown in Figure 57. Temperatures of samples range from 74° to 95°C, and the measured temperatures show a maximum temperature of 93°C at the water level at a depth of 170 m and a sharp reversal to temperatures ranging from 45° to 62°C within the next 40 m (Epp and Halunen, 1979). This sharp temperature reversal implies adjacent cold and hot water flows that are likely to result in variations in chemistry. Silica concentrations are variable though bicarbonate is relatively constant (Figure 62). The last sampling of Puna Geothermal MW 2 (2883-07) showed an increase in temperature from 56.5 °C in September 1992 to 66.9°C in April 1993 (two points on Figure 63). MW 2 has also shown significant changes in chemistry, though it is more dilute than Thermal Test Hole 3 (Figure 57).

Isotopic data are consistent with mixing between sea water and dilute meteoric water (Figure 64, 65, and 66). The 1991 and 1992 data for Puna Thermal TH 3 (2982-01) and MW 2 (2883-07) define the upper mixing line on Figure 64. Plots of isotopes versus chloride are consistent with this mixing line (Figures 65 and 66). The lower values for isotopes for Puna Thermal TH 3 on Figure 64 are from McMurtry and others (1977). These data define a different mixing line than the more recent data. McMurtry and others (1977) report salinities for their samples of 0.65 to 0.72 per cent, and the placement of the data on the lower mixing line in Figure 64 results in a calculated salinity of about 0.79 per cent. The data are consistent with mixing a dilute meteoric water and a water having the isotopic composition of sea-water. The intercept is similar to values for Keauohana 1 (2487-01). However, the flow paths are probably quite different, because Keauohana 1 is 11 km from Puna Thermal TH 3 (Figure 7). The intercepts along the meteoric water line for the two mixing lines are -10 and -16 ‰ in deuterium, and these values bracket the values for the cold water intercept for the coastal springs of -13.5 ‰. The 1993 values for MW 2 (2883-07) are intermediate between the two mixing lines and correspond to the isotopes in the coastal springs. These changes in isotopic compositions over time indicate that the flow system for the dilute water may be localized and responsive to variations in recharge, whereas large-scale ground-water systems tend to have little variation of isotopes over time compared to surface waters.

The oxygen-18 versus chloride plot (Figure 66) includes data from Buddemeier and others (in Shupe and others, 1976). No deuterium data are available for these samples. Comparison of the values in Figure 66 with values obtained in this study and with the values from McMurtry and others (1977) in Figure 64, indicates a large difference between values reported by Buddemeier and others and earlier and later measurements. A systematic comparison of all values from Buddemeier and others with values for samples from the same wells reported by McMurtry and others and with values from this report show that Buddemeier and others values are systematically low by about 3 ‰. Thus the values from Buddemeier and others cannot be used to compare with values found by others.

The depletion of magnesium compared to the sea-water dilution line for Puna Thermal TH 3 (2982-01) and Puna Geothermal MW 2 (2883-07) make them unlike the water sampled in the coastal springs (Figure 58 and 38). In addition, the temperature versus chloride relationship (Figure 67) shows that they are much hotter at a given chloride concentration than shown by the mixing line for the coastal springs. Thus if these wells sample the mixed fluid that is sampled in the coastal springs, there would have to be significant addition of thermal energy and continued reaction with rock to produce the characteristics of fluids sampled in the wells.

Just to the northwest of the two wells discussed above (Figure 36) are Puna Geothermal MW 1 (2983-01) and MW 3 (2983-02). The chemistry of these wells is essentially identical to each other (Figure 68) but quite different from other shallow wells because of the large amount of sulfate compared to chloride (Figure 49, 57, 69, 70). Amounts of Mg, Ca, and Na relative to chloride are much higher than for sea water, and the cations are largely balanced by sulfate. Bicarbonate is no higher than in a non-thermal water, but silica and temperature are relatively high for MW 1 and 3 (2983-01 and 02, Figures 71 and 72). Magnesium and sulfate are quite high compared to sea-water dilution (Figures 73 and 74). Even though chloride is only 20 mg/L, bromide is essentially on the sea water dilution line, although somewhat depleted (Figure 75). The chloride is probably high enough to reflect a small component of sea water rather than being from rainfall. Boron is anomalously high compared to other well samples in and near the east rift (Figure 76). (Other boron data in Figure 76 are slightly off the sea-water mixing line and probably indicate addition of boron from a geothermal source for 2783-01, 2982-01, and 2883-07 but may also reflect analytical difficulties for this element. Data for repeat samplings of other locations show variability of around 20 %.) Deuterium isotopes in samples for MW 1 and 3 are similar to those found in the coastal springs, possibly indicating a similar cold recharge water (2983-01 and 02, Figure 77). The high sulfate and anomalous boron and temperature for these samples are consistent with steam heating of local meteoric water as the mechanism to produce the chemistry of waters in MW 1 and 3. The sulfate would be produced by oxidation of hydrogen sulfide, and boron is naturally carried in the steam phase. The isotopes depart from the meteoric water line (though the difference may not be significant), which is consistent with adding a steam phase whose isotopes are to the left of the meteoric water line.

The Kapoho (Airstrip) well (3081-01) is further east along the north edge of the rift (Figure 36). The chemistry is shown on Figure 69 along with that for Pulama (2102-01) for comparison, and it is basically that of diluted sea water with added sulfate, calcium, and sodium. Temperature and silica are elevated, but bicarbonate is not (Figures 71 and 72). Magnesium is nearly on a sea-water dilution line (Figure 73), but sulfate is quite elevated (Figure 74). Isotopes bracket those found in the coastal springs (Figure 77), but the deuterium value of -12 ‰ may not be representative based on the close agreement of its oxygen-18 isotopes with the other samples. Although not as elevated as in Puna Geothermal MW 1 and MW 3, the high sulfate in the Kapoho (Airstrip) well may indicate that it is also steam heated.

Green Lake (3080-S1), Kapoho Crater well (3080-01), and Kapoho Shaft (3080-02) are located further east on the rift (Figure 36), and the samples have similar chemical patterns (Figure 70). Magnesium and calcium are elevated and bicarbonate is high compared to most other samples. Silica and temperature are only slightly elevated (Figures 71 and 72). Sulfate and bromide are essentially on or below a sea-water dilution line (Figures 74 and 75) indicating a significant component of sea water. Green Lake is more dilute than the well samples (Figure 70) indicating that rain is probably falling on the lake and mixing with water similar to that found in the wells; however, the isotopes for the lake samples indicate that there is substantial evaporation also affecting the lake water (Figure 77). The similar temperature of the lake water and well samples is only coincidence as the lake has cool water input from rain, cooling from evaporation, and heating from solar radiation. The difference in isotopes for the two samples of the Kapoho Crater well is large enough to be significant and probably indicates rather local and rapid recharge of cold water.

A useful comparison for the chemistry of the Kapoho Crater wells is to that for the Volcano TH 4 well (2714-01, Figure 25) shown in Figure 70. The three Volcano TH wells all have quite similar chemistries, and the data for only one are shown on Figure 70. Unlike the Kapoho Crater well and shaft, the Volcano TH wells have no sea water mixed in, only constituents from rainfall and subsequent reaction with rock . Silica for the samples from the Volcano TH wells are only 50-54 mg/L, but bicarbonate concentrations are 126-154 mg/L. These high bicarbonate concentrations indicate a significant component of carbon dioxide input to the water that is then dissolving minerals in the rock. The resulting chemistry is similar to but more dilute than that for the Kapoho Crater well and shaft. The major difference is that the relative proportion of sodium to bicarbonate in the Volcano TH 4 well sample is much lower, and this difference indicates that magnesium and calcium are much easier to dissolve from rock than is sodium. This partially explains the pattern found in many samples of modifications to magnesium and calcium concentrations in diluted sea water with little change in sodium concentrations. This pattern combined with the dominance of sodium in sea water over other cations makes it difficult to modify sodium concentrations from diluted sea water.

CHEMISTRY OF WATER SAMPLES FROM AND BEHAVIOR OF DEEP WELLS

The deep wells drilled on the east rift (Figure 7 and Figure 36) show a complex pattern of chemical and physical behavior that indicate at least four processes in the geothermal reservoir. The reservoir contains parts that are single phase liquid, two-phase steam and water, and single phase steam. The basic chemical processes in the reservoir are sea-water dilution, reaction with rock to modify diluted sea water, boiling of possibly undiluted sea water, and additional reaction with rock at high temperatures. These various processes are illustrated by data for different wells (Figure 78 and 79). Well HGP-A has a significant production history while other wells have only been briefly tested. The evolution of the chemistry of HGP-A provides important information when compared to the short term data available for other wells.

Well HGP-A was completed in 1976 and produces a two-phase mixture of steam and water (Thomas, 1987). Various tests were conducted from 1976 to 1981, and continuous production occurred from June 12, 1981 to September 4, 1981 and from December 11, 1981 to December 11, 1989, except during brief shut downs for plant maintenance (Thomas, 1987; Thomas, 1990). Measurements of flow and steam fraction were not made during much of this period; however, it is estimated that the flow decreased no more than 2.2 %/year (Thomas, 1990). The long-term data for the chemistry of fluids from HGP-A show a substantial increase in chloride concentration (Figure 80). The early testing data involve various types of samples resulting in variable concentrations, but the production data were generally collected under a standard set of conditions. Some of the low chloride concentrations in the production data are from analyses in the literature that have been recalculated to a total fluid basis, and those data have not been removed from the plot. Because the production data were collected under a standard set of conditions and they show a systematic evolution of chloride concentration with time, the following discussion will focus only on the production data. Chloride concentrations rose sharply from about 1600 mg/L to 3700 mg/L in the period June-September, 1981, and were only 2800 mg/L when production was restarted in December, 1981 (Figure 80).

The evolution of chloride with time in HGP-A fluid is not just a mixing relationship, but there is a change in chemistry that involves an evolution of chemical processes. Figure 78 is a modified Schoeller diagram for representative samples from HGP-A chosen mostly on the basis of completeness of analysis and representative values of chloride concentration. These data are also given in Table 6. Sodium and chloride closely approach sea-water dilution (Figure 81), and their behavior is the basis for proposing sea-water dilution as the base process for HGP-A fluids. Fluid samples show a nearly complete depletion of magnesium and sulfate compared to diluted sea water (Figure 78). Magnesium depletion is expected in high-temperature thermal waters, and it appears that much of the magnesium was deposited with sulfate (Thomas, 1987). As the chloride increases, the ratio of Ca:Na evolves from less than that for diluted sea water to more than that for diluted sea water. This evolution can be seen in Figure 82, where calcium concentrations vary from below that for sea-water dilution, to some that approximate sea-water dilution, to significantly above what can be obtained from sea-water dilution. A mixing process between fluids with differing calcium and chloride concentrations can explain the path of evolution of calcium versus chloride only if there are three end-member fluids. A more reasonable interpretation based on the similar data for other wells (further discussed below) is that the evolution involves sampling fluids through a chemical gradient that depends on other variables such as degree of boiling and/or temperature. Because there are no published data concerning steam fraction, enthalpy, or isotopes of produced fluids, it is not possible to further define the process.

Unlike calcium, potassium concentrations follow a mixing relationship, but one that is significantly different from sea-water dilution (Figure 83). As potassium is a reactive species that is important in several geothermometers, this relationship indicates that fluid is able to dissolve potassium in reacting with rock and may provide valid information on geothermometer temperatures. Nearly all samples for HGP-A follow a mixing line that might indicate that the well essentially obtained most of its liquid from a reservoir at a single temperature, but the last (most concentrated) samples deviate from the mixing relationship. Much of the data for lithium also follows a mixing relationship that differs significantly from sea-water dilution, but the last (most concentrated) HGP-A samples also deviate from the mixing relationship (Figure 84). Thus the latest produced fluids may be tapping a lower-temperature liquid.

An important constituent for geothermometry is silica, and Figure 85 shows the available data obtained during production. Most of the values near 450 mg/L are for samples recalculated to a total fluid basis. Most of the samples are around 825 mg/L, although the first samples produced in each production period are above 1000 mg/L. Data for various tests before production are quite variable in silica with many samples having values around 200 mg/L; it seems likely that some of these samples may not have been adequately preserved before analysis as these values are much too low for a high-temperature reservoir. In order to apply the silica geothermometer to fluids from HGP-A, the amount of added steam must be taken into account. Based on the reported separator conditions and steam fraction, the enthalpy of produced fluids from HGP-A is equivalent to a temperature of 346°C if the fluid started as liquid water (Table 6). This temperature is higher than is available in most of the well where measured temperatures are about 300-320°C from 1250 m to around 1800 m but increase to almost 370°C at 1900 m (Thomas, 1987). Thus the well fluid appears to obtain extra enthalpy either by tapping a steam zone or by boiling and obtaining energy from lowered rock temperature as a boiling front moves out into the formation. An approximate measure of the silica temperature is provided by the quartz adiabatic geothermometer that assumes the concentration of silica in the separated liquid has been produced by boiling from the reservoir temperature to 100°C (maximum steam loss). There is a slight error because the produced fluid was only boiled to 184°-

187°C, but the approximation is further corrected below. Quartz adiabatic temperatures range from 261°C to 272°C for representative fluid samples (Table 6) and would seem to indicate that most of the liquid should be coming from a relatively high level in the well where temperatures are lower.

Other geothermometers generally confirm that the liquid came from equilibrium with rock at 250-270°C, but these calculated temperatures must be regarded with some caution. Na-K-Ca temperatures are generally around 255°C although two values are 15°C and 30°C lower. Based on the behavior of K and Ca, there is significant water-rock interaction for these two elements, indicating possible equilibration between water and rock. However, Na is determined by diluting sea water, and this behavior violates one of the assumptions of the geothermometer: that amounts of dissolved constituents are determined by dissolution of rock. However, the increase in K and changes in Ca concentration are enough to change the Na-K-Ca temperature from 174°C for sea water (not in equilibrium with rock) to values well over 220°C. Na-K temperatures are somewhat higher than Na-K-Ca, but the geothermometer is suspect based on the same argument as for Na in the Na-K-Ca geothermometer. K-Mg temperatures are consistently higher than any others, and Mg-Li temperatures are consistently low enough to be dismissed. Both K and Li are increased by water-rock interaction while Mg is decreased by deposition of hydrothermal minerals. Magnesium content is low enough that one is concerned about precision and accuracy for the analyses. However, lowering the amount of magnesium increases both the K-Mg and Mg-Li temperatures, and the two geothermometers cannot be brought into agreement by adjusting values for magnesium. This comparison indicates that K, Mg, and Li systematics are not compatible for this water, and neither geothermometer is quite appropriate because of their dependence on magnesium contents.

Returning to the silica geothermometer as apparently the most consistent, we can use it to estimate the amount of steam in the produced fluids that comes from isoenthalpic boiling of liquid water and that which is added. The steam at the well head beyond that produced by isoenthalpic boiling is added steam produced by reservoir boiling, frequently by an approximately isothermal process at a distance from the well feeds. The basic notion is to assign an amount of steam produced at separator conditions to have been boiled directly from liquid water in the well feed. This amount of steam is added to the liquid phase produced at separator conditions to calculate the enthalpy and the equivalent downhole temperature of the source liquid. Silica at reservoir conditions can be calculated by adding the steam to the produced liquid to correct the measured silica concentration for steam loss. The silica at reservoir conditions is then used to calculate the reservoir temperature using the quartz conductive geothermometer. By an iterative calculation, the amount of steam needed to make the two temperatures the same can be easily determined. The remaining steam at the wellhead is known as added steam (Truesdell and others, 1989).

Two complications arise in this calculation for samples from the Hawaii wells. Temperatures of some of the wells are quite high, and the usual formulas for quartz solubility (e.g. Fournier, 1981) are not valid at such high temperatures. To deal with this problem, Fournier and Potter (1982a) presented a revised quartz geothermometer;

however, even that formulation is only valid to 330°C. Although none of the calculations for added steam yield temperatures above 318°C, the revised formula cannot deal with effect of high dissolved solids contents found in Hawaii wells. To deal with this second complication, we use the quartz solubility formula of Fournier and Potter (1982b) and the method of accounting for the effect of dissolved constituents of Fournier (1983). The density of water as a function of temperature and salinity are needed for the calculation, and we use the tables of Potter and Brown (1977). Since the wells are generally around 2 km deep, we assume that reservoir fluids were initially at 200 bars pressure. This procedure was also utilized to calculate quartz adiabatic temperatures rather than the conventional formula.

The downhole temperature in HGP-A for the boiled fluid (BF in Table 6) is 279°C for the sample collected on 12/5/83. The added steam is 0.27; or of the total steam (0.43) produced at the separator conditions, 0.16 is steam produced from the boiled fluid and 0.27 is added steam. The calculated downhole temperature of 279°C is close to the quartz adiabatic temperature of 264°C showing that the error of the quartz adiabatic temperature associated with the inconsistency between its assumed boiled temperature of 100°C and the actual separator temperature of 184°C is small. The calculated downhole silica concentration is 640 mg/L, and values close to this were found in a number of downhole samples in the early testing of HGP-A (Table 3).

The relatively low temperature for the boiled fluid of 279°C at reservoir conditions suggests that the fluid is produced from a relatively high level in the well where temperatures are lower. This may also help explain why first-produced fluids have a much higher silica content than later fluids. Assuming either a two-phase or a steam phase zone lower in the well, shut-in conditions would allow high-level liquid that filled the well to flow down the well during shut in. Assuming that this lower zone has limited permeability and higher temperature, a small amount of fluid could dissolve silica at higher temperature. This hotter fluid would come out early in the production until either the steam or two-phase zone reestablished itself, and the result would be an initial spike in silica concentrations as the well is turned on. A silica concentration of 1200 mg/L (Table 3 and Figure 85) yields a quartz adiabatic temperature of 290°C, which is closer to the higher temperatures measured deeper in the well. This suggests that equilibration of reservoir fluid is relatively rapid, as one would expect at these high temperatures.

Water chemistry data for other deep wells on the east rift show variations that help constrain the characteristics of the reservoir (Figure 79). Lanipuna 1 (2883-02) is south of HGP-A (2883-01) and Lanipuna 6 (2883-05) is east (Figure 36). Data for Lanipuna 1 show that it is similar to the most concentrated samples from HGP-A (Figure 78). Sodium and chloride are below values for sea water indicating that there is some dilute water in the sampled water. The three sodium values that plot below the sea-water dilution line (Figure 81) are partly an analytical artifact, because each of these analyses is low in total cations compared to anions. Because sodium and chloride are so dominant in the cation/anion balance, the difference from the dilution line is partly because of the failure of the analyses to balance. If the chloride values are adjusted to force a perfect balance, there is still a suggestion that sodium is lower than the dilution line. Calcium is more strongly enriched in Lanipuna 1 than in HGP-A (Figure 82). Potassium is significantly closer to the sea-water dilution line than for HGP-A (Figure 83), and lithium is slightly closer (Figure 84). Silica concentrations may be unrealistically low based on comparison between cation and silica geothermometer temperatures (Table 6). Although more concentrated than HGP-A fluids, the fluids from Lanipuna 1 appear to be lower temperature based on the lower potassium content and lower cation temperatures. Although measured temperatures in the well were quite high (>363°C at 2557 m, Thomas, 1987), the chemical data indicate that fluids were probably produced from a shallower entry at lower temperature.

Data for the shallower well Lanipuna 6 provide a useful comparison of the effects of lower temperature. Boron in Lanipuna 6 is essentially on the sea-water dilution line compared to elevated boron levels in other wells (Figure 86). Although calcium is slightly more enriched in fluid from Lanipuna 6 than in Lanipuna 1 (Figure 82), sulfate is much less depleted (Figure 87) and there is still significant magnesium in the fluid (Figure 79). Potassium in Lanipuna 6 is much closer to the sea-water dilution line than in Lanipuna 1 (Figure 83). Geothermometer temperatures are lower than for Lanipuna 1 (Table 6). The comparison between Lanipuna 6 and 1 indicates that lower temperatures result in less sulfate and magnesium depletion and less enrichment of potassium. The calcium enrichment seems not to be very temperature dependent (once above some minimum temperature?) but is related to chloride concentration or, more likely, the relative salinity of the water.

Water chemistry for deep wells Kapoho State 1A and 3 provides information on fluids hotter than those found in HGP-A. Chloride concentrations in samples from Kapoho State 1A range from below that of sea water to above sea water (Figure 81). Mostly this is the effect of concentration as liquid is boiled in the well, and the down hole concentration is less than that of sea water. Sodium values appear to be less than that obtained from sea-water dilution, but the analyses also have a systematic bias similar to that for Lanipuna 1. Adjusting the chloride concentrations to force a perfect balance, the values are systematically below the sea-water dilution line but by a smaller amount than shown in Figure 81. Magnesium and sulfate are strongly depleted in fluids from Kapoho State 1A (Figure 79). Calcium is less enriched in Kapoho State 1A than Lanipuna 1 and 6 (Figure 82). Potassium and lithium are significantly enriched in Kapoho State 1A, confirming its high-temperature origin (Figures 83 and 84). Silica concentrations are high but variable (Figure 85). The quartz adiabatic geothermometer temperature is 271°C for the listed value for silica of 900 mg/L in Table 6. A value of 1000 mg/L may be more representative (Table 3), and the corresponding quartz adiabatic temperature of 280°C is listed in Table 6. Cation geothermometers indicate temperatures of 300-330°C. The enthalpy of produced fluids cannot be accounted for by isoenthalpic boiling of liquid water, and either steam or thermal energy must be added to explain the produced enthalpy. Using a silica concentration of 1000 mg/L, the added steam calculation indicates a reservoir temperature of 310°C and added steam of 0.79 (Table 6). The down hole concentration of chloride for a measured chloride of 19645 mg/L would be 15,700 mg/L. This is somewhat greater than the lowest measured chloride of 13000 mg/L (Table 3), and this difference may indicate that the well has another feed zone of lower salinity that becomes important at the higher well head pressure of 44.1 bar at which that sample was obtained (Table 5). The calculated chloride concentration is below the chloride content of sea water, indicating that the source fluid has some dilute water mixed with sea water.

Water chemistry data for samples from Kapoho State 3 indicate that it is strongly concentrated fluid compared to sea water with chloride concentrations in produced fluids two to three times that in sea water (Figures 79 and 81). The higher magnesium content than in other deep-well fluids is probably related to the low pH of fluids in Kapoho State 3. Sodium is significantly depleted compared to fluid boiled from sea water (Figure 81), and calcium shows strong enrichment. Potassium is essentially on the same mixing line as HGP-A fluids and is significantly enriched compared to sea water (Figure 83). Lithium is more enriched than in HGP-A fluids (Figure 84). Silica concentrations are high but somewhat variable (Figure 85) with some of the range caused by data from different separation pressures. The fraction of steam in produced fluids was calculated using a representative enthalpy of 2209 j/g (950 Btu/lb). The quartz boiled-fluid temperature of 318°C is higher than the Na-K-Ca and Na-K geothermometers (Table 6). The K-Mg geothermometer temperature is low and the Mg-Li temperature is very low compared to the quartz boiled-fluid temperature. Produced fluids have an enthalpy greater than what can be produced from liquid water unless steam and or thermal energy is added. The calculated down hole chloride concentration is 30,300 mg/L or 60 % higher than that in sea water, and this indicates that the fluid has undergone significant boiling in the formation. Whether it started as a mixed water before boiling cannot be established; however its similarities to fluid from Kapoho State 1A, which clearly has some dilution, indicates that its initial chloride concentration was probably less than that of sea water.

Water chemistry data for samples from Kapoho State 8 and 9 are quite dilute compared to the deep wells discussed above (Table 6). Well head pressures under production for the sample collected from well Kapoho State 8 were 104.5 bars. A minimum reservoir temperature of 314 °C can be calculated assuming that water in the reservoir existed at the pressure measured at the well head. The well head enthalpy for KS-8 corresponds to 350°C saturated steam. The silica concentration in the total fluid was 24 mg/kg. This amount of silica corresponds to a temperature of 342°C (Table 6) if carried in saturated steam from the silica solubility formula of Fournier and Potter (1982b). Thus the dilute chemistry of the fluid from KS-8 combined with a rather high amount of dissolved silica is explained by the fluid having been 340-350°C saturated steam in the reservoir. As the fluid came up the well with constant enthalpy, liquid water was condensed from the steam and the silica preferentially went into the liquid phase. Limited data are available for wells Kapoho State 1 and 2 (Table 5), however both produced dry steam before being plugged.

The data sets from the various wells permit some tentative conclusions concerning the state of the reservoir in this part of the rift. The high flows from wells Kapoho State 8 and 9 indicate that the production of high enthalpy fluids probably involves tapping a zone that has steam as the pressure controlling phase. This steam is being produced in the reservoir in a boiling zone that was probably tapped by well Kapoho State 3 because of the high chloride concentrations found in that well. The boiling that takes place in the reservoir is caused by a leakage of steam to the surface, a process that is slowly dewatering the system. Although there can be boiling in the reservoir in response to production, the behavior of the wells as a group indicates that there was substantial pre-exploitation boiling to produce high flows of nearly pure steam. To be able to distinguish reservoir boiling from pre-exploitation boiling, detailed time histories of flow and produced enthalpy would be necessary but are not available for the only well with a long production history. To keep such a system from collapsing due to cold water recharge, it is likely that permeabilities surrounding the reservoir are low either because of mineral deposition (from removal of magnesium and sulfate) or from the pattern of dike intrusion or a combination of the two. The reservoir has significant gradients in chemistry related to temperature and degree of boiling of reservoir fluids. The liquid present in the reservoir is a mixture of sea water and dilute water that has had its chemistry modified in major ways by interaction with rock at high temperature. Surrounding the reservoir, some of the fluids are hot but may receive their thermal energy dominantly by conduction from the high-temperature reservoir at depth. The proposed configuration closely resembles the vapor-dominated system of White and others (1971) except that the strong gradients of temperature in this reservoir indicate that this system is probably in the early stages of evolution from a hot-water dominated system.

Reservoir liquid has some characteristics that are simply a more evolved version of characteristics found in shallow wells, but the most diagnostic characteristic to differentiate reservoir fluids is the depletion of sulfate. Figure 87 shows sulfate versus chloride data for deep-well fluids. The hottest fluids show the strongest depletion of sulfate. Few samples from shallow wells or springs show a similar depletion. The 1982 high-chloride sample from Allison (2881-01) is depleted in sulfate compared to the 1975 low-chloride sample (Figure 49), but the 1982 sulfate value is suspect because of the poor balance. Also the 1982 sample shows little magnesium depletion (open triangle, Figure 50) compared to the large depletion in sulfate, and the difference in depletions tends to reinforce doubt in the sulfate value. Puna Thermal TH 3 (2982-01) is the only other sample of water from a shallow well on or near the east rift that shows a significant depletion in sulfate (Figure 88) and magnesium (Figure 58). If deep fluid is part of the fluid in TH 3, there would also have to be meteoric water and some unmodified sea water. Given that temperatures in TH 3 are up to 93°C, it is entirely possible that some component of deep water is mixed in. The lack of any signature of fluids sampled by the deep wells in the other shallow wells indicates that little liquid from the deep reservoir appears to leak to the near surface. Fluids sampled by the shallow wells may still have a component of water from a deep liquid, but it is not the liquid found in the deep wells. This is consistent with the generally closed nature of a reservoir developing a steam zone due to leakage of steam over geologic time. The springs sampled along coast below the lower east rift show no evidence of any of the fluids sampled by the deep wells.

CONCLUSIONS

The chemistry of dilute ground water is determined by precipitation containing sulfate, chloride and some of the sodium and by addition of calcium, magnesium, silica, bicarbonate, some of the sodium, and possibly sulfate from reaction with minerals in volcanic rock. Mixtures of this dilute meteoric water with sea water result in water chemistry that is dominated by the constituents in sea water except for bicarbonate and silica. The amounts of silica and bicarbonate in mixed waters indicate that carbon dioxide is available for further reaction with rock after mixing. Some shallow ground-water samples have higher than normal bicarbonate concentrations (~ 50 mg/L), and these high concentrations (up to 100 mg/L) probably indicate that some areas have anomalously high partial pressures of carbon dioxide. The component of dilute meteoric water in some mixed waters at low elevations has isotopic compositions that indicate a higher elevation source (McMurtry and others, 1977; Scholl and others, 1993), and this indicates that some of the ground-water flow systems are of large extent.

Sampling and analyses of coastal springs indicates that more springs have a thermal component than previously known. Both thermal and non-thermal coastal springs approximately follow sea-water dilution for major elements except silica and bicarbonate. In the springs south of Kilauea Crater, silica increases with bicarbonate. In the thermal springs near the lower east rift, bicarbonate is constant, and silica increases with temperature and chloride concentration. This characteristic has been used in the boiling-spring mixing model to propose a possible source fluid at 165°C. Because the extrapolations used in this model are large, the derived temperature should be treated with some caution. However, it is clear that the large areal extent of these thermal springs and their high discharge rates implies that they involve a large thermal anomaly. Comparison of the chemical data for the thermal springs with samples obtained from deep wells within the east rift show that the wells do not tap a similar fluid; however it does seem likely that the thermal springs involve a heat source associated with the rift.

Samples from shallow wells within the east rift and between the east rift and the coast have rather variable water chemistry. This variability is caused by a number of different mechanisms producing the chemistry of water sampled by shallow wells. Malama Ki (2783-01), Allison (2881-01), and Pulama (2102-01) are basically diluted sea water except for silica and bicarbonate. Pulama has only a slight indication of being a thermal water, whereas Malama Ki and Allison are clearly thermal. Although Malama Ki and Allison do not sample the same mixed water as found in the coastal thermal springs, they could have some component of the same saline, hot water. Although Puna Thermal TH 3 (2982-01), Puna Geothermal MW 2 (2883-07), and Keauohana 1 (2487-01) are grouped together based on depletion of magnesium compared to the sea-water dilution, Keauohana 1 has only a slight signature of being thermal. The sample from Puna Thermal TH 3 is the only sample from a shallow well to show sulfate and magnesium depletion as found in the deep wells on the lower east rift, and it may have a component of deep fluid. Puna Thermal TH 3 and Geothermal MW 2 are both hotter than their chloride concentrations would indicate if they receive their thermal energy from the same saline, hot water as found in the coastal springs from Pohoiki to Cape Kamukahi. The chemistry of water sampled from Puna Geothermal MW 1 and MW 3 (2983-01 and 02) and Kapoho (Airstrip) well (3081-01) appears to be dominated by steam heating of local ground water. The chemistry of water sampled by the Kapoho Crater and Shaft (3080-01 and 02) has very high bicarbonate indicating a high partial pressure of carbon dioxide.

The deep wells on the east rift tap a reservoir with significant gradients of water chemistry. The basic processes are driven by boiling and reaction with rock as a steam zone has been created in the reservoir. Most deep wells show that they started as diluted sea water with substantial modification from reaction with rock at high temperatures. The relative proportions of sea water and dilute water vary significantly between various wells. Most wells that produce a two-phase mixture of steam and water have added steam beyond what would be produced from isoenthalpic boiling of liquid water from depth. Some wells produce nearly pure steam. Well KS-8 taps high-temperature (340-350°C) steam that condenses liquid water as it flows up the well. Wells KS-8 and 9 have very little dissolved solids other than silica in the liquid phase sampled at the surface, and this confirms that the fluid in the reservoir was high-temperature steam. The basic model for the reservoir tapped by the deep wells is that of an evolving vapor dominated system that has not encompassed sufficient volume to smooth gradients of temperature and fluid saturation. There seems to be no direct connection between fluids in this reservoir and the saline, hot fluid found in the coastal springs. The source of the saline, hot fluid that provides the heat for the coastal springs may be conductive heating of sea water near the margins of the deep reservoir sampled by deep wells on the east rift or a more open reservoir at lower temperature than that found by deep wells on the east rift. Fluids sampled by the deep wells are depleted in sulfate compared to sea-water dilution whereas fluids from shallow thermal wells are not. This characteristic shows that thermal water from shallow wells generally does not contain a component of fluid from the deeper reservoir sampled by the deep wells.

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Table 1. Location data for springs, wells, shafts, and tunnels. Locations for wells are from Hawaii State files. Some locations for wells as reported in the literature differ from the modern location, and these locations are also given in the table. Locations for springs are from this report. ID numbers for springs are assigned based on usual methodology used in Hawaii for wells, but the numbering has been developed for this report.

ID No.	Name	Latitude ° ' "	Longitude ° ' "	Elevation meters	Depth meters	Data Source
	Thermal and non-thermal springs					
0436-S1	Kau cane field spring near Haao	19 04 58	155 36 51	632.5		
0631-S1	Kawa Spring	19 06 51	155 31 45	1.5		
0829-S1	Kamehame Hill crack	19 08 36	155 29 03	6.1		
0830-S1	Punaluu beach spring	19 08 09	155 30 30	1.5		
0926-S1	Pueo spring near Palima Point	19 09 35	155 26 47	0.6		
0926-S2	Waiapele crack	19 09 55	155 26 22	0.6		
0927-S1	Waioala Spring	19 09 10	155 27 11	1.5		
1420-S1	Puu Elemakule spring	19 14 24	155 20 00	0.0		
1511-S1	Apua Point crack	19 15 47	155 11 52	7.6		
1518-S1	Kaaha, West crack	19 15 54	155 18 11	6.1		
1615-S1	Halape crack, large pool	19 16 27	155 15 29	4.6		
1615-S2	Halape Iki spring at beach	19 16 24	155 15 44	0		
1617-S1	Kaaha, East crack	19 16 00	155 17 47	6.1		
1617-S2	Kalue crack	19 16 06	155 17 20	6.1		
2634-S1	Ainapo Trail crack	19 26 27	155 34 49	3922.8		
2735-S1	Mauna Loa Cabin crack	19 27 53	155 35 07	4038.6		
2780-S1	Pohoiki Spring	19 27 40	154 50 45	1.5		
2780-S2	Allison Spring	19 27 55	154 50 21	~1		4
2880-S1	Campbell spring	19 28 00	154 50 17	1.5		
2934-S1	Jaggar's Cave crack	19 29 46	155 34 47	3968.2		
2979-S1	Vacationland, Roney	19 29 38	154 49 30	3.0		
2979-S2	Burgess pool, Kapoho Beach Lots	19 29 31	154 49 31	3.0		
3080-S1	Green Lake, near shore	19 30 19	154 50 31	6.1		
3080-S1	Green Lake, near center	19 30 20	154 50 32	6.1	2.5	
3178-S1	Lighthouse spring, Cape Kumukahi	19 31 15	154 48 34	1.5		
3889-S1	Haena spring at road above lake	19 38 43	154 59 19	4.6		
3889-S2	Haena spring above beach	19 38 50	154 59 09	0.6		
8836-S1	Kaalualu spring 1	18 58 28	155 36 54	0.6		
8836-S2	Kaalualu spring 2	18 58 30	155 36 54	0.6		
8837-S1	Kaalualu spring 3	18 58 32	155 37 01	0.6		
	Shallow wells ≥ 30°C					
2686-02	Puna Thermal TH 2	19 26 33	154 56 48	315.5	169.5	
2783-01	Malama Ki	19 27 28	154 53 01	83.5	97.2	
2783-01	Malama Ki	19 27 30	154 53 00	83.5	97.2	4
2881-01	Allison (Pohoiki Puna)	19 28 19	154 51 10	40.2	42.7	4
2883-07	Puna Geothermal MW 2	19 28 36	154 53 30	179.2	195.1	
2982-01	Puna Thermal TH 3	19 29 13	154 52 55	171.6	210.3	
2983-01	Puna Geothermal MW 1	19 29 08	154 53 39	185.9	219.5	
2983-02	Puna Geothermal MW 3	19 29 10	154 53 40	185.9	219.5	
3081-01	Kapoho (Airstrip)	19 30 24	154 51 59	87.5	102.7	
3081-01	Kapoho (Airstrip)	19 30 30	154 52 23	87.5	102.7	4
3081-02	Puna Thermal TH 4	19 30 39	154 51 19	76.2	88.4	

ID No.	Name	Latitude ° ' "	Longitude ° ' "	Elevation meters	Depth meters	Data Source
	Shallow wells, shafts, and tunnels < 30°C					
0335-01	Naalehu 1	19 03 47	155 35 43	227.4	273.1	
0533-01	Honuapo Mill	19 05 40	155 33 05	6.7	10.4	
0533-01	Honuapo Mill	19 05 30	155 33 00	6.7	10.4	4
0533-02	Honuapo 1	19 05 59	155 33 01	28.7	39.6	
0533-03	Honuapo 3	19 05 57	155 33 02	27.1	38.1	
0537-01	Haao Tunnel	19 05 27	155 37 27	701.0		
0632-01	Honuapo 2	19 06 02	155 32 59	31.4	42.7	
0830-01	Punaluu	19 08 28	155 30 28	6.7	6.1	
0831-01	Ninole GU TH 1	19 08 29	155 31 11	37.5	53.0	
0831-02	Ninole A	19 08 32	155 31 08	39.0	52.4	
0831-03	Ninole B	19 08 32	155 31 09	39.0	52.4	
0936-01	New Mountain House Tunnel	19 09 30	155 36 57	1036.3		
1128-01	Pahala Shaft	19 11 57	155 28 49	235.9	166.7	
1128-01	Pahala Shaft	19 12 40	155 25 40	235.9	166.7	4
1128-02	Palima	19 11 08	155 28 08			4
1128-02	Palima	19 11 08	155 28 16	92.7	114.3	
1229-01	Pahala	19 12 25	155 29 22	338.9	285.9	
1331-01	Alili Tunnel	19 13 57	155 31 17	883.9		
2102-01	Pulama	19 21 07	155 02 12	70.1	76.2	
2102-01	Pulama	19 21 15	155 02 15	70.1	76.2	4
2487-01	Keauohana 1	19 24 56	154 57 19	229.2	244.4	
2487-01	Keauohana 1	19 24 53	154 57 20	229.1	244.4	4
2487-02	Keauohana 2	19 24 57	154 57 18	229.2	244.8	
2714-01	Volcano TH 4	19 27 43	155 14 55	1159.0	100.3	
2715-02	Volcano TH 3	19 27 55	155 15 02	1170.0	106.7	
2815-01	Volcano TH 1	19 28 02	155 15 12	1180.0	114.3	
2986-01	Pahoa Battery 2A	19 29 25	154 56 46	214.9	230.1	
2986-02	Pahoa Battery 2B	19 29 24	154 56 47	216.7		
2986-02	Pahoa Battery 2B	19 29 33	154 57 00	216.7		4
PVFW	Pahoa Village Fresh Water					6
3080-01	Kapoho Crater	19 30 16	154 50 21	11.6	14.0	
3080-02	Kapoho Shaft	19 30 17	154 50 21	11.6	14.0	4
3080-02	Kapoho Shaft	19 30 16	154 50 21	11.6	14.0	
3185-01	Hawaiian Shores 1 (Beaches)	19 31 13	154 55 58	122.5	135.9	
3185-02	Hawaiian Shores 2	19 31 26	154 55 44	115.8	131.1	
3188-01	Keonepoko Nui	19 31 05	154 58 03	183.8	198.1	
3500-01	Wai Pahoehoe	19 35 17	155 00 49	94.8	110.0	
3588-01	Hawaiian Paradise 1	19 35 47	154 58 34	44.2	51.2	
3603-01	Olaa 3	19 36 32	155 03 13		ng	
3702-01	Olaa Shaft	19 37 57	155 02 00	67.1	61.9	
3802-01	Keaau 1	19 38 02	155 02 02	65.5	137.2	
9-A	Olaa mill Well	19 38 10	155 02 05	67.1	137.2	4
3802-02	Keaau 2	19 38 03	155 02 02	65.5	137.2	
3802-03	Keaau Mill 1	19 38 04	155 02 02	65.2	115.5	
3802-04	Keaau Mill 2	19 38 06	155 02 02	65.2	113.1	
3802-05	Keaau Mill 3	19 38 07	155 02 02	65.2	114.3	
3804-01	Keaau (Shipman)	19 38 12	155 04 15	168.2	212.8	
3900-01	Keaau Orchard 1	19 39 37	155 00 43	28.0	41.8	
3900-02	Keaau Orchard 2	19 39 34	155 00 45	29.0	44.8	
4003-01	Panaewa 1	19 40 35	155 03 55	62.8	93.3	

ID No.	Name	Latitude ° ' "	Longitude ° ' "	Elevation meters	Depth meters	Data Source
4003-02	Panaewa 2	19 40 40	155 03 52	61.3	92.1	
4202-01	Hilo Airport	19 42 48	155 02 45	18.0	23.2	
4203-02Z	Waiakea TH 2	19 42 23	155 03 52	12.5	16.8	1,3
4203-02	Waiakea TH 2	19 42 23	155 03 52	12.5	16.8	
4203-03	Waiakea TH 3	19 42 30	155 03 48	12.5	17.1	
4203-04	Waiakea 4	19 42 22	155 03 51	14.3	61.3	
	Hilo Electric Well(Waiakea)	19 42 28	155 03 52	16.8	61.0	4
4203-05	Kanoelehua 1	19 42 22	155 03 50	15.2	61.0	
4203-06	Kanoelehua 2	19 42 23	155 03 49	15.2	61.0	
4203-07	Kanoelehua 3	19 42 24	155 03 50	15.2	61.0	
4203-10	Helco Kan 6-2	19 42 22	155 03 47	16.8	64.0	
4211-01	Olaa Flume Tunnel	19 42 01	155 11 15	597.4		
4304-01	Waiakea	19 43 37	155 04 18	3.7	6.1	
4304-02	Waiakea	19 43 37	155 04 18	3.1	8.2	
4304-03	Waiakea	19 43 37	155 04 18	3.1	7.9	
4306-01	Piihonua A	19 43 18	155 06 18	84.7	129.5	
4706-01	Papaikou	19 47 15	155 06 13	112.5	129.5	
	Deep wells					
2317-01	Kilauea Volcano Summit Borehole	19 23 44	155 17 21	1099.1	1257.9	
2600-01	True Mid-Pacific Redrill 4	19 26 32	155 00 19	458.1	1626.1	
2685-01	Ashida 1	19 26 59	154 55 32	244.4	2529.8	
2883-01	HGP-A	19 28 31	154 53 43	182.9	1967.5	
2883-02	Lanipuna 1	19 28 16	154 53 33	182.9	2557.0	
2883-03	Kapoho State Geothermal 1	19 28 47	154 53 39	188.7	2222.0	
2883-04	Kapoho State Geothermal 2	19 28 55	154 53 22	219.2	2622.8	
2883-05	Lanipuna 6	19 28 44	154 53 04	182.9	1510.6	
2883-06	Kapoho State 1A	19 28 48	154 53 37	189.0	1982.7	
2883-09	Kapoho State Geothermal 3	19 28 43	154 53 39	186.8	2257.3	
2883-11	Kapoho State 8	19 28 48	154 53 28	192.0	1060.1	
2883-13	Kapoho State 9	19 28	154 53			
	Seawater, Hilo	19 44 26	155 00 51	0.0		17
	Seawater					13,16,2
	Seawater					Hem (1985)
	Seawater, Isaac Hale Park	19 27 37	154 50 43	0.0		
	Rain and stream samples					
2513-C	F. Trusdell's cistern, Volcano	19 25 53	155 13 24	1097.3		
2616-C	Griggs cistern, Volcano	19 26 26	155 16 25	1237.0		
2815-C	D. Thomas's cistern, Volcano	19 28 18	155 15 43	1220.7		
2835-C	Mauna Loa Cabin cistern	19 28 10	155 35 04	4038.6		
2909-C	Glenwood cistern, Picnic area	19 29 28	155 09 14	701.0		
3228-C	Red Hill Cabin cistern	19 32 00	155 28 02	3048.0		
	HVO kitchen tap, from Keaau					
3810-R	Waiakea Stream at gaging station	19 38 30	155 10 29	591.3		
4308-R	Wailuku River at Piihonua Bridge	19 43 05	155 08 27	268.0		
	Permafrost crack water					9
	Stream discharge 0.18 cfs					9
	Wailuku River not flowing					9
	Permafrost crack water					9
	Rain-Cloud Physics Observ., Hilo					4
	Rain-Cloud Physics Observ., Hilo					4

ID No.	Name	Latitude ° ' "	Longitude ° ' "	Elevation meters	Depth meters	Data Source
	Rain-Cloud Physics Observ., Hilo					4
	Rain-Cloud Physics Observ., Hilo					4
	Rain at Kalapana Station					10
	Rainwater					13
	Rainwater Sample, Kalapana Station					10
	Rainwater Sample, Airstrip					10
	Rainwater Sample, Airstrip					10
	Rainwater Sample, Isaac Hale Park					10
	Rainwater Hilo Coast-weight avg.	19 43	155 03	9.1		12,calc.
	Rainwater Hilo Coast-gen. samp.	19 43	155 03	9.1		12
	Rainfall @ HVO 4/24-4/27	19 25 25	155 17 27	1242.9		9
	Rainfall @ HVO 5/3-6/1	19 25 25	155 17 27	1242.9		9

Table 2. Dissolved constituents and isotopes for samples from springs, shallow wells, shafts, and tunnels. Data for dissolved constituents reported in this study are in mg/L. Isotopic data for water and for SO_4 in water are in parts per thousand relative to the VSMOW (Vienna-Standard Mean Ocean Water) scale (Gonfiantini, 1978). Tritium is in tritium units, and carbon-13 for inorganic carbon is relative to PDB. Data source is a reference number in Data References. P. E. Trujillo and D. Counce of Los Alamos National Laboratory provided the chemical analyses. L. Douglass White provided the water isotopic analyses. Linda Johnson performed isotopic analyses on sulfate and carbon in water, and Robert Michel and the University of Miami RSMAS tritium laboratory provided tritium analyses.

Table 2

Sample No.	ENEL Code	USGS ID #	Name	Date Collected	Temp °C	pH(f)	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	TDS Meas.	TDS Calc.	Bal %	Data Source
			Thermal and non-thermal springs																
KH92-4		0436-S1	Kau cane field spring near Haao	2/21/92	19.7	6	6.56	7.8	7.91	9.03	0.88	37.3	18.7	12.3	26.3		106	2.4	
KH91-33		0631-S1	Kawa Spring	8/10/91	18		6.84	9.9	20.2	163	7.28	38.9	45.9	289	38.9		594	-3.4	
KH92-33		0631-S1	Kawa Spring	9/18/92	18.3	7.2	6.92	13.6	23.3	187	7.8	36.1	49.8	316	40.2		657	3.4	
KH91-11		0829-S1	Kamehame Hill crack	8/7/91	18.9	6.2	6.84	22.5	50.2	424	14	44.8	109	748	51.6		1450	0.0	
KH92-15		0829-S1	Kamehame Hill crack	9/14/92	19.6	7	7.3	23.3	46	381	13.5	48.6	104	687	43.6		1330	-2.4	
KH92-32		0830-S1	Punaluu beach spring	9/18/92	19.6	7.41	7.02	14.7	26.2	218	9.5	43.5	57.3	380	38.9		768	-0.3	
KH91-24		0926-S1	Pueo spring near Palima Point	8/15/91	20	8.25	7.3	25.6	47.4	546	14	70.1	141	902	51.6		1770	-1.1	
KH92-48		0926-S1	Pueo spring near Palima Point	9/23/92	21		7.28	20.7	26.6	171	9.5	97.8	45	316	50.1		689	-5.2	
KH91-25		0926-S2	Waiapele crack	8/15/91	19	8.2	7.31	27.4	44.9	356	14	51.1	93.9	616	53.3		1240	3.0	
KH92-50		0926-S2	Waiapele crack	9/23/92	24	7.25	7.15	24.2	36.3	303	13.4	53.1	84.9	568	47.7		1110	-5.5	
KH91-26		0927-S1	Waioala Spring	8/15/91	20	7	7.76	32.2	78.9	623	28	80.9	177	1183	45.1		2210	-6.6	
KH92-49		0927-S1	Waioala Spring	9/23/92			7.4	29.4	71.8	588	22.5	82.7	147	1044	42.6		1990	-1.1	
KH92-8		1420-S1	Puu Elemakule spring	2/28/92	41.8	7	7.52	215	654	4890	208	180	1297	8183	71.9		15600	7.9	
KH92-37		1420-S1	Puu Elemakule spring	9/21/92	41.5	8	7.76	197	569	4770	183	171	1323	8365	65.9		15600	0.8	
KH91-29		1511-S1	Apua Point crack	8/6/91	16	6	7.61	48.8	108	1004	45	84.9	263	1840	44.9		3410	-4.9	
KH92-40		1511-S1	Apua Point crack	9/23/92	25.5	7.5	7.17	53.5	111	970	42	90.4	229	1702	47.3		3210	1.2	
KH91-28		1518-S1	Kaaha, West crack	8/5/91	26.7	6.5	7.88	75.1	148	1004	57	134	526	1840	59.7		3780	-6.4	
KH91-30		1615-S1	Halape crack, large pool	8/6/91	26	6	7.56	93.9	167	1468	61	129	445	2639	58.0		5010	-2.5	
KH92-41		1615-S1	Halape crack, large pool	9/22/92	26.5	7.9	7.4	90.9	158	1230	55.2	130	357	2335	58.8		4360	-4.2	
KH92-42		1615-S2	Halape Iki spring at beach	9/23/92	27	7.7	7.36	96.8	225	2070	76.9	127	543	3467	52.0		6610	3.5	
KH91-27		1617-S1	Kaaha, East crack	8/5/91	27.4	7	7.79	92.7	160	1104	61	134	555	2001	62.5		4110	-4.2	
KH92-39		1617-S1	Kaaha, East crack	9/22/92	28	7.7	7.37	81.1	153	1010	56.4	140	538	1860	59.9		3830	-6.3	
KH92-38		1617-S2	Kalue crack	9/22/92	24	7.5	7.17	57	134	1020	41.4	93.3	317	1829	49.8		3500	-0.9	
KH92-34		2634-S1	Ainapo Trail crack	9/20/92	3	6.7	6.42	2.64	0.59	1.98	0.18	6.1	7.14	0.32	7.7		23.6	4.2	
KH92-35		2735-S1	Mauna Loa Cabin crack	9/20/92	1	6	5.53	2.25	0.73	1.68	0.05	<0.5	11.3	0.28	5.1		21.6	5.8	
1		2780-S1	Pohoiki Spring	1/29/74	35.0		6.8								96				4
	23	2780-S1	Pohoiki Spring	1/7/75	36.0		7.75	32.4	200	2020	86.0	56	507	3534	81.5		6490	-2.8	5,10,2,13
		2780-S1	Pohoiki Spring	10/27/75				98.0	239	2140	87.5	61	552	3660				3.5	5,10
KH91-2		2780-S1	Pohoiki Spring	8/4/91	35	6.8	6.6	93.1	190	1740	74	52.5	452	3011	98.2		5700	2.5	
KH92-22		2780-S1	Pohoiki Spring	9/15/92	34.1	7	6.99	126	266	2410	91.6	59.6	640	4441	86.4		8110	-3.2	
2		2780-S2	Allison Spring	1/29/74	31.0		6.7								100				4,13
KH91-1		2880-S1	Campbell spring	8/3/91	37.4	7.6	7.07	95.5	203	2040	102	51.9	509	3505	93.1		6590	2.1	
KH92-10		2934-S1	Jaggar's Cave crack	3/2/92	1	5.9	6.05	1.1	0.24	3.43	2.78	16.2	2.39	2.88	2.1		23.5	-32.8	
KH92-36		2934-S1	Jaggar's Cave crack	9/20/92	0	6	6.18	3.59	0.67	3.37	0.07	2.5	13.6	0.64	12.4		37.5	-0.8	
KH91-23		2979-S1	Vacationland, Roney	8/14/91	31.5	8.8	7.31	65.1	141	1350	64	51.2	365	2168	76.4		4270	7.5	
KH92-12		2979-S2	Burgess pool, Kapoho Beach Lots	3/4/92	34	7.3	6.5	102	240	1635	72	47.8	514	2824	87.5		5510	6.9	
KH92-30		2979-S2	Burgess pool, Kapoho Beach Lots	9/17/92	32.5	7.42	7.08	78.2	166	1530	62.5	50.8	457	2729	72.3		5130	-2.0	
KH91-21		3080-S1	Green Lake, near shore	8/14/91	30	7.8	7.96	13.7	11.7	36	5.01	156	1.57	30.7	30.8		206	-3.6	
KH91-22		3080-S1	Green Lake, near center	8/14/91	26	7.5	7.93	13.9	11.2	36	5.18	156	1.82	31	35.7		212	-4.6	
KH91-20		3178-S1	Lighthouse spring, Cape Kumukahi	8/14/91	29	6.75	7.06	58.2	112	1080	46	46.8	285	1821	64.4		3500	3.5	
KH92-21		3178-S1	Lighthouse spring, Cape Kumukahi	9/15/92	28	7.5	6.91	63.2	119	1050	43.1	46.4	304	1815	64.0		3490	2.3	
KH91-7		3889-S1	Haena spring at road above lake	8/6/91	19	6.88	6.68	5.9	14.5	144	6.41	36	34.5	221	33.6		479	4.6	
KH91-17		3889-S2	Haena spring above beach	8/12/91	19	5.5	7.02	12.2	17.3	126	6.32	44.7	31.7	202	43.9		462	7.8	
KH92-29		3889-S2	Haena spring, N end of beach	9/17/92	19.4	6.83	6.97	12.2	20.4	175	8	38.2	46.7	316	38.3		637	-4.1	

Table 2

Sample No.	ENEL Code	USGS ID #	Name	Date Collected	Temp °C	pH(f)	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	TDS Meas.	TDS Calc.	Bal %	Data Source
KH91-31		8836-S1	Kaalualu spring 1	8/8/91	19	6	7.27	133	368	3630	116	63.5	888	6164	35.9		11400	2.1	
KH91-32		8836-S2	Kaalualu spring 2	8/8/91	19	6	6.85	115	292	3290	119	61.6	813	5480	38.1		10200	1.8	
KH92-47		8837-S1	Kaalualu spring 3	9/24/92	29.5	7.7	6.84	117	330	2830	101	60.9	706	5201	38.1		9370	-2.5	
			Wells ≥ 30°C																
7	G2a	2686-02	Puna Thermal TH 2	1/30/74	83.0		7.0								0				4,2,3
42	G2	2686-02	Puna Thermal TH 2	12/14/74	86.0		6.4								1.1				4,2
	25a	2783-01	Malama Ki	9/6/62	53.0		6.92	162	324	2935	155	262	681	5850	59	11700	10300	-8.4	3,1,6,2,13
10		2783-01	Malama Ki	1/31/74	56.0		3.0								90				4
38	25f	2783-01	Malama Ki	12/13/74	53.0		3.0								63				4,2
39		2783-01	Malama Ki	12/13/74	54.0		3.1								54				4
	25c	2783-01	Malama Ki	1/7/75	52.2		7.02	66.8	210	2105	109	144	471	3811	100.7		6940	-4.0	5,10,6,2,13
	25d	2783-01	Malama Ki	7/22/75			7.45	117	293	2890	149	128	598	5120				0.3	5,10,6,2
	25	2783-01	Malama Ki	7/83	55.0		6.9	293	295	3333	218	262	681	5380	59		10400	10.7	7,19,2
	25b	2783-01	Malama Ki	avg.	53.1		7.1	122	267	2695	129	178	583	6887	83.2		10900	-33.9	13,6,2
KH93-4		2783-01	Malama Ki	4/28/93		6.56	7.3	164	299	2840	158	178	589	4672	144		8980	8.6	
9	1d	2881-01	Allison (Pohoiki Puna)	1/31/74	38.0		7.0								53				4,2
	1b	2881-01	Allison (Pohoiki Puna)	1/7/75	37.8		7.35	13.4	15	216	10.8	132	69.2	281	24.1	761	694	0.4	5,3,10,6,2,13
	1	2881-01	Allison (Pohoiki Puna)	7/82	38.0		7.3	84	102	1188	68	132	69	2042	24	3709	3640	7.5	7,19,8,2
		2883-07	Puna Geothermal MW 2	4/3/91				37.5	17.75	324.3	33.6				26				14
		2883-07	Puna Geothermal MW 2	4/3/91				27.8	14.6	287	18.1	50.6	123	475	22		992	-7.8	14
		2883-07	Puna Geothermal MW 2	4/12/91				29.7	16.9	311	19.1	57.3	117	538	44		1100	-9.4	14
		2883-07	Puna Geothermal MW 2	9/4/91			8.2	31.5	18.1	326	24.3	69.5	73.8	588	44		1140	-7.5	14
KH91-5		2883-07	Puna Geothermal MW 2	8/6/91	57.5	7.58	6.73	36.4	19.5	333	16	57.4	82.5	533	54.1		1110	3.2	
KH92-23		2883-07	Puna Geothermal MW 2	9/16/92	56.5	7.95	6.77	52.6	12.7	669	31.6	59.8	108	1060	32.7		2000	1.2	
KH93-3		2883-07	Puna Geothermal MW 2	4/28/93	66.9	7.95	7.8	39.6	17	536	28.1	75.2	121	838	80.0		1700	-0.1	
31	G3a	2982-01	Puna Thermal TH 3	9/10/74	93.0		6.0								178				4,2
44	G3b	2982-01	Puna Thermal TH 3	12/14/74	95.0		6.4								184				4,2
45	G3d	2982-01	Puna Thermal TH 3	12/14/74	88.0		6.3								187				4,2
57	G3c	2982-01	Puna Thermal TH 3	12/16/74	86.0		6.2								184				4,2
	G3g	2982-01	Puna Thermal TH 3	1/7/75	93.0		6.85	76.8	52	2050	190	30	314	3274	96.6		6070	2.7	5,10,3,6,13,2
	G3e	2982-01	Puna Thermal TH 3	7/21/75				81	59	2000	195		335	3410					5,10,3,6,13,2
	G3h	2982-01	Puna Thermal TH 3	7/21/75	74.0		1.4	71	62.5	1740	158	20	317	2980			5340	-2.8	5,10,6,2
	G3	2982-01	Puna Thermal TH 3	11/82	93.0		6.8	283	137	2757	300	30	335	5257	97		9180	-1.8	7,19,2
	G3f	2982-01	Puna Thermal TH 3	avg.	89.0		6.4	78.9	55.5	2025	193	30	325	3684	156	6548	6530	-9.1	13,2
KH92-26		2982-01	Puna Thermal TH 3	9/16/92	89.4	6.66	7.17	261	205	3390	292	28.4	565	6042	220		11000	1.1	
		2983-01	Puna Geothermal MW 1	4/4/91				22.4	12.82	62.2	7.2				105				14
		2983-01	Puna Geothermal MW 1	4/4/91				20.6	12.7	58.2	6.4	36.6	208	19.5	119		462	-13.9	14
		2983-01	Puna Geothermal MW 1	4/12/91				21.1	12.4	56.7	6.2	36	215	20	119		468	-18.1	14
		2983-01	Puna Geothermal MW 1	9/4/91			7.70	18.4	12.4	58	9	36.6	192	19.5	100		427	-9.3	14
KH91-6		2983-01	Puna Geothermal MW 1	8/6/91	41.6	6.8	7.09	22.9	14.2	61	11.1	34.1	192	16.4	104		439	4.2	
KH92-25		2983-01	Puna Geothermal MW 1	9/16/92	43.9	7.53	7.06	24.6	13.1	62.9	11.2	36	195	19.6	104		449	2.3	
KH92-24		2983-02	Puna Geothermal MW 3	9/16/92	44	7.67	7.07	24.4	13.5	62.7	10.9	37.4	203	19.9	106		459	-1.4	
	13b	3081-01	Kapoho (Airstrip)	1961	28.0		7.2	14.1	17.1			61	65.4	220	70.5				3,2,13
3	13g	3081-01	Kapoho (Airstrip)	1/29/74	38.0		7.0								56				4,2
40	13f	3081-01	Kapoho (Airstrip)	12/13/74	34.0		6.1								53				4,2
41		3081-01	Kapoho (Airstrip)	12/13/74	34.0		6.4								70				4
	13c	3081-01	Kapoho (Airstrip)	1/6/75	36.8		7.42	23.0	28	238	13.6	48	204	303.5	71.3		905	4.0	5,10,6,2

Table 2

Sample No.	ENEL Code	USGS ID #	Name	Date Collected	Temp °C	pH(f)	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	TDS Meas.	TDS Calc.	Bal %	Data Source
	13d	3081-01	Kapoho (Airstrip)	7/22/75	33.5		7.75	12.5	27.2	223	16.8	44	211	316				-7.7	5,10,6,2,13
	13e	3081-01	Kapoho (Airstrip)	11/82	35.0		7.2	38.5	22.4	269	20.1		65	390	70				7,19,2
	13	3081-01	Kapoho (Airstrip)	avg.	35.6		7.1	16.5	24.1	231	15.2	46	160	450	62.7		982	-23.6	13,6,2
		3061-02	Puna Thermal TH 4	6/21/61			7.9	16.2	7.5	49.2			18.4	72	44	220			6
			Wells, shafts, and tunnels < 30°C																
		0335-01	Naalehu 1	5/14/71	19.5		7.0	6.0	4.6	12	1.5	44	14	8.0	45		115	-3.7	1
	26	0335-01	Naalehu 1	1975	19.0		7.8	6.4	4.6	11	1.5	42	13	10	43	110	112	-5.5	3,2,13
KH91-9		0335-01	Naalehu 1	8/7/91	19.5	7.41	6.91	5.3	5.92	13.8	1.69	60.8	12	8.66	41.1		119	-7.3	
KH92-14		0335-01	Naalehu 1	9/14/92	18.6	7.64	7.01	7.2	5.46	12.7	1.66	55.3	12	7.85	47.1		121	1.4	
	8	0533-01	Honuapo Mill	4/12/72	19.0		7.0	33	86	680	24	46	169	1240	43		2300	-0.9	1,3,2,13
14		0533-01	Honuapo Mill	2/20/74			6.6								48				4
	5	0533-02	Honuapo 1	4/12/72	19.0		7.1	20	44	320	14	42	86	580	43		1130	0.2	1,3,2,13
	7	0533-03	Honuapo 3	4/12/72	19.0		7.0	18	38	272	12	41	75	500	43		980	-1.3	1,3,2,13
KH92-2		0537-01	Haao Tunnel	2/21/92	18.3	6	6.33	6.1	3.16	7.51	1.47	25	14.3	6.54	33.8		85.4	3.7	
KH92-45		0537-01	Haao Tunnel	9/24/92	18.5	7.02	6.48	5.99	3.02	7.38	1.07	18.8	16.3	8.55	32.5		84.2	0.4	
	6	0632-01	Honuapo 2	4/12/72	19.0		7.3	17	33	245	11	44	66	440	41		876	-0.3	1,3,2,13
	42	0830-01	Punaluu	4/12/72	19.0		7.1	9.6	16	118	5.5	34	37	205	32		441	-0.9	1,3,2,13
	29	0831-01	Ninole GU TH 1	4/12/72	19.0		7.3	9.2	12	80	4.4	43	24	136	41		329	-0.6	1,3,2,13
		0831-02	Ninole A	3/1/72	18.5		7.1	10	16	88	4.8	40	28	165	46		378	-2.6	1
	27a	0831-02	Ninole A	1974	18.0		7.3	13	18	100	5.9	41	29	150	43	411	379	18.3	3,2,13
13		0831-03	Ninole B	2/1/74	21.0		6.9								48				4
	28	0831-03	Ninole B	1974	21.0		6.9	13.2	18	89	5.2	51	28	166	48		393	0.5	3,2,13
KH91-10		0831-03	Ninole B	8/7/91	18	6.8	6.79	20	20	95	5.06	44	27.9	181	51.6		423	8.0	
KH92-31		0831-03	Ninole B	9/18/92	18.1	7.24	6.65	11.2	13.7	91.4	4.91	45.4	26.5	154	44.5		370	2.3	
KH92-6		0936-01	New Mountain House Tunnel	2/26/92	16.5	6.2	6.22	3.7	1.55	4.54	1.23	13.7	8.65	3.05	23.1		52.8	8.5	
KH92-44		0936-01	New Mountain House Tunnel	9/24/92	15.8	6.78	6.46	4.08	1.55	4.46	1.99	14.4	9.3	3.51	24.2		56.4	7.1	
	32	1128-01	Pahala Shaft	4/13/72	19.0		7.2	6.6	3.6	7.2	1.0	43	10	3.5	42		96.1	-7.0	3,1,2,13
12		1128-01	Pahala Shaft	2/28/74			6.9								49				4
11		1128-02	Palima	2/1/74	21.0		6.7								54				4
	35a	1128-02	Palima	1974	21.0		7.0	6.1	4.3	12	1.2	41	7.5	12	54	110	118	1.2	3,2,13
		1229-01	Pahala	1974	17.0			7.5	3.3	5.7	1.3	40	6.6	3.2	42	94	89.4	3.7	3,13
KH91-8		1229-01	Pahala	8/7/91	17.2	7.12	6.88	6.4	3.38	6.14	1.4	41.2	6.93	3.3	42.4		90.9	-1.2	
KH92-13A		1229-01	Pahala	9/14/92	18	7.6		7.1	3.21	6.02	1.29		9.48	2.6	42.4				
KH92-5		1331-01	Alili Tunnel	2/26/92	17	6.2	6.35	4.5	2.63	3.55	0.6	20.6	7.28	2.66	23.3		55.1	6.1	
KH92-43		1331-01	Alili Tunnel	9/24/92	17.4	6.71	6.62	4.78	2.85	4.01	0.45	20.8	8.78	3.4	24.0		58.7	5.0	
	41	2102-01	Pulama	12/6/63	28.0		7.5	15.9	31.2	170	8.5	54	65.1	345	72.4	838	735	-8.8	3,1,2,13
8		2102-01	Pulama	1/31/74	28.0		7.1								59				4
	21a	2487-01	Keauohana 1	3/3/72	23.0		7.3	6.6	3.3	54	3.8	42	22	70	41		222	-2.5	3,1,2,13
6	21b	2487-01	Keauohana 1	1/30/74	24.0		6.9								48				4,2
	21c	2487-01	Keauohana 1	1/6/75	28.5		7.68	5.3	6.6	89.6	5.2	38	37.2	132.2	44.5		339	-5.8	5,10,2,6
	21d	2487-01	Keauohana 1	7/21/75	20.8		7.05	5.9	5.6	78.8	5.0	36.8	28.6	120				-6.3	5,10,2,6
	21	2487-01	Kaeuohana 1	11/82	24.0		7.3	12.4	3.8	64	5.0	42	22	105.6	41		274	-7.1	7,19,2
		2487-01	Keauohana 1		20.8		7.05	15.4	5.1	95.1	12.4		28.6	160	44.5				9.98
KH91-14		2487-01	Keauohana 1	8/8/91	24.2	7.7	7.03	5.6	2.46	37	3.05	34	10.9	53.9	46.8		177	-6.7	
KH92-19		2487-01	Keauohana 1	9/15/92	24.7	7.76	6.97	8.43	3.25	50.2	3.65	34.3	16.2	75.9	50.5		225	-3.0	
	22	2487-02	Keauohana 2	1974	24.0		7.0	11.8	5.9	57	5.4	42	25	160	45.3	304	332	-42.8	3,2,13
WR-4		2714-01	Volcano TH 4	3/10/75			7.93	17	11	6.2	1.7	126	2.8	2.3	52	155	155	-6.1	9

Table 2

Sample No.	ENEL Code	USGS ID #	Name	Date Collected	Temp °C	pH(f)	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	TDS Meas.	TDS Calc.	Bal %	Data Source
WR-3		2715-02	Volcano TH 3	3/10/75			7.94	22	13	6.8	1.4	154	2.2	2.2	54	178	178	-5.5	9
WR-1		2815-01	Volcano TH 1	3/10/75			8.31	18	12	7.1	2.3	129	3.0	3.0	50	159	159	-0.7	9
		2986-01	Pahoa Battery 2A	3/3/72	22.5		7.6	3.9	3.3	16	3.3	51	12	6.0	54		124	-2.6	1
		2986-01	Pahoa Battery 2A	1973	22.5		7.4	4.8	0.86	17	3.5	51	13	12	39.6	110	117	-25.4	3,13
	33b	2986-01	Pahoa Battery 2A	1/6/75			7.3	1.58	2.7	36.0	2.72	48	21.1	13.5	50		151	18.4	5,10,6,2
	33c	2986-01	Pahoa Battery 2A	7/21/75	23.3		6.65	1.6	1.9	19.3	2.7	44	27.3	9.8				-31.5	5,10,6,2
	33	2986-01	Pahoa Battery 2A	11/82	21.0		7.4	4.5	3.1	16.7	9.3	51	13	4.9	39		116	14.8	7,19,2
KH91-13		2986-01	Pahoa Battery 2A	8/8/91	23.4	7.36	7.22	1.8	2.46	15.9	3.3	43.9	12.4	4.29	50.5		113	-4.3	
KH92-18		2986-01	Pahoa Battery 2A	9/15/92	24.3	7.47	6.83	3.65	2.48	16.4	3.32	45.6	13.5	4.49	57.3		124	0.9	
	34a	2986-02	Pahoa Battery 2B	3/3/72	22.5		7.4	2.7	3.3	17	3.4	50	13	6.0	50		121	-5.7	1,2
4	34b	2986-02	Pahoa Battery 2B	1/30/74	23.0		6.9								60				4,2
	34	2986-02	Pahoa Battery 2B	1974	23.0		6.4	3.9	2.4	16	3.2	48	13	5.8	55	126	124	-6.5	3,2,13
		PVFW	Pahoa Village Fresh Water	10/85	23.9		8.5	19	5.1	16	3.3	71	11	4	62	120	155	35.2	6
		3080-01	Kapoho Crater	3/15/68			7.7	48	26	97	14	283	5.5	125	44	540	501	8.9	1,6
		3080-01	Kapoho Crater	5/22/70			7.0	120	96	64	10	976	3.8	72	39	766	895	-7.6	1
		3080-01	Kapoho Crater	3/3/72			8.4	72	31	57	7.6	393	11	54	39		492	2.0	1
	12a	3080-01	Kapoho Crater	1974	25.0		6.5	60	31	80	7	331	19	170	58	548	615	-18.5	3,2,13
	12	3080-01	Kapoho Crater		25.0		7.7	80	51	73	10.5	546.7	6.8	84	41		615	1.4	2
KH91-19		3080-01	Kapoho Crater	8/14/91	25	6.8	7.86	55.6	34.1	111	7.7	344	17.2	128	57.3		589	8.3	
KH92-20		3080-01	Kapoho Crater	9/15/92	26.1	7.2	7.98	61.9	34.2	97.1	7.61	352	18.1	143	56.9		603	-0.3	
5	12g	3080-02	Kapoho Shaft	1/30/74	25.0		7.3								56				4,2
	12c	3080-02	Kapoho Shaft	1/6/75	25.5		7.8	42.4	37	85.8	6.6	372	20	16.9	53.6		445	25.7	5,10,2,6
	12d	3080-02	Kapoho Shaft	7/21/75	22.1		7.1	23.2	25.7	86.5	6.2	328	22.7	95.7				-17.3	5,10,2,6
		3080-02	Kapoho Shaft	10/27/75				32.0	27.8	92.0	5.8	330	23.0	105				-9.6	5,10
	9a	3080-02	Kapoho Shaft				7.2	14	17	139	25	61	65.4	33	70.5	723	394	90.9	6
		3185-01	Hawaiian Shores 1 (Beaches)	5/5/64			7.7	4.2	4.8	16	2.0	46	6.7	16	59	122	132	-0.5	1
	2	3185-01	Hawaiian Shores 1 (Beaches)	1974	21.5		7.7	3.9	3.8	13	3.2	56	5.1	14	51.9	126	123	-21.6	3,2,13
KH91-15		3185-01	Hawaiian Shores 1 (Beaches)	8/8/91	21.3	7.44	7.3	3.1	2.51	14.5	2.77	40.7	4.02	9.54	61.8		119	2.6	
KH92-27		3185-01	Hawaiian Shores 1 (Beaches)	9/16/92	23	7.61	7.26	3.42	2.72	17.5	2.64	41.9	4.8	15.5	55.8		123	-1.0	
		3185-02	Hawaiian Shores 2	5/22/72			7.6	5.8	3.6	23	3.2	56	6.9	23	49		142	-3.4	1
	3	3185-02	Hawaiian Shores 2	1974			7.6	3.9	4.5	19	3.5	56	7	28	49	140	143	-22.4	3,2,13
KH91-12		3188-01	Keonepoko Nui	8/8/91	20.4	7.44	7.67	4.1	3.81	8.79	2.36	47.7	2.69	3.68	48.1		98.1	-0.9	
KH92-17		3188-01	Keonepoko Nui	9/15/92	20.2	7.3	7.6	6.29	3.96	8.8	2.55	51.6	3.74	3.49	50.3		106	3.5	
	48	3500-01	Wai Pahoehoe	1961	22.0		7.1	5.3	6.7			71	10.9	5.5	46.5				3,2,13
KH92-51		3588-01	Hawaiian Paradise 1	10/19/92	18	6.7	6.95	7.1	7.75	48.8	4.02	49	12.7	77.9	41.3		226	-2.5	
KH92-16		3603-01	Olaa 3	9/15/92	19.6	6.59	6.7	5.26	2.53	5.3	1.97	36.3	3.03	3.11	38.5		77.6	0.6	
	30d	3702-01	Olaa Shaft	6/7/72	23.0		7.0	6.0	2.7	5.8	2.4	38	5.5	4.0	40		88.0	-7.5	1,3,2,13
PSM-1		3702-01	Olaa Shaft	5/16/74	18.0		7.6	5.1	2.8	6.5	2.0	35	8.2	3.5	36	82	81.5	-3.7	9
	30c	3702-01	Olaa Shaft	1978	19.7		7.0	6.9	3.3	7.2	2.1	38	5.5	5.08	38.49	88	87.4	10.1	11,7,19,2,13
	30	3702-01	Olaa Shaft					4.8	3.5	8.7	1.8	32.9	8.4	7.3	21		71.7	3.4	2
		3802-01	Keaau 1	3/23/34				1.6	4.3	14		32	6.1	14	12	72		-0.4	1
		3802-01	Keaau 1	2/3/55			7.4	8.1	3.4	6.3		30	14	4.0	20	72		5.2	1
		3802-01	Keaau 1	3/3/72	24.5		7.4	4.6	2.9	5.7	1.8	36	5.0	4.0	31		73.3	-7.3	1
	14	3802-01	Keaau 1	1973	24.5		7.4	5.6	1.8	6	2	36	6.2	3.4	37.7	80	81.0	-11.2	3,2,13
27	30b	9-A	Olaa mill Well	6/11/74	22.0		6.8								39				4
	15	3802-02	Keaau 2	1974	24.5		7.4	4.9	2.8	5	2	45	5.6	5.4	34.6	80	82.9	-30.7	3,2,13
	15a	3802-02	Keaau 2	1978	19.2		7.4	4.8	2.5	6.8	1.8	45	10.0	3.63	38.5	80	90.6	-29.1	11,7,19,2,13
		3802-03	Keaau Mill 1	6/7/72	19.5		7.0	4.8	2.8	5.2	1.9	35	5.3	4.0	33		74.4	-8.1	1

Table 2

Sample No.	ENEL Code	USGS ID #	Name	Date Collected	Temp °C	pH(f)	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	TDS Meas.	TDS Calc.	Bal %	Data Source
	16	3802-03	Keaau Mill 1	1974	18.5		7.8	6.9	3.1	6.5	2	36	6.2	3.5	36	85	82.0	12.1	3,2,13
	16a	3802-03	Keaau Mill 1	1978	19.44		7.8	4.8	2.5	6.3	1.8	36	10	2.49	27.8	85	73.5	-13.6	11,7,19,2
		3802-03	Keaau Mill 1	78-79	19.4				2.5					2.5	39				13
	17a	3802-04	Keaau Mill 2	1972	22.0		7.4	5.5	3.3	5.2	2.1	38	5.5	4	36	82	81.9	-6.3	3,2,13
	17	3802-04	Keaau Mill 2	1978	19.7		7.4	4.8	2.5	6.3	1.8	38	10	3.27	36.4	82	85.4	-21.8	11,7,19,2,13
	18a	3802-05	Keaau Mill 3	6/7/72	22.0		7.4	5.5	3.3	5.2	2.1	38	5.5	4.0	36		81.9	-6.3	1,3,2,13
	18	3802-05	Keaau Mill 3	1978	19.7		7.4	6.1	3.2	7.1	2.1	38	10.0	3.88	38.5	81	91.1	-4.1	11,7,19,2,13
KH91-18		3804-01	Keaau (Shipman)	8/12/91	19	5.5	7.04	4	1.83	5.56	1.76	31.2	3.75	1.69	29.7		83.7	-0.4	
KH92-28		3804-01	Keaau (Shipman)	9/17/92	18.6	7.45	6.98	4.21	1.83	5.5	1.62	28.8	5.42	1.61	31.7		66.2	1.1	
		3900-01	Keaau Orchard 1	3/7/72			7.3	6.5	5.9	39	3.7	44	12	58	33		183	-2.6	1
	19	3900-01	Keaau Orchard 1	1974	18.5		7.1	7.8	7.7	38	3.8	44	14	64	39	197	200	-4.0	3,2,13
	19a	3900-01	Keaau Orchard 1	1978	18.5		7.1	8.1	7.8	41	3.5	44	10	66.6	38.5	197	201	1.5	11,7,19,2,13
		3900-02	Keaau Orchard 2	7/15/66			6.3	11	20	126	7.0	39	34	230	33	504	483	-0.3	1
		3900-02	Keaau Orchard 2	3/7/72	19.5		7.3	6.8	7.1	54	4.1	44	16	81	33		227	-0.7	1
	20a	3900-02	Keaau Orchard 2	1974	19.5		6.8	8.9	13.6	90	5.6	44	25	156	33	355	357	-1.5	3,2,13
	20	3900-02	Keaau Orchard 2	1978	19.5		6.8	8.8	9.7	54	4.0	44	10.0	88.4	38.5	355	239	5.7	11,7,19,2,13
		4003-01	Panaewa 1	3/13/72	22.0		7.5	7.8	3.3	5.3	1.6	50	1.4	4.0	37		85.1	-3.6	1
	36	4003-01	Panaewa 1	1973	20.0		7.5	6.8	2.7	5.1	1.8	45	0	4	34	76	76.5	-2.5	3,2,13
	36a	4003-01	Panaewa 1	1978	20.0		7.5	6.4	2.6	5.5	1.4	45	10	3.42	36.4	76	88.0	-25.8	11,2,13
		4003-02	Panaewa 2	1974	20.0			7.2	2.3	5	1.8	54	5	4	36.6	80	88.9	-31.5	3,13
		4003-02	Panaewa 2	1978	20.0			6.2	2.5	5.4	1.6	54	10	2.7	36.4	80	91.8	-39.7	11,13
		4202-01	Hilo Airport	11/10/53			7.4	38	15	80		34	32	180	28	440	390	4.6	1
		4202-01	Hilo Airport	10/12/54			7.4	40	16	76		32	46	186	23	488	403	-1.7	1
		4202-01	Hilo Airport	2/2/60			6.7	8.2	12	62		35	7.6	108	8	286	223	8.0	1,13
	46	4203-02Z	Waiakea TH 2	8/20/64	21.1		7.0	8.0	4.4	10	1.0	50	2.5	11	33	128	94.7	3.1	1,3,2,13
	46a	4203-02	Waiakea TH 2	1978	23.0		7.0	6.6	3.3	9.2	1.6	50	2.5	10.4	38.5	94	96.9	-11.4	11,2,13
	47	4203-03	Waiakea TH 3	3/2/72	23.5		7.1	6.0	3.6	7.4	1.8	44	2.0	7.5	36		86.8	-3.0	1,3,2,13
		4203-03	Waiakea TH 3	78-79	21.0				3.1					9.2	36				13
	45	4203-04	Waiakea 4	3/27/72	26.0		7.2	8.4	2.9	6.9	1.8	47	2.6	6.5	55		108	-0.4	3,1,2,13
	45a	4203-04	Waiakea 4	1978	21.0		7.2	7.8	5.9	25	2.4	47	2.6	39.8	37.6	107	144	3.9	11,2,13
26			Hilo Electric Well(Waiakea)	6/11/74	24.0		6.9								40				4
		4203-05	Kanoelehua 1	1978	23.0			7.6	4.8	17	2.2			27	38.5				11,13
	10	4203-06	Kanoelehua 2	1974	21.0		6.2	11	3.5	12	2.1	39	5	18	37	109	109	10.9	3,2,13
	10a	4203-06	Kanoelehua 2	1978	21.0		6.2	7.8	5	17	2.2	39	5	28	38.5	109	123	3.0	11,2,13
	11	4203-07	Kanoalehua 3	1972	26.0		7.2	8.4	2.9	6.5	1.8	47	2.6	6.5	55	107	107	-2.6	3,2,13
	11a	4203-07	Kanoelehua 3	1978	23.0		7.2	7.6	4.6	15	2.1	47	2.6	24.5	36.4	107	116	-3.8	11,2,13
		4203-10	Helco Kan 6-2	1978	20.0			8.5	5.8	22	2.3		10	38	37.5				11,13
KH91-16		4211-01	Olaa Flume Tunnel	8/9/91	17.6	6.5	6.73	2.1	1.05	4.42	0.5	13.1	3.92	21.8	12.3		52.7	-79.2	
	43	4304-01	Waiakea	1972	20.5		7.2	132	390	3400	110	97	832	16000	44	10900	21000	-77.1	3,2,13
	44	4304-02	Waiakea	1972	19.5		7.2	340	800	7200	240	105	1630	12500	33	22700	22800	3.5	3,2,13
	44a	4304-03	Waiakea	1972	20.0		7.1	132	460	3540	110	88	868	6250	46	11400	11500	2.7	3,2,13
	40	4306-01	Piihonua A	1973	17.8		8.0	5	3.3	7.8	2.2	46	5.9	2	37	88	86.3	-3.4	3,2,13
	40a	4306-01	Piihonua A	1978	17.8		8.0	5	3.4	6.4	2.2	46	10	1.44	40.6	88	94.2	-6.8	11,2,13
	38a	4706-01	Papaikou	1974			7.3	7.2	3.6	6	1.3	66	5	15	29.8	76	101	-52.1	3,2,13
	38b	4706-01	Papaikou	1978	20.0		7.3	9.5	5	6.9	1.4	66	10	2.1	34.2	76	102	-10.8	11,2,13

Table 2

Sample No.	ENEL Code	USGS ID #	Name	Date Collected	Temp °C	pH(f)	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	TDS Meas.	TDS Calc.	Bal %	Data Source
			Seawater, Hilo	10/1/90	<25	8.0	8.11	413	1265	10640	420	145	2654	18900	<1		34400	1.3	17
			Seawater		25.0		8.2	450	1290	9600	398	130	2200	19500	4	33442	33500	-7.2	13,18,2
			Seawater					410	1350	10500	390	142	2700	19000	6.4		34500	0.5	Hem (1985)
KH91-3			Seawater, Isaac Hale Park	8/4/91	26.1	8	7.68	380	1174	9540	392	130	2497	17440	11.3		31600	-1.1	
			Rain and stream samples																
KH91-C1		2513-C	F. Trusdell's cistern, Volcano	8/16/91			6.55	5.1	0.19	0.68	0.17	11.6	2.47	0.89	1.7		17.0	12.1	
FC93		2513-C	F. Trusdell's cistern, Volcano	1/5/93			6.13	2.59	0.06	0.84	0.07	4.5	2.78	0.7	1.1		11.0	14.4	
HVO90-6		2616-C	Griggs cistern, Volcano	10/2/90			6.11	0.2	0.12	0.7	<0.1	13.4	1.61	0.72	<0.2		10.0	-107	17
KH92-11		2815-C	D. Thomas's cistern, Volcano	3/3/92	16	5.7	4.98	0.9	0.47	1.63	0.39	<0.6	5.41	2.42	0.2		11.4	-9.2	
KH92-9		2835-C	Mauna Loa Cabin cistern	3/2/92	8	5.3	4.46	0.4	0.27	2.96	0.34	<0.6	2.12	6.52	<0.2		12.8	-0.5	
HVO90-9		2909-C	Glenwood cistern, Picnic area	10/4/90	21.9	5.5	5.93	0.4	0.14	1.0	0.1	14.6	0.94	1.14	<0.2		11.0	-94.3	17
KH92-7		3228-C	Red Hill Cabin cistern	2/25/92			4.7	0.1	0.01	1.86	0.27	<0.6	1.87	2.64	0.2		7.1	-9.8	
KH92-C1			HVO kitchen tap, from Keaau	3/5/92			6.09	0.99	0.33	1.9	0.03	3.2	2.76	2.42	2.6		12.6	0.3	
KH91-4		3810-R	Waiakea Stream at gaging station	8/5/91	18.4	6	6.65	2.4	0.87	2.89	0.62	14.5	1.41	2.18	17.8		35.7	4.5	
KH92-1		3810-R	Waiakea Stream at gaging station	2/17/92	20		6.52	2.4	0.74	3.48	0.91	14.6	1.43	1.84	18.6		37.5	8.6	
KH92-46		3810-R	Waiakea Stream at gaging station	9/13/92		6	6.8	2.92	0.81	3.09	0.7	16.6	1.39	1.82	17.8		37.3	0.4	
HVO90-3		4308-R	Wailuku River at Piihonua Bridge	10/1/90	22.1	5.0	6.77	2.2	1.03	2.4	0.3	24.4	1.33	2.16	7.9		29.7	-45.6	17
MLS-1			Permafrost crack water	8/4/76			6.35	4.2	1.1	5.3	2.0	12	19	3.6	12	56	53.7	-19.9	9
HILEA-1			Stream discharge 0.18 cfs	8/10/76	15.0		7.03	3.8	2.2	3.3	0.7	19	6.7	4.4	14	50	44.6	-8.7	9
WLK-1			Wailuku River not flowing	10/19/76	16.0		7.01	1.9	1.9	2.0	0.8	18	0.2	1.6	9.2	18	26.5	4.8	9
MLS-2			Permafrost crack water	6/6/78															9
15			Rain-Cloud Physics Observ., Hilo	2/8/74			7.2								0.0				4
28			Rain-Cloud Physics Observ., Hilo	6/14/74			6.5								0.0				4
29			Rain-Cloud Physics Observ., Hilo	6/28/74			7.0								0.5				4
30			Rain-Cloud Physics Observ., Hilo	7/15/74			4.1								0.3				4
			Rain at Kalapana Station	1/6/75				0.25	0.75	4.5	0.25		~2.5	7.2	0				10
			Rainwater				5.3	0.9	1.1	4.5	0.4		1.8	7.9	0.2			28.5	13
			Rainwater Sample, Kalapana Station	7/22/75															10
			Rainwater Sample, Airstrip	1/6/75															10
			Rainwater Sample, Airstrip	7/22/75															10
			Rainwater Sample, Isaac Hale Park	7/22/75															10
			Rainwater Hilo Coast-weight avg.	10/20/54			5.3	1.26	1.46	6.0	0.62		1.94	9.8				37.3	12,calc.
			Rainwater Hilo Coast-gen. samp.	10/20/54			4.8	0.36	0.94	6.3	0.40		2.07	10.7				12.6	12
HVO-1			Rainfall @ HVO 4/24-4/27	4/27/76			4.25	0.5	0.1	2.6	0.1	0	7.3	1.2	1.0		12.6	9.8	9
HVO-2			Rainfall @ HVO 5/3-6/1	6/1/76			5.04	0.2	0.0	0.2	0.0	1	0.7	0.8	0		2.4	-63.3	9

Table 2

USGS ID #	Name	Date Collected	Fe	Mn	Sr	F	NO_3	Li	B	Br	δD ‰	$\delta^{18}O$ ‰	^3H TU	$\delta^{18}O$ $-SO_4$	$\delta^{13}C$ -TIC	Collection Information	Data Source
	Thermal and non-thermal springs																
0436-S1	Kau cane field spring near Haao	2/21/92	<0.01	<0.01	0.04	0.05	4.43	<0.01	<0.02	<0.02	-23	-4.1					
0631-S1	Kawa Spring	8/10/91	<0.01	<0.01	0.14	0.1	<0.05	<0.01	0.08	0.91	-19	-4.2			-16.38		
0631-S1	Kawa Spring	9/18/92	0.02	<0.01	0.16	0.07	0.29	<0.01	<0.02	1.07	-20	-4.1	2.7				
0829-S1	Kamehame Hill crack	8/7/91	2.4	0.55	0.38	0.33	0.74	<0.02	0.16	2.57	-31	-4.8	1.9				
0829-S1	Kamehame Hill crack	9/14/92	0.02	<0.01	0.32	0.06	2.02	<0.01	0.15	2.31	-34	-5.16	1.83				
0830-S1	Punaluu beach spring	9/18/92	0.02	<0.01	0.19	0.08	0.72	<0.01	<0.02	1.26	-26	-4.65					
0926-S1	Pueo spring near Palima Point	8/15/91	0.06	<0.02	0.37	0.62	6.25	<0.02	0.16	3.35	-41	-6.0			-9.73		
0926-S1	Pueo spring near Palima Point	9/23/92	0.04	<0.01	0.21	0.41	<0.05	0.01	0.16	1.01	-37	-5.94	0.81				
0926-S2	Waiapele crack	8/15/91	0.04	<0.02	0.35	0.49	0.5	<0.02	0.13	2.28	-41	-5.8					
0926-S2	Waiapele crack	9/23/92	0.03	<0.01	0.27	0.43	0.54	<0.01	<0.02	1.92	-38	-5.9	0.98				
0927-S1	Waioala Spring	8/15/91	1.23	0.12	1.43	0.13	<0.05	0.02	0.28	4.2	-36	-5.7		8.42	-10.50		
0927-S1	Waioala Spring	9/23/92	0.05	<0.01	0.43	0.15	<0.05	0.01	0.29	3.51	-37	-5.72					
1420-S1	Puu Elemakule spring	2/28/92	0.01	0.7	3.26	0.32	<0.02	0.11	2.26	30.1	-18	-2.6	1.2	7.89	-3.68		
1420-S1	Puu Elemakule spring	9/21/92	0.03	<0.01	3.37	0.7	<0.1	0.09	2.56	23.2	-22	-2.78	0.82	7.56	-3.92		
1511-S1	Apua Point crack	8/6/91	0.12	<0.02	0.85	2.3	0.16	0.06	0.57	6.83	-18	-3.8	0.7		-4.36		
1511-S1	Apua Point crack	9/23/92	0.04	<0.01	0.83	1.58	<0.05	0.02	0.68	5.41	-24	-4.1					
1518-S1	Kaaha, West crack	8/5/91	<0.02	<0.02	0.94	0.27	<0.05	0.05	0.49	6.3	-30	-4.4			-5.06		
1615-S1	Halape crack, large pool	8/6/91	0.04	<0.02	1.23	0.13	1.93	0.06	0.58	10.4	-24	-4.0			-4.30		
1615-S1	Halape crack, large pool	9/22/92	0.02	<0.01	1.14	0.4	1.36	0.03	0.67	7.83	-26	-4.19					
1615-S2	Halape Iki spring at beach	9/23/92	0.02	<0.01	1.48	0.57	1.18	0.04	1.04	12.3	-23	-3.85	1.34				
1617-S1	Kaaha, East crack	8/5/91	0.04	<0.02	1	0.19	<0.05	0.04	0.55	6.74	-28	-4.5			-4.96		
1617-S1	Kaaha, East crack	9/22/92	0.02	<0.01	0.97	0.5	<0.1	0.03	0.78	5.92	-29	-4.62	1.2				
1617-S2	Kalue crack	9/22/92	0.03	<0.01	0.76	0.53	0.59	0.02	<0.02	6.08	-28	-4.66					
2634-S1	Ainapo Trail crack	9/20/92	0.02	<0.01	0.01	0.06	<0.02	<0.01	<0.02	<0.02	-81	-11.57	4.34				
2735-S1	Mauna Loa Cabin crack	9/20/92	0.66	0.02	<0.01	0.11	0.09	<0.01	<0.02	<0.02	-85	-12.14					
2780-S1	Pohoiki Spring	1/29/74									-14	-2.7				surface	4
2780-S1	Pohoiki Spring	1/7/75											8.5				5,10,2,13
2780-S1	Pohoiki Spring	10/27/75			1.3												5,10
2780-S1	Pohoiki Spring	8/4/91	<0.02	<0.02	1.37	0.17	7.29	0.11	0.83	10.3	-10	-2.5		7.86	-9.25		
2780-S1	Pohoiki Spring	9/15/92	0.05	<0.01	1.79	<0.1	4.72	0.07	1.17	14.3	-12	-2.32	3.18	7.98	-9.01		
2780-S2	Allison Spring	1/29/74									-12	-2.2					4,13
2880-S1	Campbell spring	8/3/91	<0.02	0.04	1.58	0.11	0.98	0.18	1.03	12.5	-11	-2.3		7.87			
2934-S1	Jaggar's Cave crack	3/2/92	<0.01	<0.01	0.03	0.14	0.47	<0.01	<0.02	<0.02							
2934-S1	Jaggar's Cave crack	9/20/92	0.03	0.01	0.02	0.41	1.48	<0.01	<0.02	<0.02	-85	-12.04					
2979-S1	Vacationland, Roney	8/14/91	<0.02	<0.02	1.09	0.5	2.18	<0.02	0.75	8.32	-14	-2.5			-8.82		
2979-S2	Burgess pool, Kapoho Beach Lots	3/4/92	<0.01	<0.01	1.21	0.36	1.09	0.04	0.87	9.76	-10	-2.3		7.84	-9.80		
2979-S2	Burgess pool, Kapoho Beach Lots	9/17/92	0.03	<0.01	1.14	0.54	0.5	0.05	0.88	8.5	-13	-2.7		7.53	-8.08		
3080-S1	Green Lake, near shore	8/14/91	<0.02	<0.02	0.07	0.18	<0.02	<0.01	0.02	0.07	-6	-0.3					
3080-S1	Green Lake, near center	8/14/91	0.1	0.04	0.09	0.16	<0.02	<0.01	0.02	0.07	-7	-0.6			-10.82		
3178-S1	Lighthouse spring, Cape Kumukahi	8/14/91	<0.02	<0.02	0.91	0.81	0.37	<0.02	0.53	6.59	-10	-2.7			-9.33		
3178-S1	Lighthouse spring, Cape Kumukahi	9/15/92	0.04	<0.01	0.85	0.18	<0.1	0.04	0.55	5.98	-13	-2.85	3.68				
3889-S1	Haena spring at road above lake	8/6/91	<0.02	<0.02	0.1	0.1	<0.05	<0.01	0.06	0.76	-16	-3.9					
3889-S2	Haena spring above beach	8/12/91	0.12	0.02	0.12	0.08	0.14	0.02	0.05	0.69	-23	-3.8					
3889-S2	Haena spring, N end of beach	9/17/92	0.02	<0.01	0.16	0.1	0.35	<0.01	<0.02	0.99	-20	-4.09	2.25				

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8836-S1	Kaalualu spring 1	8/8/91	<0.02	<0.02	2.35	0.55	<0.05	0.1	1.31	23.7	-19.5	-3.3					
8836-S2	Kaalualu spring 2	8/8/91	<0.02	<0.02	1.95	0.51	0.27	0.11	1.01	20.4	-22	-3.6			-6.22		
8837-S1	Kaalualu spring 3	9/24/92	0.03	<0.01	1.96	0.6	0.98	0.04	1.36	17.6	-20	-3.53					
	Wells ≥ 30°C																
2686-02	Puna Thermal TH 2	1/30/74									-10	-4.5				condensate	4,2,3
2686-02	Puna Thermal TH 2	12/14/74									-4	-2.4				condensate	4,2
2783-01	Malama Ki	9/6/62	3.16	0.05		1.5	0.5										3,1,6,2,13
2783-01	Malama Ki	1/31/74									-9	-1.7				surface	4
2763-01	Malama Ki	12/13/74									-9	-1.6				surface	4,2
2783-01	Malama Ki	12/13/74									-10	-1.5				col. @ 13.1 m	4
2783-01	Malama Ki	1/7/75										-4.57	15.6				5,10,6,2,13
2783-01	Malama Ki	7/22/75			2.2							-5.08	8.6			col. @ 84.1m	5,10,6,2
2783-01	Malama Ki	7/83															7,19,2
2783-01	Malama Ki	avg.															13,6,2
2783-01	Malama Ki	4/28/93	0.1	0.14	2.22	0.28	1.36	0.2	2.25	17.4	-11.2	-2.25	2.09	8.74	0.94		
2881-01	Allison (Pohoiki Puna)	1/31/74									-17	-3.3				surface	4,2
2881-01	Allison (Pohoiki Puna)	1/7/75											12.9			wet year	5,3,10,6,2,13
2881-01	Allison (Pohoiki Puna)	7/82														dry year	7,19,8,2
2883-07	Puna Geothermal MW 2	4/3/91															14
2883-07	Puna Geothermal MW 2	4/3/91															14
2883-07	Puna Geothermal MW 2	4/12/91															14
2883-07	Puna Geothermal MW 2	9/4/91															14
2883-07	Puna Geothermal MW 2	8/6/91	0.06	0.04	0.24	0.65	0.15	<0.02	0.16	1.76	-10	-2.7		6.81	-11.14		
2683-07	Puna Geothermal MW 2	9/16/92	0.06	0.02	0.44	0.31	<0.02	0.04	0.45	3.23	-9.1	-2.59	3.47				
2883-07	Puna Geothermal MW 2	4/28/93	0.02	0.02	0.37	0.35	<0.01	0.04	0.29	2.99	-12.6	-2.78	3.53	8.67	-4.45		
2962-01	Puna Thermal TH 3	9/10/74									-13	-2.4					4,2
2982-01	Puna Thermal TH 3	12/14/74									-12	-2.5					4,2
2982-01	Puna Thermal TH 3	12/14/74									-12	-2.5				@ 15.2 m	4,2
2962-01	Puna Thermal TH 3	12/16/74									-12	-2.5				@ 15.2 m	4,2
2982-01	Puna Thermal TH 3	1/7/75										-4.66	10.3				5,10,3,6,13,2
2982-01	Puna Thermal TH 3	7/21/75			1.4							-5.33	7.3			col. @ 167.7 to 182.9m	5,10,3,6,13,2
2982-01	Puna Thermal TH 3	7/21/75			1.2								9.1			Thief	5,10,6,2
2982-01	Puna Thermal TH 3	11/82															7,19,2
2982-01	Puna Thermal TH 3	avg.															13,2
2982-01	Puna Thermal TH 3	9/16/92	0.11	1.15	3.11	0.27	<0.1	0.49	2.11	20.8	-6.5	-1.81	2.22	6.19	-6.59		
2963-01	Puna Geothermal MW 1	4/4/91															14
2983-01	Puna Geothermal MW 1	4/4/91															14
2983-01	Puna Geothermal MW 1	4/12/91															14
2983-01	Puna Geothermal MW 1	9/4/91															14
2983-01	Puna Geothermal MW 1	8/6/91	0.02	0.02	0.12	0.31	<0.1	<0.01	0.21	<0.04	-13	-2.9	4.2	5.63	-6.70		
2983-01	Puna Geothermal MW 1	9/16/92	0.16	<0.01	0.12	0.29	<0.02	0.02	0.27	0.05	-11.35	-3.04	3.6	5.83	-7.33		
2983-02	Puna Geothermal MW 3	9/16/92	0.03	<0.01	0.11	0.28	<0.02	0.03	0.28	0.04	-11.05	-3.05	4.07	5.35			
3081-01	Kapoho (Airstrip)	1961	0.2	0.1		0.1	0.1										3,2,13
3081-01	Kapoho (Airstrip)	1/29/74									-15	-3.2				surface	4,2
3081-01	Kapoho (Airstrip)	12/13/74									-12	-3.0				surface	4,2
3081-01	Kapoho (Airstrip)	12/13/74									-15	-3.1				collected @ 15.2m	4
3081-01	Kapoho (Airstrip)	1/6/75			0.2							-5.29					5,10,6,2

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3081-01	Kapoho (Airstrip)	7/22/75										-6.13	11.1				5,10,6,2,13
3081-01	Kapoho (Airstrip)	11/82															7,19,2
3081-01	Kapoho (Airstrip)	avg.															13,6,2
3081-02	Puna Thermal TH 4	6/21/61	0.1														6
	Wells, shafts, and tunnels < 30°C																
0335-01	Naalehu 1	5/14/71				0.3	1.9										1
0335-01	Naalehu 1	1975	10	5.0		0.1	1.9									Bal. w/ Fe & Mn 31.1%	3,2,13
0335-01	Naalehu 1	8/7/91	<0.02	<0.02	0.03	0.16	0.15	<0.01	<0.02	<0.01	-19.5	-4.1	-0.3				
0335-01	Naalehu 1	9/14/92	0.03	<0.01	0.04	0.16	<0.02	<0.01	<0.02	<0.02	-22	-4.24	0.02	5.55	-14.32		
0533-01	Honuapo Mill	4/12/72				0.2	0.0										1,3,2,13
0533-01	Honuapo Mill	2/20/74									-21	-3.9				Pumped	4
0533-02	Honuapo 1	4/12/72				0.1	0.7										1,3,2,13
0533-03	Honuapo 3	4/12/72				0.2	1.7										1,3,2,13
0537-01	Haao Tunnel	2/21/92	<0.01	<0.01	0.04	0.07	<0.02	<0.01	<0.02	<0.02	-24	-4.2	2.9				
0537-01	Haao Tunnel	9/24/92	0.03	<0.01	0.04	0.1	<0.02	<0.01	<0.02	0.02	-21	-4.14					
0632-01	Honuapo 2	4/12/72				0.2	1.3										1,3,2,13
0830-01	Punaluu	4/12/72				0.2	0.7										1,3,2,13
0831-01	Ninole GU TH 1	4/12/72				0.2	1.2										1,3,2,13
0831-02	Ninole A	3/1/72				0.2	0.8										1
0831-02	Ninole A	1974	20	0.00		0.1	0.17									Bal. w/ Fe 28.4%	3,2,13
0831-03	Ninole B	2/1/74									-24	-4.6				pumped	4
0831-03	Ninole B	1974	0.01	0.01		0.15	0.29										3,2,13
0831-03	Ninole B	8/7/91	1.14	0.24	0.11	0.15	<0.05	<0.01	0.02	0.6	-24	-4.2	3		-15.08		
0831-03	Ninole B	9/18/92	0.02	<0.01	0.13	0.15	0.53	<0.01	0.07	0.45	-26	-4.5					
0936-01	New Mountain House Tunnel	2/26/92	<0.01	<0.01	0.07	0.11	0.11	<0.01	<0.02	<0.02	-24	-4.3			-14.08		
0936-01	New Mountain House Tunnel	9/24/92	0.02	<0.01	0.03	0.17	<0.02	<0.01	0.06	<0.02	-20	-4.23					
1128-01	Pahala Shaft	4/13/72	0.02	0.03		0.2	0.9										3,1,2,13
1128-01	Pahala Shaft	2/28/74									-31	-5.4				pumped	4
1128-02	Palima	2/1/74									-42	-6.7				pumped	4
1128-02	Palima	1974	10	0.00		0.4										Bal. w/ Fe 27.0%	3,2,13
1229-01	Pahala	1974	20			0.1										Bal. w/ Fe 59.2%	3,13
1229-01	Pahala	8/7/91	0.39	0.08	0.02	0.14	0.53	<0.01	<0.02	<0.01	-25	-4.4	3.4				
1229-01	Pahala	9/14/92	0.04	<0.01	0.04	<0.1		<0.01	<0.02	<0.1	-28	-4.8	2.91		-16.51		
1331-01	Alili Tunnel	2/26/92	0.01	<0.01	0.07	0.13	0.32	<0.01	<0.02	<0.02	-26	-4.5	2.1				
1331-01	Alili Tunnel	9/24/92	0.02	<0.01	0.02	0.16	<0.02	<0.01	<0.02	<0.02	-24	-4.5					
2102-01	Pulama	12/6/63	0.10	0.05		0.1	0.32										3,1,2,13
2102-01	Pulama	1/31/74									-21	-4.0				surface	4
2487-01	Keauohana 1	3/3/72	0.10	0.10		0.2	0.0										3,1,2,13
2487-01	Keauohana 1	1/30/74									-16	-3.4				Pumped	4,2
2487-01	Keauohana 1	1/6/75										-5.42	16.7				5,10,2,6
2487-01	Keauohana 1	7/21/75			0.1							-6.33	18.0				5,10,2,6
2487-01	Kaeuohana 1	11/82															7,19,2
2487-01	Keauohana 1																8
2487-01	Keauohana 1	8/8/91	<0.02	<0.02	0.04	0.2	<0.02	<0.01	0.02	0.11	-13	-3.1	4.9		-11.00		
2487-01	Keauohana 1	9/15/92	0.07	<0.01	0.05	0.22	<0.02	<0.01	<0.02	0.21	-16	-3.34	4.81	7.29	-10.63		
2487-02	Keauohana 2	1974	0.66	0.03		0.33	0.15										3,2,13
2714-01	Volcano TH 4	3/10/75			0.12	0.2			0.00		-21.3	-4.61					9

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2715-02	Volcano TH 3	3/10/75			0.14	0.2			0.00		-21.1	-4.49					9
2815-01	Volcano TH 1	3/10/75			0.15	0.2			0.01								9
2986-01	Pahoa Battery 2A	3/3/72				0.3	0.5										1
2986-01	Pahoa Battery 2A	1973	0.02	0.03		0.46	0.22										3,13
2986-01	Pahoa Battery 2A	1/6/75											9.9				5,10,6,2
2986-01	Pahoa Battery 2A	7/21/75										-6.7	10.6			pumped	5,10,6,2
2986-01	Pahoa Battery 2A	11/82															7,19,2
2986-01	Pahoa Battery 2A	6/8/91	<0.02	<0.02	0.02	0.25	0.13	<0.01	0.02	<0.01	-15	-3.4	3.4		-10.64		
2986-01	Pahoa Battery 2A	9/15/92	0.02	<0.01	0.02	0.31	<0.02	<0.01	<0.02	<0.02	-16	-3.59	3.17	6.19	-10.93		
2986-02	Pahoa Battery 2B	3/3/72				0.8	0.2										1,2
2986-02	Pahoa Battery 2B	1/30/74									-16	-3.8				pumped	4,2
2986-02	Pahoa Battery 2B	1974	60	0.03		0.3	0.41									Bal. w/ Fe 90.6%	3,2,13
PVFW	Pahoa Village Fresh Water	10/85	8.8													Bal. w/ Fe 48.3%	6
3080-01	Kapoho Crater	3/15/68				0.3	2.4										1,6
3080-01	Kapoho Crater	5/22/70				0.2	9.7										1
3060-01	Kapoho Crater	3/3/72				0.3	27										1
3080-01	Kapoho Crater	1974	20	0.00		0.3	27									Bal. w/ Fe -11.1%	3,2,13
3060-01	Kapoho Crater																2
3080-01	Kapoho Crater	6/14/91	<0.02	<0.02	0.26	0.22	8.06	<0.01	0.03	0.43	-14	-3.0	3.1	6.16	-15.14		
3080-01	Kapoho Crater	9/15/92	0.03	<0.01	0.32	0.14	10.1	<0.01	<0.02	0.44	-17	-3.45	2.61	6.14	-16.05		
3060-02	Kapoho Shaft	1/30/74									-19	-3.6				surface	4,2
3080-02	Kapoho Shaft	1/6/75											14.1			Cl is "suspect"	5,10,2,6
3080-02	Kapoho Shaft	7/21/75			0.2							-6.33	10.5				5,10,2,6
3080-02	Kapoho Shaft	10/27/75			0.25												5,10
3080-02	Kapoho Shaft																6
3185-01	Hawaiian Shores 1 (Beaches)	5/5/64				0.2	0.2										1
3185-01	Hawaiian Shores 1 (Beaches)	1974	0.01	0.03		0.28	0.17										3,2,13
3185-01	Hawaiian Shores 1 (Beaches)	8/8/91	0.04	<0.02	0.02	0.21	0.16	<0.01	<0.02	<0.01	-14	-3.0	2.5				
3185-01	Hawaiian Shores 1 (Beaches)	9/16/92	0.02	<0.01	0.03	0.24	<0.02	<0.01	0.12	0.02	-15	-3.3	3.53				
3185-02	Hawaiian Shores 2	5/22/72				0.3	0.0										1
3185-02	Hawaiian Shores 2	1974	0.01	0.03		0.57	0.11										3,2,13
3188-01	Keonepoko Nui	8/8/91	<0.02	<0.02	0.03	0.16	0.96	<0.01	<0.02	<0.01	-16	-3.6	2.8		-17.63		
3188-01	Keonepoko Nui	9/15/92	0.02	<0.01	0.03	0.2	0.95	<0.01	<0.02	<0.02	-22	-4.13					
3500-01	Wai Pahoehoe	1961	0.10	0.10		0.1											3,2,13
3588-01	Hawaiian Paradise 1	10/19/92	0.05	0.07	0.06	0.08	2.08	<0.01	<0.02	0.24	-14	-3.36	2.77				
3603-01	Olaa 3	9/15/92	0.02	<0.01	0.03	0.05	<0.02	<0.01	<0.02	<0.02	-17	-3.63					
3702-01	Olaa Shaft	6/7/72				0.1	2.8										1,3,2,13
3702-01	Olaa Shaft	5/16/74				0.1			0.12		-18.4	-3.78					9
3702-01	Olaa Shaft	1978				0.14		0.00									11,7,19,2,13
3702-01	Olaa Shaft																2
3802-01	Keaau 1	3/23/34															1
3802-01	Keaau 1	2/3/55				0.2	0.2										1
3802-01	Keaau 1	3/3/72				0.1	0.5										1
3802-01	Keaau 1	1973	0.02	0.03		0.12	0.5										3,2,13
9-A	Olaa mill Well	6/11/74									-20	-3.9				pumped	4
3802-02	Keaau 2	1974	0.08	0.01		0.1	0.36										3,2,13
3802-02	Keaau 2	1978	0.08	0.01		0.1	0.36										11,7,19,2,13
3802-03	Keaau Mill 1	6/7/72				0.2	0.0										1

Table 2

USGS ID #	Name	Date Collected	Fe	Mn	Sr	F	NO_3	Li	B	Br	δD ‰	$\delta^{18}O$ ‰	^3H TU	$\delta^{18}O$ $-SO_4$	$\delta^{13}C$ -TIC	Collection Information	Data Source
3802-03	Keaau Mill 1	1974	10	0.00		0.1										Bal. w/ Fe 43.9%	3,2,13
3802-03	Keaau Mill 1	1978	10			0.1										Bal. w/ Fe 24.6%	11,7,19,2
3802-03	Keaau Mill 1	78-79															13
3802-04	Keaau Mill 2	1972				0.1	1.5										3,2,13
3802-04	Keaau Mill 2	1978				0.1	1.5										11,7,19,2,13
3802-05	Keaau Mill 3	6/7/72				0.1	1.5										1,3,2,13
3802-05	Keaau Mill 3	1978				0.1	1.5										11,7,19,2,13
3804-01	Keaau (Shipman)	8/12/91	<0.02	<0.02	0.03	0.06	<0.02	<0.01	<0.02	<0.01	-16.5	-4.0	2.2				
3804-01	Keaau (Shipman)	9/17/92	0.03	<0.01	0.02	0.1	<0.02	<0.01	<0.02	<0.02	-24	-4.53					
3900-01	Keaau Orchard 1	3/7/72				0.1	3.6										1
3900-01	Keaau Orchard 1	1974	10			0.1	3.6									Bal. w/ Fe 8.2%	3,2,13
3900-01	Keaau Orchard 1	1978	10			0.1	3.6									Bal. w/ Fe & Zn 21.9%	11,7,19,2,13
3900-02	Keaau Orchard 2	7/15/66					2.5										1
3900-02	Keaau Orchard 2	3/7/72				0.1	3.6										1
3900-02	Keaau Orchard 2	1974				0.1	3.6										3,2,13
3900-02	Keaau Orchard 2	1978	40			0.08	3.6									Bal. Fe & Zn 47.7%	11,7,19,2,13
4003-01	Panaewa 1	3/13/72				0.1	0.0										1
4003-01	Panaewa 1	1973				0.0											3,2,13
4003-01	Panaewa 1	1978				0.11											11,2,13
4003-02	Panaewa 2	1974	0.01	0.03		0.22	0.24										3,13
4003-02	Panaewa 2	1978	0.01	0.03		0.22	0.24										11,13
4202-01	Hilo Airport	11/10/53				0.2	0.1										1
4202-01	Hilo Airport	10/12/54				0.1	0.0										1
4202-01	Hilo Airport	2/2/60				0.0	0.1										1,13
4203-02Z	Waiakea TH 2	8/20/64				0.0	0.2										1,3,2,13
4203-02	Waiakea TH 2	1978					0.2										11,2,13
4203-03	Waiakea TH 3	3/2/72				0.1	0.8										1,3,2,13
4203-03	Waiakea TH 3	78-79															13
4203-04	Waiakea 4	3/27/72	0.20	0.05		0.1	0.22										3,1,2,13
4203-04	Waiakea 4	1978	0.20	0.05		0.14											11,2,13
	Hilo Electric Well(Waiakea)	6/11/74									-15	-3.3				pumped	4
4203-05	Kanoelehua 1	1978															11,13
4203-06	Kanoelehua 2	1974	20	0.00		0.0	0.8									Bal. w/ Fe 50.8%	3,2,13
4203-06	Kanoelehua 2	1978	20				0.8									Bal. w/ Fe 39.6%	11,2,13
4203-07	Kanoalehua 3	1972				0.1											3,2,13
4203-07	Kanoelehua 3	1978				0.1											11,2,13
4203-10	Helco Kan 6-2	1978															11,13
4211-01	Olaa Flume Tunnel	8/9/91	<0.02	<0.02	0.01	0.04	0.11	<0.01	<0.02	0.06	-15	-3.6	1.4				
4304-01	Waiakea	1972	0.20			0.6	0.6									Cl is too high	3,2,13
4304-02	Waiakea	1972				1.1											3,2,13
4304-03	Waiakea	1972				0.6	2.1										3,2,13
4306-01	Piihonua A	1973				0.2	0.3										3,2,13
4306-01	Piihonua A	1978				0.2	0.3										11,2,13
4706-01	Papaikou	1974	0.01	0.01		0.26	0.22										3,2,13
4706-01	Papaikou	1978	0.01	0.01		0.26	0.22										11,2,13

Table 2

USGS ID #	Name	Date Collected	Fe	Mn	Sr	F	NO_3	Li	B	Br	δD ‰	$\delta^{18}O$ ‰	^3H TU	$\delta^{18}O$ $-SO_4$	$\delta^{13}C$ -TIC	Collection Information	Data Source
	Seawater, Hilo		<0.05	<0.05	7.60	2.1	<2	0.20	4.20	67.3	-0.4	0.23					17
	Seawater		0.3	0.07		1.0											13,16,2
	Seawater		0.03		8	1.3	3.0	0.17	4.5	67							Hem (1985)
	Seawater, Isaac Hale Park	8/4/91	0.38	<0.05	7.63	0.68	<1	0.38	4.53	62.5	1	0.4		7.64	-3.80		
	Rain and stream samples																
2513-C	F. Trusdell's cistern, Volcano	8/16/91	0.08	0.02	<0.01	0.11	<0.02	<0.01	<0.02	<0.01	-22	-3.8					
2513-C	F. Trusdell's cistern, Volcano	1/5/93	<0.01	<0.01	0.02	0.09	<0.02	<0.01	0.57	<0.02							
2816-C	Griggs cistern, Volcano	10/2/90	0.02		<0.01	0.02	0.09	<0.01	<0.02	<0.05	-32.2	-4.96					17
2815-C	D. Thomas's cistern, Volcano	3/3/92	<0.01	0.1	<0.01	0.02	<0.02	<0.01	<0.02	<0.02	-4	-2.2					
2835-C	Mauna Loa Cabin cistern	3/2/92	0.69	<0.01	<0.01	<0.02	0.14	<0.01	<0.02	<0.02	-65	-8.4					
2909-C	Glenwood cistern, Picnic area	10/4/90	0.14	<0.01	0.03	0.03	0.12	<0.01	<0.02	<0.05	-15.5	-3.45					17
3228-C	Red Hill Cabin cistern	2/25/92	<0.01	<0.01	<0.01	<0.02	0.13	<0.01	<0.02	<0.02	-59	-8.5					
	HVO kitchen tap, from Keaau	3/5/92	<0.01	<0.01	<0.01	<0.02	<0.02	<0.01	<0.02	<0.02	-19	-3.3					
3810-R	Waiakea Stream at gaging station	8/5/91	0.51	0.1	<0.01	0.04	0.53	<0.01	<0.02	<0.02	-15	-3.5	2.1				
3810-R	Waiakea Stream at gaging station	2/17/92	0.01	<0.01	0.02	0.03	0.27	<0.01	<0.02	<0.02	-16	-3.6					
3810-R	Waiakea Stream at gaging station	9/13/92	0.02	<0.01	0.02	<0.02	0.74	<0.01	<0.02	0.02	-15	-3.53					
4308-R	Wailuku River at Piihonua Bridge	10/1/90	0.09	<0.01	0.04	0.02	0.32	<0.01	0.09	<0.05	-18.7	-3.74					17
	Permafrost crack water	8/4/76	0.02		0.0	0.2	0.4	0.0	0.00		-91.5	-12.5					9
	Stream discharge 0.18 cfs	8/10/76				0.1			0.02								9
	Wailuku River not flowing	10/19/76	0.07						0.02								9
	Permafrost crack water	6/6/78									-91.5	-12.53					9
	Rain-Cloud Physics Observ., Hilo	2/8/74									-1	-1.6					4
	Rain-Cloud Physics Observ., Hilo	6/14/74									-6	-2.1					4
	Rain-Cloud Physics Observ., Hilo	6/28/74									0	-1.2					4
	Rain-Cloud Physics Observ., Hilo	7/15/74									-4	-1.4					4
	Rain at Kalapana Station	1/6/75										-5.01	9.1				10
	Rainwater																13
	Rainwater Sample, Kalapana Station	7/22/75										-5.8					10
	Rainwater Sample, Airstrip	1/6/75										-4.04					10
	Rainwater Sample, Airstrip	7/22/75										-6.21					10
	Rainwater Sample, Isaac Hale Park	7/22/75										-4.78					10
	Rainwater Hilo Coast-weight avg.	10/20/54					0.12										12,calc.
	Rainwater Hilo Coast-gen. samp.	10/20/54					0.22										12
	Rainfall @ HVO 4/24-4/27	4/27/76									-24.5	-4.89					9
	Rainfall @ HVO 5/3-6/1	6/1/76									-20.9						9

Table 2

USGS ID #	Date Collected	Ag	Al	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn
Thermal and non-thermal springs																										
0436-S1	2/21/92			<0.05					0							0.03		<0.02		<0.05						
0631-S1	8/10/91			<0.05					0							0.11				<0.1						
0631-S1	9/18/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.003	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.009		<0.1	<0.02		<0.01
0829-S1	8/7/91			<0.1					0							0.09				<0.1						
0829-S1	9/14/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	0.004	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	0.19	0.01		<0.1	<0.02		<0.01
0830-S1	9/18/92	<0.001	<0.05	<0.05	<.01	<0.001	0.003		0	0.003	0.002	0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	0.01		<0.1	<0.02		<0.01
0926-S1	8/15/91			<0.1					0							<0.02				0.19						
0926-S1	9/23/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.005	<0.02	<0.002		0.03	<0.002	<0.02	<0.002	<0.1	0.009		<0.1	<0.02		<0.01
0928-S2	8/15/91			<0.1					0							0.07				0.51						
0926-S2	9/23/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	0.005	<0.002	0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	0.33	0.013		<0.1	<0.02		<0.01
0927-S1	8/15/91			<0.1					0							<0.02				<0.1						
0927-S1	9/23/92	<0.001	0.08	0.11	<.01	<0.001	<0.002		0	<0.002	<0.002	0.01	<0.02	<0.002		0.02	0.002	<0.02	0.002	<0.1	0.012		<0.1	<0.02		<0.01
1420-S1	2/28/92			<0.05					0							<0.02		<0.02		<0.05						
1420-S1	9/21/92	<0.001	<0.05	<0.05	0.02	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	0.003		0.02	<0.002	<0.02	<0.002	<0.3	0.052		<0.1	<0.02		<0.01
1511-S1	8/6/91			<0.1					0							<0.02				0.34						
1511-S1	9/23/92	<0.001	<0.05	<0.05	0.02	<0.001	<0.002		0	0.003	<0.002	0.003	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.2	0.038		<0.1	<0.02		<0.01
1518-S1	8/5/91			<0.1					0							<0.02				<0.1						
1615-S1	8/6/91			<0.1					0							<0.02				0.54						
1615-S1	9/22/92	<0.001	<0.05	<0.05	0.02	<0.001	<0.002		0	0.005	<0.002	0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.3	0.064		<0.1	<0.02		<0.01
1615-S2	9/23/92	<0.001	0.05	<0.05	<.01	<0.001	<0.002		0	0.005	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.3	0.054		<0.1	<0.02		<0.01
1617-S1	8/5/91			<0.1					0							<0.02				<0.1						
1617-S1	9/22/92	<0.001	<0.05	<0.05	0.03	<0.001	<0.002		0	0.004	<0.002	0.003	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.3	0.062		<0.1	<0.02		<0.01
1617-S2	9/22/92	<0.001	<0.05	<0.05	0.02	<0.001	<0.002		0	0.005	<0.002	0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.2	0.036		<0.1	<0.02		<0.01
2634-S1	9/20/92	<0.001	<0.05	<0.05	0.02	<0.001	0.003		0	0.003	<0.002	0.003	<0.02	<0.002		0.03	<0.002	<0.02	<0.002	<0.05	0.002		<0.1	<0.02		<0.01
2735-S1	9/20/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.008	<0.02	<0.002		0.02	0.004	<0.02	<0.002	<0.05	<0.002		<0.1	<0.02		0.03
2780-S1	1/29/74																									
2780-S1	1/7/75														1.218					0.049						
2780-S1	10/27/75														<0.01											
2780-S1	8/4/91			<0.1					0							<0.02				<0.5						
2780-S1	9/15/92	<0.001	<0.05	<0.05	0.02	<0.001	<0.002		0	0.002	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.3	0.11		<0.1	<0.02		<0.01
2780-S2	1/29/74																									
2880-S1	8/3/91			<0.1					0							<0.02				<0.5						
2934-S1	3/2/92			<0.05					0							0.6		0.6		<0.05						
2934-S1	9/20/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.006	<0.02	<0.002		0.04	<0.002	<0.02	<0.002	<0.05	<0.002		<0.1	<0.02		<0.01
2979-S1	8/14/91			<0.1					0							<0.02				<0.1						
2979-S2	3/4/92			<0.05					0							0.04		<0.02		<0.05						
2979-S2	9/17/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.004	<0.02	<0.002		0.03	<0.002	<0.02	<0.002	<0.3	0.054		<0.1	<0.02		<0.01
3080-S1	8/14/91			<0.05					0							0.03				<0.05						
3080-S1	8/14/91			<0.05					0							<0.02				<0.05						
3178-S1	8/14/91			<0.1					0							<0.02				<0.1						
3178-S1	9/15/92	<0.001	<0.05	<0.05	0.01	<0.001	0.005		0	<0.002	<0.002	<0.002	<0.02	<0.002		0.04	<0.002	<0.02	<0.002	<0.3	0.045		<0.1	<0.02		<0.01
3889-S1	8/6/91			<0.05					0							<0.02				0.07						
3889-S2	8/12/91			<0.05					0							0.06				0.08						
3889-S2	9/17/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.003	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	0.012		<0.1	<0.02		<0.01

Table 2

USGS ID #	Date Collected	Ag	Al	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn
8836-S1	8/8/91			<0.2					0							<0.02				<0.1						
8836-S2	8/8/91			<0.2					0							0.02				<0.1						
8837-S1	9/24/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	0.003	<0.002	0.005	<0.02	<0.002		0.06	<0.002	<0.02	<0.002	<0.5	0.044		<0.1	<0.02		<0.01
Wells ≥ 30°C																										
2686-02	1/30/74																									
2686-02	12/14/74																									
2763-01	9/6/62		101	0.01								0.2						0.01	0.01						0.08	0.2
2783-01	1/31/74																									
2783-01	12/13/74																									
2783-01	12/13/74																									
2783-01	1/7/75														0.28					0.018						
2783-01	7/22/75														0.41					0.040						
2763-01	7/83																									
2783-01	avg.																									
2783-01	4/26/93	<0.002	<0.01	0.08	0.03	<0.002	<0.004		0	<0.004	<0.004	0.004	0.03	0.002		0.08	0.046	<0.05	<0.004	<0.1	0.29	0.2		<0.01		<0.01
2881-01	1/31/74																									
2881-01	1/7/75														>14					<.006						
2881-01	7/62																									
2883-07	4/3/91																									
2883-07	4/3/91																									
2883-07	4/12/91																									
2883-07	9/4/91																									
2883-07	8/6/91			<0.05					0							1.69				<0.2						
2883-07	9/16/92	<0.001	<0.05	<0.05	0.24	<0.001	0.002		0	0.002	<0.002	0.063	<0.02	0.004		0.25	0.005	<0.02	0.006	<0.05	0.065		<0.1	<0.02		0.02
2883-07	4/28/93	<0.001	<0.01	<0.05	0.1	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.01	0.003		1.93	<0.002	<0.01	<0.002	<0.02	0.058	1.3		<0.01		<0.01
2982-01	9/10/74																									
2982-01	12/14/74																									
2982-01	12/14/74																									
2982-01	12/16/74																									
2982-01	1/7/75							0.0							0.003					0.018						
2982-01	7/21/75														0.32					0.23						
2982-01	7/21/75																			0.16						
2982-01	11/82																									
2982-01	avg.																									
2982-01	9/16/92	<0.001	<0.05	0.05	0.25	<0.001	<0.002		0	<0.002	0.01	0.005	<0.02	<0.002		0.06	<0.002	<0.02	<0.002	<0.3	0.64		<0.1	<0.02		0.04
2983-01	4/4/91																									
2983-01	4/4/91																									
2983-01	4/12/91																									
2963-01	9/4/91																									
2983-01	8/6/91			<0.05					0							<0.02				<0.2						
2983-01	9/16/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	0.035		<0.1	<0.02		<0.01
2983-02	9/16/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.003	<0.02	0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.034		<0.1	<0.02		<0.01
3081-01	1961		0.1	0.01								0.1						0.00	0.03						0.05	0.03
3081-01	1/29/74																									
3081-01	12/13/74																									
3081-01	12/13/74																									
3081-01	1/6/75														0.014					0.12						

Table 2

USGS ID #	Date Collected	Ag	Al	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn
3081-01	7/22/75														0.39					0.23						
3081-01	11/82																									
3081-01	avg.																									
3081-02	6/21/61																									
Wells, shafts, and tunnels < 30°C																										
0335-01	5/14/71																									
0335-01	1975							1.1	0.0						0.28					0.37						
0335-01	8/7/91			<0.05					0							<0.02				<0.05						
0335-01	9/14/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.005		<0.1	<0.02		0.02
0533-01	4/12/72																									
0533-01	2/20/74																									
0533-02	4/12/72																									
0533-03	4/12/72																									
0537-01	2/21/92			<0.05					0							0.03		<0.02		<0.05						
0537-01	9/24/92	<0.001	<0.05	0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.003		<0.1	<0.02		<0.01
0632-01	4/12/72																									
0830-01	4/12/72																									
0831-01	4/12/72																									
0831-02	3/1/72																									
0831-02	1974	0.01	0.02	0.01	0.3	0.00		3.3		0.01		0.02			0.26			0.01	0.01	0.28					0.00	0.02
0831-03	2/1/74																									
0831-03	1974	0.01	0.10	0.01	0.1	0.00				0.01		0.01						0.01	0.01						0.00	0.01
0831-03	8/7/91			<0.05					0							<0.02				<0.1						
0831-03	9/18/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	0.002	0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.007		<0.1	<0.02		<0.01
0936-01	2/26/92			<0.05					0							0.03		0.04		<0.05						
0936-01	9/24/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	0.003		<0.1	<0.02		<0.01
1128-01	4/13/72	0.01	0.02	0.01	0.3	0.00				0.01		0.02						0.01	0.01						0.00	0.01
1128-01	2/28/74																									
1128-02	2/1/74																									
1128-02	1974							6.6							0.28					0.52						
1229-01	1974														0.86					0.28						
1229-01	8/7/91			<0.05					0							0.02				<0.05						
1229-01	9/14/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002			0.002	<0.002	<0.002	<0.02	<0.002		0.02	<0.002		<0.002	<0.3	0.005		<0.1	<0.02		<0.01
1331-01	2/26/92			<0.05					0							0.04		0.02		<0.05						
1331-01	9/24/92	<0.001	<0.05	<0.05	<.01	<0.001	0.004		0	<0.002	<0.002	<0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	<0.002		<0.1	<0.02		<0.01
2102-01	12/6/63		0.05	0.01								0.10						0.00	0.00						0.00	0.10
2102-01	1/31/74																									
2487-01	3/3/72		0.20	0.01								0.10							0.03						0.05	0.03
2487-01	1/30/74																									
2487-01	1/6/75														0.07					0.17						
2487-01	7/21/75														0.16					0.59						
2487-01	11/82																									
2487-01																										
2487-01	8/8/91			<0.05					0							<0.02				0.24						
2487-01	9/15/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	<0.002		0.03	<0.002	<0.02	<0.002	0.22	0.008		<0.1	<0.02		0.02
2487-02	1974		0.10	0.01	0.1	0.00				0.01		0.02						0.01	0.01						0.00	0.02
2714-01	3/10/75															0.07				0.11						

Table 2

USGS ID #	Date Collected	Ag	Al	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn
2715-02	3/10/75															0.09				0.04						
2815-01	3/10/75															0.24				0.00						
2966-01	3/3/72																									
2986-01	1973	0.01	0.02	0.01	0.30	0.00		3.2		0.01		0.03			0.20			0.01	0.01						0.00	0.03
2986-01	1/6/75														0.25					0.24						
2986-01	7/21/75														0.57					0.40						
2986-01	11/82																									
2986-01	8/8/91			<0.05					0							<0.02				0.14						
2986-01	9/15/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	0.21	0.009		<0.1	<0.02		<0.01
2986-02	3/3/72																									
2986-02	1/30/74																									
2986-02	1974	0.01	0.10	0.01	0.1	0.00		31.0		0.01		0.02			0.53			0.01	0.01	0.43					0.00	0.01
PVFW	10/85																									
3080-01	3/15/68																									
3080-01	5/22/70																									
3080-01	3/3/72								6																	
3080-01	1974							167	6.0						4.20					0.86						
3080-01																										
3080-01	8/14/91			<0.05					0							0.13				0.5						
3080-01	9/15/92	<0.001	<0.05	<0.05	<.01	<0.001	0.004		0	<0.002	<0.002	0.003	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	0.57	0.011		<0.1	<0.02		<0.01
3080-02	1/30/74																									
3080-02	1/6/75														0.38					0.71						
3080-02	7/21/75														4.47					0.82						
3080-02	10/27/75														2.51											
3080-02																										
3185-01	5/5/64																									
3185-01	1974	0.01	0.10	0.01	0.1	0.00				0.01		0.02						0.01	0.01						0.00	0.06
3185-01	8/8/91			<0.05					0							<0.02				0.23						
3185-01	9/16/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	<0.002	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.01		<0.1	<0.02		<0.01
3185-02	5/22/72																									
3185-02	1974	0.01	0.10	0.01	0.10	0.00				0.01		0.07						0.01	0.02						0.00	0.74
3188-01	8/8/91			<0.05					0							<0.02				0.28						
3188-01	9/15/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	0.003	<0.002	<0.002	<0.02	<0.002		<0.02	<0.002	0.04	<0.002	0.24	0.008		<0.1	<0.02		<0.01
3500-01	1961		0.20	0.01								0.10							0.03						0.05	0.03
3588-01	10/19/92	<0.001	<0.05	<0.05	<.01	<0.001	0.003		0	0.005	<0.002	0.008	<0.02	<0.002		0.03	0.1	<0.02	<0.002	<0.05	0.01		<0.1	<0.02		<0.01
3603-01	9/15/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	0.002	<0.002	<0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	0.006		<0.1	<0.02		<0.01
3702-01	6/7/72																									
3702-01	5/16/74																			0.09						
3702-01	1978																									0.00
3702-01																										
3802-01	3/23/34																									
3802-01	2/3/55																									
3802-01	3/3/72																									
3802-01	1973	0.01	0.02	0.00	0.30	0.00				0.01		0.02						0.01	0.01						0.00	0.01
9-A	6/11/74																									
3802-02	1974	0.01	0.10	0.01	0.10	0.01				0.01		0.02						0.01	0.01						0.00	0.02
3802-02	1978			0.01	0.10	0.01				0.01		0.02						0.01	0.01							0.02
3802-03	6/7/72																									

Table 2

USGS ID #	Date Collected	Ag	Al	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn
3802-03	1974							0.9							0.49					0.21						
3802-03	1976							0.9							0.49					0.21						
3802-03	78-79																									
3802-04	1972																									
3802-04	1976																									
3802-05	6/7/72																									
3802-05	1978																									
3804-01	8/12/91			<0.05					0							<0.02				<0.05						
3804-01	9/17/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.002	<0.02	<0.002		<0.02	<0.002	<0.02	<0.002	<0.05	0.006		<0.1	<0.02		<0.01
3900-01	3/7/72																									
3900-01	1974							4.4	0.0						1.10					0.21						
3900-01	1978							4.4							1.10					0.21						10
3900-02	7/15/66																									
3900-02	3/7/72																									
3900-02	1974																									
3900-02	1978																									18
4003-01	3/13/72																									
4003-01	1973							2.3																		
4003-01	1978							2.3																		
4003-02	1974	0.01	0.10	0.01	0.1	0.00				0.01		0.02						0.01	0.02						0.00	0.01
4003-02	1978			0.01	0.1					0.01		0.02						0.01	0.02							0.01
4202-01	11/10/53																									
4202-01	10/12/54																									
4202-01	2/2/60																									
4203-02Z	8/20/64																									
4203-02	1978																									
4203-03	3/2/72																									
4203-03	78-79																									
4203-04	3/27/72		0.05	0.01								0.10							0.01						0.01	0.01
4203-04	1978											0.10														0.01
	6/11/74																									
4203-05	1978																									
4203-06	1974		0.05	0.01				39.0				0.10			0.01				0.01	0.18					0.01	0.01
4203-06	1978			0.01				39.0				0.10			0.01				0.01	0.18					0.01	0.01
4203-07	1972																									
4203-07	1978																									
4203-10	1978																									
4211-01	8/9/91			<0.05					0							<0.02				<0.05						
4304-01	1972		1449.6	0.01								0.10							0.10						0.01	0.10
4304-02	1972																									
4304-03	1972																									
4306-01	1973																									
4306-01	1976																									
4706-01	1974	0.01	0.10	0.01	0.10	0.00				0.01		0.01						0.01	0.01						0.00	0.12
4706-01	1978			0.01	0.10					0.01		0.01						0.01	0.01							0.12

Table 2

USGS ID #	Date Collected	Ag	Al	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn
		<0.01	<0.5	<0.5	<0.05	<0.01	<0.01			<0.01	<0.01	<0.01	<0.01	<0.002		0.06	<0.01		<0.05	<3	0.14		<0.5	<0.01	<0.5	<0.05
	8/4/91			<0.2					0							<0.02				<2						
Rain and stream samples																										
2513-C	8/16/91			<0.05					0							<0.02				<0.05						
2513-C	1/5/93		0.05	<0.001	<0.01				0				<0.01			<0.02		<0.02		<0.05			<0.001	<0.01		0.24
2616-C	10/2/90	<0.001	<0.1	<0.05	<0.01	<0.001	<0.002			<0.002	<0.002	0.52	<0.01	<0.002		<0.02	<0.002		0.002	<0.1	<0.002			<0.01		1.06
2815-C	3/3/92			<0.05					0							0.03		<0.02		<0.05						
2835-C	3/2/92			<0.05					0							0.1		<0.02		<0.05						
2909-C	10/4/90	<0.001	<0.1	<0.1	0.01	<0.001	<0.002			<0.002	<0.002	0.06	0.01	<0.002		0.04	0.007		0.034	<0.1	<0.002		<0.1	<0.01	<0.1	0.7
3228-C	2/25/92			<0.05					0							<0.02		<0.02		<0.05						
	3/5/92		<0.05	<0.05	<.01				0							0.02		<0.02		<0.05			<0.1			0.61
3810-R	8/5/91			<0.05					0							<0.02				<0.05						
3810-R	2/17/92			<0.05					0							0.03		<0.02		<0.05						
3810-R	9/13/92	<0.001	<0.05	<0.05	<.01	<0.001	<0.002		0	<0.002	<0.002	0.006	<0.02	<0.002		0.02	<0.002	<0.02	<0.002	<0.05	0.003		<0.1	<0.02		<0.01
4308-R	10/1/90	<0.001	<0.1	<0.1	0.01	<0.001	<0.002			<0.002	<0.002	0.007	<0.01	<0.002		0.11	0.005		<0.002	<0.1	0.004		<0.1	<0.01	<0.1	0.05
	8/4/76																			0.02						
	8/10/76																									
	10/19/76																									
	6/6/78																									
	2/8/74																									
	6/14/74																									
	6/28/74																									
	7/15/74																									
	1/6/75														0.024					<0.006						
	7/22/75																									
	1/6/75																									
	7/22/75																									
	7/22/75																									
	10/20/54																									
	10/20/54																									
	4/27/76																									
	6/1/76																									

Table 3. Dissolved constituents for samples from deep wells. See Table 2 for other information.

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
		2317-01	Kilauea Volcano Summit Borehole																
	NSF	avg.	79.0		7.1	124	63.5	610	130			1660?	170						13,2
32		9/11/74	75.0	7.3									159						18,4,3
50		12/15/74	83.0	6.9									180						18,4
KBW-1		9/4/73	71.0	7.0-7.5	8.5	49	39	740	90	274	1560	84	67		0.93	2780	2770	0.2	9
KBW-2		9/18/73		7.0-7.5	8.5	47	43	720	104	248	1570	84	109		1.00	2830	2800	0.0	9
KBW-3		10/10/73	75.0	7.0-7.5	8.5	52	42	710	116	194	1620	95	91		1.07	2850	2820	-1.3	9
KBW-4		12/4/73	73.0		8.65	36	22	545	47	366	972	54	14		0.46	1900	1870	-1.1	9
KBW-5		2/21/74	74.0		8.2	106	51	700	124	338	1660	95	135		1.09	3070	3040	-2.0	9
KBW-6		8/27/74	79.0		8.1	62	65	750	140	295	1860	100	140		1.09	3260	3260	-4.0	9
KBW-7		12/18/74	79.0		8.2	63	70	759	142	270	1960	110	119		1.32	3360	3360	-6.1	9
KBW-8		12/18/74			8.25	49	64	769	142	150	1900	110	122		1.59	3230	3230	-0.9	9
KBW-9		6/5/75	71.0		7.55	72	87	730	111	792	1490	83	89	0.10	0.77	3050	3050	-2.2	9
KBW-10		7/18/75	73.0		7.95	101	72	537	90	985	925	60	121	0.07	0.49	2390	2390	-1.3	9
KBW-11		7/24/75	70.0	7.0-7.5	7.97	104	69	490	66	1030	796	50	101	0.07	0.46	2180	2180	-2.9	9
KBW-12		4/17/76			8.05	104	107	221	44	1040	285	14	98		0.14	1390	1390	5.4	9
KBW-13		4/19/76			8.0	106	110	214	43	1080	269	12	94		0.14	1380	1380	4.3	9
GT24SI91		8/9/91	35.7	7.0	6.5	66	86	71	7.9	799	154	4.1	87	0.03	0.07		870	-18.3	
GT35SI91		9/13/91			6.75	93	91	73	8.6	793	174	4.5	101	0.036	0.04		940	-7.5	
		2685-01	Ashida 1																
	AS	6/25/80	288.0			113	1.45	432	20.5		185	174		0.45	12.3				2
		2883-01	HGP-A																
I-1		drilling				2.1	1.8	15.8	2.7	0.6	16.1	6.3	35.6				81	63.5	18
avg. I-2,5,9		6/24/76				5.0	1.2	407	52.0	1.0	176	552							18
II-1		7/3/76		6.5		<0.1		350		27	160	610	151			2322			18
G1-A		7/22/76										757							18
G1-B		7/22/76																	18
G1-C		7/22/76				1.3		50.9	7.0			94.5							18
		7/22/76			5.52	35	0.4	552	70	136	87	950	296	0.2	0.83	2190	2060	-10.8	9
G1-D		7/23/76		6.6						81	72	166	220						18
		undated		6.3		56.7	<0.5	980	165			1830	203						5
		8/4/76		5.1								880	200						18
		8/12/76		5.5								930	240						18
		8/17/76		5.3								950	300						18
		8/18/76		2.3								710	530						18
		8/19/76		2.5								800	340						18
		8/19/76		3.5								780	430						18
		8/19/76		5.2								1000	370						18
		8/19/76		5.6								830	210						18
		8/19/76		5.3								900	270						18
		8/19/76		3.0								660	190						18
		10/12/76		4.9								725	220						18,5
		10/12/76		1.4								730	620						18,5
		10/12/76		1.9								735	650						18,5
		10/29/76		2.7								685	630						18,5
		10/29/76		3.4								850	630						18,5

Table 3

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
		10/30/76		2.3								685	630						18,5
		10/30/76		3.5								440	630						18,5
	5	11/3/76		7.0		46.2	<0.5	1140	205			2170	132						5,2
		11/4/76		7.0		54.8	<0.5	1200	209			2180	113						5
	6	11/5/76		7.0		56.7	<0.5	1200	205			2210	128						5,2
		11/6/76		7.0		60.3	<0.5	1180	215			2225	113						5
	7	11/7/76		8.8		60.3	<0.5	1200	207.5			2350	110						5,2
	8	11/8/76		8.8		81.9	<0.5	1200	212.5			2190	105						5,25,(21),2
		11/8/76		8.8								2330	140						5
		11/8/76		4.5		18.9	<0.5	360	57.5			660	255						5
		11/9/76		8.8								2330	140						5
		11/9/76		5.8		54.8		1000	180			1990	123						5
	9	11/10/76		8.8		81.9		1260	250			2190	145						5,2
		11/11/76		8.9		70.4		1260	212.5			2350	128						5
	10	11/12/76		8.9		74.4		1260	215			2410	140						5,2
		11/13/76		8.8		74.0		1280	217.5			2450	150						5
	11	11/14/76		8.8		68.7	<0.5	1280	215			2450	153						5,2
	12	11/16/76		8.8		75.7	<0.5	1320	225.5			2530	150						5,2
		11/16/76		5.6		58.3	<0.5	980	167.5			1870	225						5
	13	11/17/76		8.8		78.8	<0.5	1320	222.5			2520	130						5,25,2
		12/2/76		9.4								1100	130						5
	F1	12/2/76		3.6		24.2	1.9	540	75			950	740						5,2
	F2	12/2/76		3.4		21	1.9	500	77.5			910	760						5,25,2
	F4	12/2/76		2.6		22.6	0.6	500	222.5			980	740						5,25,2
	F3	12/2/76		2.8		17.3	0.7	480	85			920	740						5,25,8,2,14
	14	12/12/76		7.0		41.4	0.2	1040	227.5			2130	140						5,2
	15	12/13/76		6.0		57.2	0.1	1170	212.5			2330	130						5,2
		12/14/76		6.0		70.0	0.2	1220	215			2470	140						5
	16	12/15/76		6.0		78.1	0.4	1300	225			2560	130						5,2
		12/76		3		53.8	1.0	730	123			1040	440						5,20,22
		1/18/77																	16
		1/25/77		9.7		78.7	0.2	1240	155			2230	140						5
		1/25/77		8.7		82.8	0.8	1120	177.5			2190	140						5
	F20	1/25/77		2.3		10.4	0.5	480	92.5			1000	670						5,2
	F21	1/25/77		5.3		121	1.1	1060	153.8			2280	400						5,2
	F19	1/25/77		2.3		13.2	1.1	480	92.5			980	670						5,2
	D31	1/26/77		3.3		79.2	2.1	740	122.5			1490	580						5,2
	D29	1/26/77		2.9		7.5	0.3	500	117.5	0		1000	710						5,2
	D28	1/26/77		2.6		24.4	1.1	550	95	0		1080	650						5,2
	D30	1/26/77		2.5		8.4	0.5	480	87.5	0		960	700						5,2
		1/26/77				18.6	<0.1	520	20.7			1100							5
		1/26/77				31.8	<0.1	860	38.0										5
	23	1/26/77		5.8		17.7	0.8	500	92.5	93		1080	210						5,2
	24	1/26/77		6.3		14.2	0.7	500	92.5	132		1010	180						5,2
		1/26/77		7.3		14.7	<0.5	520	100	68		1020	160						5
		1/26/77		5.4		4.1	0.1	160	28.8	24		800	195						5
	26	1/26/77		8.5		37.8	0.1	1100	220	34		2190	150						5,2
	35	1/26/77		8.5		32.4	0.4	1000	210	24		2110	150						5,2
		1/26/77		5.3		6.8	0.1	260	55	49		600	160						5
		1/26/77		5.0		7.5	0.1	240	47.5	39		550	280						5

Table 3

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
		1/26/77		4.8			0.1	340	52.5	20		660	280						5
		1/26/77		4.8		13.2	0.1	360	68.5	88		2400	340						5
	25	1/26/77		5.8		180.4	4.8	1360	188.8	63		3090	250						5,2
	22	1/26/77		5.5		88	5.5	820	120	122		1730	360						5,2
	32	1/26/77		8.0		30.6		1020	62	59		2040	150						5,2
	33	1/26/77		8.5		40.6	0.1	1100	225.5	59		2230	150						5,2
	F34	1/26/77		2.6		22.6	0.3	480	103.8	0		1040	710						5,2
		1/27/77		8.3		49.7	0.1	1140	222	34		2360	160						5
		1/27/77		4.8		15.5	0.1	330	57.5	44		820	280						5
		1/28/77		8.5		70.1	0.2	1220	200			2550	140						5
	36	1/29/77				78.2	0.3	1260	225			2590	140						5,25,2
	18	1/30/77		8.4		84.7	0.4	1280	242.5			2650	130						5,2
	17	1/30/77		8.5		72.7	0.3	1280	235			2650	200						5,2
	37	1/30/77		8.5		24	0.11	390	68			780	41						5,20,2
	38	2/9/77	100	5.3		30.1	<0.1	720	135			1610	170						5,8,2,14
		2/9/77		5.5		32.2	<0.1	860	157.5			1790	160						5
		2/10/77		5.6		30.1	<0.1	860	152.5			1690	195						5
		2/14/77		11.5		11.5	0.1	860	173.8			920	170						5
	F43	2/14/77		4.8		95.7	1.9	620	87.5			1310	210						5,25,2
	F41	2/14/77		8.2		39.3	0.4	600	82.5			1030	195						5,25,2
	F39	2/14/77		2.9		430	13.0	2000	240			4620	440						5,2
	F42	2/14/77		5.2		161	2.0	1080	160			2330	170						5,25,2
	F40	2/14/77		3.2		465	14.7	2160	247.5			4800	425						5,25,2
		2/14/77	149-177	3		445	14	2008	245			4720	432						5,20,6
		4/5/77		8.4				1480	269			2920	145						5
		4/5/77		3.5				240	40.0				185						5
		4/5/77		3.5				260	45.0			520	160						5
		4/6/77		8.4				1460	247			2940	165						5
		4/9/77		4.6		13.9	0.1	240	35			500	165						5
	44	4/9/77		8.1		75.6	0.1	1400	266			3000	140						5,2
		4/11/77		5.3		12.2	0.1	240	40.0			610	180						5
	45	4/11/77		8.2		77.3	0.1	1460	266			3050	150						5,25,(21),2
		4/16/77		8.3		77.3	<0.1	1480	283			3130	145						5
		4/16/77		4.6		10.5	<0.1	200	38.0			500	185						5
		4/20/77		8.1		80.0	<0.1	1480	288			3150	155						5
		4/20/77		3.6		10.5	<0.1	200	40.0			560	190						5
	46	4/22/77	100	8.2		72.2	<0.1	1480	277			3190	160						5,8,2,14
		4/22/77		4.4		12.2	<0.1	200	45.0			590	195						5
		5/8/77																	16
		5/8/77																	16
	47	6/15/78				56.6	0.08	1500	250			2420							25,2
		1978 or 79	~250				1					1040	942						13
		avg.	300		4.4	96	1.0	800	149	~45	~176	1150	501				2900	16.6	13
		10/17/79																	16
		11/9/79																	16
		11/9/79																	16
		12/28/79																	16
		1/3/80																	16
	49	1/10/80	165.4			16.3	≤1.0	1430	200		50	2390	865						16,2,14
	51	1/11/80	186.6			33.2	≤1.0	1463	211		60	2450	792						16,2,14

Table 3

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
		1/12/80																	16
	53	1/12/80				25.9	<1.0	1405	204		62	2350							16,2
	55	1/14/80				30.5	<1.0	1440	205		60	2450	796						16,2
		1/14/80				33.2	0.1	1440	216			2450							25
	56	1/16/80	175.8			33.9	0.01	1520	224		69	2593	832						8,2,14
	58	1/16/80	180.0			33.2	≤1.0	1530	216		67	2600	832						16,2
	60	1/17/80				17.9	<1.0	1713	247		59	2920	875						16,2
	61	1/18/80				17.9	<1.0	1700	248		73.6	2930	873						16,2
		1/18/80																	16
	63	6/12/81	100			25.5	0.008	900	200			2065	1198						8,2,14
		6/12/81				18.5	0.02	806	154			1593	1200						25,(21)
		6/17/81				15.9	0.061	806	148		50	1593	1233						23
	64	6/18/81				25	0.006	1100	200			1986		0.34					24,2
	65	6/20/81				30	0.01	1280	220			2320		0.38					2
	66	6/29/81				36	0.01	1250	265			2360		0.39					2
	67	7/4/81				39.5	0.01	1320	255			2470		0.41					2
	68	7/16/81				46.5	0.01	1460	255			2660		0.45					2
	69	8/3/81				55	0.03	1710	265			2940		0.49					2
	70	8/12/81				58	0.02	1700	270			3110		0.52					2
	71	8/22/81				61	0.03	1810	280			3310		0.56					2
	72	8/28/81				63	0.03	1900	305			3470		0.59					2
	73	9/4/81				72	0.1	2190	250		63	3700	795						25,23,(21),2
	74	9/4/81	187.9			66.5	0.029	1890	295			3622	860						8,2,14
	75	12/11/81	100			33	0.012	1590	300			2763	1004						8,2,14
	76	12/17/81				48.5	0.02	1850	310			3210		0.56					2
	77	12/22/81				56	0.015	1820	295			3290		0.58					22,2
		12/22/81				58.3	0.038	1745	281			3261	1100						25,23
	79	2/5/82				90.5	0.06	2320	405			4270		0.73					2
		2/5/82				84.4	0.054	2253	364			4226	850						23
	80	2/8/82				95.5	0.06	2410	410			5240		0.84					2
	81	2/26/82				115	0.06	2920	490			5290		0.86					2
	83	3/22/82					0.07	2820	470			5020		0.84					2
	82	3/22/82				121	0.08	2655	431			5050							25,2
		4/5/82										5119							23
	84	4/12/82				112	0.06	2840	495			5150		0.95					2
	85	4/19/82				70.1	0.076	1591	269			3017	455						21,2
		4/19/82				123	0.134	2792	472			5293	799						25,(21)
	86	5/3/82				120	0.06	2970	495			5320		0.88					2
	87	5/17/82				120	0.05	2990	500			5380		0.88					2
		5/17/82				124	0.06	3066	508			5489	802						25
	88	6/7/82	186.8			122.5	0.051	3120	525			5667	803	0.94					24,8,2,14
	89	6/14/82				149	0.07	3200	513			5677	818						25,2
	90	6/23/82				129	0.05	3210	520			5800		0.95					2
	91	7/5/82				134	0.06	3150	525			5900		0.98					2
	92	7/12/82				89.5	0.041	1881	306			3445	466						21,2
	93	7/12/82				157	0.073	3300	536			6044							25,(21),2
	94	7/19/82				140	0.06	3240	535			6050		0.98					2
	95	8/2/82				149	0.06	3260	565			6120		0.98					2
	96	8/6/82				153	0.06	3400	560			6390		1					2
	97	9/4/82				41	0.06	1250	143			2110	456						2

Table 3

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
	98	9/7/82				158	0.07	3420	565			6440		1.02					2
	99	9/14/82				165	0.07	3420	605			6400		1.02					2
	100	10/4/82				176	0.081	3590	620			6549		1.02					22,2
	101	10/11/82				181	0.08	3590	615			6650		1.02					2
	102	10/12/82				182	0.08	3650	610			6660		1.03					2
	78	11/1/82				205	0.09	3650	585			6730		1.04					2
	103	11/8/82				205	0.10	3720	620			6880		1.06					2
	104	11/16/82	186.8			217	0.104	3940	650			7029	829						8,2,14
		2/1/83	358.0			250	0.153	5058	654	60	23	7473	850				14300	16.0	7,19
	105	2/15/83				242	0.12	4020	665			7470		1.08					2
	106	3/23/83				247	0.12	3980	630			7480		1.08					2
	107	4/18/83				156	0.096	2888	366			4392	467						21,2
	108	5/4/83	186.8			270	0.152	4220	675			7965	805						8,2,14
	109	5/24/83				268	0.16	4120	685			7990		1.12					2
	110	6/9/83				269	0.14	4480	660			8000		1.13					24,2
	111	7/5/83				275	0.16	4270	685			8280		1.11					2
	112	7/28/83				309	0.14	4610	622										2
	113	7/31/83					0.16	4660	695			8320		1.11					2
	114	8/5/83				280	0.16	4600	675			8220		1.08					2
	115	8/12/83				306	0.15	5030	639			8090							2
	116	9/20/83				321	0.18	5980	718			8560							2
	117	10/31/83				320	0.18	4450	791			8930		1.22					2
	118	12/5/83	184.0			319	0.21	4650	763		24	8827	825	1.25					8,2,14
	119	1/6/84				377	0.22	4750	808			9060		1.26					2
	121	1/12/84	358.0		6.6	358	0.26	4927	756	18.9	24	8968	836?	1.1	4.3	15434	15900	-1.0	2,14
	122	5/14/84				414	0.312	4710	724			8840		1.2					22,2
		6/26/84				443	0.229	4840	660			9000		1.12					24
	123	6/26/84	184.0			489	0.25	4840	773		15	8900	885						8,2,14
	124	11/28/84	184.0			399	0.2	5420	733		4.5	9514	913						8,2,14
	125	2/21/85				430	0.402	5280	735			9560							22,2
		6/13/85				493	0.241	5400	664			10035		1.12					24
		2/28/86				493	0.234	5360	587			9800		1.12					24
		2883-02	Lanipuna 1																
		4/22/81	160.0		7.00	1530	0.5	8578	8.1	92	112	15700	53	0.64	5.4		26000	0.7	14
		7/14/81			6.88	794	0.16	5950	399	45.3	89.8	10500	201	0.81	3.5		18000	3.3	14
		7/15/81			7.14	1160	0.85	6830	505	56.6	59.1	13700	150	0.95	5.3		22400	-5.4	14
		7/15/81			4.48	1590	0.62	8240	983	0	57.8	17500	284	1.66	16.4		28700	-6.6	14
		7/81			6.55	1350	0.23	7800	840	9.3	70.9	16400	0	1.53	7.3		26500	-8.0	14
		2883-03	Kapoho State Geothermal 1																
		1983	45.0			53.2	30.2	614	46.1		169	1150	80						6
		2883-04	Kapoho State Geothermal 2																
		6/9/82				2400	20	15000	3600				1100	12.00	25.0				14
		1984	<37.8		9.5	65	0.5	1000	94		210	1600	93			3140			6

Table 3

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
		2883-09 Kapoho State Geothermal 3																	
		1991			3.58	3948.9	58.32	22674.9	5288	0.0	6.0	50100	1399	16.28	23.3		83500	0.3	14
BC-001		3/25/91			3.18	3537.1	50.09	19848.01	4624.01		2.9	43100	1436.3	13.68	21.18	69750	72600	2.6	15
BC-002		3/25/91			3.88	3747.32	37.69	21116.28	4929.34		1.2	47800	1281.6	15.14	18.99	80975	78900	-0.9	15
BC-003		3/26/91			3.82	3503.86	39.94	21079.4	4869.29		2.1	46300	1340.86	14.74	20.75	79900	77200	0.1	15
BC-004		3/26/91			3.62	3540.71	39.4	20975.07	4950.58		2.3	46000	1339.26	15.26	21.31	78700	76900	0.6	15
BC-005		3/27/91			3.77	3604.02	42.95	20891.97	4891.78		2.5	46600	1300.26	15.63	22.63	79600	77400	-0.6	15
BC-006		3/27/91	148.9		3.75	3904.84	46.61	22496.66	5262.96		2.3	50700	1244.87	16.73	24.08	86500	83700	-1.4	15
BC-007		3/28/91	146.1		3.75	3292.72	44.22	18989.83	4364.5		3.3	43100	1281.46	14.15	20.09	73850	71100	-2.4	15
BC-008		3/28/91	146.1		3.66	3732.27	51.41	20892.27	4846.7		4.5	45700	1361.52	14.95	22.74	78350	76600	2.0	15
BC-009		3/29/91	143.3		3.80	4300.52	59.5	23852.99	5605.02		6.3	54200	1339.04	16.79	26.22	90850	89400	-1.5	15
BC-010		3/29/91	143.3		3.62	3188.86	44.24	18277.89	4236.89		3.8	41000	1291.85	13.44	19.70	70050	68100	-1.0	15
BC-011		3/30/91	142.8		3.57	4774.51	70.6	26775.39	6232.23		1.1	60700	1356.08	18.86	27.86	10200	100000	-0.6	15
BC-012		3/30/91	142.8		3.61	4198.13	62.03	23995.41	5535.24		6.2	52500	1397.3	16.64	24.75	89200	87700	1.5	15
BC-013		3/31/91	142.8		3.58	3948.92	58.32	22674.93	5288.01		6	50100	1399.18	16.28	23.34	85800	83500	0.5	15
BC-014		3/31/91	142.8		3.63	3950.29	58.24	22605.16	5254.35		6.3	50400	1401.03	16.58	23.31	85150	83700	-0.4	15
BA-001		3/25/91	101.7		3.68	4055.08	38.48	22618.13	5396.74		4.5	49600	1368.06	16.67	21.23	84250	83100	2.7	15
BA-002		3/25/91	101.7		3.53	4129.27	45.1	23743.74	5522.95			52800	1401.34	17.50	20.81	86550	87700	0.4	15
BA-003		3/26/91	101.7		3.46	4065.8	48.08	24554.27	5683.74			52300	1509.55	17.65	23.32	86850	88200	3.1	15
BA-004		3/26/91	101.7		3.48	3848.14	53.84	22816.39	5379.58		2.7	50400	1428.4	16.65	23.30	85700	84000	0.0	15
BA-005		3/27/91	101.7		3.88	4039.86	46.36	23160.46	5443.64			52500	1394.17	16.63	24.45	86800	86600	-2.0	15
BA-006		3/27/91	101.7		3.71	4456.17	53.46	24883.4	5872.67		1.8	56300	1381.53	17.47	26.61	94550	93000	-1.1	15
BA-007		3/28/91	101.7		3.84	3730.5	53.85	20966.9	4884.83		1.4	47200	1406.99	14.01	21.87	79850	78300	-1.0	15
BA-008		3/28/91	101.7		3.51	4136.48	60.38	22574.55	5288.23		4.6	50700	1476.33	14.44	24.03	86200	84300	0.0	15
BA-009		3/29/91	101.1		3.41	4706.75	64.71	25908.3	6084.9		3.7	59400	1431.74	17.71	27.73	100850	97600	-2.4	15
BA-010		3/29/91	101.1		3.51	3645.65	46.68	20489.97	4777.47		4.4	43980	1444.1	14.75	21.17	76300	74400	3.8	15
BA-011		3/30/91	100.0		3.56	5419.04	78.46	30108.95	7022.71		4.7	67100	1508.24	20.43	30.44	111950	111000	0.5	15
BA-012		3/30/91	100.0		3.39	4703.38	66.58	26704.1	6164.38		2.6	58500	1514.13	19.51	26.66	97475	97700	1.5	15
BA-013		3/31/91	100.0		3.40	4496.16	64.6	25475.64	5915.1		2.3	56700	1550.13	18.20	26.11	93550	94300	0.0	15
BA-014		3/31/91	100.0		3.40	4569.14	67.42	25865.16	6049.96		7	55400	1581.62	18.47	26.68	94350	93600	3.9	15
KS3-1		3/25/91																	
KS3-2		3/26/91																	
KS3-3		3/26/91																	
KS3-4		3/27/91																	
KS3-5		3/27/91																	
KS3-6		3/28/91																	
KS3-7		3/28/91																	
KS3-8		3/29/91																	
		KS3-1 Well Water																	
		11/20/90				10.8	3.6	33.4	3.3			7	41.8	0.01	2.8	388			15
		2883-05 Lanipuna 6																	
	L6a	8/3/84			8.40	1393	14	7750	397	50.0	430	14400	137		3.5		24500	0.5	2,14
	L6	8/8/84			8.20	1480	14	8230	408	39.0	430	15400	133		3.4		26100	-0.1	2,14
	L6b	8/9/84			8.30	1524	15	8380	420	34.0	403	15600	135		3.4		26500	0.8	2,14

Table 3

Sample No.	ENEL Code	Date Collected	Temp °C	pH(f)	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Li	B	TDS meas.	TDS calc.	Bal %	Data Source
		2883-06	Kapoho State 1A																
		10/16/85	183.3		5.8	950	1.2	9750	2500	15	25	19000	850	8.40	11.0		33100	0.0	14
		10/19/85	180.6		4.8	900	1.7	10000	2500	0	11	19500	1000	8.20	10.0		34000	-1.0	14
		10/19/85	180.6		4.8	800	0	9428	2308	1.2	15	18800	870	7.33	8.8		32300	-4.0	14
		10/24/85	185.0		4.6	860	1.7	10000	2500	0	20	21000	1500	8.60	7.0		36000	-8.8	14
		10/24/85	185.0		4.6	838	0	9805	2400	1.2	14	19465	1390	7.68	8.4		34000	-3.5	14
		10/24/85	185.0		8.32	903	2.15	10720	2940	3.5	25	19645	900		5.5		35100	5.7	14
		10/24/85	185.0		5.42	853	2.19	11030		3.3		19620							14
		10/26/85	157.2		4.7	1100	2.4	12500	2400	0	7.2	24000	1700	10.00	14.0		41800	-2.4	14
		10/28/85	185.0			870	1.8	9500	2500					8.40					14
		10/28/85	183.9		3.8	710	1.5	8100	2100	0	7.2	17000	1000	6.90	8.7		29000	-8.1	14
		10/29/85	183.9		3.8	590	0.6	6700	1800	0	6.3	13000	950	3.90	7.2		23100	0.1	14
	KS1A	10/31/85	185.0		4.5	920	2	10000	2700	0	12	21000	2000	8.70	11.0		36700	-7.3	2,14
		1985	>37.8		8.5	65.8	2.71	921	26.0		74	1098	104.6						6
		2883-11	Kapoho State 8																
KS8-Set1 B		8/13/92	199.5	6.3		19.6	0.25	17.4	3.3	0	6.49	44.3	154	0.02	3.22		250	30.4	
KS8-Set1 S		8/13/92	201.7	4.0	3.13	0.3	0.01	0.12	0.19	0	29.3	0.03	0.4	<0.01	0.11		30.5	-101.6	
KS8-Set2 B		8/14/92	196.1	5.88	4.38	6.66	0.18	8.1	2.37	0	4.11	20.4	184	0.02	4.63		231	15.4	
KS8-Set2 S		8/14/92	200.0	4.2	3.55	0.2	0.02	0.14	0.09	0	11.9	<0.02	1.5	<0.01	0.11		14.0	-16.2	
KS8-Set3 B		8/15/92	201.7	6.49	4.76	21.1	0.07	7.16	3.17	0	5.26	43.6	220	0.02	5.64		306	8.2	
KS8-Set3 S		8/15/92	201.7	4.5	3.62	0.2	<0.01	0.06	0.03	0	9.95	<0.02	0.6	<0.01	0.11		11.0	-98.1	
KS8-Set4 B		8/16/92	198.3	5.84	4.39	12.1	0.06	7.99	2.92	0	2.76	33	182	<0.01	5.25		246	4.8	
KS8-Set4 S		8/16/92	198.3	4.23	3.75	0.2	0.01	0.11	0.09	0	7.01	<0.02	0.2	<0.01	0.07		7.7	-33.2	
KS8-Set5 B		8/17/92	198.3	5.33	4.25	3.97	0.04	4.83	1.29	0	3.59	13	222	<0.01	6.07		255	0.7	
KS8-Set5 S		8/17/92	198.3	4.14	3.73	<0.1	0.02	<0.02	<0.02	0	7.31	<0.02	0.1	<0.01	0.81		8.2	-62.8	
KS8-Set6 B		8/18/92	198.3	5.57	4.22	5.39	0.04	4.72	1.51	0	2.98	17	203	<0.01	6.1		241	-4.0	
KS8-Set6 S		8/18/92	198.3	4.13	3.8	<0.1	<0.01	0.1	0.08	0	5.76	<0.02	0.1	<0.01	0.29		6.3	-27.9	
		2883-13	Kapoho State 9																
KH93-1B		4/20/93			6.87	0.62	0.02	31.2	4.55	41.4	6.63	10.7	114	0.07	4.82		193	28.3	
KH93-1S		4/20/93																	
KH93-2B		4/28/93	200	5.66	4.99	0.38	<0.01	8.32	1.72	0	3.59	8.1	210	<0.01	7.54		240	23.1	
KH93-2S		4/28/93	200			<0.01	<0.01	<0.02	0.05		21	0.11	0.2	<0.01	0.17				
KH93-5B		4/29/93	200	5.85	4.84	0.58	<0.01	7.19	1.63	0	1.91	11.3	231	<0.01	8.24		262	1.0	
KH93-5S		4/29/93	200	4.04		<0.01	<0.01	<0.02	0.01		11.7	<0.05	0.2	<0.01	0.19				
			Kapoho State 1A, KS-9 injectate																
KH93-6		4/29/93	72.2	4.68	3.88	0.65	0.34	2.89	0.41	0	15.9	1.51	24.2	<0.01	1.15		47.2	-45.3	

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^3H TU	$\delta^{18}O$-SO_4	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
2317-01 Kilauea Volcano Summit Borehole																
avg.																13,2
9/11/74							-31	-4.7					downhole, 488-490 m			18,4,3
12/15/74							-29	-4.7					downhole, 518.5 m			18,4
9/4/73				0.9									downhole, 490 m			9
9/18/73	8.4			0.8			-26.5	-4.57					downhole, 490 m			9
10/10/73				0.8			-25	-4.56					downhole, 490 m			9
12/4/73				1.0			-25.8	-4.60					downhole, 490 m; much magnetic matter			9
2/21/74				0.8			-28.6	-4.83					downhole, 490 m			9
8/27/74				1.5									downhole, 490 m			9
12/18/74				1.5									downhole, 488 m; top of water column			9
12/18/74				1.5									downhole, 518.5 m			9
6/5/75	0.02	0.57	1.9	1.9			-27.5	-4.20					downhole, 490 m			9
7/18/75	0.01	0.1	0.7	1.0			-28.5	-4.20					488-490.4 m depth interval			9
7/24/75	0.04	0.12	0.8	1.0			-29.5	-4.62					downhole, 488 m; top of water column			9
4/17/76				1.3			-30	-5.03					488-503 m depth interval			9
4/19/76				1.3			-31	-4.55					488-503 m depth interval			9
8/9/91	<0.01	<0.02					-33	-5.6					downhole,478 m; much suspended matter		<0.06	
9/13/91	0.01	0.007					-32	-5.5					downhole, 468 m; top of water column		<0.06	
2685-01 Ashida 1																
6/25/80																2
2883-01 HGP-A																
drilling													Water used in drilling			18
6/24/76													first water flow			18
7/3/76				0.8	0.04				7±2				after steam			18
7/22/76								stm -3.7					before flash, 11:15a			18
7/22/76								-2.00					just before production, 13:40			18
7/22/76								stm -6.5					1 hr into test, side stream, liq. and vap.			18
7/22/76	3.3		0.2	0.4	1.2								Side stream, liq. and vap. mixture			9
7/23/76								-3.90					after production test, 9:20			18
undated													First side stream, liq. and vap. mixture			5
8/4/76													Surface			18
8/12/76													Surface			18
8/17/76													downhole, 691.9 m			18
8/18/76													downhole, 914.4 m			18
8/19/76													downhole, 1768 m			18
8/19/76													downhole, 1768 m			18
8/19/76													Surface			18
8/19/76													downhole, 304.8 m			18
8/19/76													downhole, 1311 m			18
8/19/76													downhole, 1920 m			18
10/12/76													downhole, 304.8 m			18,5
10/12/76													downhole, 691.9 m			18,5
10/12/76													downhole, 1676 m			18,5
10/29/76													downhole, 1311 m			18,5
10/29/76													downhole, 1768 m			18,5

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^3H TU	$\delta^{18}O$-SO_4	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
10/30/76													downhole, 691.9 m			18,5
10/30/76													downhole, 1920 m			18,5
11/3/76													weir, 8:33p			5,2
11/4/76													weir, 4:00p			5
11/5/76													weir, 10:30a			5,2
11/6/76													weir, 9:40a			5
11/7/76													weir, 9:00a			5,2
11/8/76													weir, 9:00a			5,25,(21),2
11/8/76													weir, p.m.			5
11/8/76													Side stream, liq. and vap. mixture			5
11/9/76													weir			5
11/9/76													Side stream, liq. and vap. mixture			5
11/10/76													weir, 9:00a			5,2
11/11/76													weir, 2:00a			5
11/12/76													weir, 9:30a			5,2
11/13/76													weir, 2:45p			5
11/14/76													weir, 12:05p			5,2
11/16/76													weir, 11:03a			5,2
11/16/76													Side stream, liq. and vap. mixture, 1:30p			5
11/17/76													weir			5,25,2
12/2/76													surface			5
12/2/76													downhole, 692 m			5,2
12/2/76													downhole, 692 m			5,25,2
12/2/76													downhole, 1768 m			5,25,2
12/2/76													downhole, 1311 m			5,25,8,2,14
12/12/76													weir, 11:00a			5,2
12/13/76													weir, 11:00a			5,2
12/14/76													weir, 9:00a			5
12/15/76													weir, 10:00a			5,2
12/76									<0.1				downhole, avg. of 5 non-flowing profiles			5,20,22
1/18/77												12,203±142	discharge from ANX-1			16
1/25/77													surface			5
1/25/77													off 2" temp. bleed line, 9:30a			5
1/25/77													downhole, 1067 m, 4:30p			5,2
1/25/77													downhole, 1676 m, 5:30p			5,2
1/25/77													downhole, 692 m, 3:30 p			5,2
1/26/77													downhole, 1768 m, 9:15a			5,2
1/26/77													downhole, low flow, 692 m, 1:00p			5,2
1/26/77													downhole, low flow, 638 m, 11:00a			5,2
1/26/77													downhole, low flow, 732 m, 11:50a			5,2
1/26/77													liq. phase, sep. upstream of orifice plate			5
1/26/77													liq. phase, sep. downstream of orifice plate			5
1/26/77													weir, low flow, 1:00p			5,2
1/26/77													weir, low flow, 1:30p			5,2
1/26/77													weir, 1:30p, first of flash			5
1/26/77													Side stream, liq. and vap. mixture, 3:30p			5
1/26/77													weir, 8:00p			5,2
1/26/77													weir, 5:00p			5,2
1/26/77													Side stream, liq. and vap. mixture, 5:00p			5
1/26/77													Side stream, liq. and vap. mixture, 5:00p			5

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^{3}H TU	$\delta^{18}O$-SO_4	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
1/26/77													Side stream, liq. and vap. mixture, 8:00p			5
1/26/77													Side stream, liq. and vap. mixture, 12:00p			5
1/26/77													weir, low flow, 11:00a			5,2
1/26/77													weir, low flow, 12:00a			5,2
1/26/77													weir, 4:30p			5,2
1/26/77													weir, 12:00p			5,2
1/26/77													downhole, low flow, 1311 m, 12:30p			5,2
1/27/77													weir, 8:30a			5
1/27/77													Side stream, liq. and vap. mixture, 8:30p			5
1/28/77													weir, 8:00a			5
1/29/77													weir, 8:00a			5,25,2
1/30/77													weir, 10:00a			5,2
1/30/77													weir, 10:00a			5,2
1/30/77													weir, steady state			5,20,2
2/9/77													liq. phase, cyclone sep. upstream of orifice			5,8,2,14
2/9/77													liq. phase, cyclone sep. downstream of orif.			5
2/10/77													liq. phase, cyclone sep. downstream of orif.			5
2/14/77													surface			5
2/14/77													downhole, 1920.2 m			5,25,2
2/14/77													downhole, 1066.8 m			5,25,2
2/14/77													downhole, 692 m			5,2
2/14/77													downhole, 1768 m			5,25,2
2/14/77													downhole , 692 m			5,25,2
2/14/77													downhole 692m			5,20,6
4/5/77													weir			5
4/5/77													side stream, liq. and vap. mixture			5
4/5/77													side stream, liq. and vap. mixture, 3:20p			5
4/6/77													weir, 3:20p			5
4/9/77													side stream, liq. and vap. mixture, 11:00a			5
4/9/77													weir, 11:00a			5,2
4/11/77													side stream, liq. and vap. mixture, 8:45a			5
4/11/77													weir, 8:45a			5,25,(21),2
4/16/77													weir, 10:00a			5
4/16/77													side stream, liq. and vap. mixture, 10:00a			5
4/20/77													weir, 12:00 noon			5
4/20/77													side stream, liq. and vap. mix., 12:00 noon			5
4/22/77													weir (103 kPa), 0715 hrs			5,8,2,14
4/22/77													side stream, liq. and vap. mixture, 7:15a			5
5/8/77												12,800±200	discharge from wellhead			16
5/8/77												13,600±200	discharge from wellhead			16
6/15/78																25,2
1978 or 79													collected by HIG			13
avg.		<0.1	0.37													13
10/17/79									4.00				weir			16
11/9/79									6.48				discharge from wellhead			16
11/9/79									7.93				discharge from fire hydrant			16
12/28/79									2.31				weir			16
1/3/80									2.08				weir			16
1/10/80													1000 hrs, liq. phase, Sep P = 88 psig			16,2,14
1/11/80													1300 hrs, liq. phase, Sep P = 154 psig			16,2,14

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^3H TU	$\delta^{18}O$-SO_4	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
1/12/80									1.32				discharge from ANX-2			16
1/12/80													liq. phase, Sep P = 155 psig			16,2
1/14/80													liq. phase, Sep P = 156 psig			16,2
1/14/80																25
1/16/80													liq. phase, Sep P = 910 kPa			8,2,14
1/16/80													liq. phase, Sep P = 130 psig			16,2
1/17/80													liq. phase, Sep P = 52 psig			16,2
1/18/80													liq. phase, Sep P = 55 psig			16,2
1/18/80									0.50				discharge from ANX-2			16
6/12/81													weir (103 kPa)			8,2,14
6/12/81																25,(21)
6/17/81													liq. phase, Sep P = 175 psia (~1200 kPaa)			23
6/18/81													brine			24,2
6/20/81																2
6/29/81																2
7/4/81																2
7/16/81																2
8/3/81																2
8/12/81																2
8/22/81																2
8/28/81																2
9/4/81													liq. phase, Sep P = 175 psia (~1200 kPaa)			25,23,(21),2
9/4/81													liq. phase, Sep P = 1200 kPa			8,2,14
12/11/81													weir (103 kPa)			8,2,14
12/17/81																2
12/22/81													brine			22,2
12/22/81													liq. phase, Sep P = 175 psia (~1200 kPaa)			25,23
2/5/82																2
2/5/82													liq. phase, Sep P = 175 psia (~1200 kPaa)			23
2/8/82																2
2/26/82																2
3/22/82																2
3/22/82																25,2
4/5/82													liq. phase, Sep P = 175 psia (~1200 kPaa)			23
4/12/82																2
4/19/82													Calc. total fluid composition (liq. + vap.)			21,2
4/19/82													liq. phase, Sep P ~ 1200 kPa			25,(21)
5/3/82																2
5/17/82																2
5/17/82													liq. phase, Sep P ~ 1200 kPa			25
6/7/82													liq. phase, Sep P = 1170 kPa			24,8,2,14
6/14/82													liq. phase, Sep P ~ 1200 kPa			25,2
6/23/82																2
7/5/82																2
7/12/82													Calc. total fluid composition (liq. + vap.)			21,2
7/12/82																25,(21),2
7/19/82																2
8/2/82																2
8/6/82																2
9/4/82																2

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^3H TU	$\delta^{18}O-SO_4$	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
9/7/82																2
9/14/82																2
10/4/82													brine			22,2
10/11/82																2
10/12/82																2
11/1/82																2
11/8/82																2
11/16/82													liq. phase, Sep P = 1170 kPa			8,2,14
2/1/83																7,19
2/15/83																2
3/23/83																2
4/18/83													Calc. total fluid composition (liq. + vap.)			21,2
5/4/83													liq. phase, Sep P = 1170 kPa			8,2,14
5/24/83																2
6/9/83													brine			24,2
7/5/83																2
7/28/83																2
7/31/83																2
8/5/83																2
8/12/83																2
9/20/83																2
10/31/83																2
12/5/83													liq. phase, Sep P = 1100 kPa			8,2,14
1/6/84																2
1/12/84	0.0	0.2		0.25		44.0										2,14
5/14/84													brine		.	22,2
6/26/84													brine			24
6/26/84													liq. phase, Sep P = 1100 kPa			8,2,14
11/28/84													liq. phase, Sep P = 1100 kPa			8,2,14
2/21/85													brine			22,2
6/13/85													brine			24
2/28/86													brine			24
2883-02 Lanipuna 1																
4/22/81				0.27									air lift from permeable zone, 1219 m			14
7/14/81				0.28									blooie line, air lift			14
7/15/81				0.38									blooie line, air lift			14
7/15/81				0.27									blooie line, air lift			14
7/81				0.14									blooie line, air lift from 1219 m +			14
2883-03 Kapoho State Geothermal 1																
1983	15												Top of dike-impounded water			6
2883-04 Kapoho State Geothermal 2																
6/9/82	1100	110.0		0.80		1.5										14
1984	70												Top of dike -impounded water			6

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^3H TU	$\delta^{18}O$-SO_4	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
2883-09 Kapoho State Geothermal 3																
1991	2354.11	195.5		2.00												14
3/25/91	2117.12	176.13	51.05	1.58									6:15p, liq. phase, Sep P = 53 psig			15
3/25/91	2505.76	205.06	54.13	1.82									8:40p, liq. phase, Sep P = 65 psig			15
3/26/91	2134.05	178.06	53.00	1.78									8:35a, liq. phase, Sep P = 62 psig			15
3/26/91	2125.45	178.77	53.52	1.69									5:30p, liq. phase, Sep P = 60 psig		3.31	15
3/27/91	2192.63	183.11	53.77	1.70									9:30a, liq. phase, Sep P = 61 psig			15
3/27/91	2398.63	197.13	58.15	1.74									6:50p, liq. phase, Sep P = 64 psig			15
3/28/91	1976.99	163.79	48.81	1.72									11:20a, liq. phase, Sep P = 59 psig			15
3/28/91	2246.07	185.36	54.33	1.78									5:20p, liq. phase, Sep P = 60 psig			15
3/29/91	2610.59	212.88	62.25	1.92									8:00a, liq. phase, Sep P = 59 psig			15
3/29/91	1917.18	160.21	46.74	1.70									2:30p, liq. phase, Sep P = 59 psig			15
3/30/91	2939.93	238.86	668.96	2.00									8:15a, liq. phase, Sep P = 58 psig			15
3/30/91	2524.28	208.29	60.83	1.98									5:20p, liq. phase, Sep P = 60 psig			15
3/31/91	2354.11	195.45	57.84	2.00									8:15a, liq. phase, Sep P = 60 psig			15
3/31/91	2342.45	195.05	57.98	1.98									1:25p, liq. phase, Sep P = 60 psig			15
3/25/91	2707.50	228.41	58.04	1.92									6:30p, Sep P = 0 psig			15
3/25/91	2753.39	225.38	60.01	2.25									8:50p, Sep P = 0 psig			15
3/26/91	2478.05	206.15	60.87	1.87									8:45a, Sep P = 0 psig			15
3/26/91	2305.96	193.81	57.92	1.87									5:35p, Sep P =0 psig			15
3/27/91	2454.82	204.07	59.93	1.88									9:35a, Sep P = 0 psig			15
3/27/91	2725.35	223.82	65.40	1.83									6:55p, Sep P = 0 psig			15
3/28/91	2229.04	183.38	54.32	1.80									11:25a, Sep P = 0 psig			15
3/28/91	2482.91	203.18	59.61	1.92									5:25p, Sep P = 0 psig			15
3/29/91	2863.63	133.45	68.48	2.17									8:05a, Sep P = 0 psig			15
3/29/91	2183.30	181.20	53.14	1.72									2:35p, Sep P = 0 psig			15
3/30/91	3336.80	270.65	78.57	2.50									8:20a, Sep P = 0 psig			15
3/30/91	2824.18	232.29	68.67	2.20									5:25p, Sep P = 0 psig			15
3/31/91	2694.03	220.74	65.46	2.04									8:25a, Sep P = 0 psig			15
3/31/91	2723.84	221.77	66.24	2.00									1:30p, Sep P = 0 psig			15
3/25/91							-5	1.5					23:30 hrs			
3/26/91							-8	1.6					11:00 hrs			
3/26/91							-3	1.7					21:27 hrs			
3/27/91							-4	1.6					11:45 hrs			
3/27/91							-5	1.8					20:35 hrs			
3/28/91							-5	1.7					08:23 hrs			
3/28/91							-3	2.0					19:50 hrs			
3/29/91							-4	1.9					07:45 hrs			
KS3-1 Well Water																
11/20/90				0.41	1.39									<0.01		15
2883-05 Lanipuna 6																
8/3/84													airlift to unload; blooie 1320 hrs			2,14
8/8/84													airlift to unload; blooie, 1600 hrs			2,14
8/9/84													airlift to unload; blooie, 1600 hrs			2,14

Table 3

Date Collected	Fe total	Mn total	Sr	F	NO_3	Br	δD	$\delta^{18}O$	^3H TU	$\delta^{18}O$-SO_4	$\delta^{13}C$-TIC	^{14}C Age	Collection Information	Ag	Al total	Data Source
2883-06 Kapoho State 1A																
10/16/85	0.30	4.0		1.10		20.0							0930 hrs, Sep P = 160 psig			14
10/19/85	3.00	8.1		1.00		40.0							1700 hrs, Sep P = 156 psig			14
10/19/85		7.8		0.93		53.0							1700 hrs, Sep P = 156 psig			14
10/24/85	8.60	8.1		0.91		80.0							2100 hrs, Sep P = 155 psig			14
10/24/85	9.77	8.8				74.0							2100 hrs, Sep P = 155 psig			14
10/24/85	8.32	13.8		0.75									2100 hrs, Sep P = 155 psig			14
10/24/85	10.01	13.3		0.76									2100 hrs, Sep P = 155 psig			14
10/26/85	8.10	9.5		1.10		100.0							2100 hrs, Sep P = 72 psig			14
10/28/85	5.40	8.0											0400 hrs, Sep P = 154 psig			14
10/28/85	6.50	7.6		0.76		70.0							2330 hrs, Sep P = 153 psig			14
10/29/85	3.40	5.8		0.69		50.0							1330 hrs, Sep P = 153 psig			14
10/31/85	8.40	8.5		0.86		80.0							1245 hrs, Sep P = 153 psig			2,14
1985													Top of dike-impounded water			6
2883-11 Kapoho State 8																
8/13/92	0.82	0.08	0.25	<0.05		<1	-4.35	-0.01	0.86				liq. phase, 6:15p, Sep P = 216 psig	<0.001	<0.05	
8/13/92	2.03	0.05	<0.01	0.03	0.04	<0.02	-6.55	-2.41					vap. phase, 7:00p, Sep P = 218 psig		<0.05	
8/14/92	0.39	0.31	0.08	0.31	<0.02	<0.02	-1.5	0.11	1.15				liq. phase, 1:45p, Sep P = 222-225 psig	<0.001	<0.05	
8/14/92	3.46	0.1	<0.01	<0.02	<0.02	<0.02	-5.55	-2.15	0.61				vap. phase, Sep P = 220 psig		<0.05	
8/15/92	0.18	0.08	0.34	0.31	<0.02	<0.02	-1.95	0.15					liq. phase, afternoon, Sep P = 220 psig	<0.001	0.05	
8/15/92	0.69	0.03	<0.01	<0.02	<0.02	<0.02	-4.35	-2.13					vap. phase, Sep P = 225 psig		<0.05	
8/16/92	0.27	0.16	0.23	0.27	<0.02	<0.02	-1.45	0.32	0.71				liq. phase, 4:00p, Sep P = 205-210 psig	<0.001	<0.05	
8/16/92	0.75	0.02	<0.01	<0.02	<0.02	<0.02	-4.75	-2.06	0.63				vap. phase, 2:45p, Sep P = 217 psig		<0.05	
8/17/92	0.3	0.12	0.04	0.3	<0.02	<0.02	-0.8	0.34					liq. phase, afternoon, Sep P = 216 psig	<0.001	<0.05	
8/17/92	0.15	<0.01	<0.01	<0.02	<0.02	<0.02	-5.1	-2.07					vap. phase, Sep P = 213 psig		<0.05	
8/18/92	0.31	0.11	0.1	0.26	<0.02	<0.02	-0.35	0.24					liq. phase, 10:00a, Sep P = 214 psig	<0.001	0.008	
8/18/92	0.28	<0.01	<0.01	<0.02	<0.02	<0.02	-3.1	-2.05					vap. phase, 11:00a, Sep P = 215±3 psig		<0.05	
2883-13 Kapoho State 9																
4/20/93	0.23	0.02	<0.01	0.43	<0.01	0.01	6.0	1.16	0.31		-3.54		liq. phase, 1400 hrs	<0.001	0.1	
4/20/93							-8.8	-2.21					vap. phase			
4/28/93	0.06	0.03	<0.01	0.6	0.01	0.02	-3.5	0.34	0.34				liq. phase, 9:30a	<0.001	<0.01	
4/28/93	0.6	0.02	<0.01	<0.01	0.02	<0.01	-6.0	-1.83					vap. phase, 3:30p, Sep P = 215 psig		<0.01	
4/29/93	0.15	0.11	<0.01	0.52	0.03	0.03	-3.5	0.32	0.39				liq. phase, 3:00p	<0.001	0.01	
4/29/93	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	-6.0	-1.84	0.50				vap. phase, 3:30p, Sep P = 218 psig		<0.01	
Kapoho State 1A, KS-9 injectate																
4/29/93	0.54	0.06	<0.01	0.09	0.03	<0.01	-5.7	-1.66	0.37				KS-9 injectate	<0.001	<0.01	

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH_4	Ni	NO_2	Pb	PO4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
2317-01 Kilauea Volcano Summit Borehole																									
avg.																									
9/11/74																									
12/15/74																									
9/4/73						20												0.03							
9/18/73						30												0.05							
10/10/73						24												0.01							
12/4/73						31												0.07							
2/21/74						35												0.03							
8/27/74																									
12/18/74																									
12/18/74																									
6/5/75														0.15				0.02							
7/18/75																		0.00							
7/24/75																		0.02							
4/17/76																									
4/19/76																									
8/9/91			<0.05	<0.015			<0.02		<0.01			<0.04			<0.05		<0.01							<0.01	0.056
9/13/91			<0.05	<0.015			<0.02		<0.01			<0.04			<0.10		<0.01							0.051	0.069
2685-01 Ashida 1																									
6/25/80																									
2883-01 HGP-A																									
drilling										3.5															
6/24/76										0–6															
7/3/76							<0.1			<0.1							0.3								
7/22/76																									
7/22/76																				319					
7/22/76																				117					
7/22/76																		0.54		42					
7/23/76																				665					
undated																									
8/4/76																									
8/12/76																									
8/17/76										2.4															
8/18/76																									
8/19/76										3.2															
8/19/76																									
8/19/76																									
8/19/76										44.4										202					
8/19/76										3.5										319					
8/19/76										1.6															
10/12/76										26.3										266					
10/12/76										3.6															
10/12/76										7.5															
10/29/76										0.82										223					
10/29/76										0.5										223					

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
10/30/76										0.95										223					
10/30/76										0.72										393					
11/3/76																									
11/4/76																									
11/5/76																									
11/6/76																									
11/7/76																									
11/8/76																									
11/8/76																									
11/8/76																									
11/9/76																									
11/9/76																				61.6					
11/10/76																									
11/11/76																									
11/12/76																									
11/13/76																									
11/14/76																									
11/16/76																									
11/16/76																									
11/17/76																									
12/2/76																				60.6					
12/2/76																				108					
12/2/76																				222					
12/2/76																				104					
12/2/76																				151					
12/12/76																									
12/13/76																									
12/14/76																									
12/15/76																									
12/76																				143					
1/18/77																									
1/25/77																									
1/25/77																				59.9					
1/25/77																				90.3					
1/25/77																				86.1					
1/25/77																				56.9					
1/26/77																				85.6					
1/26/77																									
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1/26/77																									

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
1/26/77																									
1/26/77																									
1/26/77																									
1/26/77																									
1/26/77																									
1/26/77																									
1/26/77																									
1/27/77																				9.6					
1/27/77																				247					
1/28/77																				9.8					
1/29/77																				8.8					
1/30/77																									
1/30/77																									
1/30/77																									
2/9/77																									
2/9/77																									
2/10/77																									
2/14/77																				73.8					
2/14/77																				53.1					
2/14/77																				60.2					
2/14/77																				4.1					
2/14/77																				65.4					
2/14/77																				11.2					
2/14/77																				0.70					
4/5/77																									
4/5/77																									
4/5/77																									
4/6/77																									
4/9/77																									
4/9/77																									
4/11/77																									
4/11/77																									
4/16/77																									
4/16/77																									
4/20/77																									
4/20/77																									
4/22/77																									
4/22/77																									
5/8/77																									
5/8/77																									
6/15/78																									
1978 or 79 avg.	<0.5								0.13								<2								
10/17/79																									
11/9/79																									
11/9/79																									
12/28/79																									
1/3/80																									
1/10/80																									
1/11/80																									

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
1/12/80																									
1/12/80																									
1/14/80																									
1/14/80																									
1/16/80																									
1/16/80																									
1/17/80																									
1/18/80																									
1/18/80																									
6/12/81																									
6/12/81																									
6/17/81																									
6/18/81																									
6/20/81																									
6/29/81																									
7/4/81																									
7/16/81																									
8/3/81																									
8/12/81																									
8/22/81																									
8/28/81																									
9/4/81																									
9/4/81																									
12/11/81																									
12/17/81																									
12/22/81																									
12/22/81																									
2/5/82																									
2/5/82																									
2/8/82																									
2/26/82																									
3/22/82																									
3/22/82																									
4/5/82																									
4/12/82																									
4/19/82					559															387					
4/19/82																									
5/3/82																									
5/17/82																									
5/17/82																									
6/7/82																									
6/14/82																									
6/23/82																									
7/5/82																									
7/12/82					540															398					
7/12/82																									
7/19/82																									
8/2/82																									
8/6/82																									
9/4/82																									

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
9/7/82																									
9/14/82																									
10/4/82																									
10/11/82																									
10/12/82																									
11/1/82																									
11/8/82																									
11/16/82																									
2/1/83																									
2/15/83																									
3/23/83																									
4/18/83					538															412.8					
5/4/83																									
5/24/83																									
6/9/83																									
7/5/83																									
7/28/83																									
7/31/83																									
8/5/83																									
8/12/83																									
9/20/83																									
10/31/83																									
12/5/83																									
1/6/84																									
1/12/84	0.09													0.0						15.0					
5/14/84																									
6/26/84																									
6/26/84																									
11/28/84																									
2/21/85																									
6/13/85																									
2/28/86																									
2883-02	Lanipuna 1																								
4/22/81						0.0																			
7/14/81						0.0																			
7/15/81						0.0																			
7/15/81						0.0																			
7/81						0.0																			
2883-03	Kapoho State Geothermal 1																								
1983																									
2883-04	Kapoho State Geothermal 2																								
6/9/82	0.0																								
1984																									

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH_4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
2883-09	Kapoho State Geothermal 3																								
1991	0.0					0.0																			
3/25/91		18.21															4.14								
3/25/91		102.13															1.38							42.32	
3/26/91		99.42																						38.86	
3/26/91		98.90															2.09							39.69	
3/27/91		100.67																						35.58	
3/27/91		106.00																						40.37	
3/28/91		88.81															1.27							34.67	
3/28/91		99.40																						42.99	
3/29/91		112.86															1.23							52.94	
3/29/91		84.43																						33.40	
3/30/91		128.27																						59.55	
3/30/91		11.50															1.76							52.48	
3/31/91		104.75															2.76							51.49	
3/31/91		106.98															1.94							51.71	
3/25/91		106.62	0.43														5.45							45.12	
3/25/91		116.55	0.30														6.44							47.78	
3/26/91		116.83															6.61							45.90	
3/26/91		110.69	0.29														9.87							43.63	
3/27/91	2.68	113.20	0.38						1.55								3.85							42.21	
3/27/91		122.81							1.53								4.01							48.73	
3/28/91		99.90							1.20								1.27							41.72	
3/28/91		112.84							1.50								3.96							49.04	
3/29/91		127.49							0.39								2.72							59.14	
3/29/91		101.44							0.54															44.91	
3/30/91		150.78															2.41							69.92	
3/30/91		131.37							0.37								1.56							59.35	
3/31/91		118.33															4.19							58.54	
3/31/91		120.26															5.28							59.34	
3/25/91																									
3/26/91																									
3/26/91																									
3/27/91																									
3/27/91																									
3/28/91																									
3/28/91																									
3/29/91																									
KS3-1	Well Water																								
11/20/90	<0.002	<0.1	0.01				0.05			1.1					0.06		0.06						<0.002		0.7
2883-05	Lanipuna 6																								
8/3/84						0.0																			
8/8/84						0.0																			
8/9/84						0.0																			

Table 3

Date Collected	As	Ba	Cd	Co	CO_2	CO_3	Cr	Cs	Cu	Hg µg/L	I	Mo	N	NH4	Ni	NO_2	Pb	PO_4	Rb	S as H_2S	Sb	S_2O_3	Se	Zn	V
2883-06	Kapoho State 1A																								
10/16/85	0.4					0.0								0.17						6.0					
10/19/85	0.5					0.0								0.19						3.4					
10/19/85	0.3					0.0								15.0						3.2					
10/24/85	0.6					0.0								0.13						7.8					
10/24/85	0.44					0.0								0.13						7.2					
10/24/85	0.06					0.0								0.21						30.0					
10/24/85	0.06					0.0														26.0					
10/26/85	0.8					0.0								0.12						2.2					
10/28/85	0.5													0.11						4.3					
10/28/85	0.4					0.0														8.3					
10/29/85	0.4					0.0								0.10						7.8					
10/31/85						0.0								0.10						5.2					
1985																									
2883-11	Kapoho State 8																								
8/13/92	<0.05	1.85	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.02	0.002		0.21	<0.002	<0.02	<0.002	<0.1	0.013	8.6	<0.1	0.05		<0.01	
8/13/92	<0.05	0.07				0								0.99		<0.02		0.07			<0.1			<0.01	
8/14/92	0.08	0.67	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.02	<0.002		0.26	<0.002	<0.02	<0.002	<0.05	0.007	5.7	<0.1	1.96		<0.01	
8/14/92	<0.05	0.05				0								1.46		<0.02		<0.05			<0.1			<0.01	
8/15/92	0.11	1.7	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.02	0.002		0.19	<0.002	<0.02	<0.002	<0.05	0.009	9.9	<0.1	6.5		<0.01	
8/15/92	<0.05	0.03				0								0.88		<0.02		<0.05			<0.1			<0.01	
8/16/92	0.11	0.67	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.02	<0.002		0.28	<0.002	<0.02	<0.002	<0.05	0.009	8.2	<0.1	2.58		<0.01	
8/16/92	<0.05	0.01				0								1.21		<0.02		<0.05			<0.1			<0.01	
8/17/92	0.13	0.43	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.02	<0.002		0.27	<0.002	<0.02	<0.002	<0.05	0.003	5.4	<0.1	1.41		<0.01	
8/17/92	<0.05	<.01				0								1.14		<0.02		<0.05			<0.1			<0.01	
8/18/92	0.17	0.17	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.02	<0.002		0.27	<0.002	<0.02	<0.002	<0.05	0.004	5.1	<0.1	0.82		<0.01	
8/18/92	<0.05	<.01				0								0.92		<0.02		<0.05			<0.1			<0.01	
2883-13	Kapoho State 9																								
4/20/93	0.08	0.09	<0.001	<0.002		0	0.006	<0.002	0.003		<0.01	0.11		0.12	<0.002	<0.01	<0.002	0.44	0.017			41		<0.01	
4/20/93																									
4/28/93	0.14	0.1	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.01	0.007		0.18	<0.002	<0.01	<0.002	0.27	0.005	7.3		6.15		<0.01	
4/28/93	<0.05	<0.01														<0.01		0.04						<0.01	
4/29/93	0.22	0.57	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.01	<0.002		0.21	<0.002	<0.01	<0.002	0.14	0.005	5.8		2.67		<0.01	
4/29/93	<0.05	<0.01							<0.002							<0.01		<0.02						<0.01	
	Kapoho State 1A, KS-9 injectate																								
4/29/93	<0.05	0.1	<0.001	<0.002		0	<0.002	<0.002	<0.002		<0.01	<0.002		0.77	<0.002	<0.01	<0.002	<0.02	0.002			3.53		<0.01	

Table 4. Gas analyses for samples from deep wells. Cathy Janik and Linda Johnson performed gas analyses reported in this study.

Well (USGS ID#)	Sample No.	Date	Hours	Sep P psig	T °C	G/S Ratio ppmw	CO_2 ppm	H_2S ppm	NH_3 ppm	Ar ppm	N_2 ppm	O_2	CH_4 ppm	H_2 ppm	CO	He ppm	C-13, CO_2	N-15, N_2	S-34, H_2S	$^3He/^4He$ x 10^{-6}	Data Source
HGP-A		7/22/76															-3.62				26
(2883-01)		11/8/76															-2.35				26
		11/16/76															-3.28				26
		1/25/77																		>>8.25	26
		1/25/77																		8.25	26
		1/29/77		50	30	991	714	99			178			1							26
		1/30/77															-1.97				26
		2/77															-2.29				26
		2/9/77																		17	26
		2/9/77					4431	1435			131			46.3							25
		4/5/77		165	185	1604	946	321			337			8							26
		5/8/77																55.7			26
		5/8/77																56.7			26
		5/8/77					2378	878			375			15.1							25
		5/9/77		167	188	1912	1090	402			402			19							26
		5/9/77		40	188	2697	1753	647			270			11							26
		7/19/77																55.9			
		7/19/77																57.6			
		7/19/77		25	180	1337	949	241			147			7							26
		7/19/77					445	112			116			2.3							25
		1/10/80		88			825	704													16
		1/11/80		154			864	782													16
		1/13/80		156				766													16
		1/14/80		156			930	837													16
		1/15/80		155			900	825			195			10.9							16
		1/16/80		155			1010	760			169			11.0							16
		1/17/80		96			1000	750			168			11.0							16,25
		1/18/80		56			783	690			117			8.9							16
		1/18/80		56			760	900			108			6.4							16
		6/12/81																	6.2		21
		6/14/81					670	609			130.5			9.0	≈1						23
		6/25/81																	5.6		21
		7/22/81																	5.2		21
		8/3/81																	5.0		21
		2/8/82					964	1297			125			12.9	≈1						23
		5/31/82					1238	886			129			11.0							25
		initial production (1981)		155		2390	1300	950			130		1	13							22,14
		after 3.5 years (1985)		155		2130	1150	850			120			11							22,14

Table 4

Well (USGS ID#)	Sample No.	Date	Hours	Sep P psig	T °C	G/S Ratio ppmw	CO_2 ppm	H_2S ppm	NH_3 ppm	Ar ppm	N_2 ppm	O_2	CH_4 ppm	H_2 ppm	CO	He ppm	C-13, CO_2	N-15, N_2	S-34, H_2S	$^3He/^4He$ x 10^{-6}	Data Source
KS-1A (2883-06)		10/85 test		155		2000 to 2200	230 to 320	1200													14
KS-3	G-001	3/25/91	5:25 PM			1790	1250	493	1.49	0.4	18.7		17.5	7.03							15
(2883-09)	G-002	3/25/91	8:30 PM			1800	1180	575	0.89	0.26	19.2		18.6	9.86							15
	G-003	3/26/91	8:30 AM			1330	734	559	1.08	0.28	15.5		8.29	8.69							15
	G-004	3/26/91	5:25 PM			1330	692	592	0.769	0.44	27.19		5.71	10.4							15
	G-005	3/26/91	10:00 AM			1290	606	637	0.72	0.52	32.7		3.93	10.8							15
	G-006	3/27/91	6:40 PM			1200	540	623	0.86	0.31	20.6		3.58	10.4							15
	G-007	3/28/91	11:10 AM			1390	598	753	0.36	0.38	19.2		3.38	13.6							15
	G-008	3/28/91	5:10 PM			1390	596	754	0.33	0.41	24.4		2.73	13.1							15
	G-009	3/29/91	8:20 AM			1190	505	655	0.46	0.28	19.1		1.9	11.4							15
	G-010	3/29/91	2:25 PM			1190	553	611	0.2	0.41	7.86		2.66	16.4							15
	G-011	3/30/91	8:10 AM			1190	556	611	0.23	0.17	11.5		1.75	13.7							15
	G-012	3/30/91	5:10 PM			1200	517	658	0.24	0.16	10.5		1.75	14.6							15
	G-013	3/31/91	8:10 AM			1170	487	654	0.17	0.3	13.1		1.55	13.2							15
	G-014A	3/31/91	1:20 PM			1320	510	760	0.18	0.38	27.5		1.72	15.7							15
	G-014B	3/31/91	2:00 PM			1250	475	613	0.12	1.77	139		1.63	14.0							15

Well	Sample No.	Date	Hours	Sep P psig	T °C	G/S (mol dry/ 1000 mol H_2O vap.)	CO_2 mol % dry	H_2S mol % dry	NH_3 mol% dry	Ar mol% dry	N_2 mol% dry	O_2 mol % dry	CH_4 mol% dry	H_2 mol% dry	CO mol% dry	He mol% dry	C-13, CO_2
KS-8	Set #1	8/13/92	7:30 PM	218	201.7	1.065	17.56	67.94	0.043	0.103	3.69	0.003	0.110	10.62		0.0004	
(2883-11)	Set #2	8/14/92	4:00 PM	220	200.0	0.921	18.70	69.05	0.047	0.084	3.00	0.018	0.080	9.16		0.0000	-4.6
	Set #3	8/15/92	2:45 PM	225	201.7	0.902	18.34	68.71	0.050	0.091	3.21	0.002	0.064	9.77		0.0000	-4.6
	Set #4	8/16/92	3:40 PM	217	198.3	0.908	18.25	68.93	0.046	0.086	3.10	0.004	0.064	9.72		0.0002	-3.9
	Set #5	8/17/92	~2 PM	213	198.3	0.868	18.50	68.55	0.043	0.085	3.11	0.003	0.058	9.89		0.0000	-3.9
	Set #6	8/18/92	11:05 AM	215	198.3	0.840	17.55	69.54	0.044	0.086	3.05	0.005	0.053	9.91		0.0000	-4.1
KS-9	KH93-2S	4/28/93	3:30 PM	222	200	0.757	17.89	64.43	0.029	0.095	3.65	0.009	0.238	13.98		0.0000	-5.5
(2883-13)	KH93-5S	4/29/93	3:30 PM	225	200	0.735	17.74	64.97	0.027	0.097	3.83	0.003	0.232	13.36		0.0000	-5.7

Table 5. Physical data for samples from deep wells.

Well (ID No.)	Status	Date	Hours	WHP psia	WHP psig	WHT °C	Orifice inches	Sep P psia	Sep P psig	Sep T °C	Weir T °C	Total Flow K-lbs/hr	Steam flow % of total	Enthalpy BTU/lb	Data Source
HGP-A	Produced up to 3 MW	11/76	after 7 hrs		55	150					95.0	97.3	75.2	912	18
(2883-01)	between 1982-89;	11/76	after 25 hrs		47	146					95.0	87.9	72.6	888	18
	now shut in	12/16/76	after 7 hrs		66	157					97.2	120	56.9	725	18
		12/17/76	after 25 hrs		53	150					96.1	103.4	67.7	833	18
		1/77	after 7 hrs		72	160					97.8	139.7	65.6	805	18
		1/77	after 25 hrs		59	151					96.1	114.3	68.2	845	18
		1/77			51	146	8					101	69.3		18
		1/77			54	149	6					99	70.7		18
		1/77			100	170	4					93	71		18
		1/77			165	189	3					89	69.7		18
		1/77			237	205	2.5					84	69		18
		1/77			293	215	2					81	66.7		18
		1/77			375	226	1.75					76	65.8		18
		4/22/77						14.9		100.4			54.6	710	8, 14
		1/10/80	10:00						88	165.4			46.2	710	16, 14
		1/11/80	13:00						154	186.6			43.2	710	16, 14
		1/16/80						132.0		175.8			44.7	710	8, 14
		6/12/81						14.9		100.4			54.5	710	8, 14
		9/4/81						174.0		187.9			43	710	8, 14
		12/11/81						14.9		100.4			54.5	710	8, 14
		6/7/82						169.7		186.8			43.2	710	8, 14
		11/16/82						169.7		186.8			43.2	710	8, 14
		5/4/83						169.7		186.8			43.2	710	8, 14
		12/5/83						159.5		184			43.5	710	8, 14
		1/12/84			160										14
		6/26/84						159.5		184			43.5	710	8, 14
		11/28/84						159.5		184			43.5	710	8, 14
KS-1	Tested at 3.2 MW -	8/11/82		122								71.0		dry steam	14
(2883-03)	damaged and plugged	through		126								78.9		dry steam	14
		8/28/82		233								59.7		dry steam	14
		"		168								69.6		dry steam	14
		"		154								69.5		dry steam	14
		"		133								68.0		dry steam	14
		"		193								66.4		dry steam	14
		"		131								73.0		dry steam	14
		"		216								59.7		dry steam	14
		"		129								72.5		dry steam	14
KS-2	Tested at 2 MW -	6/9/82			175										14
(2883-04)	damaged and plugged	7/28/82		163								37.8		wet steam	14
		through		225								19		dry steam	14
		8/2/82		188								35.2		dry steam	14

Table 5

Well (ID No.)	Status	Date	Hours	WHP psia	WHP psig	WHT °C	Orifice inches	Sep P psia	Sep P psig	Sep T °C	Weir T °C	Total Flow K-lbs/hr	Steam flow % of total	Enthalpy BTU/lb	Data Source
KS-1A	Tested at 3 MW -	10/7/85		170								74.9		1038	14
(2883-06)	damaged and plugged;	through		94								70.9		1049	14
	re-opened as injector	10/31/85		124								77.5		1038	14
	for KS-8, 9, and 10	"		170								79.1		1034	14
		"		217								78.1		1021	14
		"		271								76.6		1009	14
		"		314								75.5		999	14
		"		364								74.7		976	14
		"		418								73.5		980	14
		"		486								68.4		960	14
		"		514								70.6		955	14
		"		679								63.9		906	14
		"		920								49.3		782	14
		"		168								80.7		1046	14
		10/16/85	9:30		155				160	183.3			83.0		14
		10/19/85	17:00		155				156	180.6			83.0		14
		10/19/85	17:00		155				156	180.6			83.0		14
		10/24/85	21:00		155				155	185			83.0		14
		10/24/85	21:00		155				155	185			83.0		14
		10/24/85	21:00		155				155	185			83.4	1054	14
		10/24/85	21:00		155				155	185			83.4	1054	14
		10/26/85	21:00		80				72	157.2			85.0	1050	14
		10/28/85	4:00		155	187			154	185			83.0		14
		10/28/85	23:30	345					153	183.9			83.0		14
		10/29/85	13:30	640					153	183.9			83.0		14
		10/31/85	12:45		155				153	185			82.0	1042	14
KS-3	Tested at 3.2 MW -	3/25/91		190								92.9		937	14
(2883-09)	shut -in, then	through		103								90.3		951	14
	converted to injector	3/31/91		315								83.1		912	14
	for KS-8, 9, and 10	"		119								88.1		970	14
		"		450								75.2		884	14
		"		615								72.1		856	14
		"		237								85.2		957	14
		"		241								85.2		957	14
		3/25/91	6:15 PM		200	196			53						15
		3/25/91	8:40 PM		195	196			65						15
		3/26/91	8:35 AM		182	193			62						15
		3/26/91	5:30 PM		175	192			60						15
		3/27/91	9:30 AM		172	192			61						15
		3/27/91	6:50 PM		94	167			64						15
		3/28/91	11:20 AM		300	214			59						15
		3/28/91	5:20 AM		304	215			60						15
		3/29/91	8:00 AM		102	170			59						15
		3/29/91	2:30 PM		445	232			59						15
		3/30/91	8:15 AM		237	203			58						15
		3/30/91	5:20 PM		228	201			60						15
		3/31/91	8:15 AM		236	202			60						15
		3/31/91	1:25 PM		232	201			60						15

Table 5

Well (ID No.)	Status	Date	Hours	WHP psia	WHP psig	WHT °C	Orifice inches	Sep P psia	Sep P psig	Sep T °C	Weir T °C	Total Flow K-lbs/hr	Steam flow % of total	Enthalpy BTU/lb	Data Source
KS-8	Damaged during	8/13/92	6:05 PM		1370	304			210	197.2		248	92.7		PGV
(2883-11)	flowtest; plugged	8/13/92	7:03 PM		1800	324			218	201.7		128	85.9		PGV
		8/14/92	4:00 PM		1550	319			220	200		218.2	87.1		PGV
		8/15/92	2:00 PM		1135	298			225	201.7		303.5	87.3		PGV
		8/16/92	2:00 PM		1800	331			217	198.3		133.9	84.4		PGV
		8/17/92	3:00 PM		1625	322			213	198.3		191.7	91.3		PGV
		8/18/92	10:00 AM		1625	320			215	198.3		201.5	87.3		PGV
		8/18/92	11:00 AM		1500	318			215	198.3		228	88.2		PGV
KS-9	In production since	4/28/93	3:45 PM		1694				215	200		266			PGV
(2883-13)	5/93	4/29/93	3:30 PM		1700				218	200		270			PGV

Table 6. Selected chemical analyses (mg/L) and physical data for deep wells on the east rift and sea water. ENEL code is from ENEL (1990). Cation geothermometers are from Fournier (1981), Giggenbach (1986), Kharaka and Mariner (1989). Quartz geothermometer temperatures calculated using the quartz solubility equation of Fournier and Potter (1982b), the method of Fournier (1983) for correcting for the effect of dissolved constituents, and the water density tables of Potter and Brown (1977) for an assumed pressure of 200 bars. Quartz BF is the quartz conductive temperature from the added steam calculation. Added steam is the fraction of steam at the well head that did not come from boiling liquid water in the reservoir. Downhole chloride is the concentration in the calculated amount of liquid water at depth.

Sample No.	ENEL Code	Well No.	Name	Date Collected	pH(l)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	F	Li	B	TDS calc.	Bal %	Collection Information	Data Source
			Seawater			410	1350	10500	390	142	2700	19000	6.4	1.3	0.17	4.5	34400	0.5		Hem (1985)
	64	2883-01	HGP-A	6/18/81		25	0.006	1100	200			1986			0.34				brine	24,2
	73	2883-01	HGP-A	9/4/81		72	0.1	2190	250		63	3700	795						liq. phase	25,23,(21),2
	88	2883-01	HGP-A	6/7/82		122.5	0.051	3120	525			5667	803		0.94				liq. phase	24,8,2,14
	104	2883-01	HGP-A	11/16/82		217	0.104	3940	650			7029	829						liq. phase	8,2,14
	118	2883-01	HGP-A	12/5/83		319	0.21	4650	763		24	8827	825		1.25				liq. phase	8,2,14
	124	2883-01	HGP-A	11/28/84		399	0.2	5420	733		4.5	9514	913						liq. phase	8,2,14
		2883-02	Lanipuna 1	7/15/81	7.14	1160	0.85	6830	505	56.6	59.1	13700	150	0.38	0.95	5.3	22400	-5.4	blooie line, air lift	14
	L6b	2883-05	Lanipuna 6	8/9/84	8.30	1524	15	8380	420	34.0	403	15600	135			3.4	26500	0.8	airlift to unload; blooie, 1600 hrs	2,14
		2883-06	Kapoho State 1A	10/24/85	8.32	903	2.15	10720	2940	3.5	25	19645	900	0.75		5.5	35100	5.7	2100 hrs	14
BC-005		2883-09	Kapoho State 3	3/27/91	3.77	3604	43.0	20892	4892		2.5	46600	1300	1.70	15.6	22.6	77400	-0.6	9:30a, liq. phase	15
KS8-6 B		2883-11	Kapoho State 8	8/18/92	4.22	5.39	0.04	4.72	1.51	0	2.98	17	203	0.26	<0.01	6.1	241	-4.0	liq. phase, 10:00a	
KH93-5B		2883-13	Kapoho State 9	4/29/93	4.84	0.58	<0.01	7.19	1.63	0	1.91	11.3	231	0.52	<0.01	8.24	262	1.0	liq. phase, 3:00p	

Table 6 (continued).

Name	Date Collected	WHP bar	WHT °C	Sep P bar	Sep T °C	Total flow kg/s	Steam flow %	Enthalpy j/g	Enthalpy Temp. °C	Quartz ad. °C	Na-K-Ca °C	Na-K °C	K-Mg °C	Mg-Li °C	Quartz BF °C	Added Steam	Downhole Chloride mg/kg
Seawater											174	145	97	9			
HGP-A	6/18/81										255	274	346	183			
HGP-A	9/4/81			12.1						261	227	229	268				
HGP-A	6/7/82			11.7	186.8					262	256	266	338	180			
HGP-A	11/16/82			11.7	186.8					264	253	264	328				
HGP-A	12/5/83			11.0	184.0	14	43	1641	346	264	252	263	314	164	279	0.27	6900
HGP-A	11/28/84			11.0	184.0					272	239	244	313		288	0.24	7100
Lanipuna 1	7/15/81									153	195	192	247	130			
Lanipuna 6	8/9/84									147	174	164	173				
Kapoho State 1A	10/24/85	11.7		11.7	185.0	10	83.4	2451	>lw	280	301	322	327		310	0.79	15700
Kapoho State 3	3/27/91	12.9	192	5.2	153	12	74.3	2209	>lw	302	287	303	264	159	318	0.61	30300
Kapoho State 8	8/18/92	104.5		15.8	198.3	28.7	88.2	2562	350° steam	342							
Kapoho State 9	4/29/93	118		16.0	200	34											

Notes:

HGP-A: Charge balances are within ±5 % without HCO_3 (and SO_4 when not determined). Total flow, steam fraction, and enthalpy assumed constant for duration of flow.

KS-1A: Flow is on unknown date at 170 psia wellhead pressure. Constant reported steam fraction is assumed to be at separator. Variation in amounts of dissolved constituents with well head pressure is assumed to reflect sampling at well head rather than at separator. Listed data have same conditions at well head and separator. Quartz adiabatic and boiling fluid calculation use representative silica of 1000 mg/L.

KS-3: Representative enthalpy of 950 Btu/lb used to calculate steam fraction at separation pressure.

KS-8: Quartz adiabatic temperature based on the solubility of silica in high-temperature steam using the equation of Fournier and Potter (1982b) and assuming that the steam-water mixture sampled at the well head was produced from saturated steam in the reservoir.

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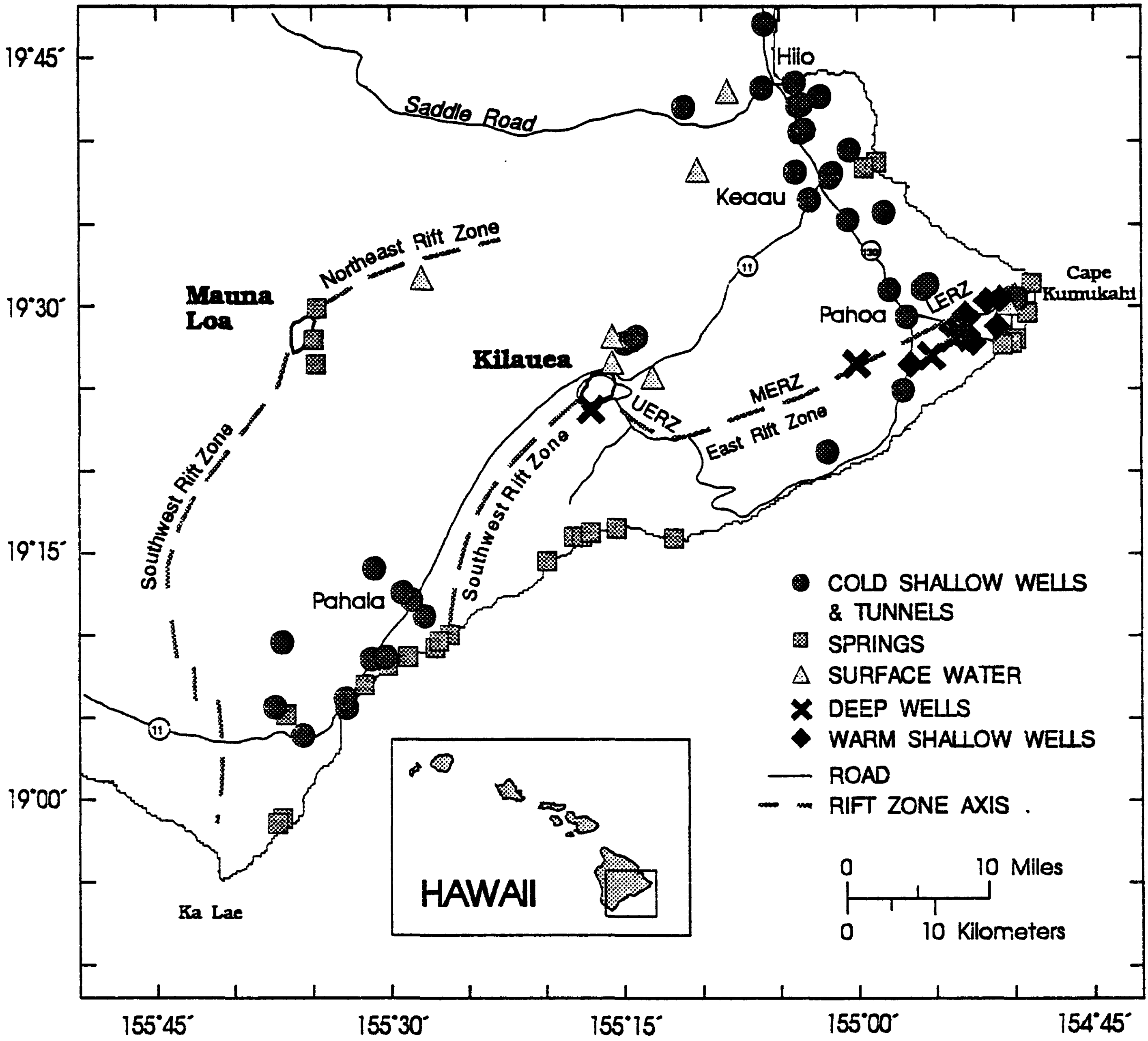

Figure 1. Map of southern part of island of Hawaii with sample locations reported in this study.

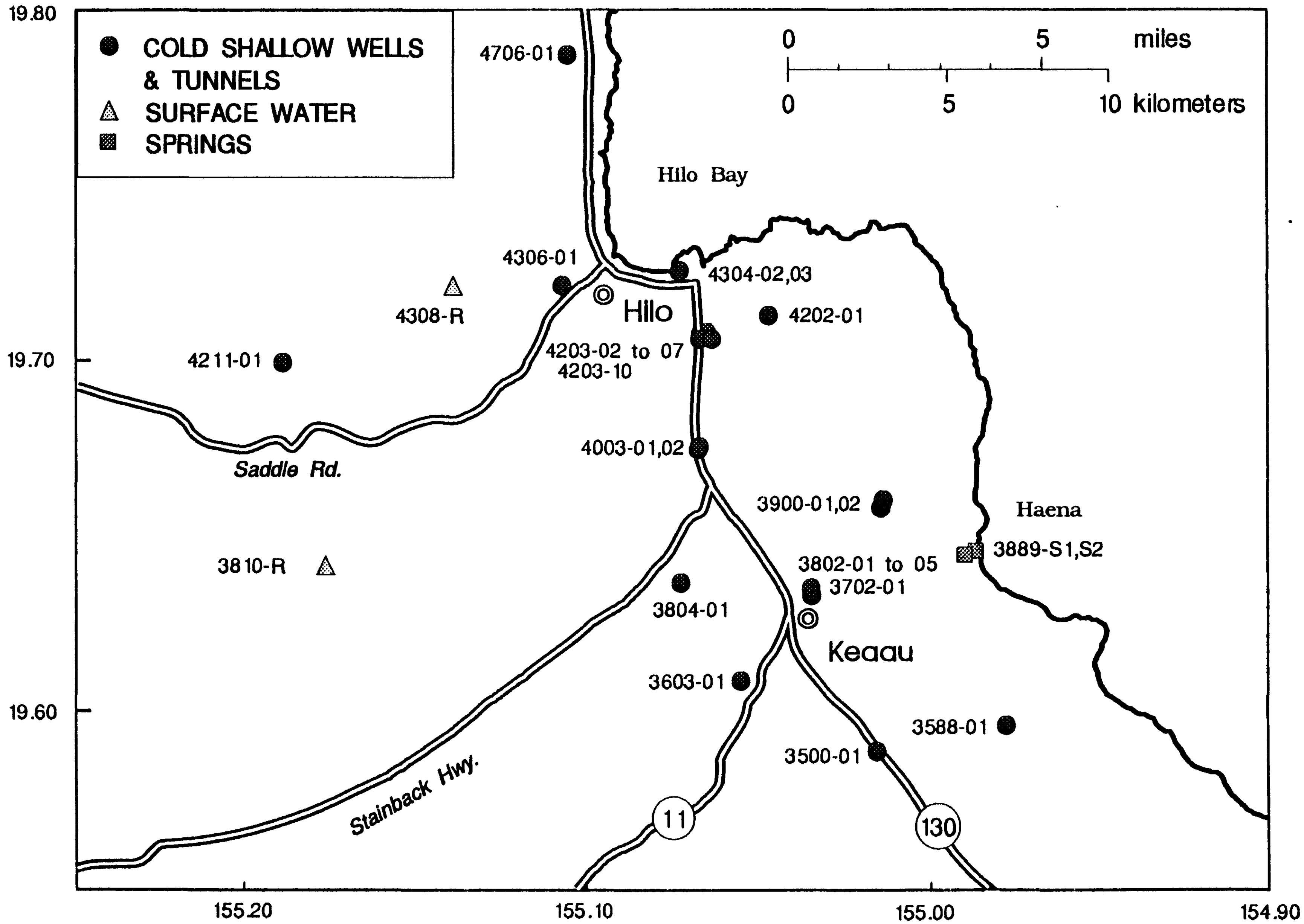

Figure 2. Map of Hilo and vicinity with sample locations.

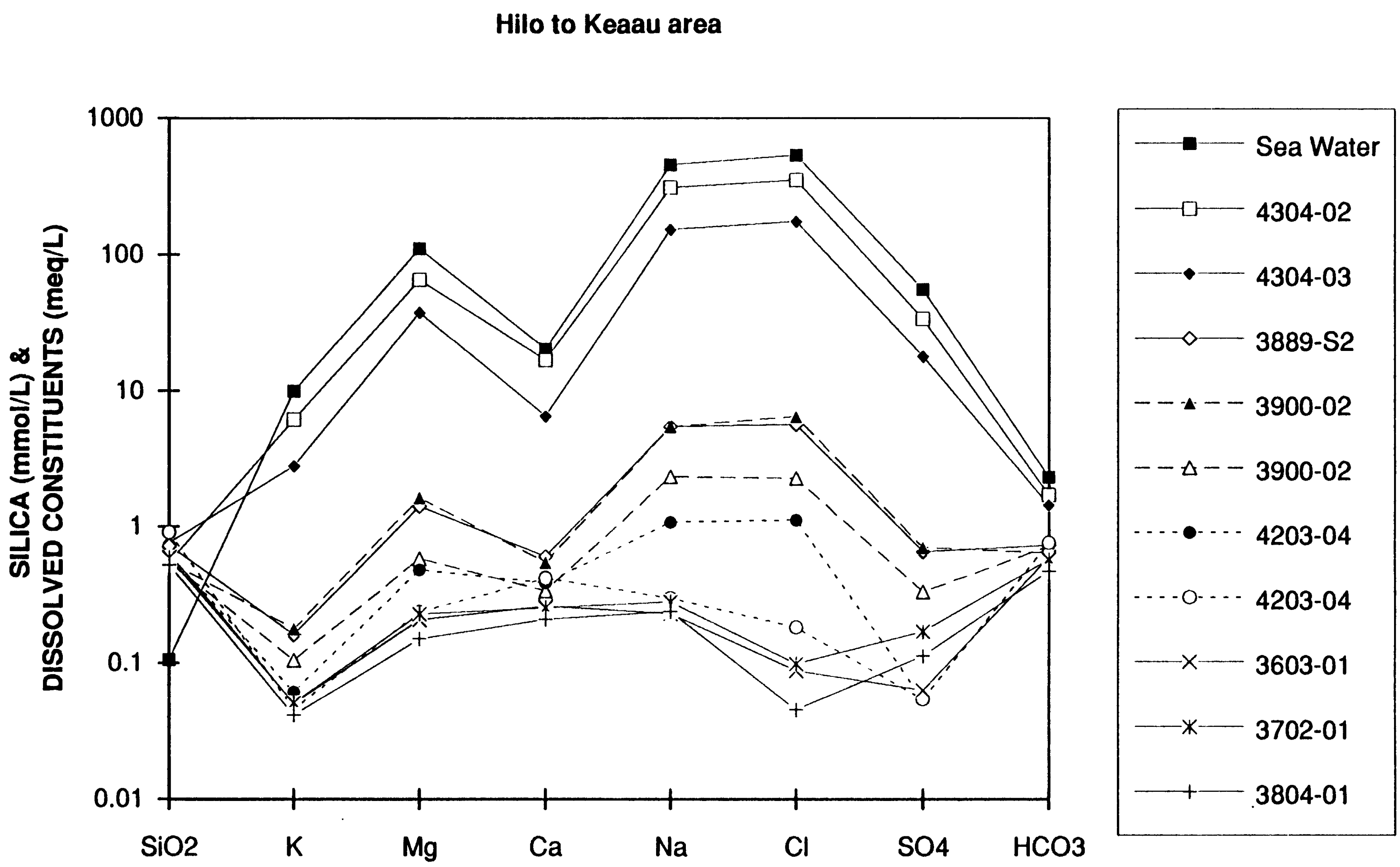

Figure 3. Modified Schoeller diagram for samples from Hilo to Keaau area. Haena Spring above beach (3889-S2) is along coast. Wells in order listed are: Waiakea (4304-02, 4304-03), Keaau Orchard 2 (3900-02), Waiakea 4 (4203-04), Olaa 3 (3603-01), Olaa Shaft (3702-01), and Keaau (Shipman) (3804-01).

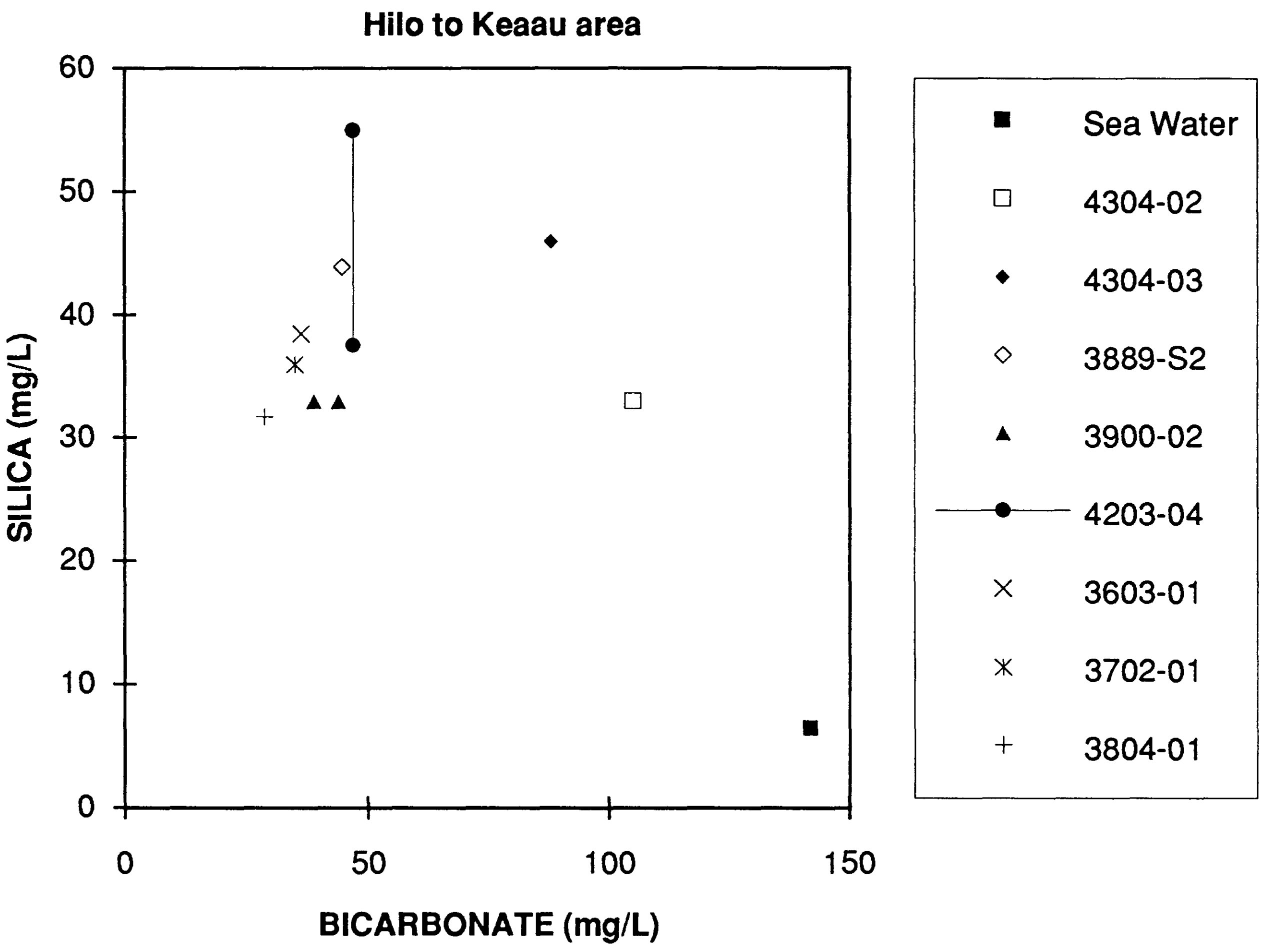

Figure 4. Silica versus bicarbonate for samples of Figure 3.

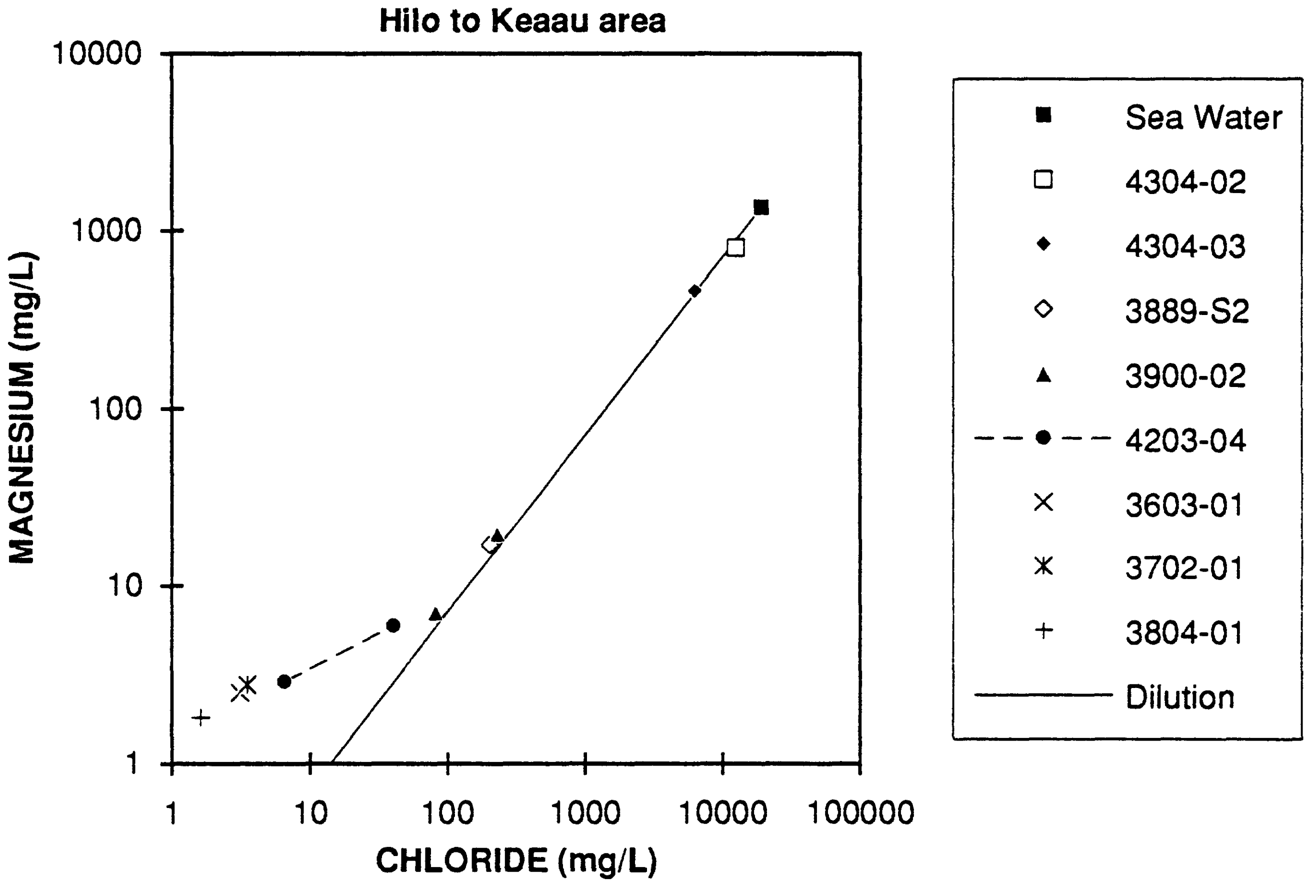

Figure 5. Magnesium versus chloride for samples of Figure 3. Dilution line shown differs from mixing line at low concentrations.

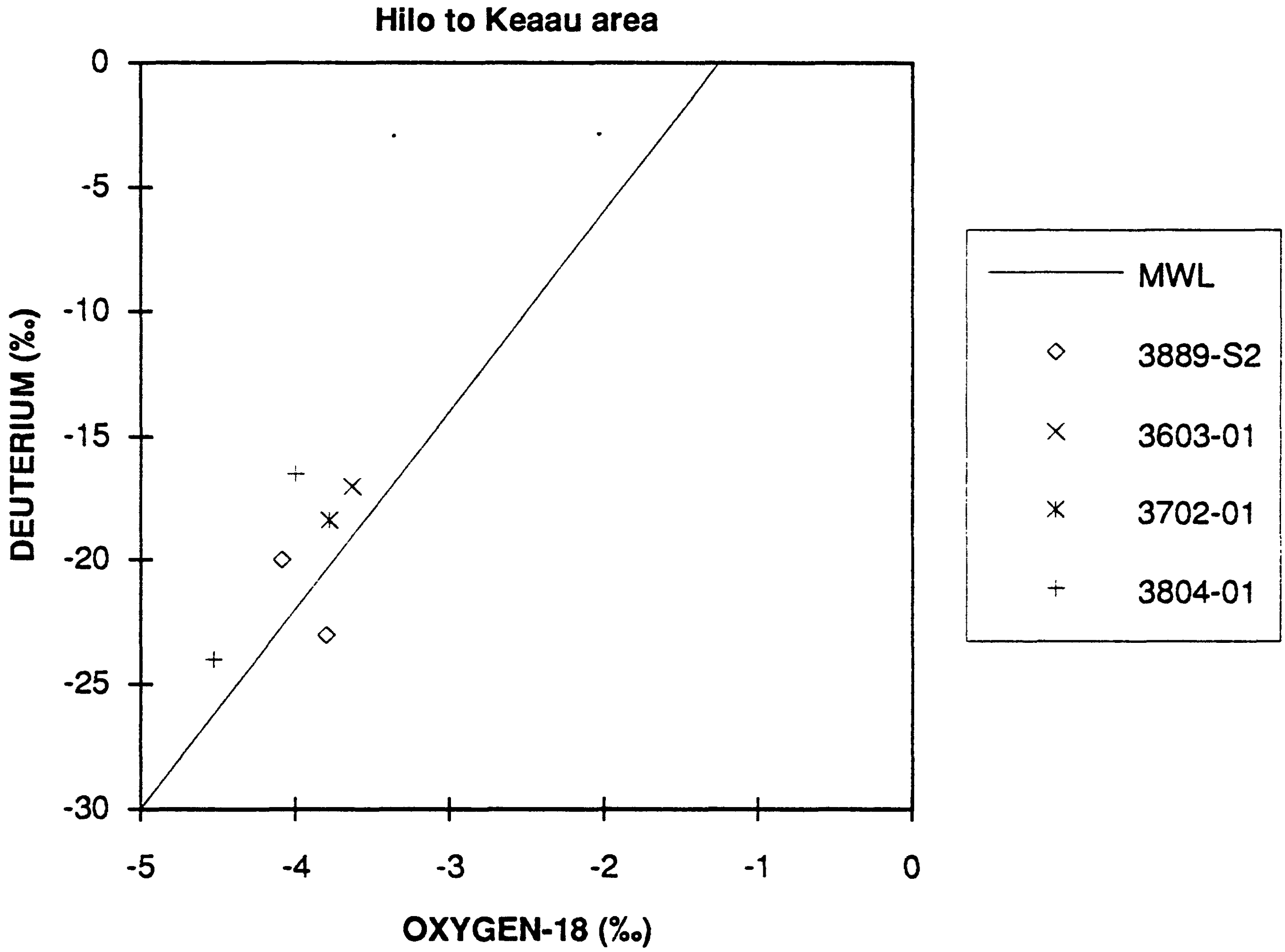

Figure 6. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) relative to SMOW for samples of Figure 3. Data for repeat samplings shown. Global meteoric water line is from Craig (1961).

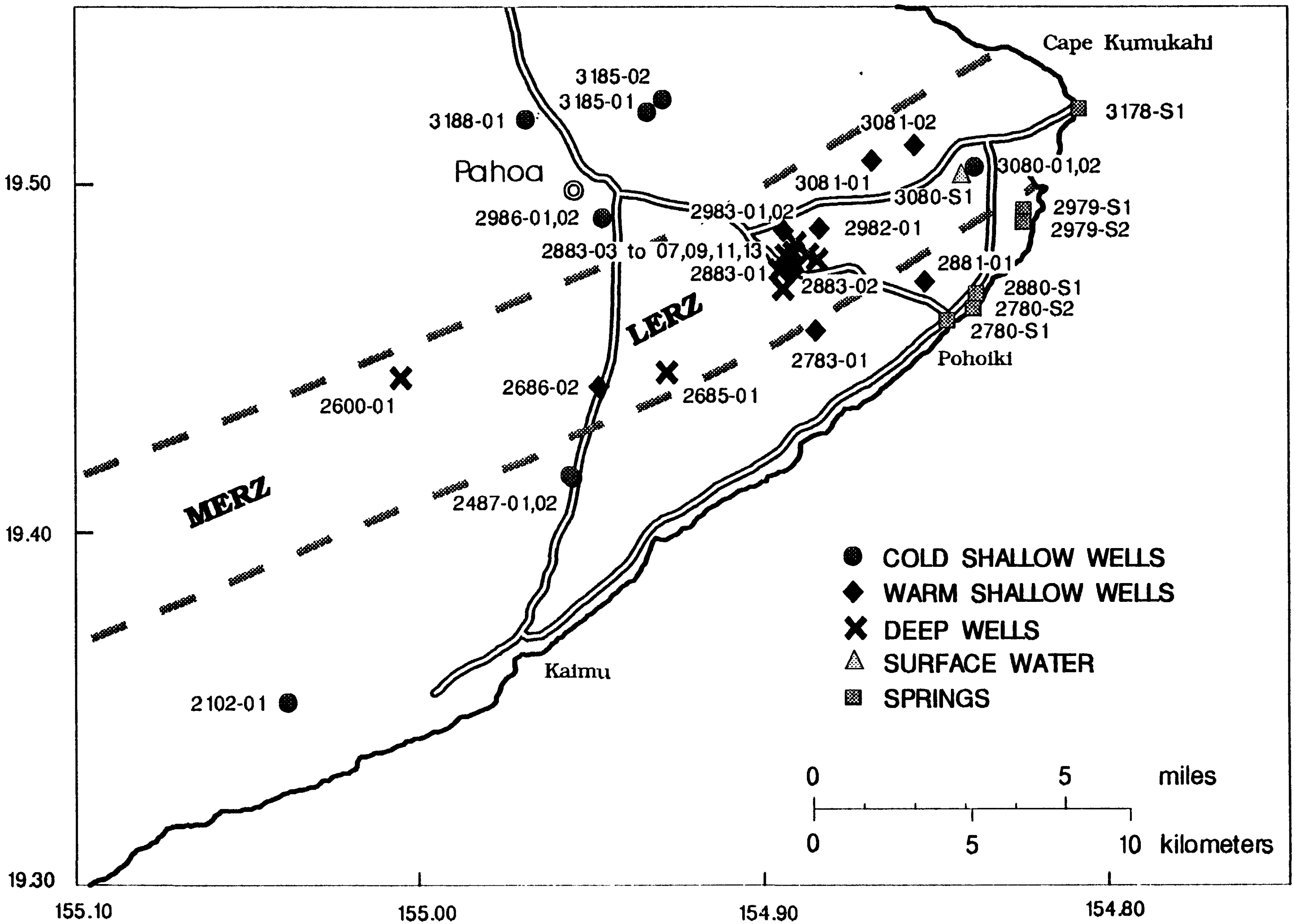

Figure 7. Map of part of east rift area of Kilauea and vicinity.

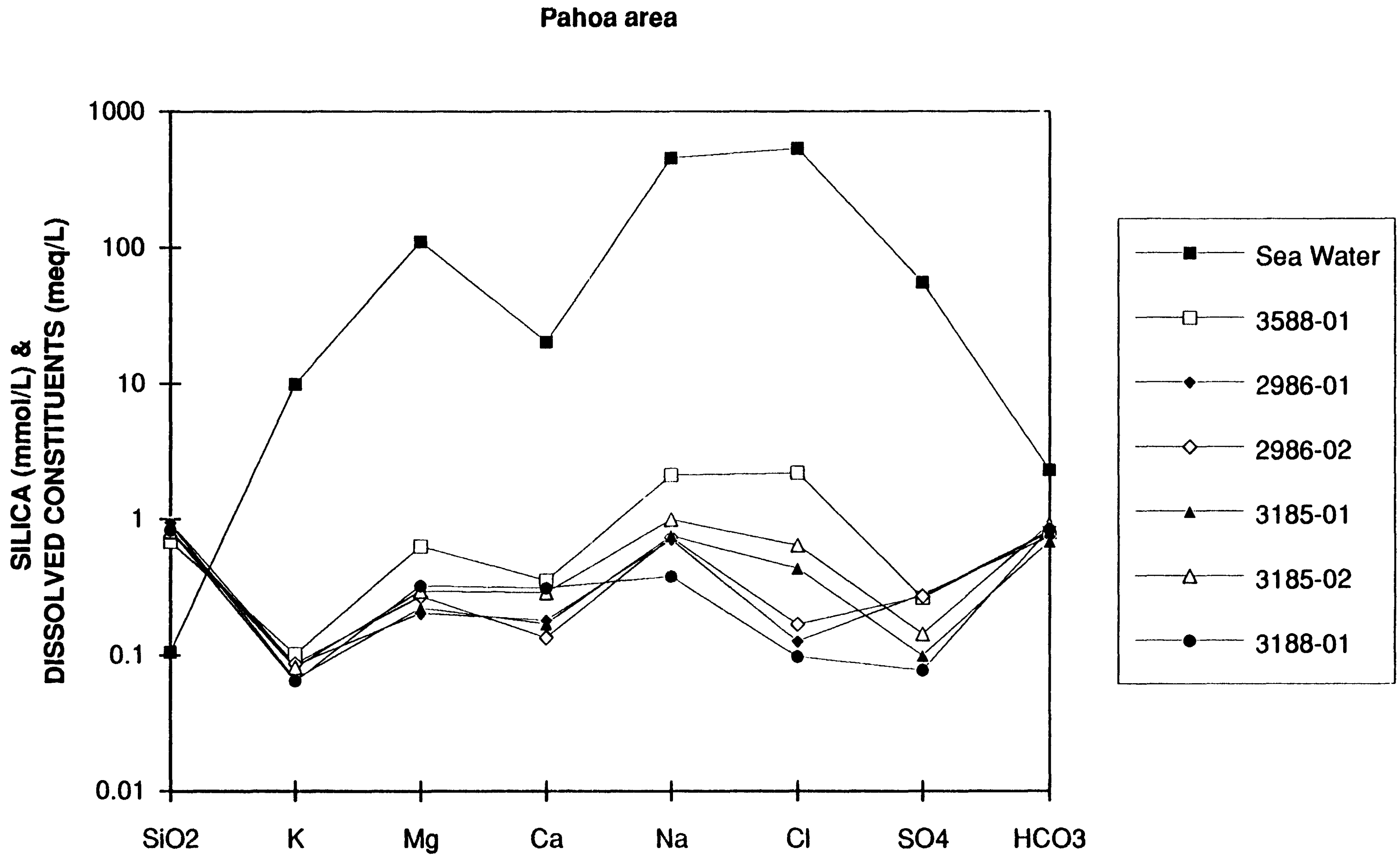

Figure 8. Modified Schoeller diagram for samples from Pahoa area and Hawaiian Paradise. Wells in order listed are: Hawaiian Paradise 1 (3588-01), Pahoa Battery 2A (2986-01), Pahoa Battery 2B (2986-02), Hawaiian Shores 1 (3185-01), Hawaiian Shores 2 (3185-02), and Keonepoko Nui (3188-01).

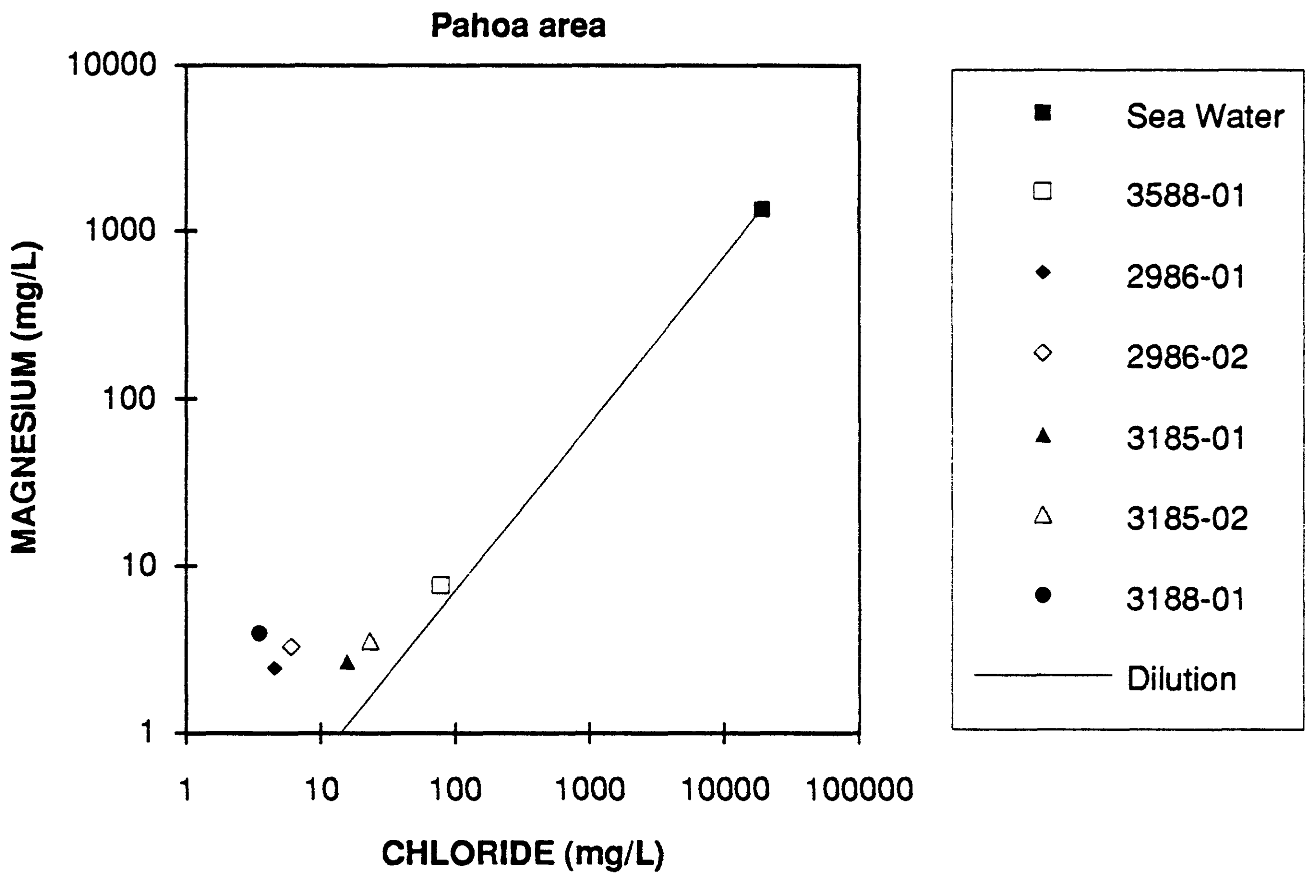

Figure 9. Magnesium versus chloride for samples of Figure 8. Dilution line shown differs from mixing line at low concentrations.

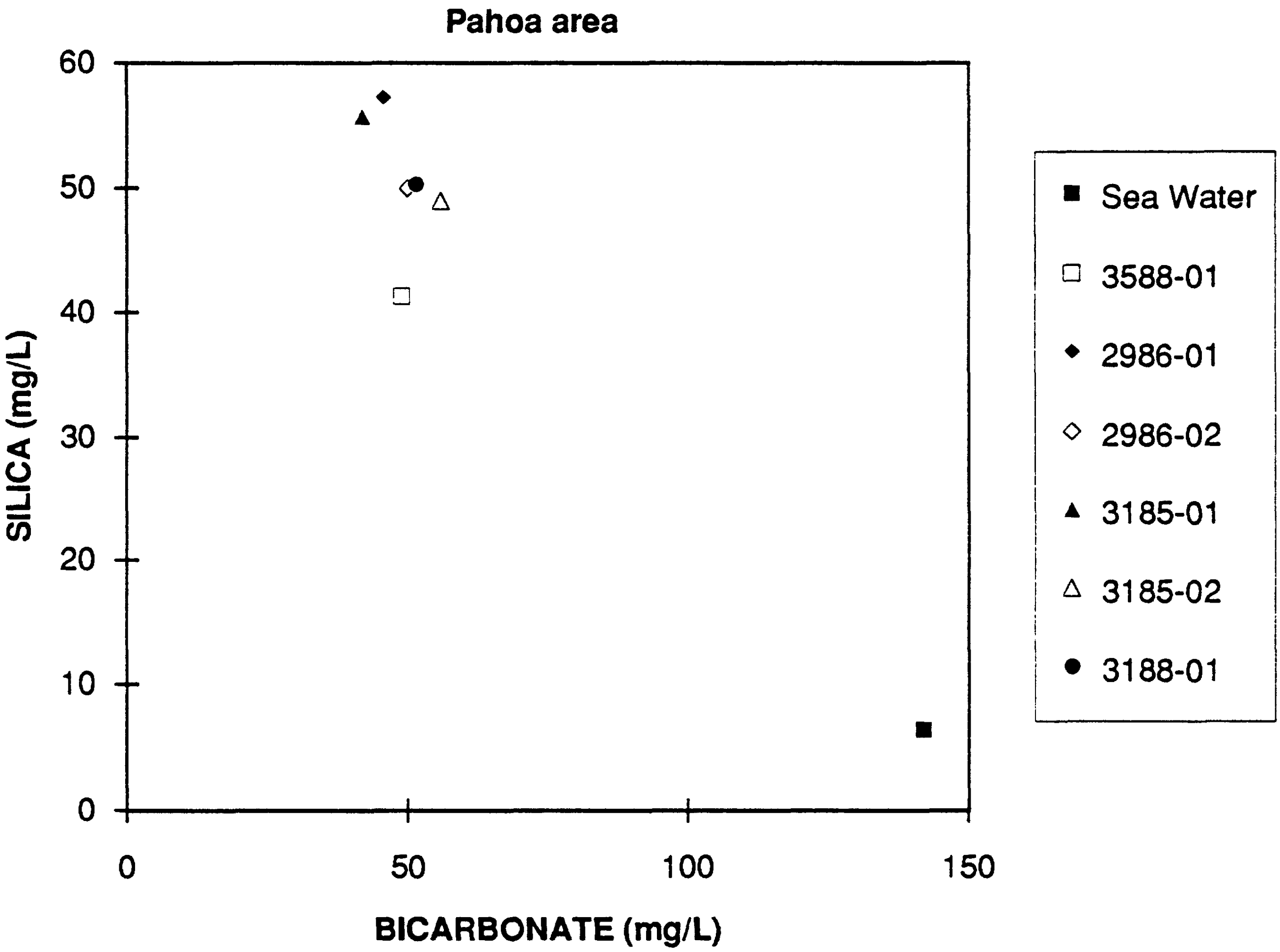

Figure 10. Silica versus bicarbonate for samples of Figure 8.

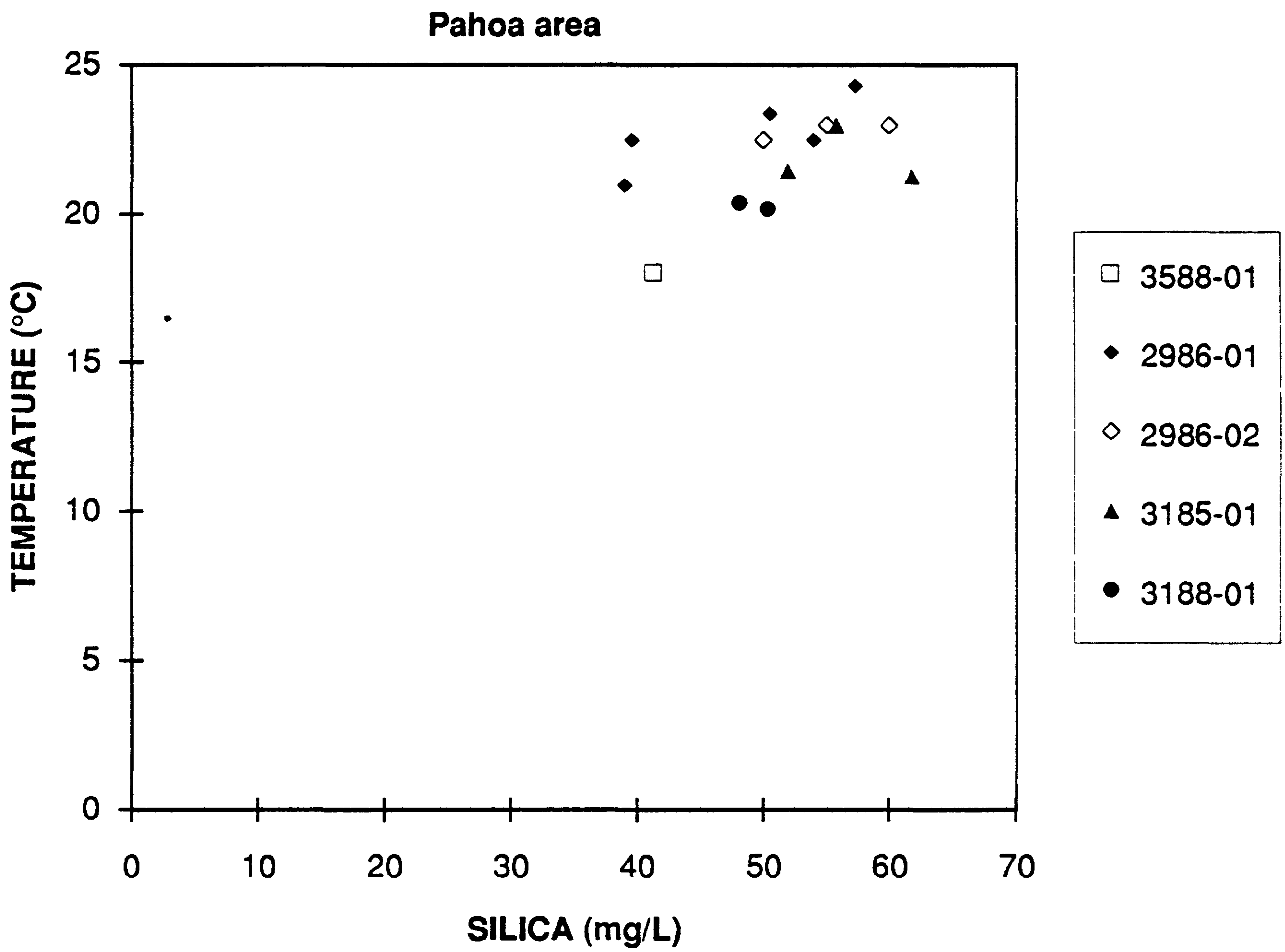

Figure 11. Temperature versus silica for samples of Figure 8. Data for repeat samplings shown.

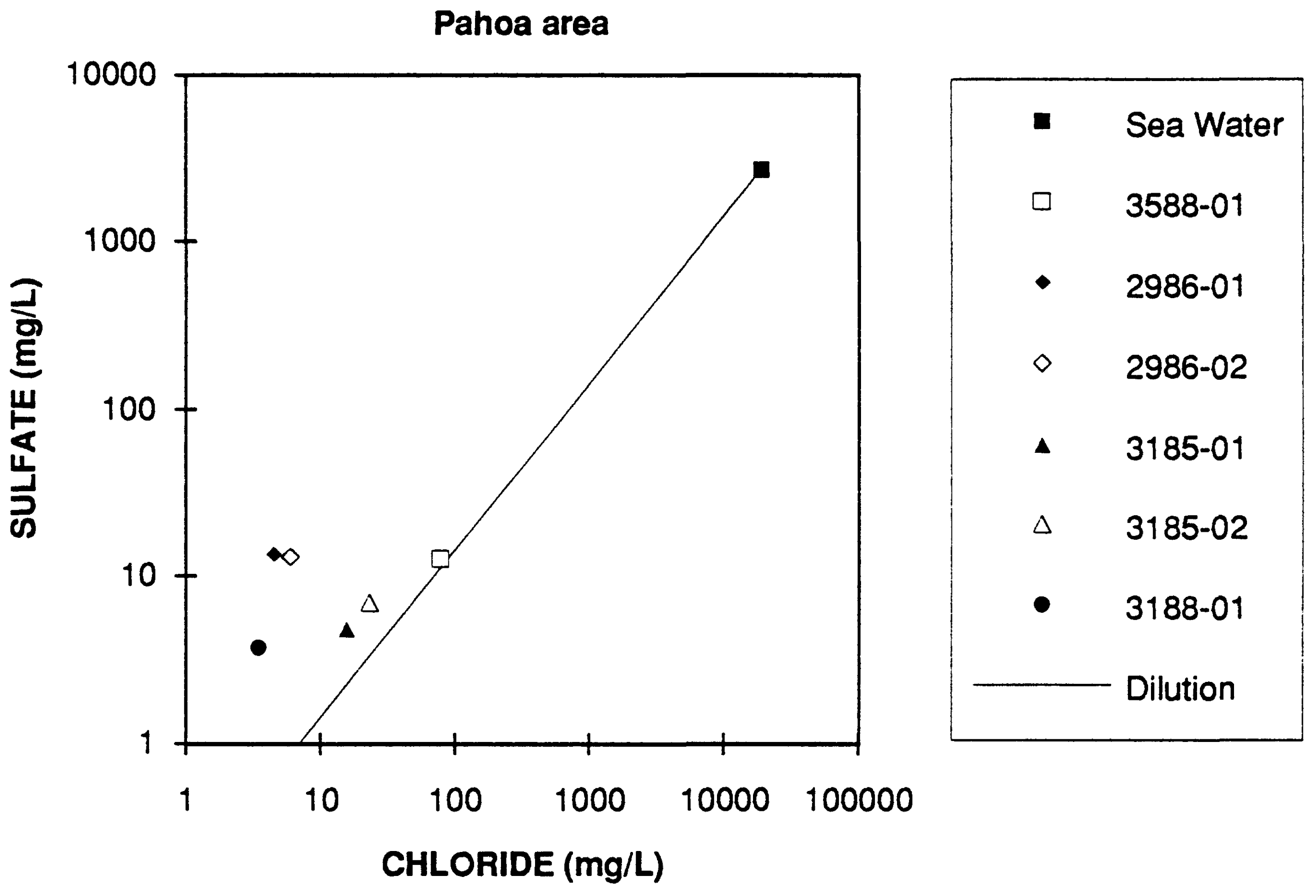

Figure 12. Sulfate versus chloride for samples of Figure 8.

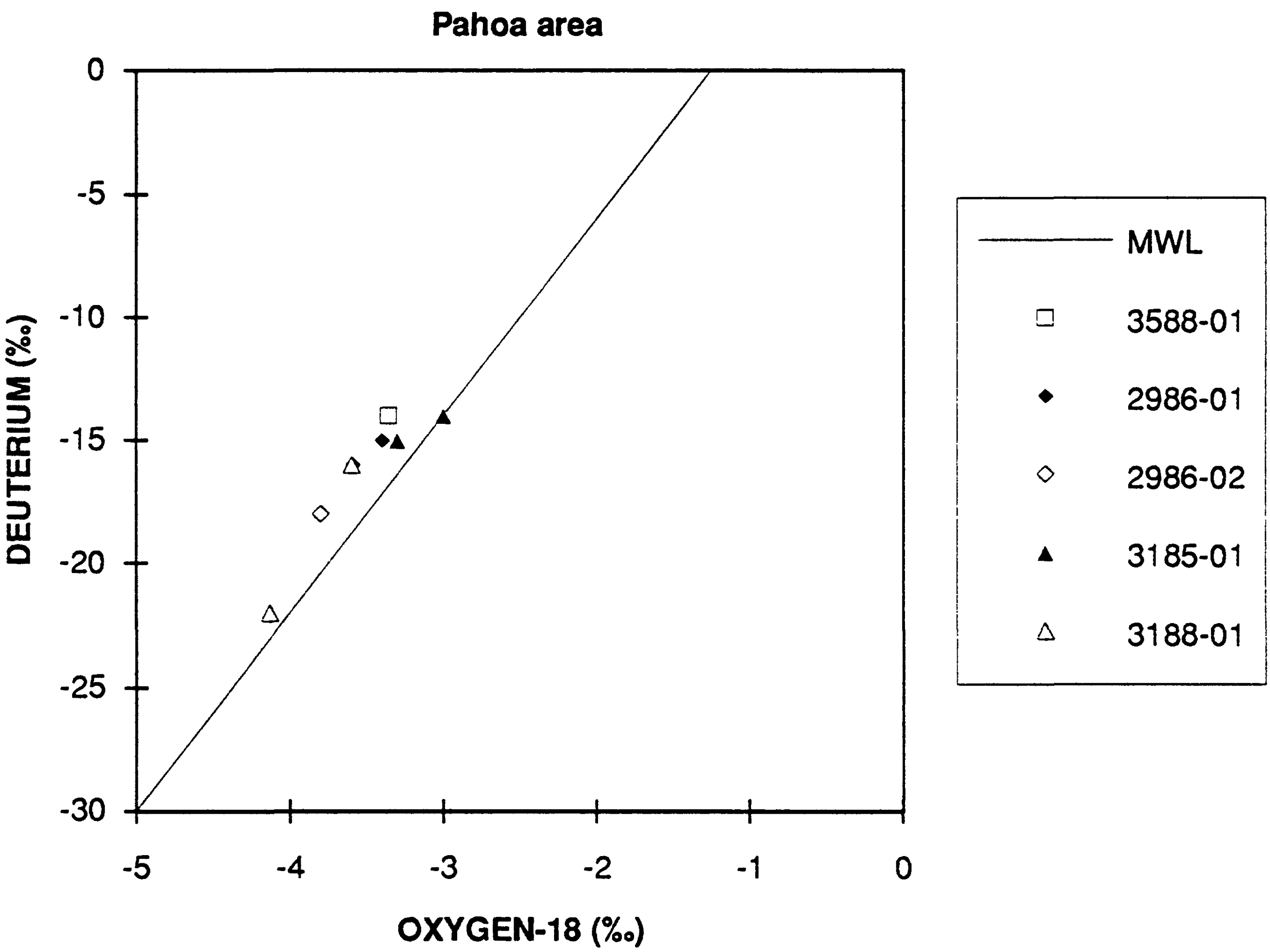

Figure 13. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples of Figure 8. Data for repeat samplings shown. Global meteoric water line is from Craig (1961).

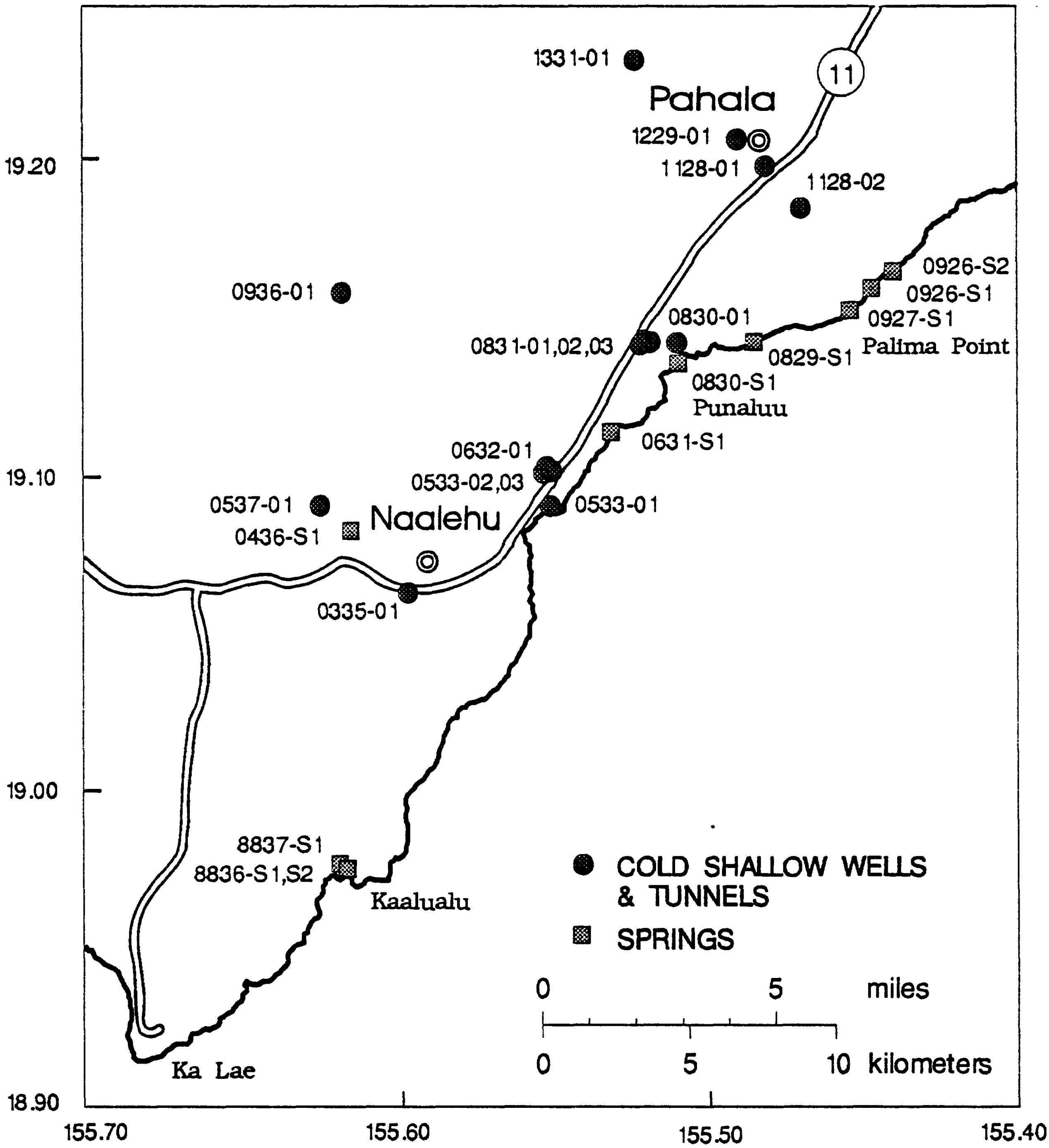

Figure 14. Map of area from Pahala to Kaalualu showing sample locations.

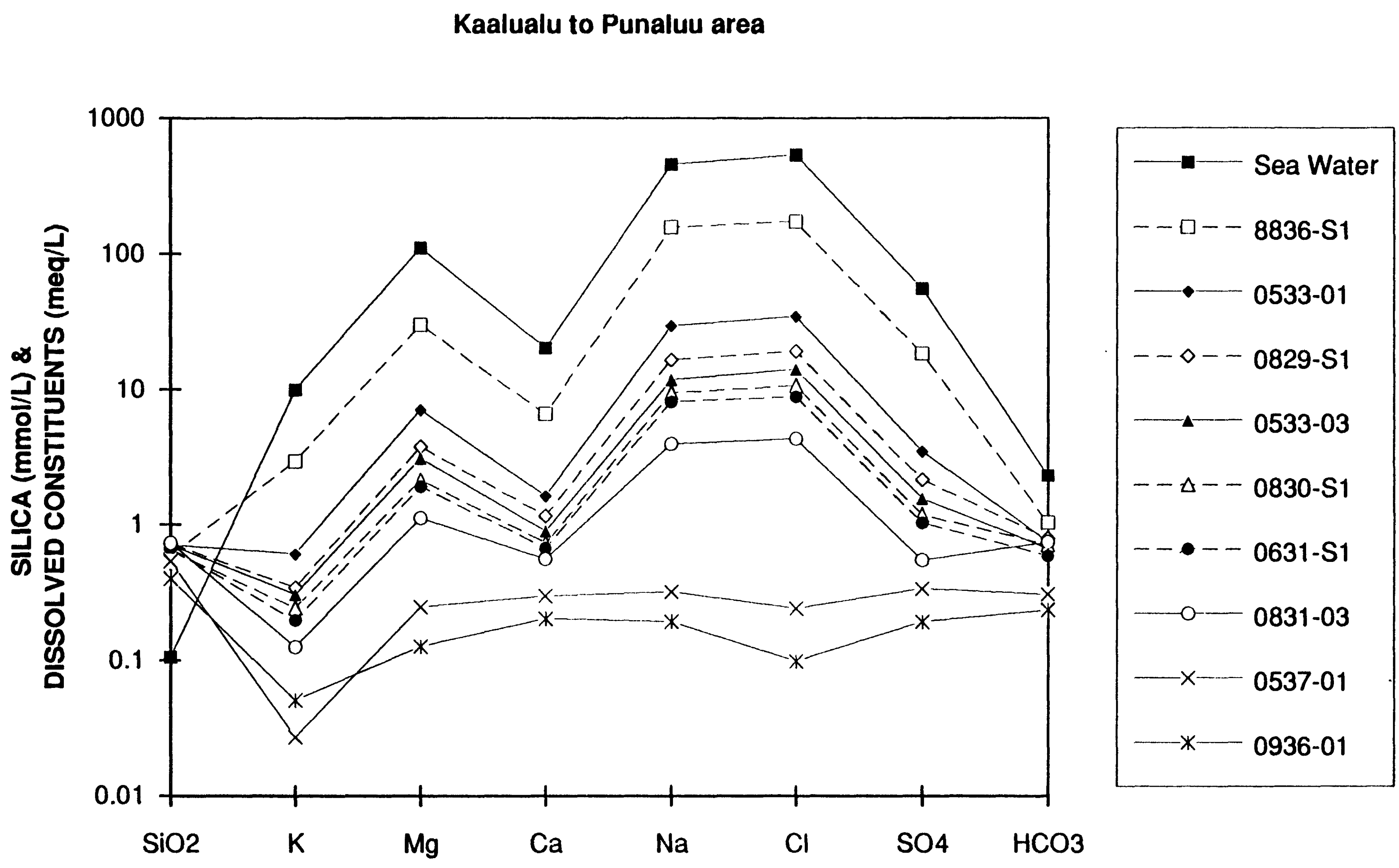

Figure 15. Modified Schoeller diagram for samples from Kaalualu to Punaluu area. Kaalualu Spring 1 (8836-S1), Kamehame Hill crack (0829-S), and Punaluu beach spring (0830-S1), and Kawa Spring (0631-S1) are along coast and are shown with broken lines. Wells and tunnels in order listed are: Honuapo Mill (0533-01), Honuapo 3 (0533-03), Ninole B (0831-03), Haao Tunnel (0537-01), and New Mountain House Tunnel (0936-01).

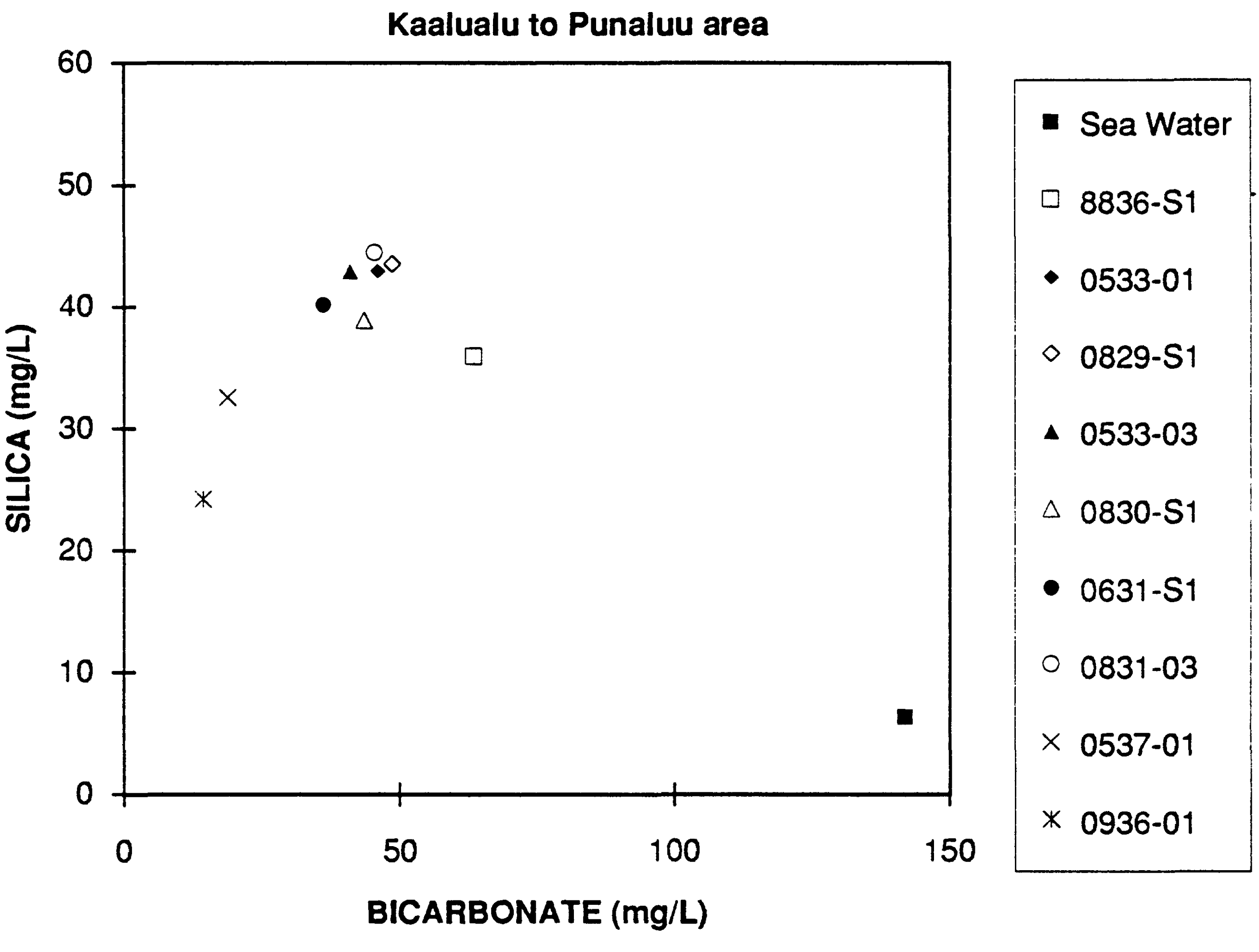

Figure 16. Silica versus bicarbonate for samples of Figure 15.

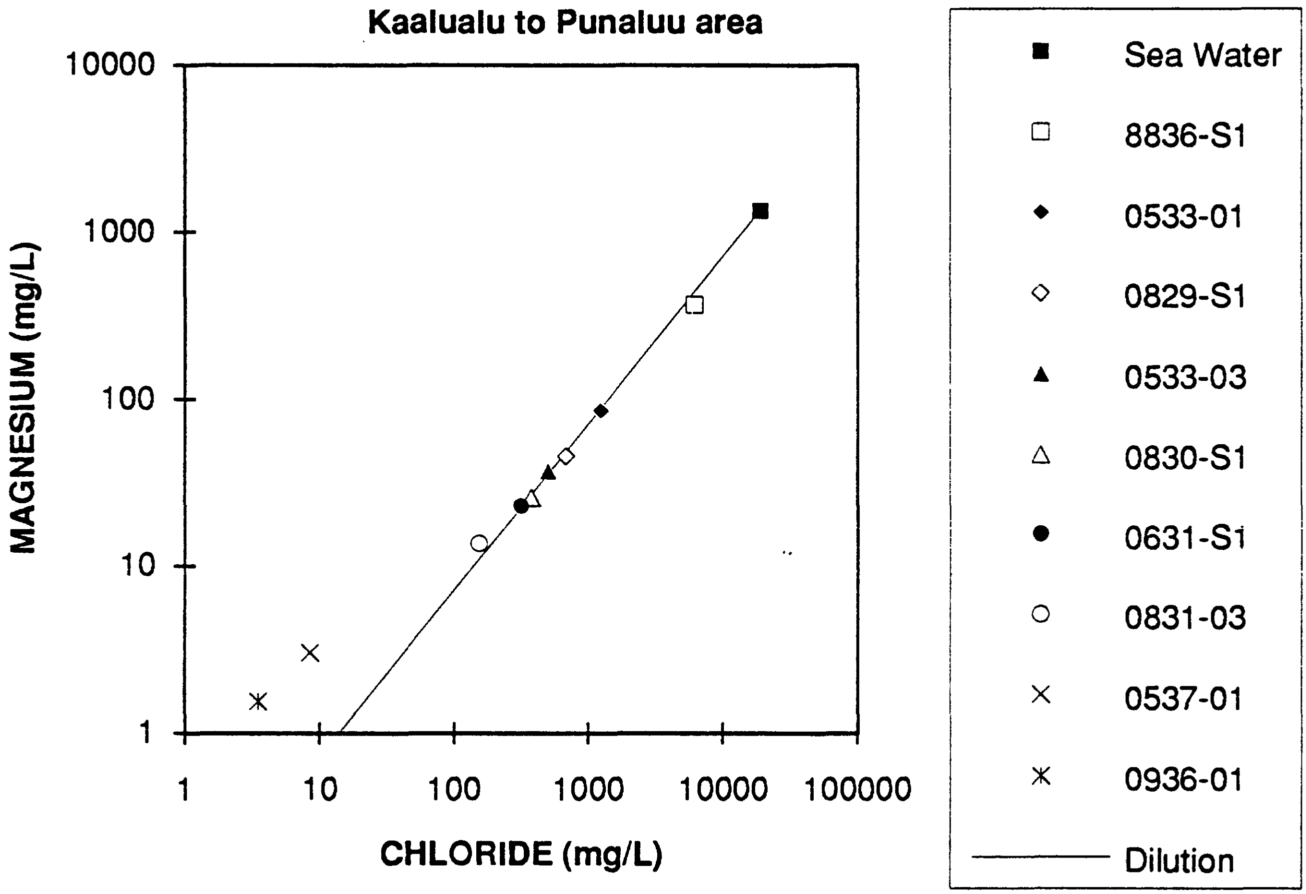

Figure 17. Magnesium versus chloride for samples of Figure 15. Dilution line shown differs from mixing line at low concentrations.

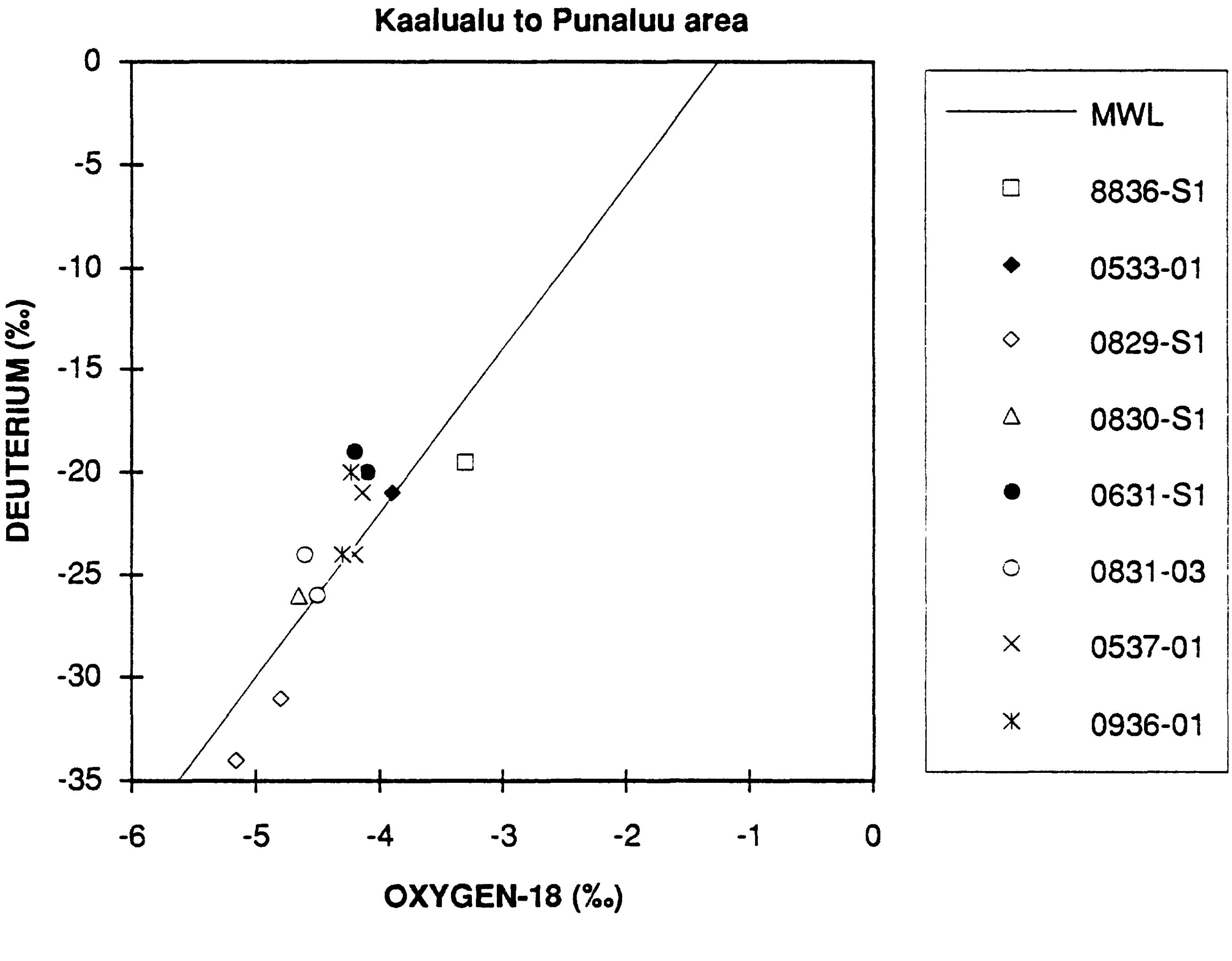

Figure 18. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples of Figure 15. Data for repeat samplings shown. Global meteoric water line is from Craig (1961).

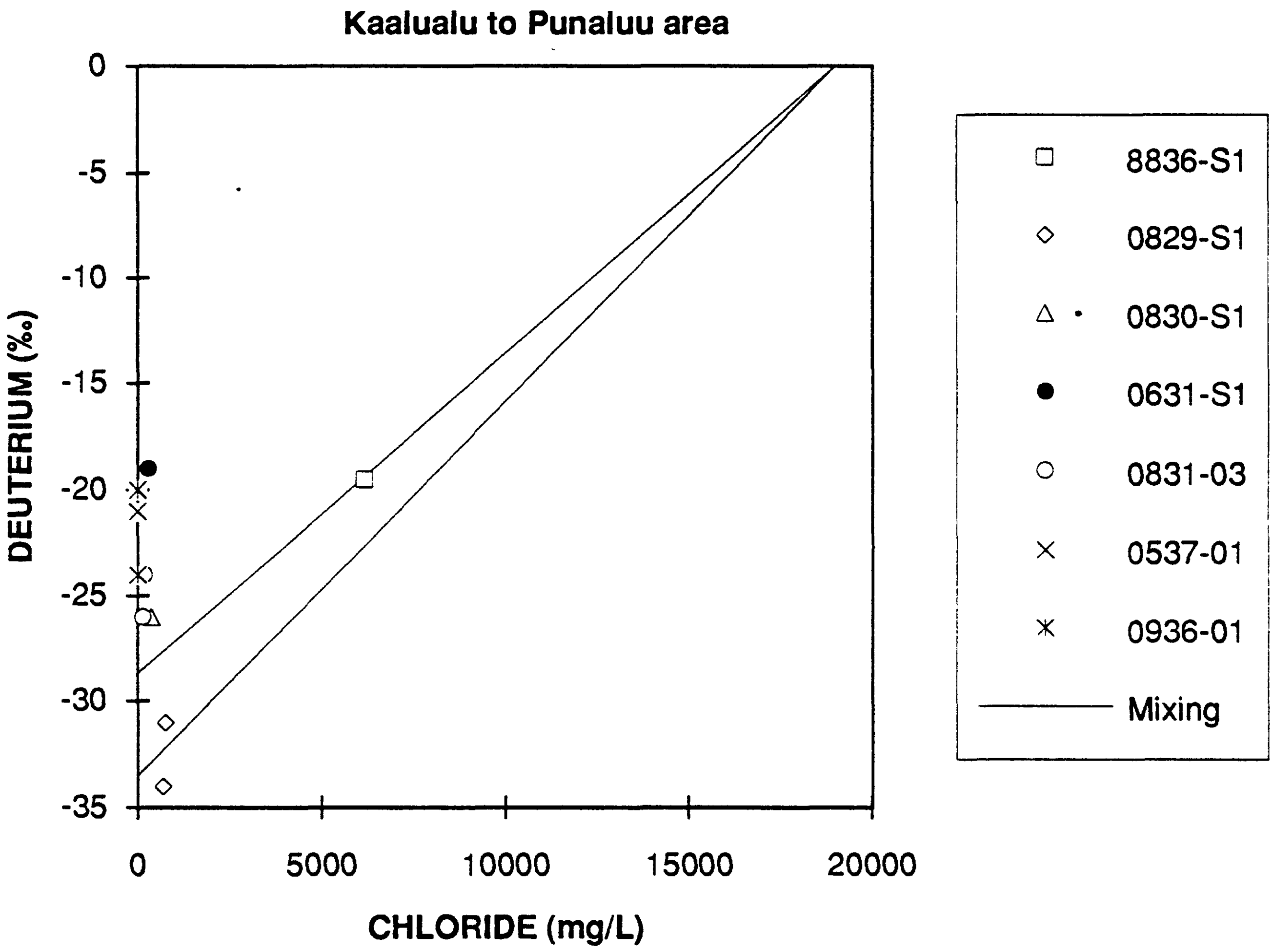

Figure 19. Deuterium versus chloride for samples of Figure 15. Data for repeat samplings shown. Mixing lines are from assumed sea water and passing through data point for 8836-S1 and between data points for 0829-S1 and project to deuterium values for zero chloride.

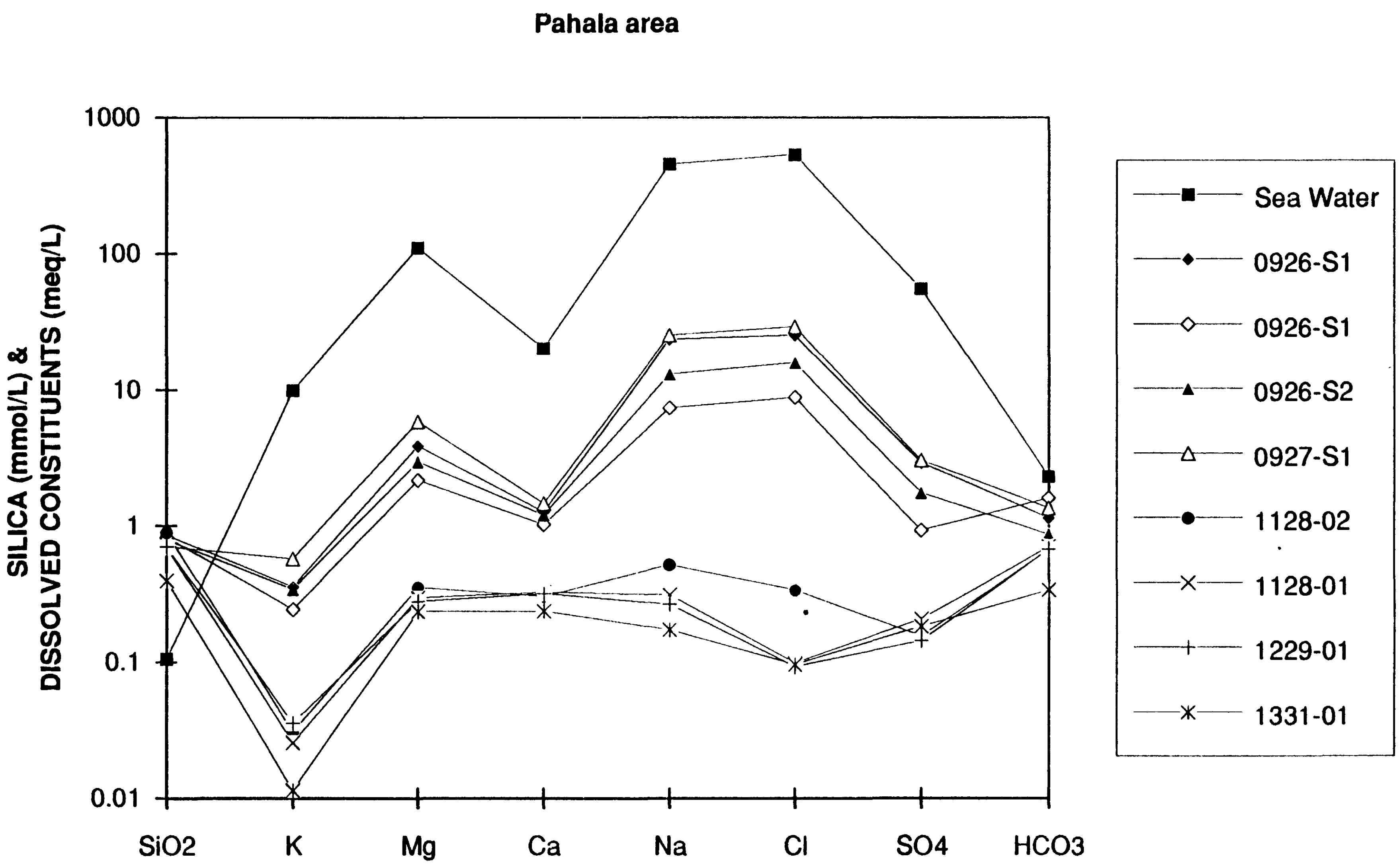

Figure 20. Modified Schoeller diagram for samples from Pahala area. Pueo spring (0926-S1), Waiapele crack (0926-S2), and Waioala Spring (0927-S1) are along coast. Wells, shafts, and tunnels in order listed are: Palima (1128-02), Pahala Shaft (1128-01), Pahala (1229-01), and Alili Tunnel (1331-01).

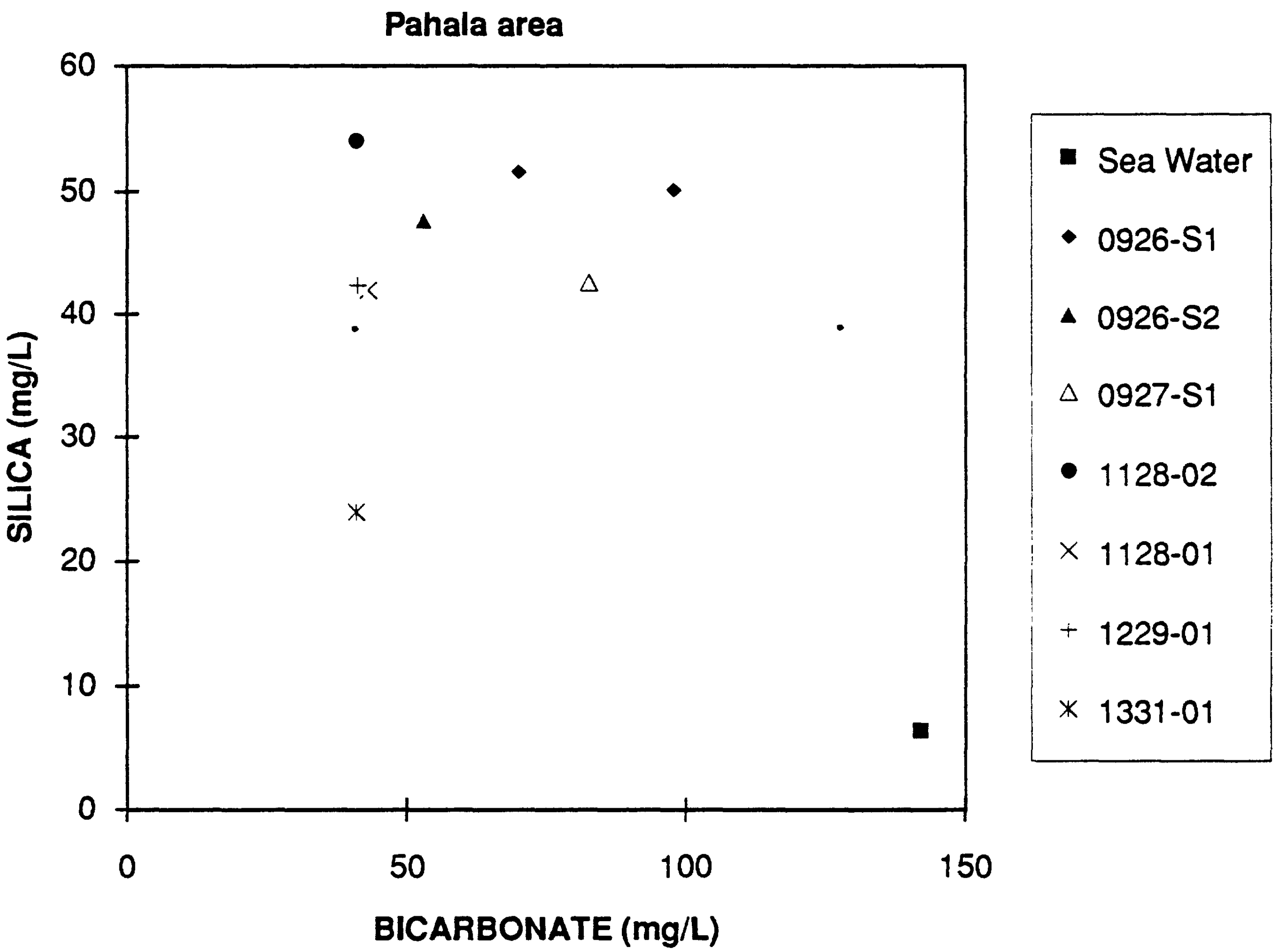

Figure 21. Silica versus bicarbonate for samples of Figure 20.

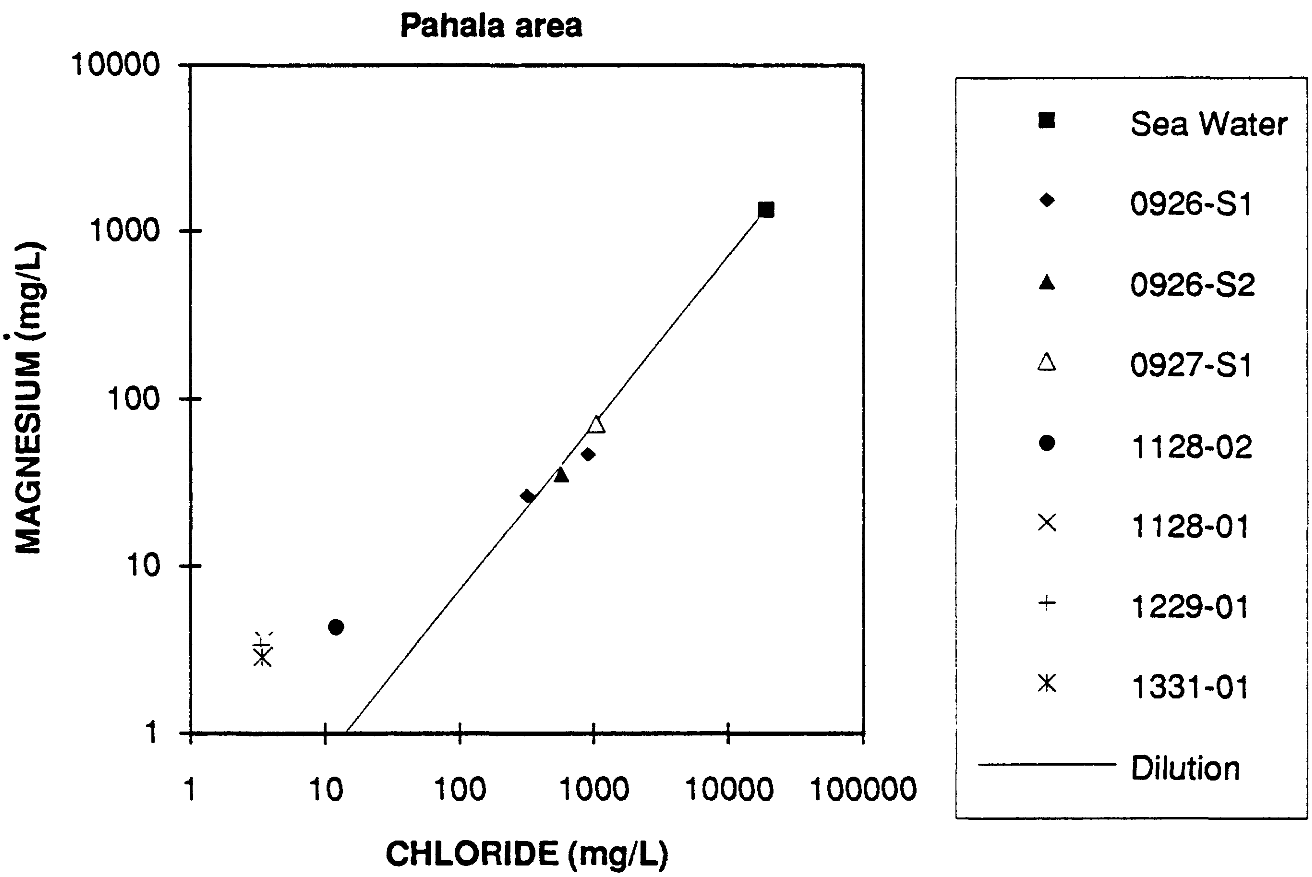

Figure 22. Magnesium versus chloride for samples of Figure 20. Dilution line shown differs from mixing line at low concentrations.

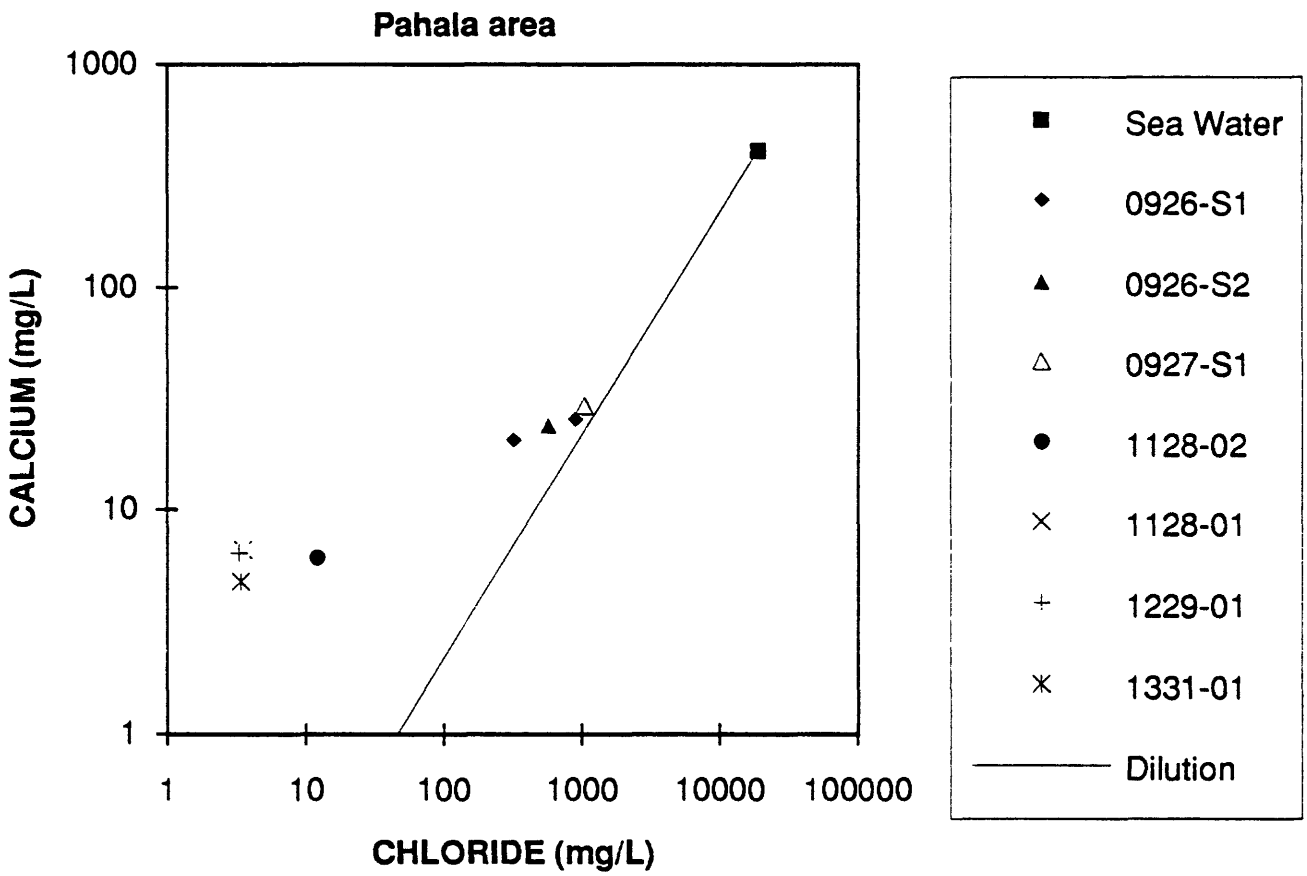

Figure 23. Calcium versus chloride for samples of Figure 20. Dilution line shown differs from mixing line at low concentrations.

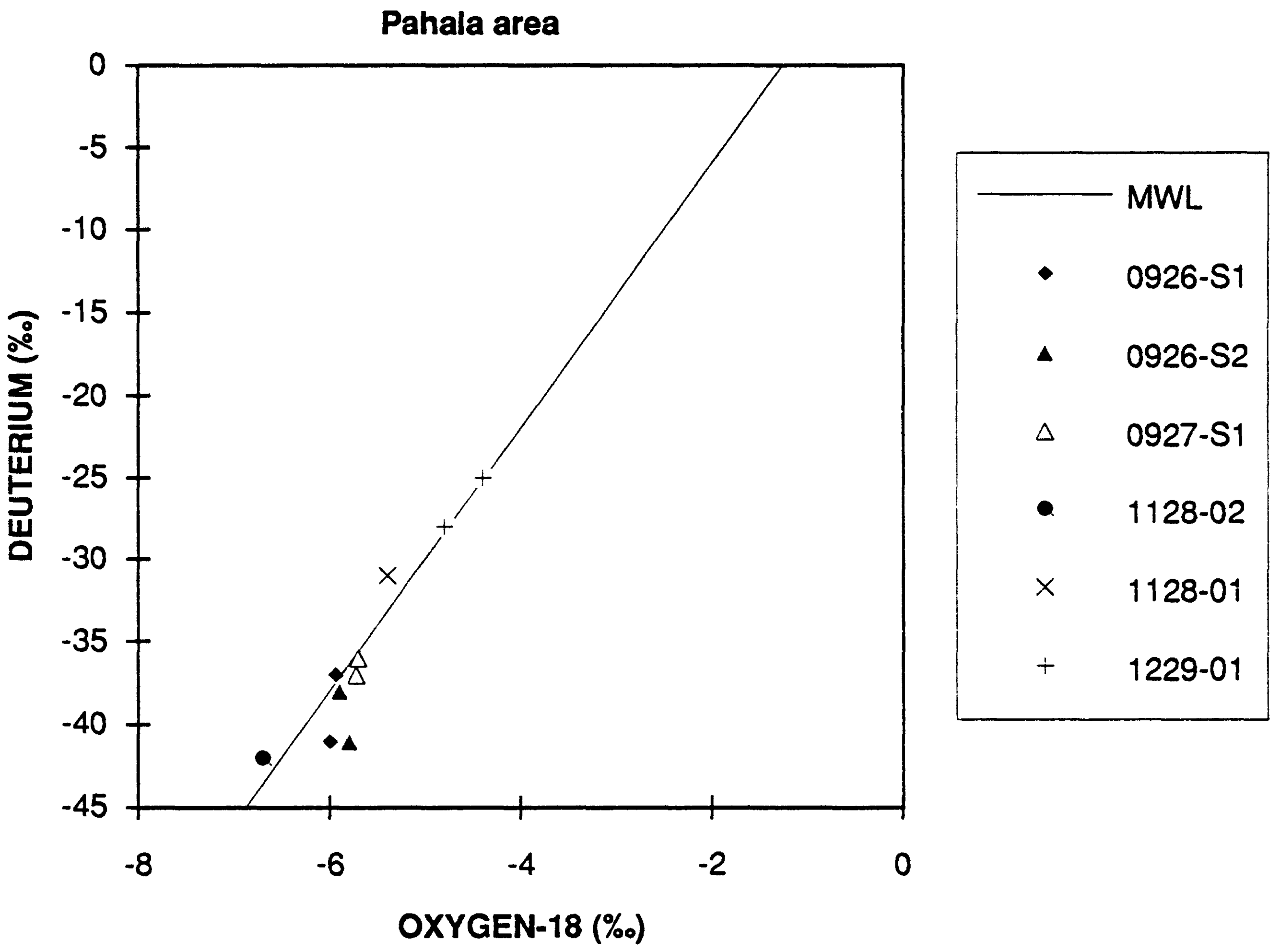

Figure 24. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples of Figure 20. Data for repeat samplings shown. Global meteoric water line is from Craig (1961).

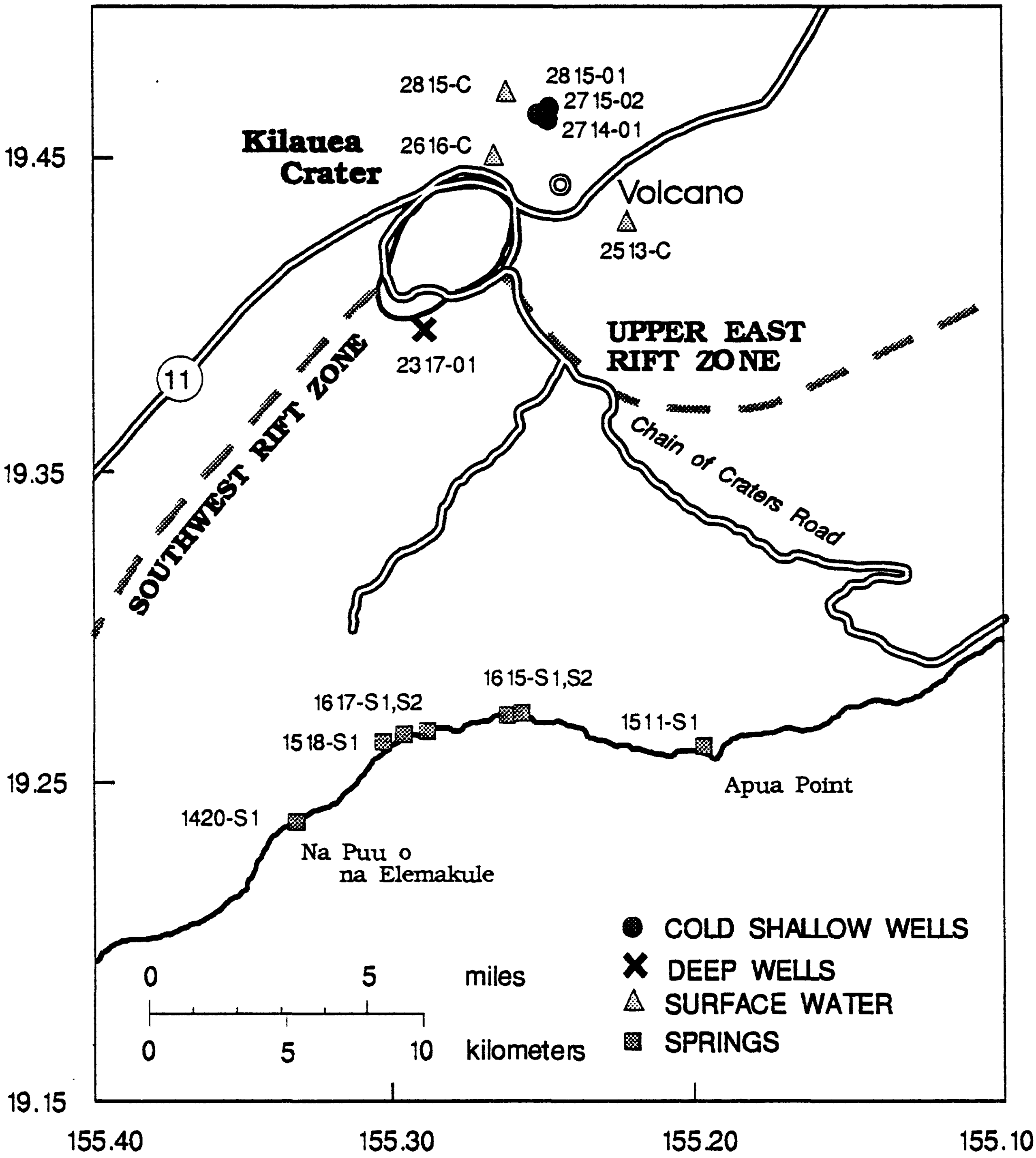

Figure 25. Map of area from Kilauea Crater to Puu Elemakule and Apua Point on the coast.

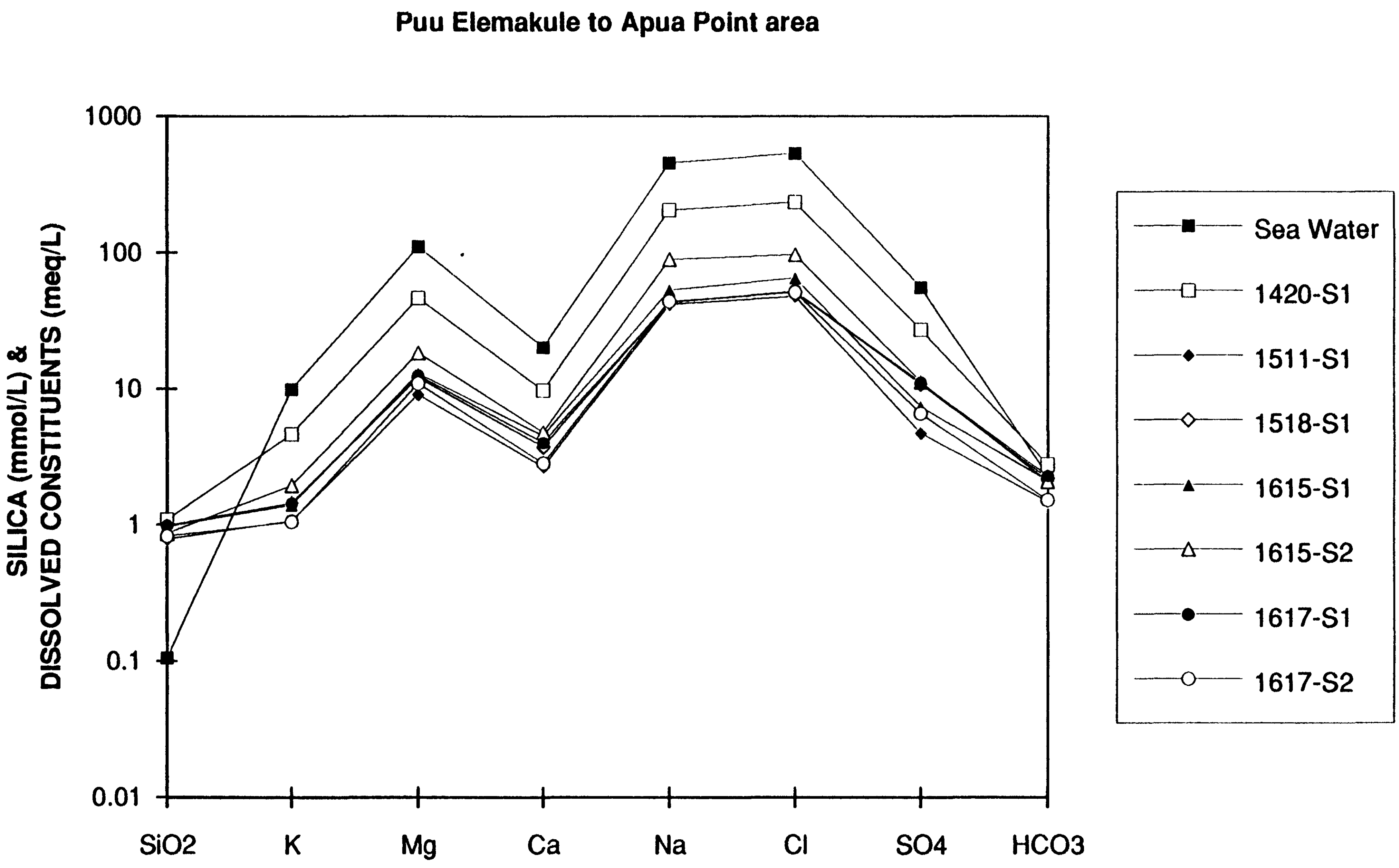

Figure 26. Modified Schoeller diagram for spring samples from Puu Elemakule to Apua Point area. Springs from south to north along the coast are: Puu Elemakule (1420-S1), Kaaha, West crack (1518-S1), Kaaha, East crack (1617-S1), Kalue crack (1617-S2), Halape Iki spring (1615-S2), Halape crack (1615-S1), Apua Point crack (1511-S1).

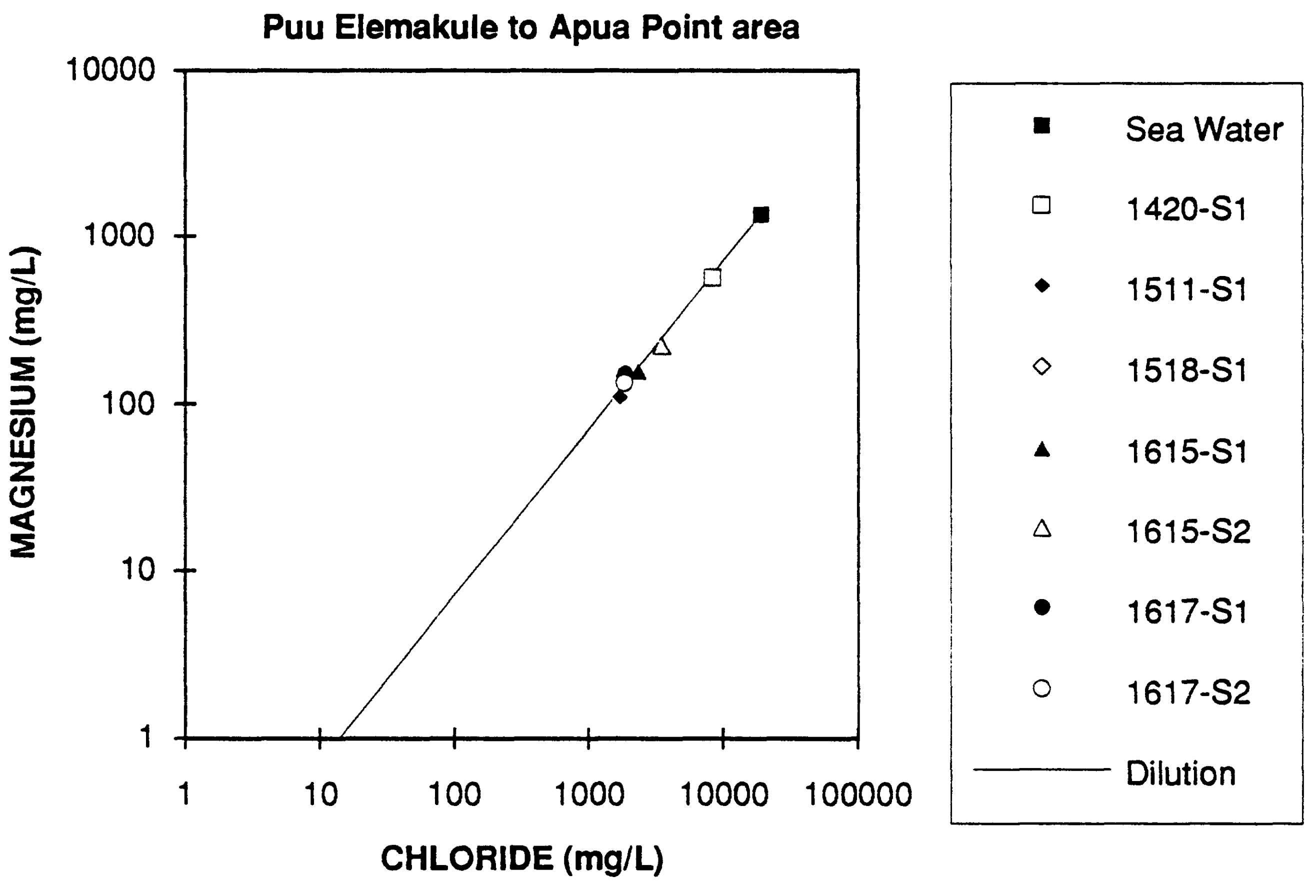

Figure 27. Magnesium versus chloride for samples of Figure 26. Dilution line shown differs from mixing line at low concentrations.

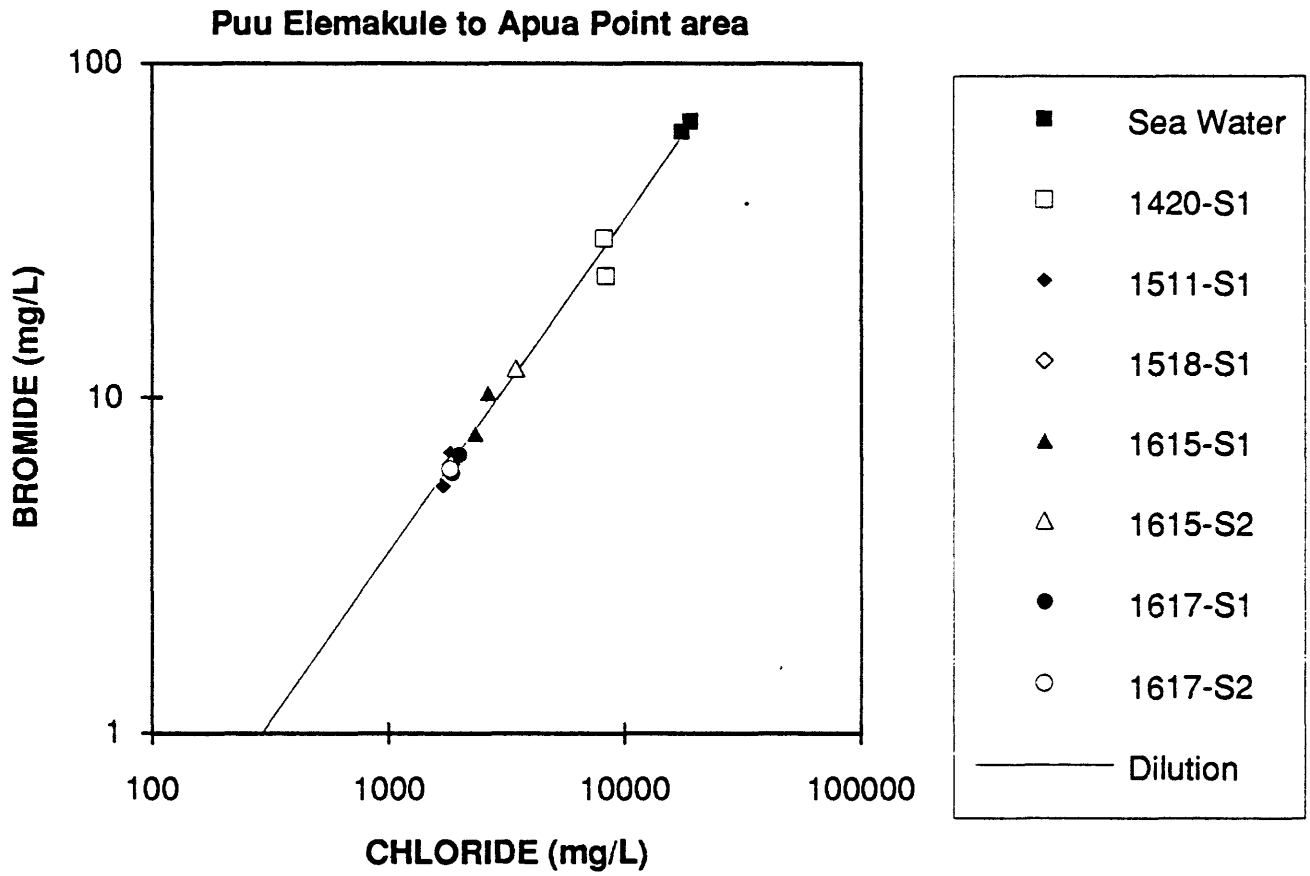

Figure 28. Bromide versus chloride for samples of Figure 26. Data for repeat samplings shown. Dilution line shown differs from mixing line at low concentrations.

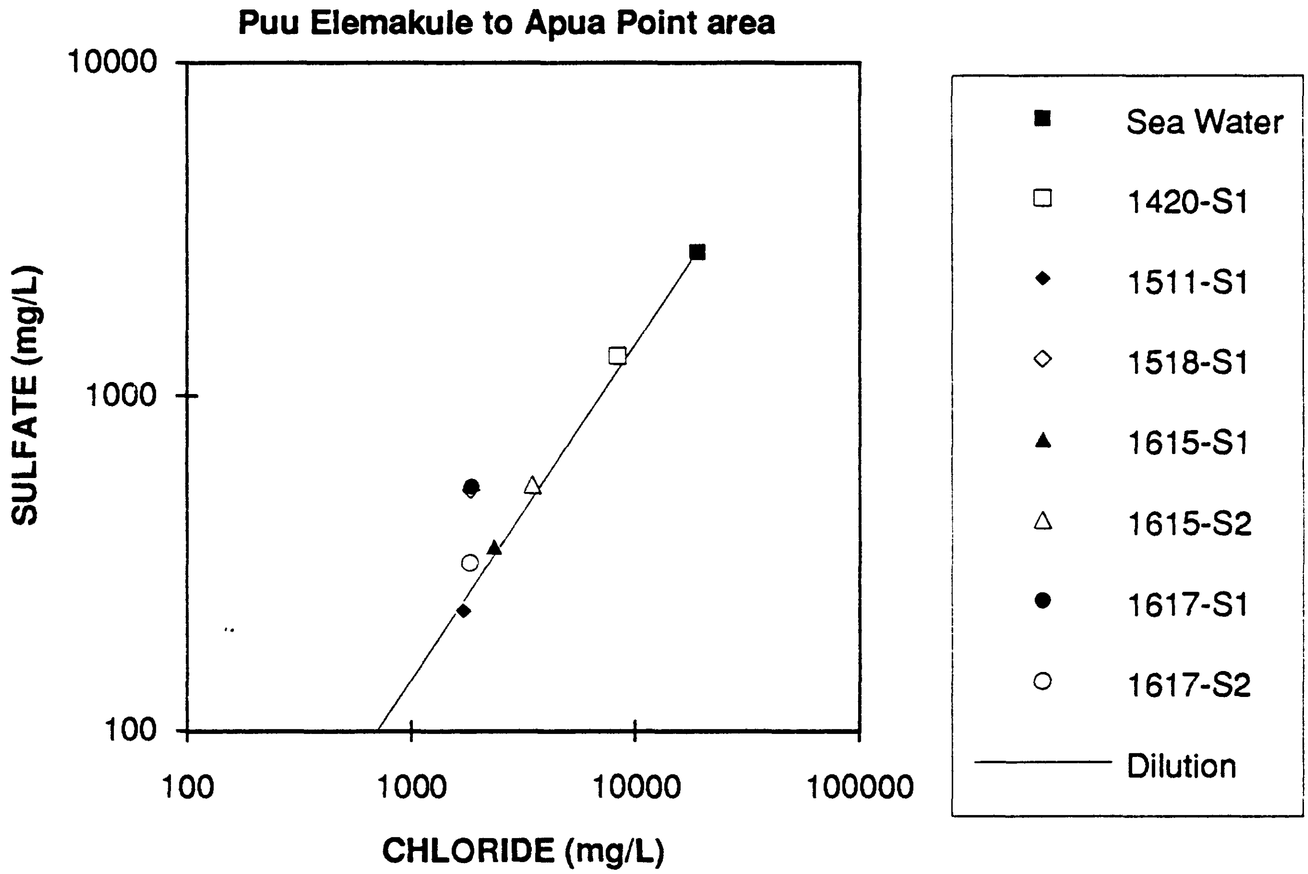

Figure 29. Sulfate versus chloride for samples of Figure 26. Dilution line shown differs from mixing line at low concentrations.

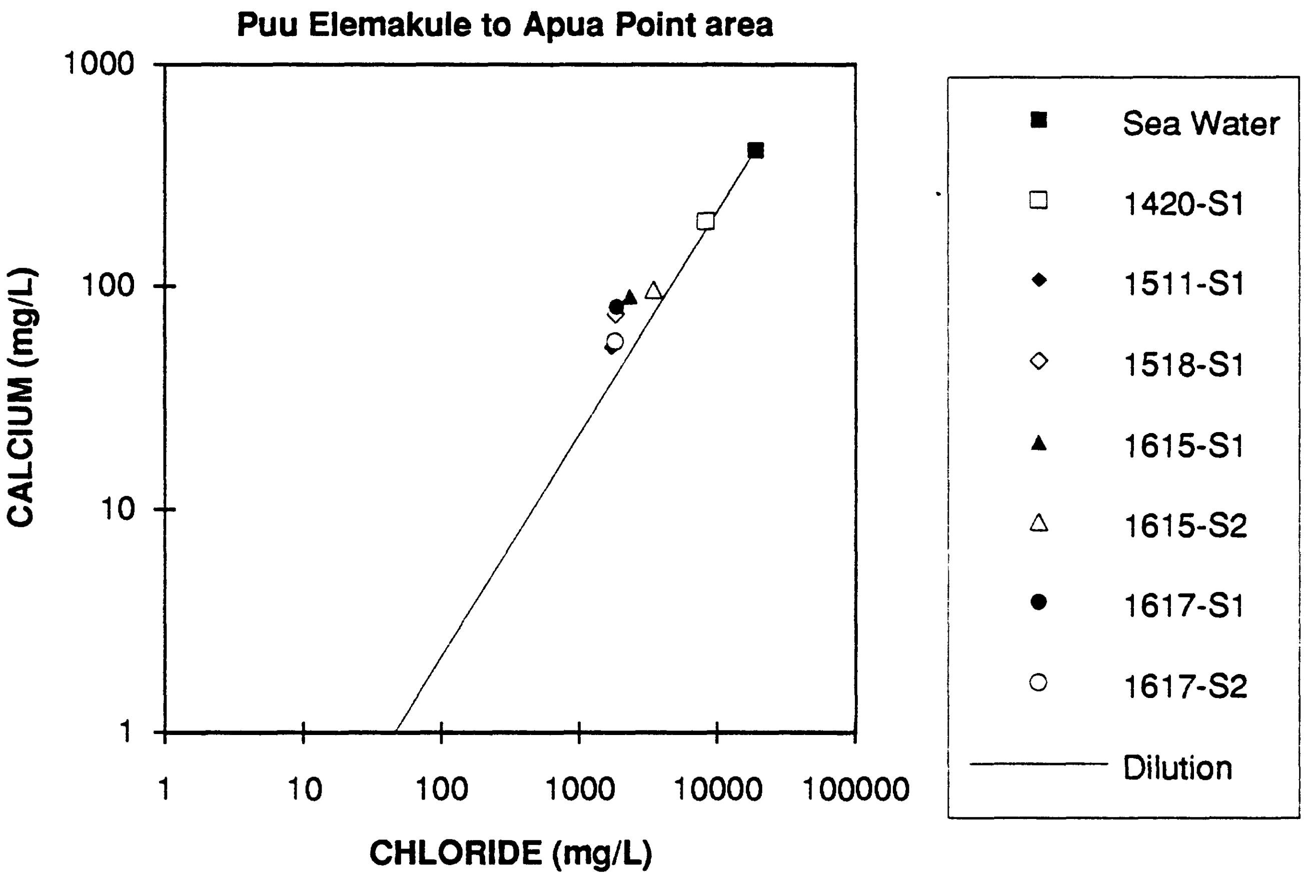

Figure 30. Calcium versus chloride for samples of Figure 26. Dilution line shown differs from mixing line at low concentrations.

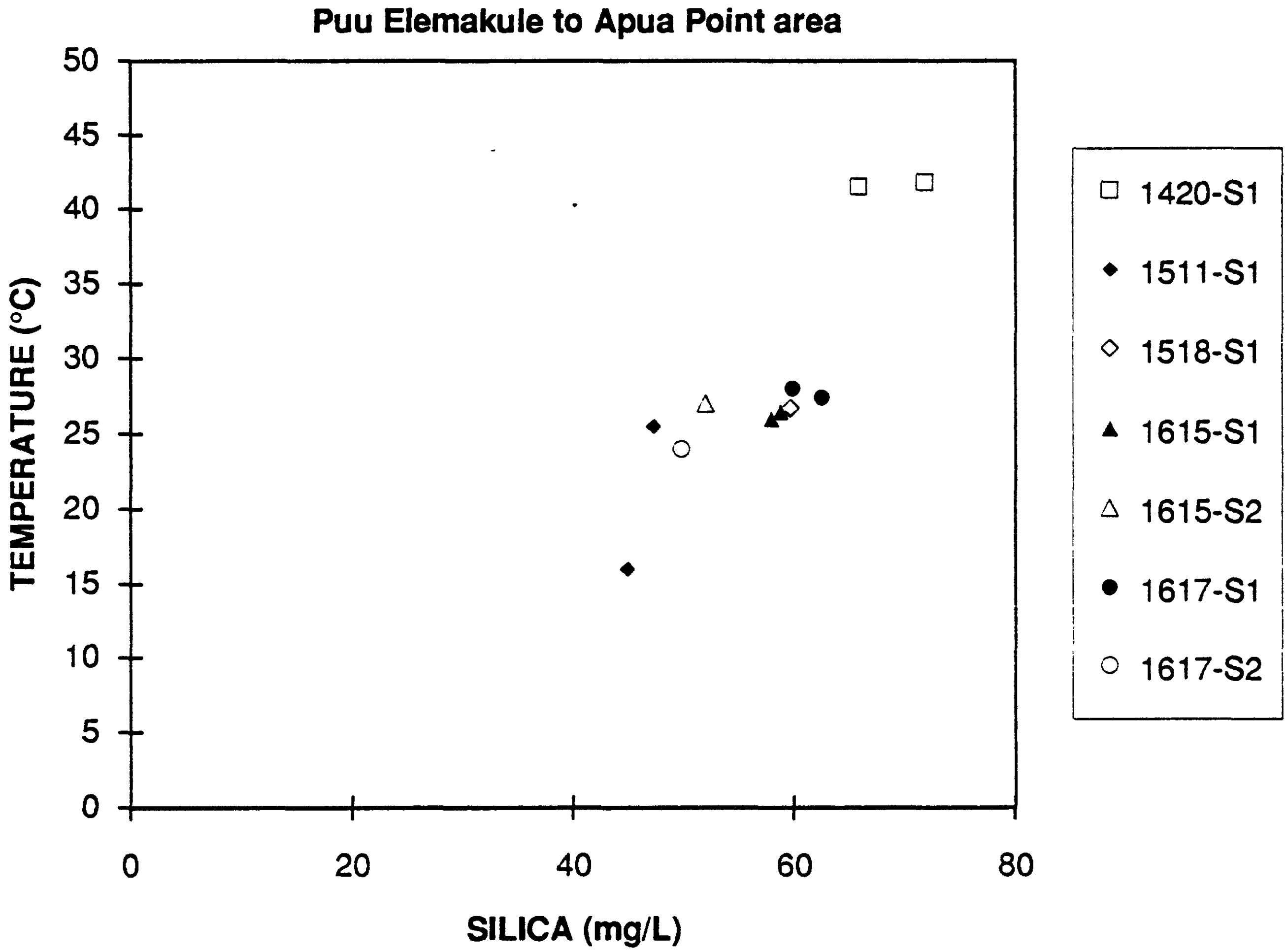

Figure 31. Temperature versus silica for samples of Figure 26. Data for repeat samplings shown.

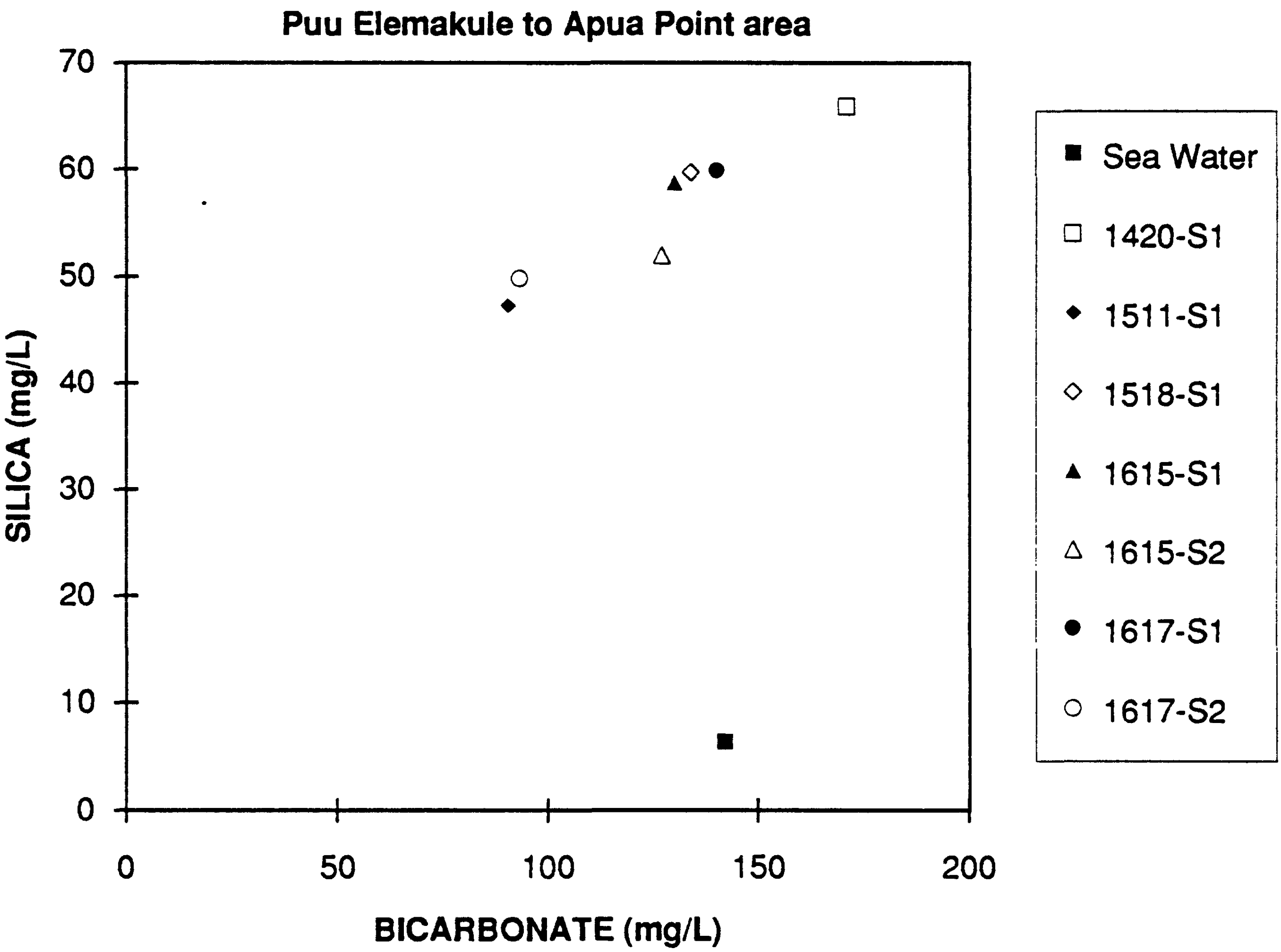

Figure 32. Silica versus bicarbonate for samples of Figure 26.

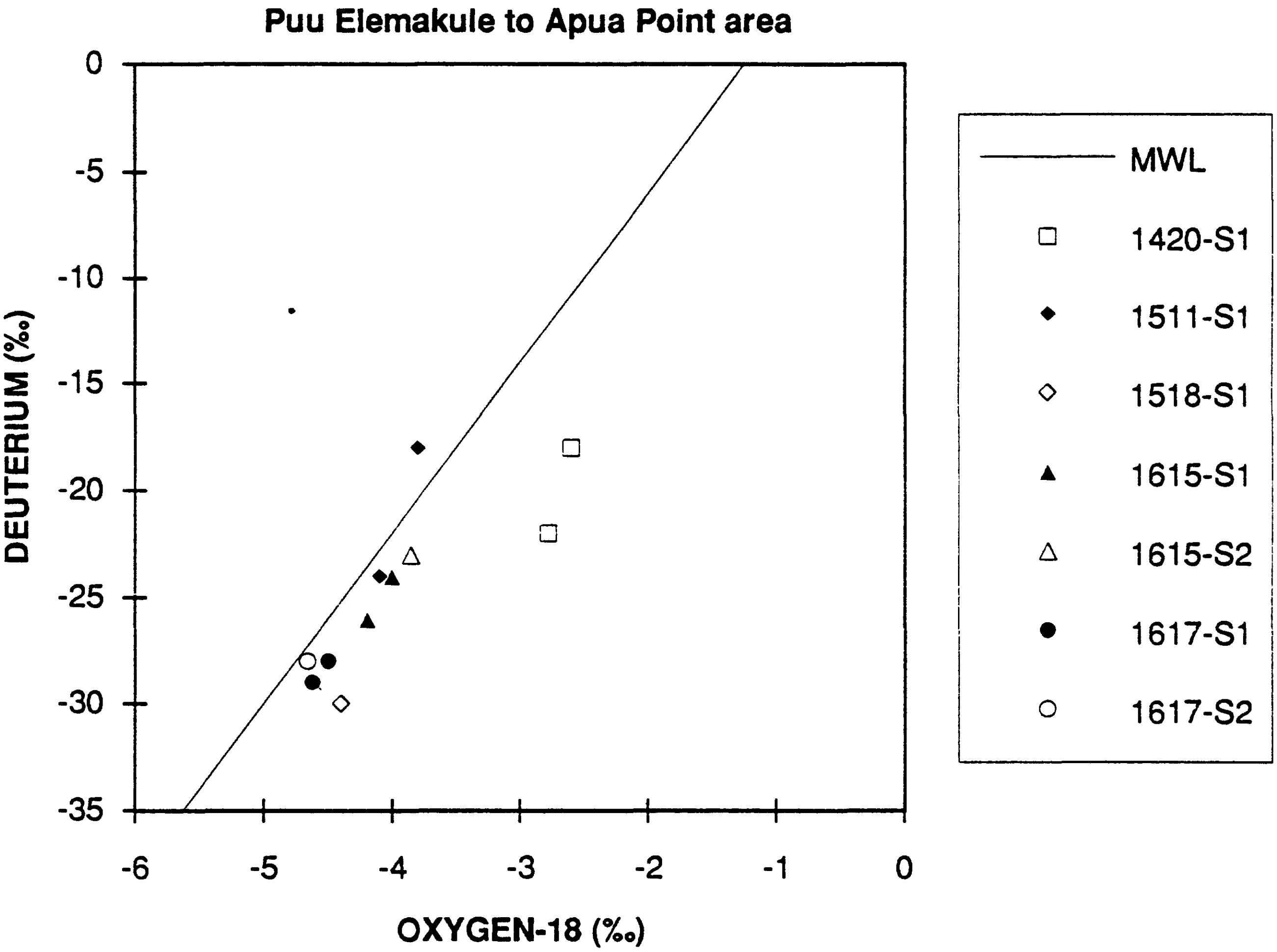

Figure 33. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples of Figure 26. Data for repeat samplings shown. Global meteoric water line is from Craig (1961).

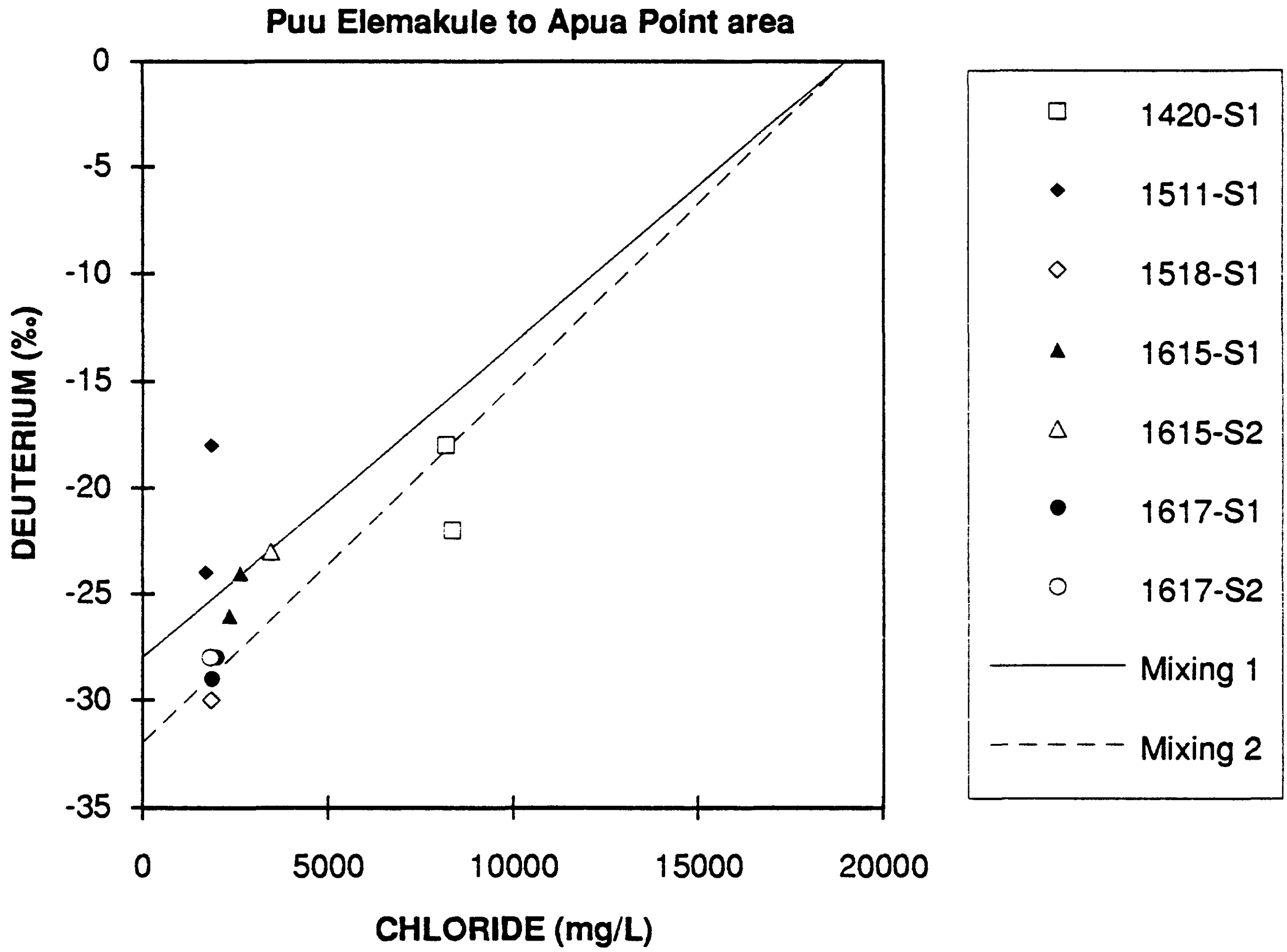

Figure 34. Deuterium versus chloride for samples of Figure 26. Data for repeat samplings shown. Mixing lines are from assumed sea water and passing through data groups discussed in text to project to deuterium value for zero chloride.

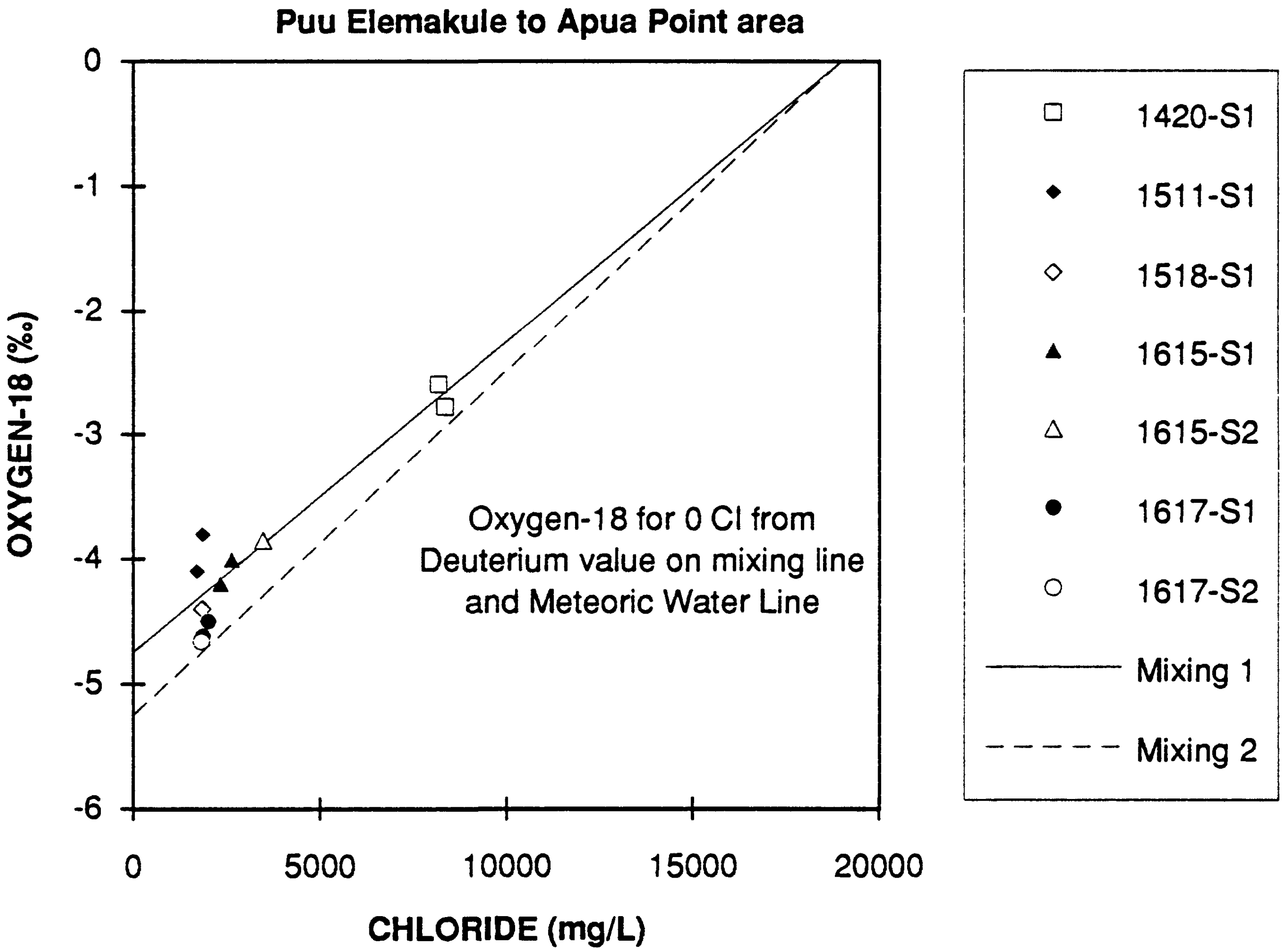

Figure 35. Oxygen-18 versus chloride for samples of Figure 26. Data for repeat samplings shown. Mixing lines are from assumed sea water and passing through values calculated using the global meteoric water line and deuterium intercepts from Figure 34.

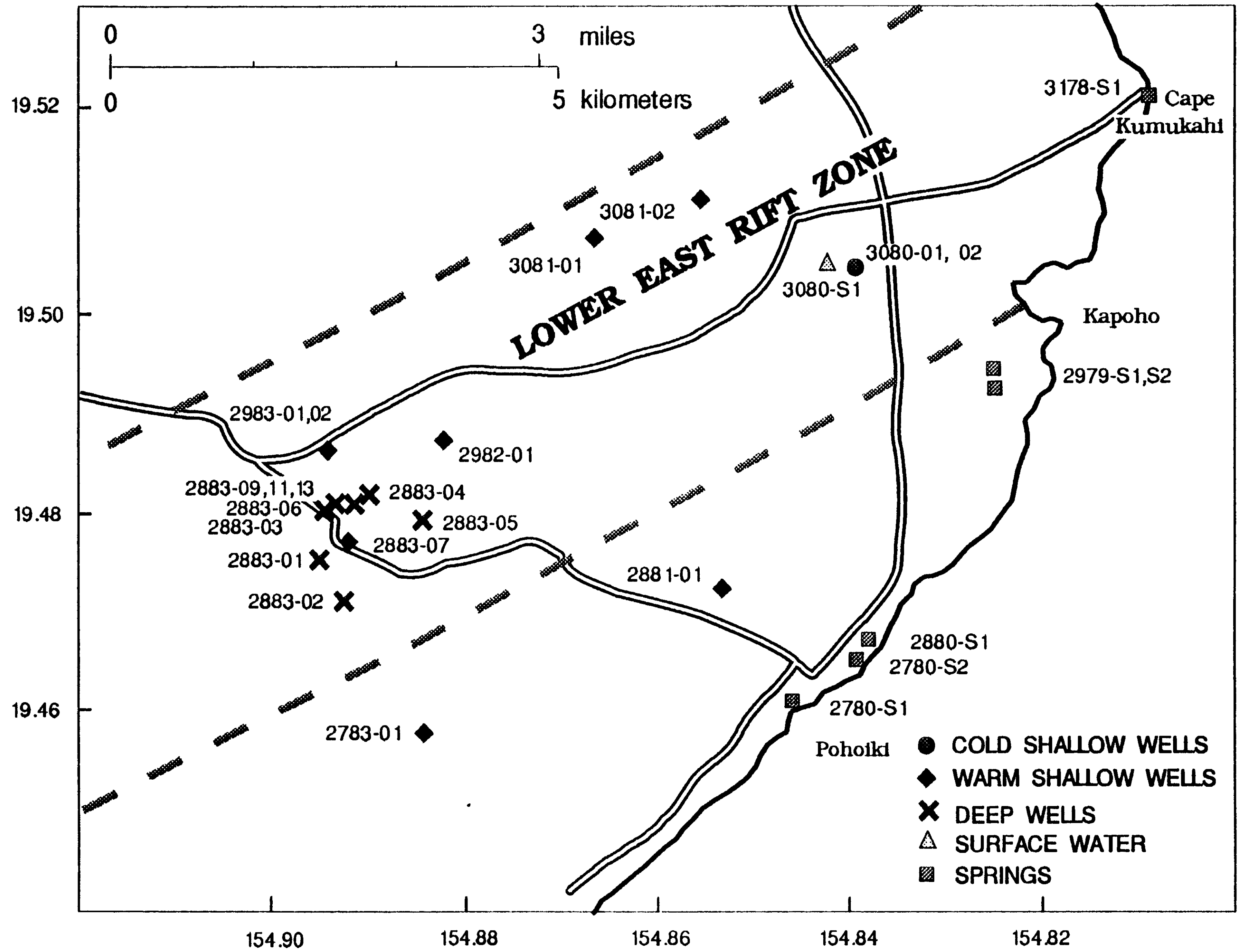

Figure 36. Map of lower east rift.

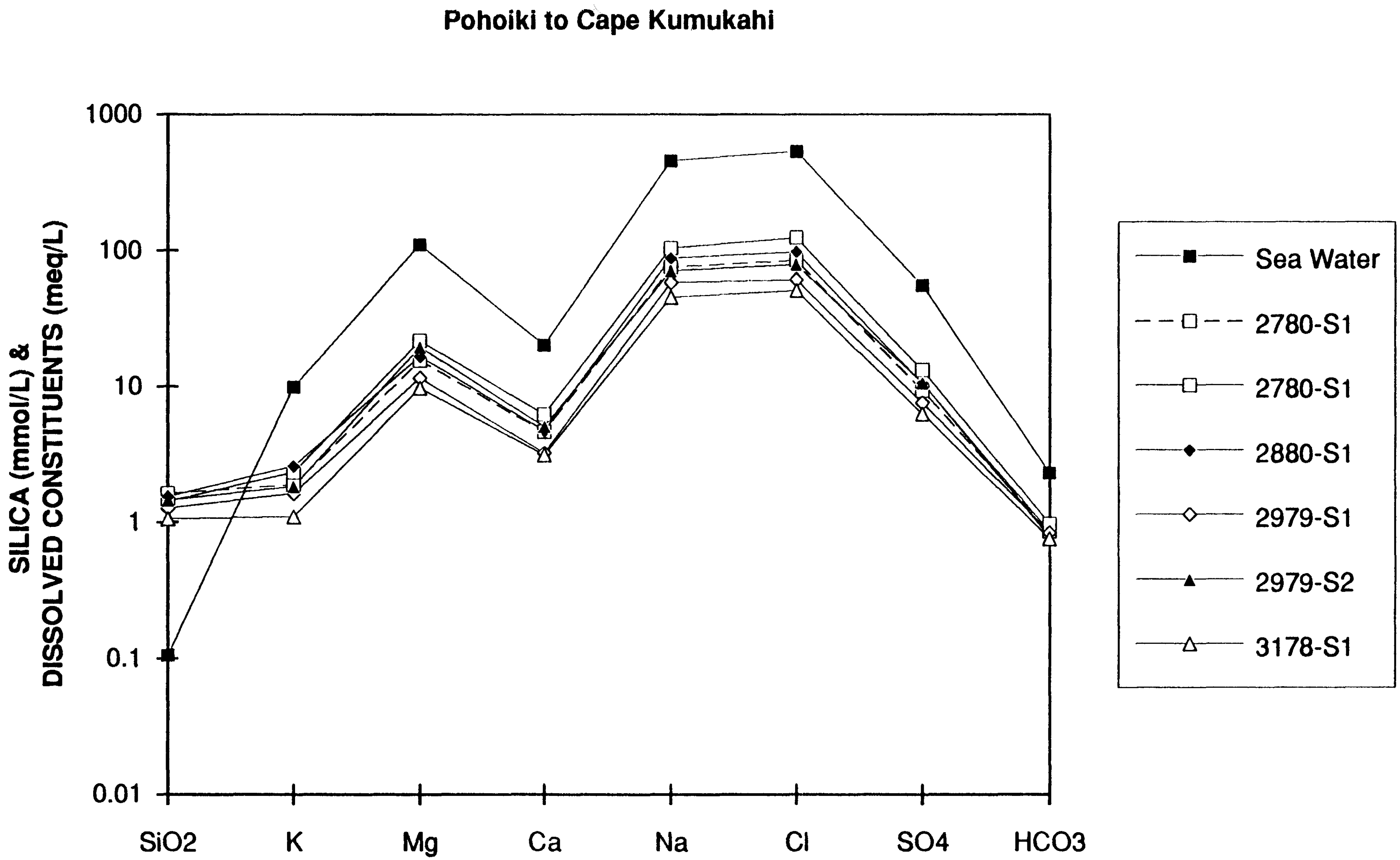

Figure 37. Modified Schoeller diagram for spring samples from Pohoiki to Cape Kumukahi area. Springs from south to north along the coast are: Pohoiki Spring (2780-S1), Campbell spring (2880-S1), Vacationland (2979-S1), Burgess pool (2979-S2), and Lighthouse spring (3178-S1).

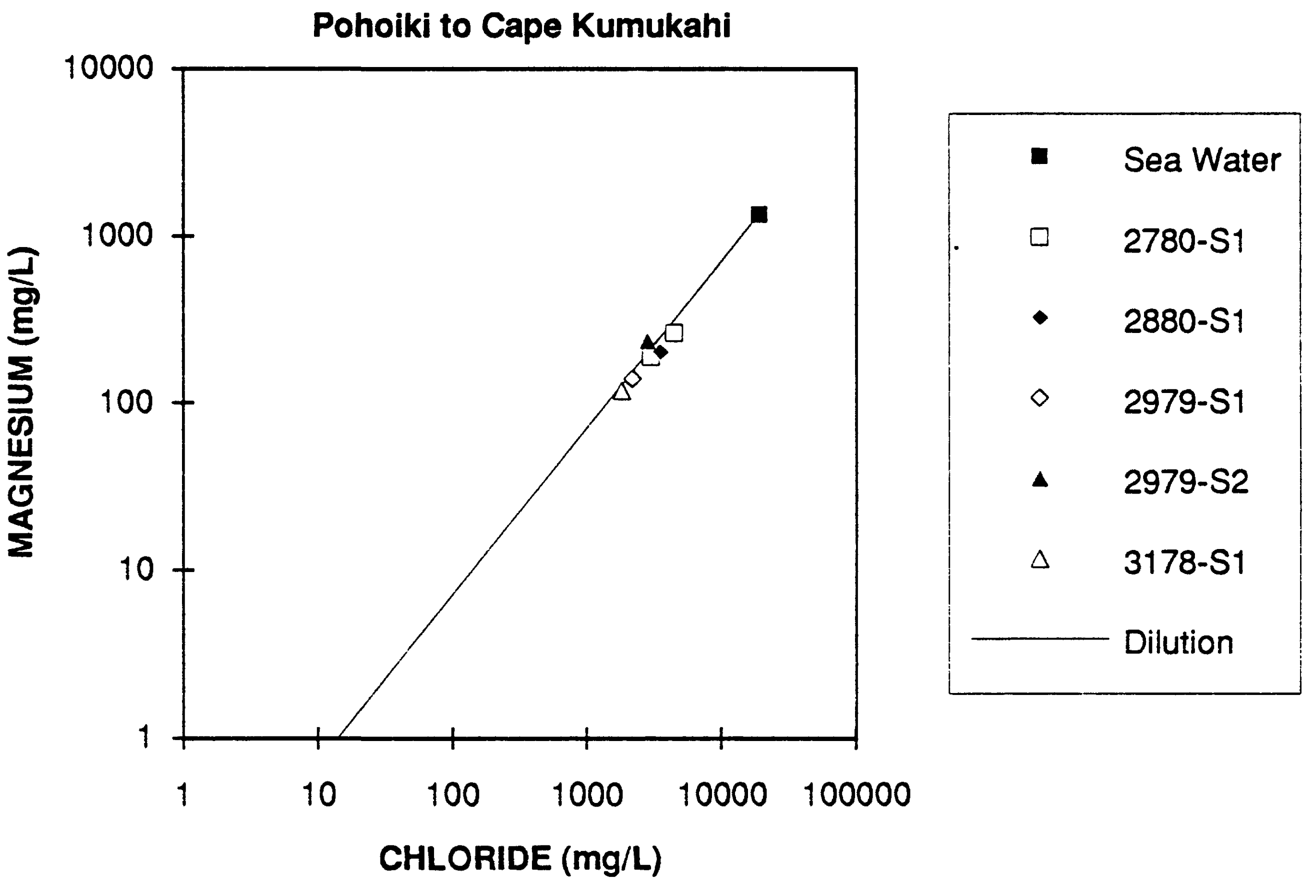

Figure 38. Magnesium versus chloride for samples of Figure 37. Dilution line shown differs from mixing line at low concentrations.

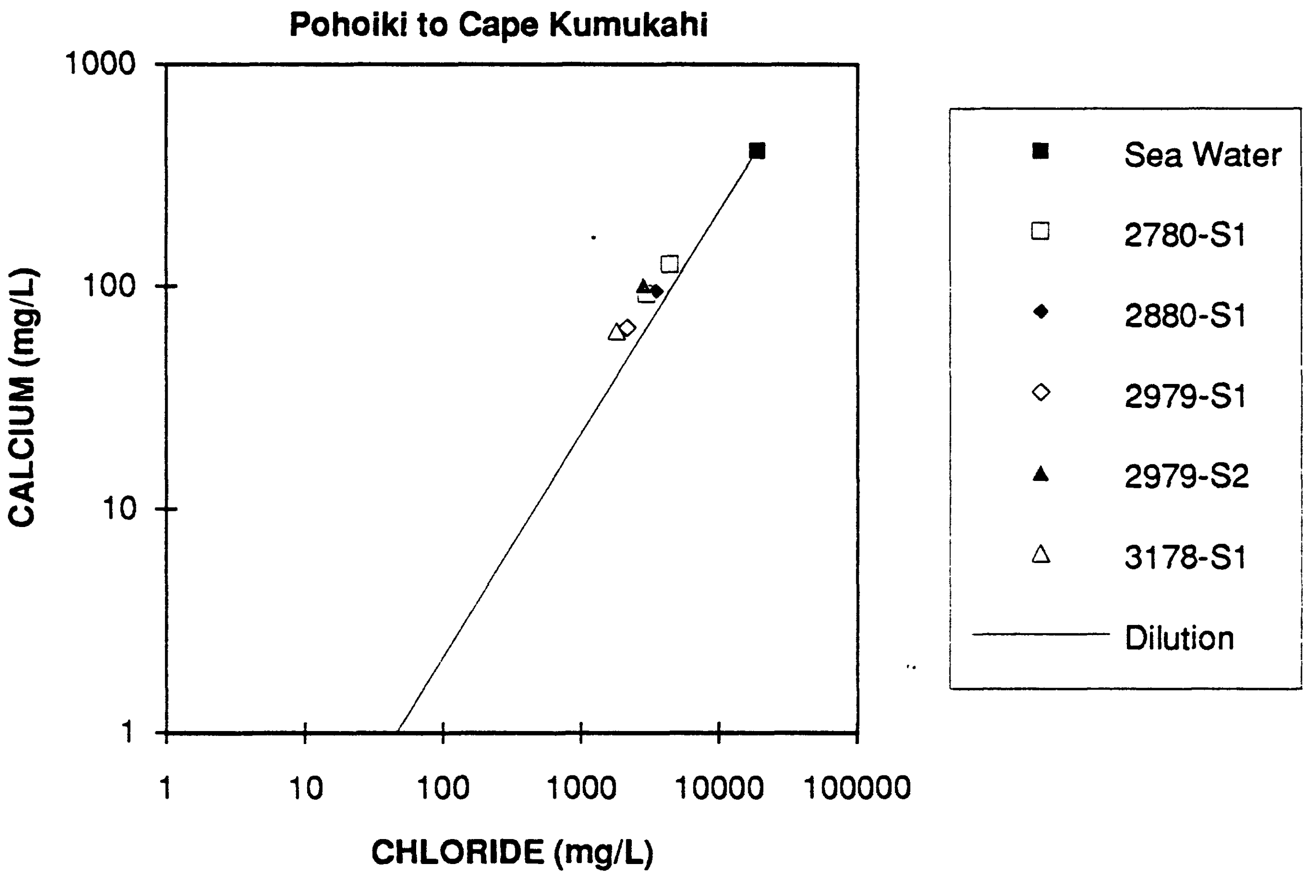

Figure 39. Calcium versus chloride for samples of Figure 37. Dilution line shown differs from mixing line at low concentrations.

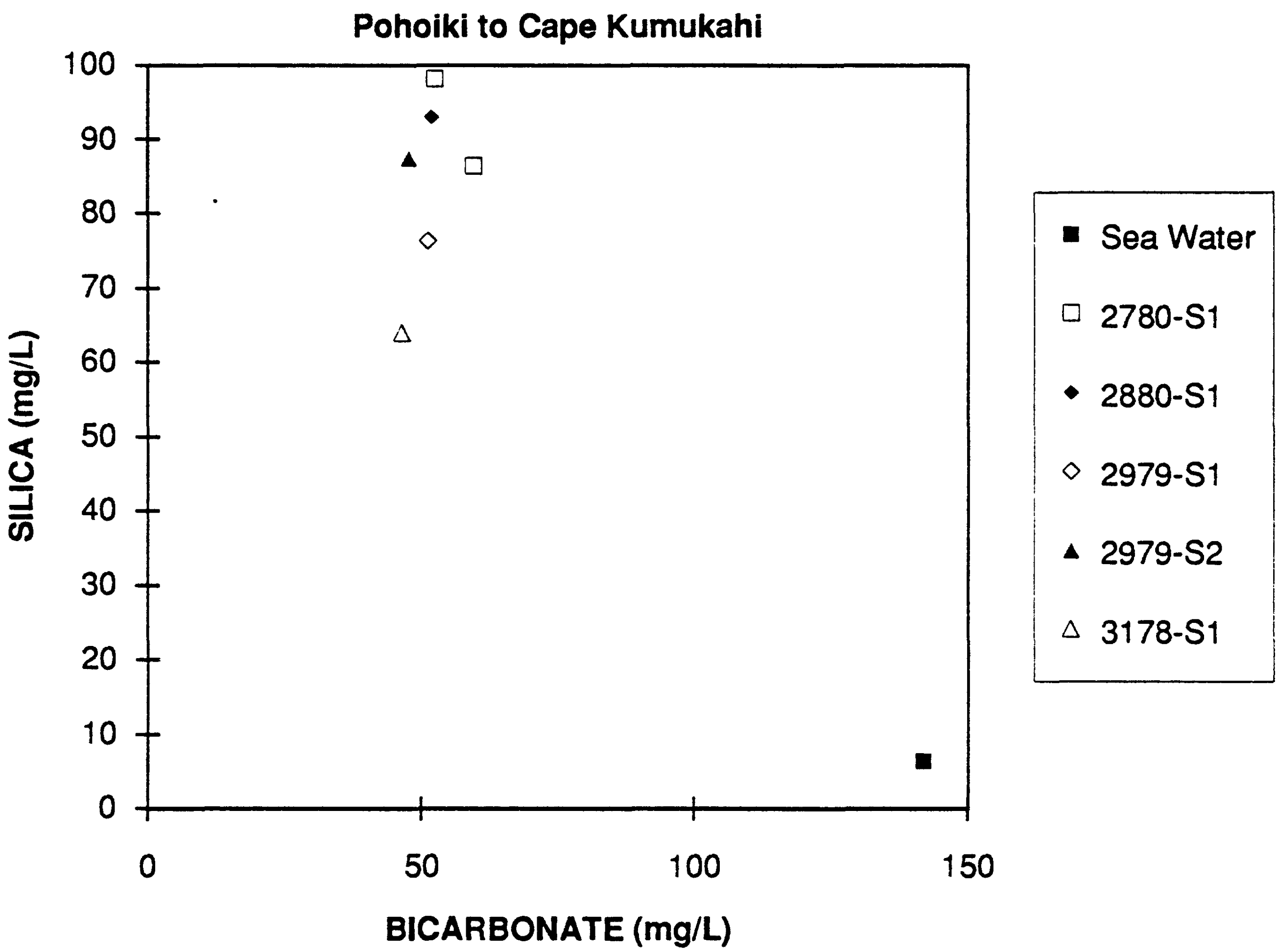

Figure 40. Silica versus bicarbonate for samples of Figure 37.

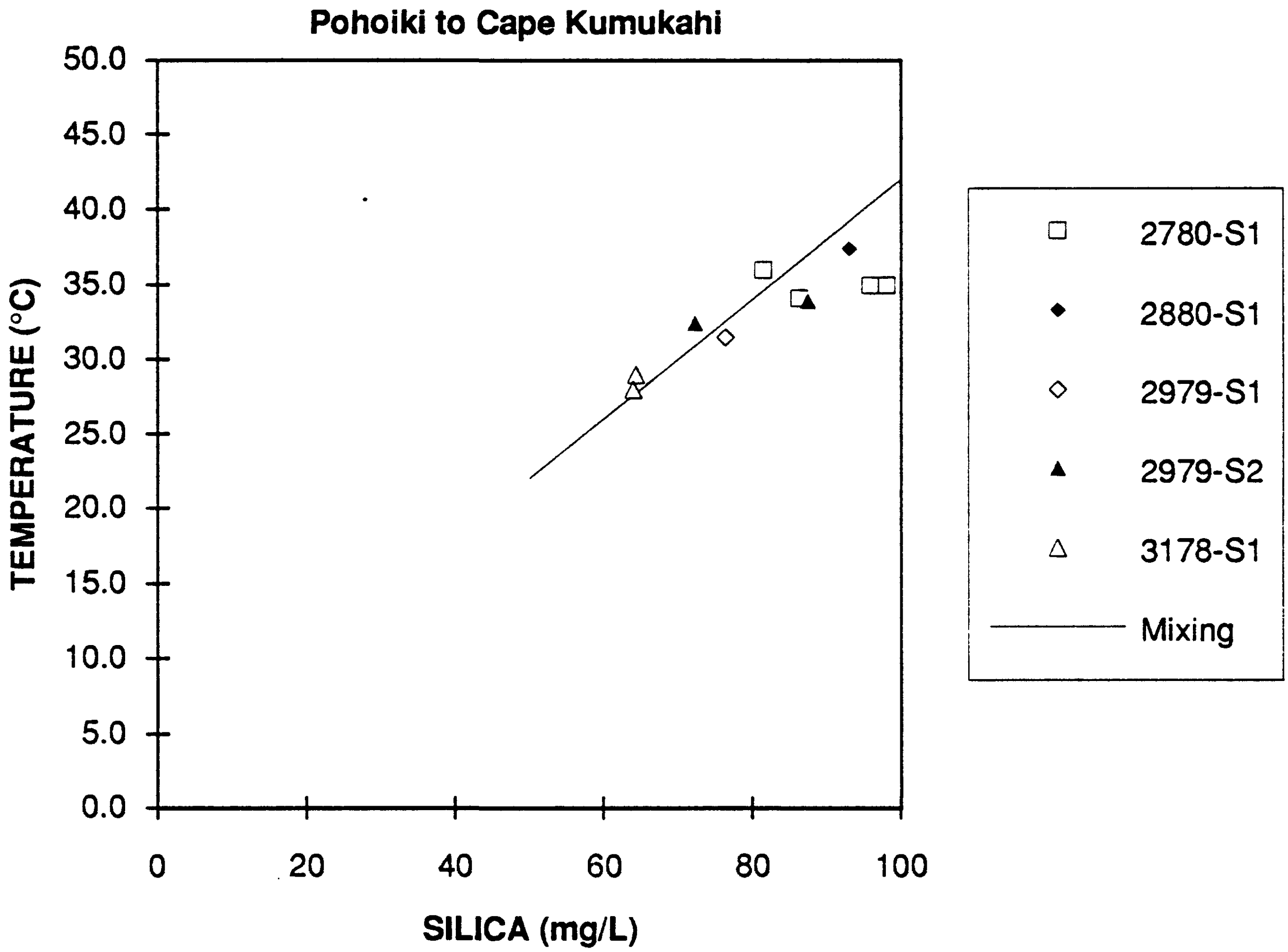

Figure 41. Temperature versus silica for samples of Figure 37. Data for repeat samplings shown.

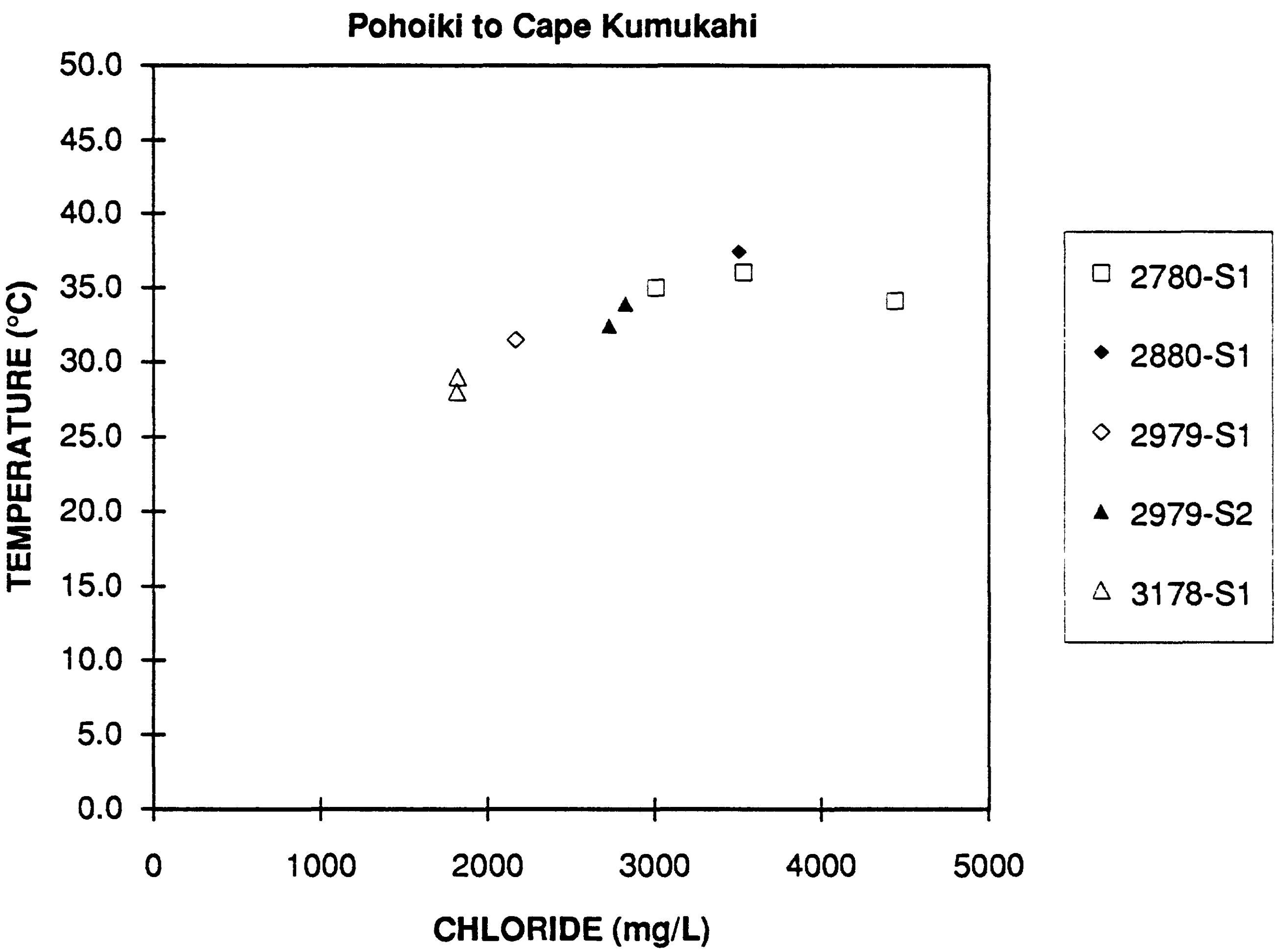

Figure 42. Temperature versus chloride for samples of Figure 37. Data for repeat samplings shown.

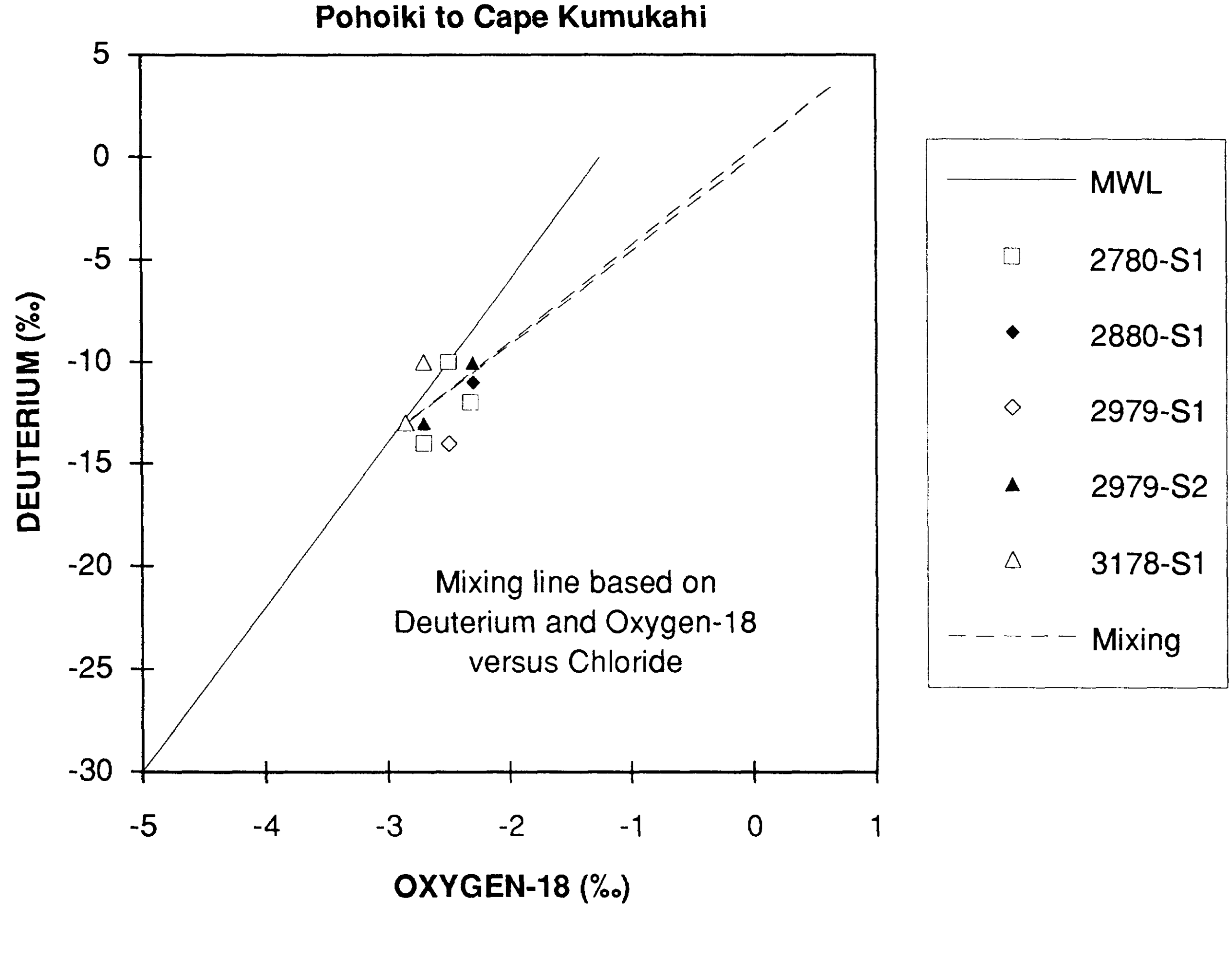

Figure 43. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples of Figure 37. Data for repeat samplings shown. Global meteoric water line is from Craig (1961). Mixing lines based on deuterium and oxygen-18 versus chloride plots are shown for water with isotopic content of sea water (assumed 0, 0 ‰) and for boiled sea water (0.8, 4.2 ‰).

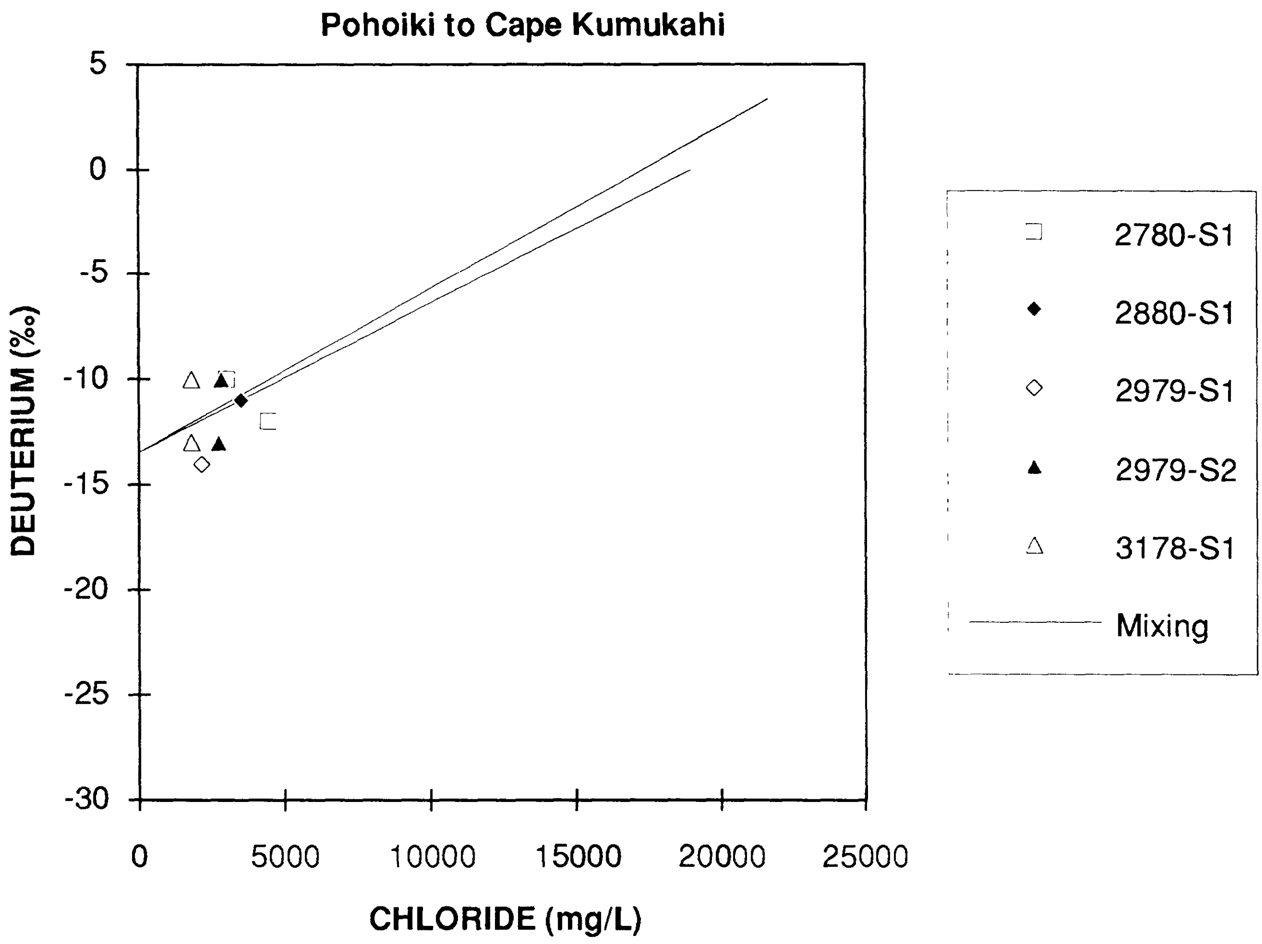

Figure 44. Deuterium versus chloride for samples of Figure 37. Data for repeat samplings shown. Mixing lines are from assumed sea water and boiled sea water and pass through data group to project to deuterium value for zero chloride.

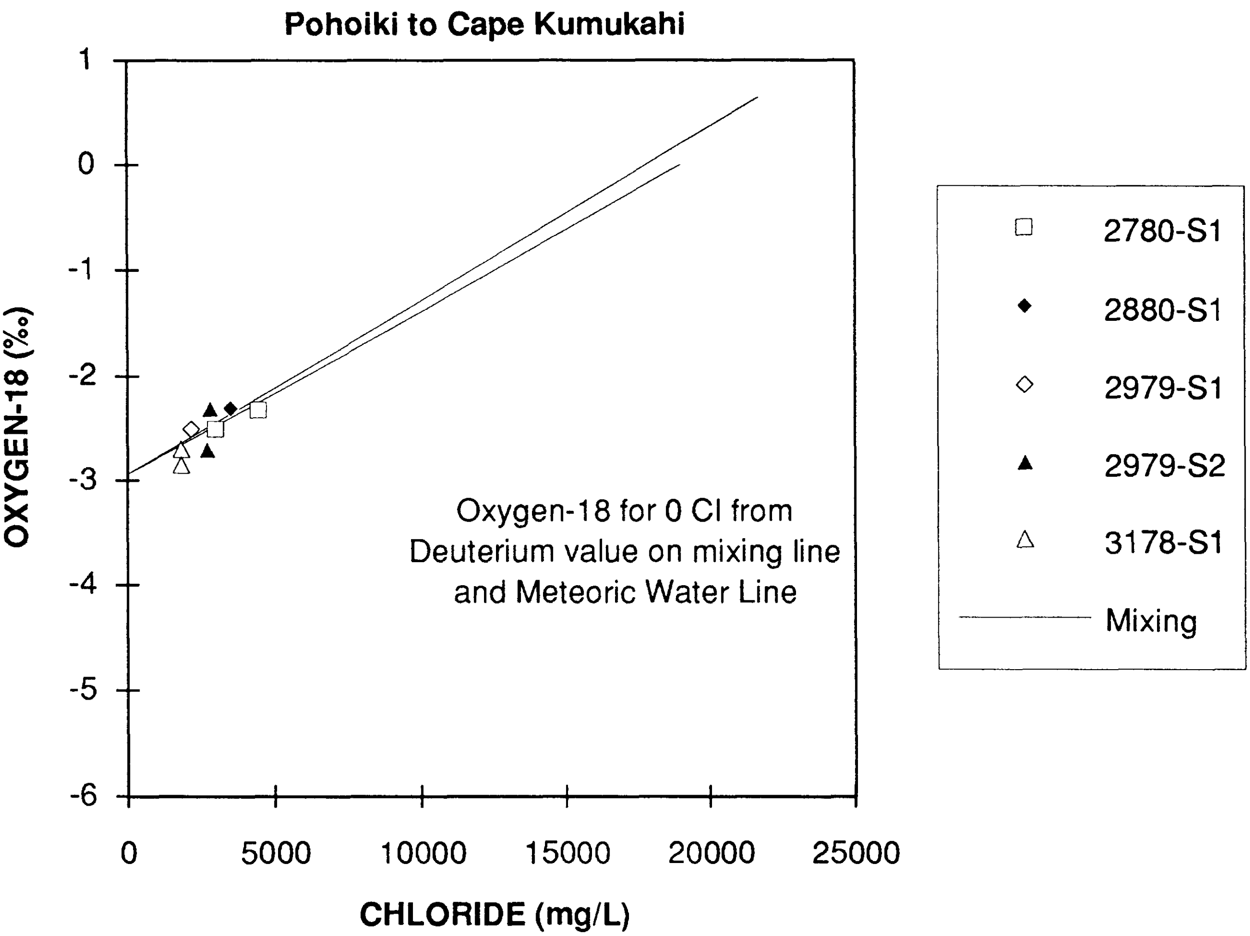

Figure 45. Oxygen-18 versus chloride for samples of Figure 37. Data for repeat samplings shown. Mixing lines are from assumed sea water and boiled sea water and pass through value calculated using the global meteoric water line and the deuterium intercept from Figure 44.

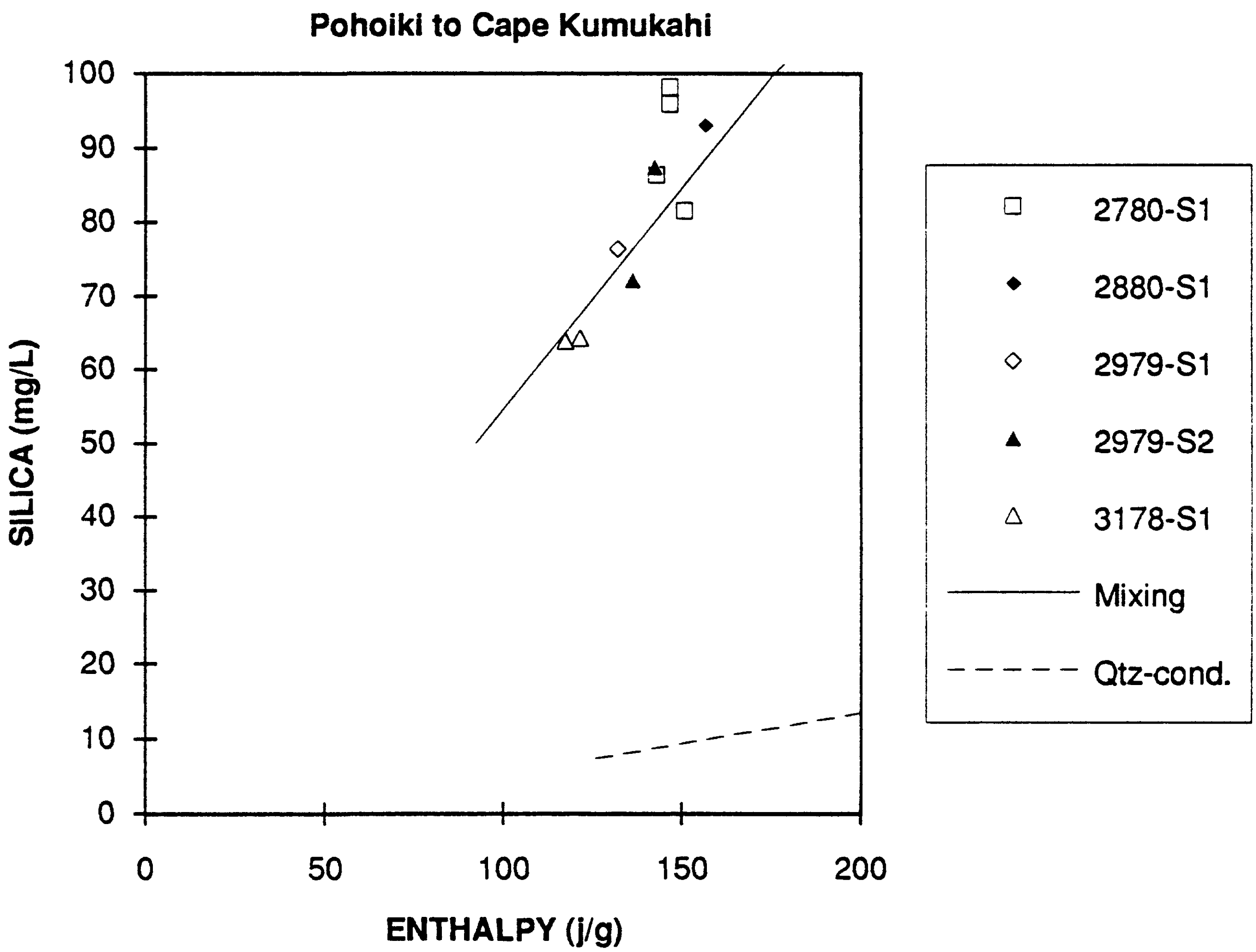

Figure 46. Silica versus enthalpy for samples of Figure 37. Data for repeat samplings shown. Mixing line is from assumed cold water and passing through center of data shown.

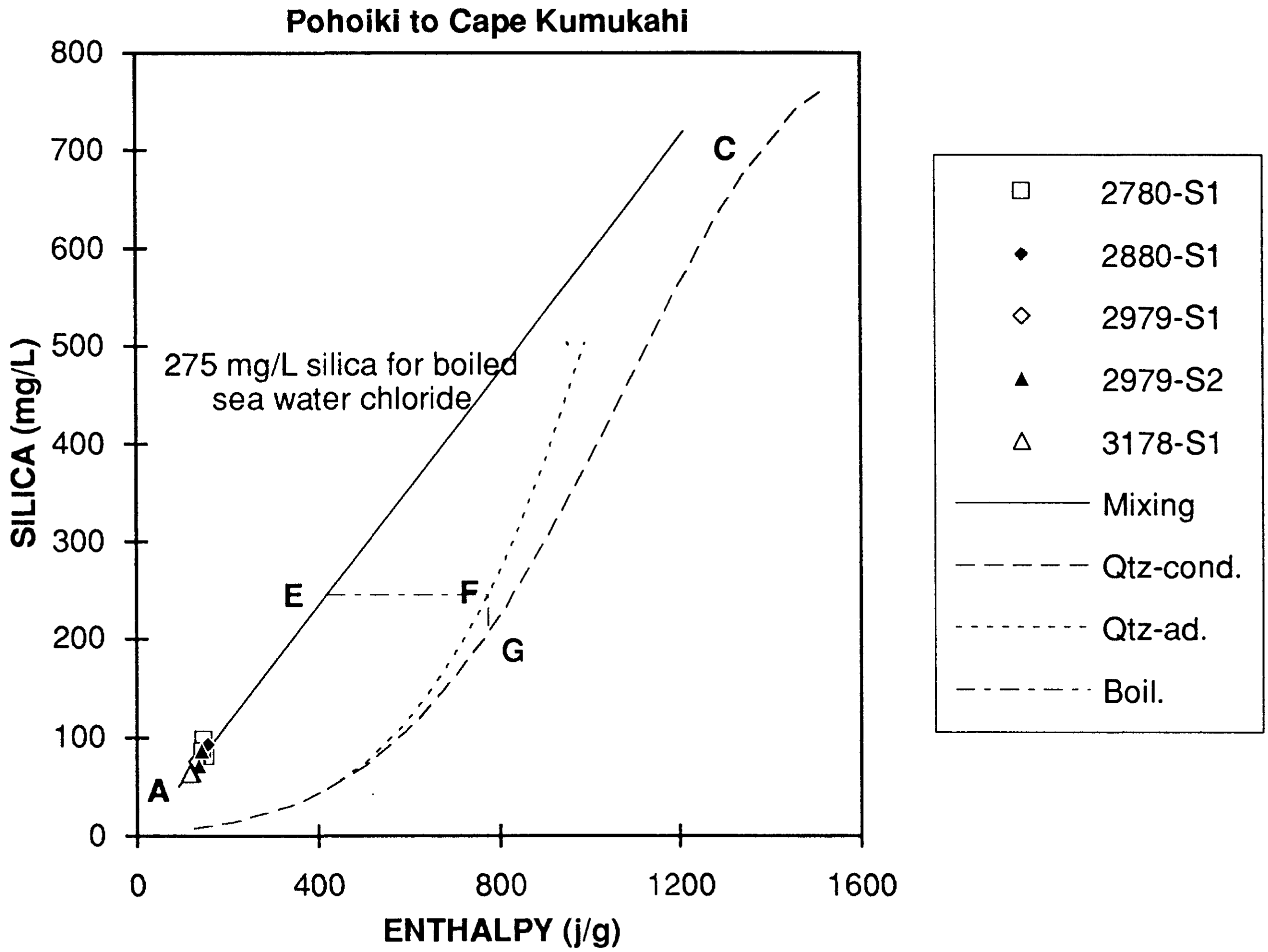

Figure 47. Silica versus enthalpy for samples of Figure 37. Mixing line is from Figure 46. Silica solubility is from Fournier and Potter (1982a). Point C is where intercept might be for warm-spring mixing model if mixing line had a lower slope. Points E, F, and G define relations for boiling spring mixing model.

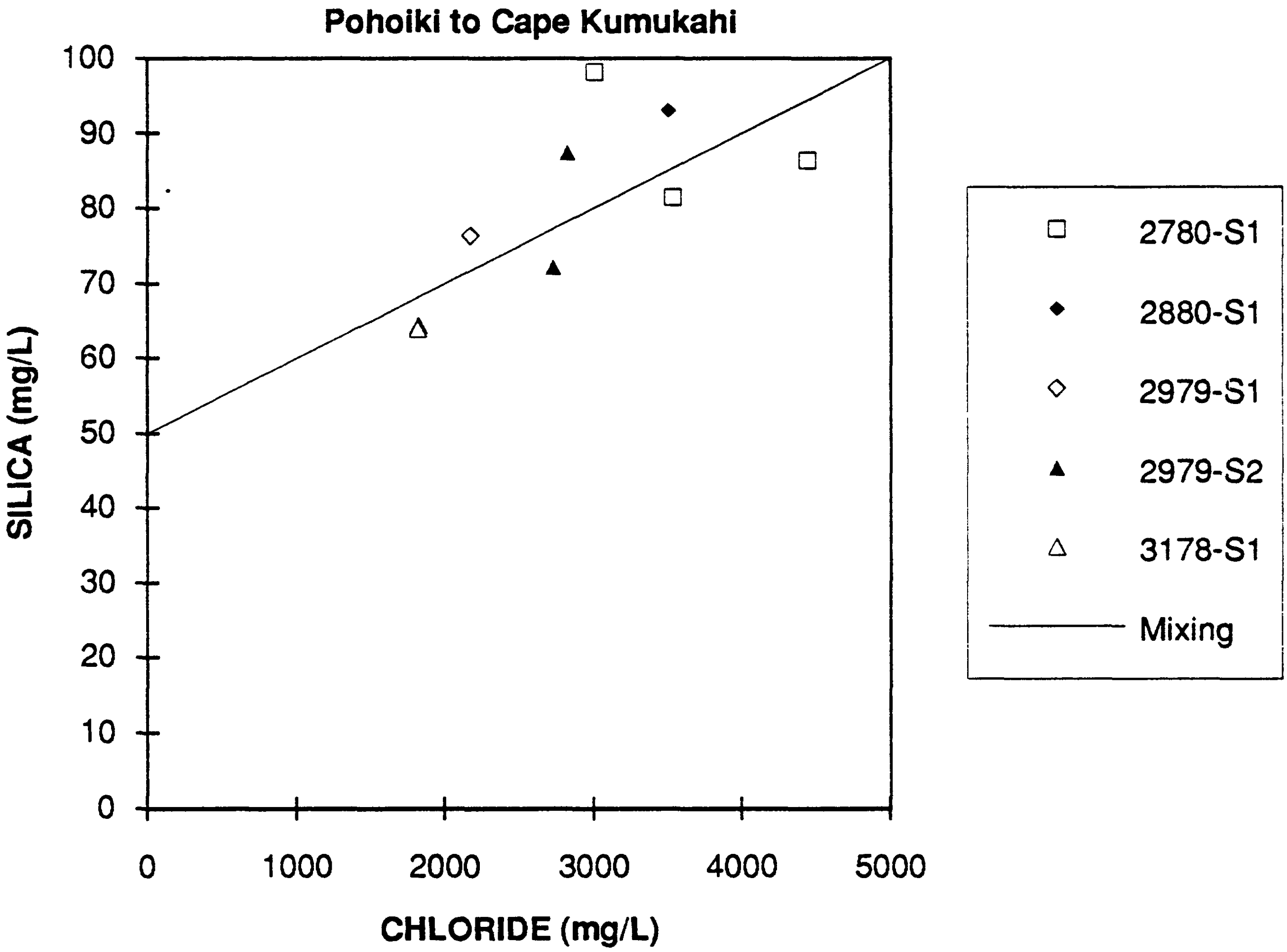

Figure 48. Silica versus chloride for samples of Figure 37. Data for repeat samplings shown. Mixing line is from assumed cold water and passing through center of data shown.

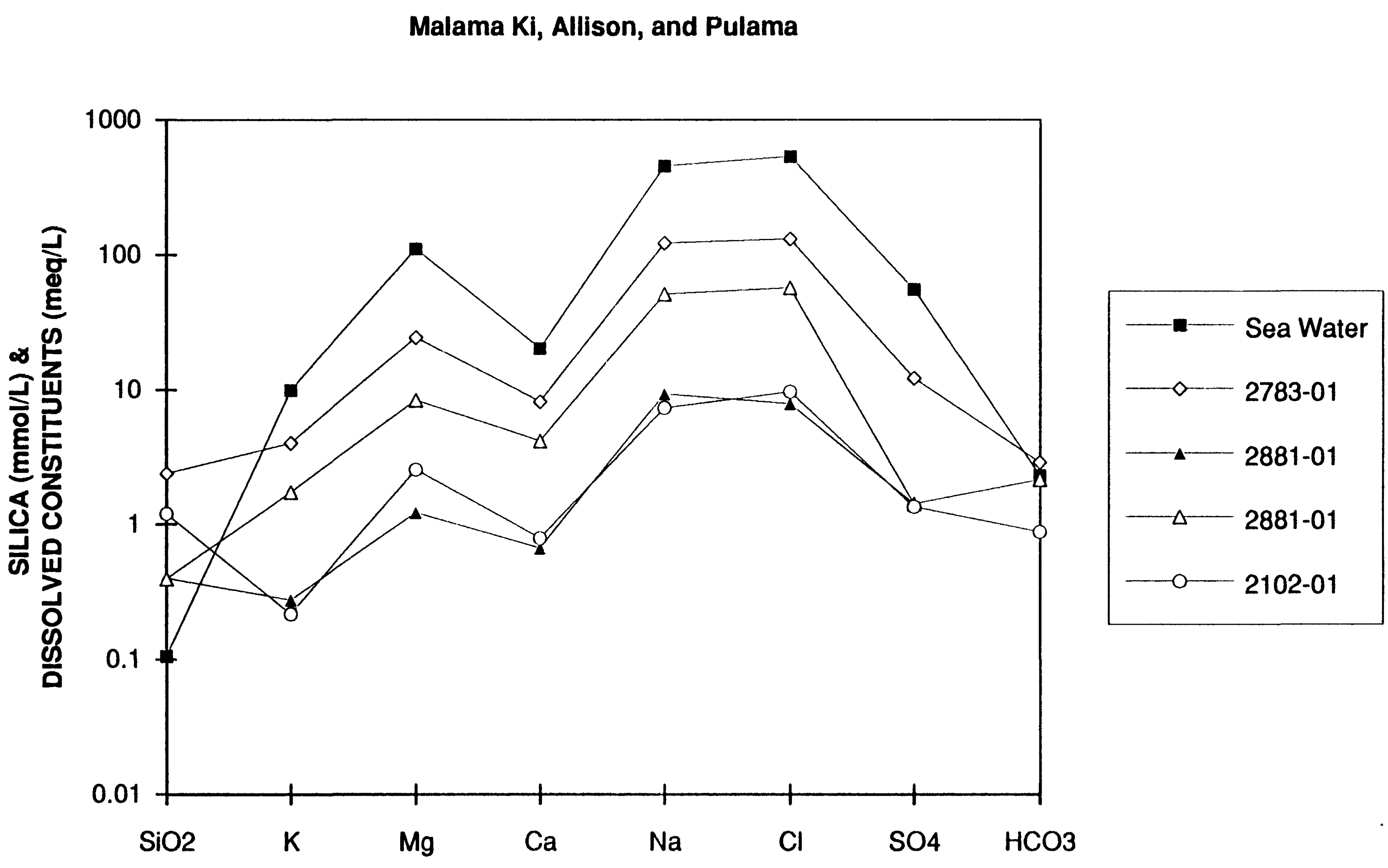

Figure 49. Modified Schoeller diagram for samples from the first group of wells between the east rift and the coast: The first group is Malama Ki (2783-01), Allison (2881-01), and Pulama (2102-01).

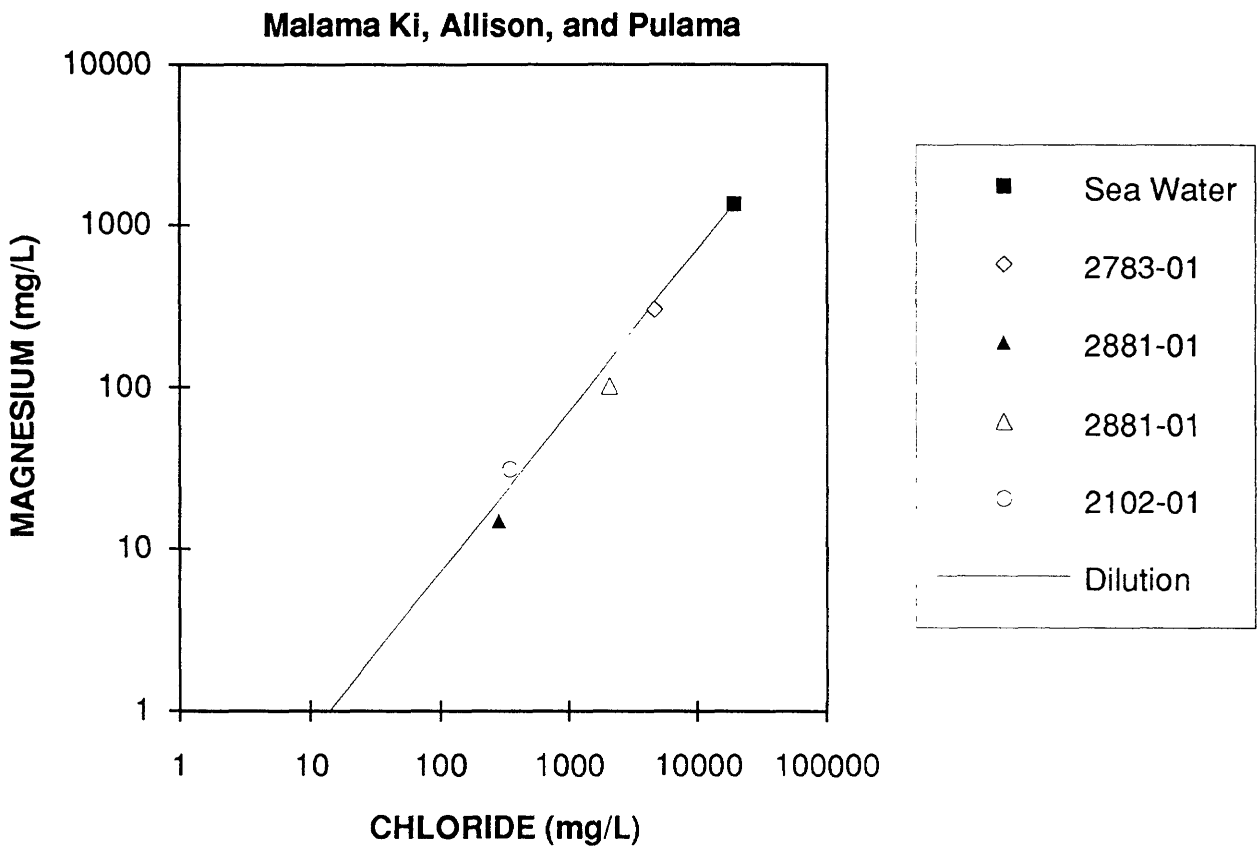

Figure 50. Magnesium versus chloride for samples of Figure 49. Dilution line shown differs from mixing line at low concentrations.

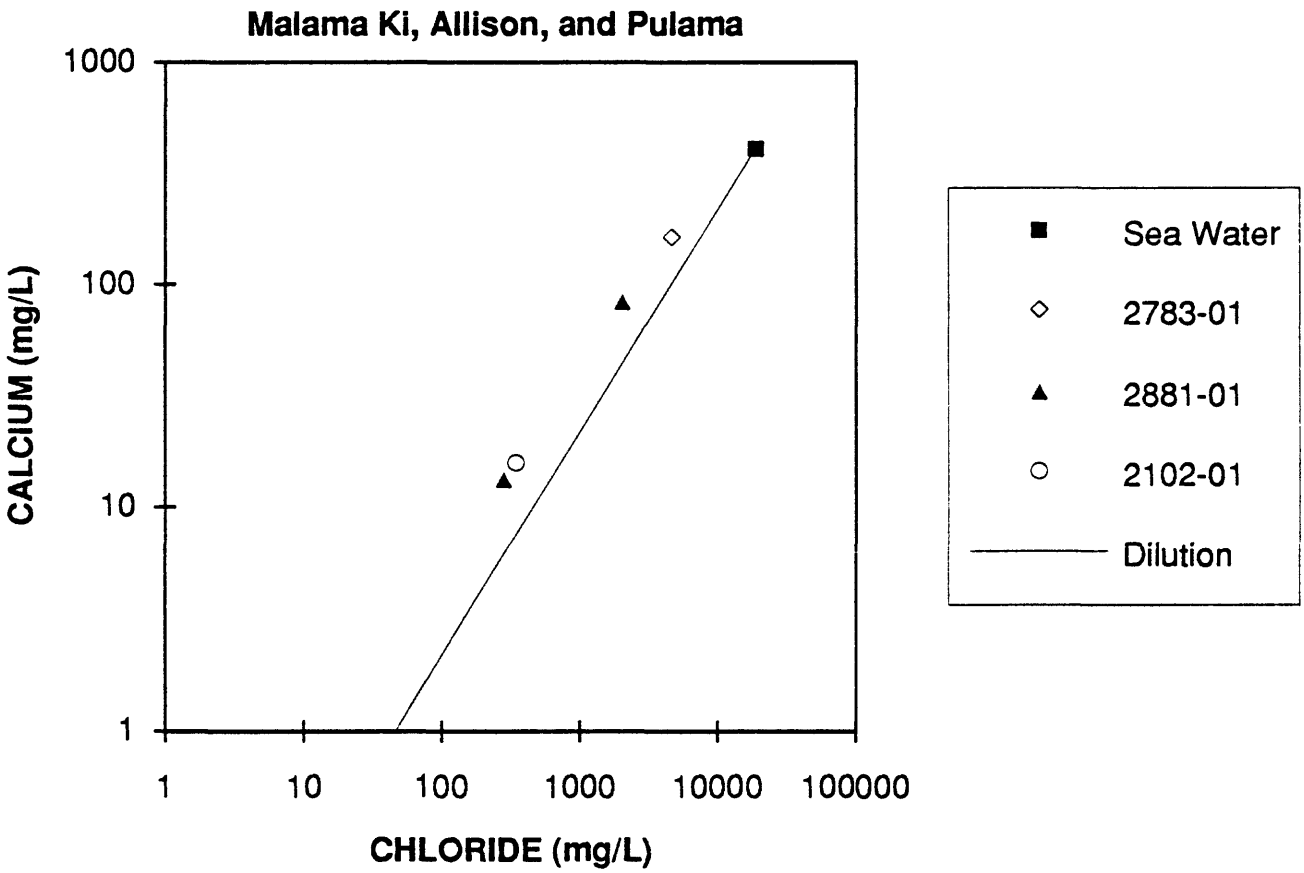

Figure 51. Calcium versus chloride for samples of Figure 49. Dilution line shown differs from mixing line at low concentrations.

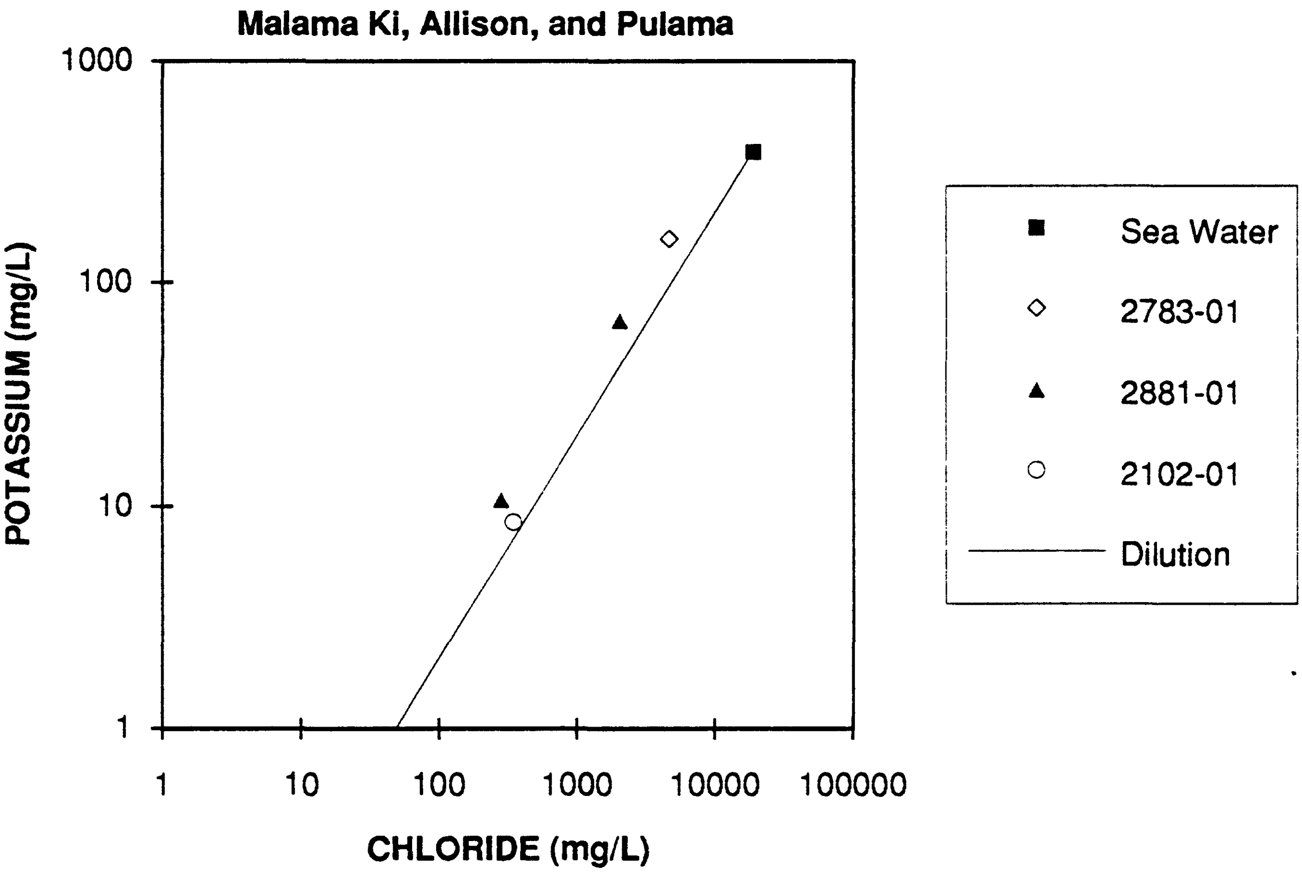

Figure 52. Potassium versus chloride for samples of Figure 49. Dilution line shown differs from mixing line at low concentrations.

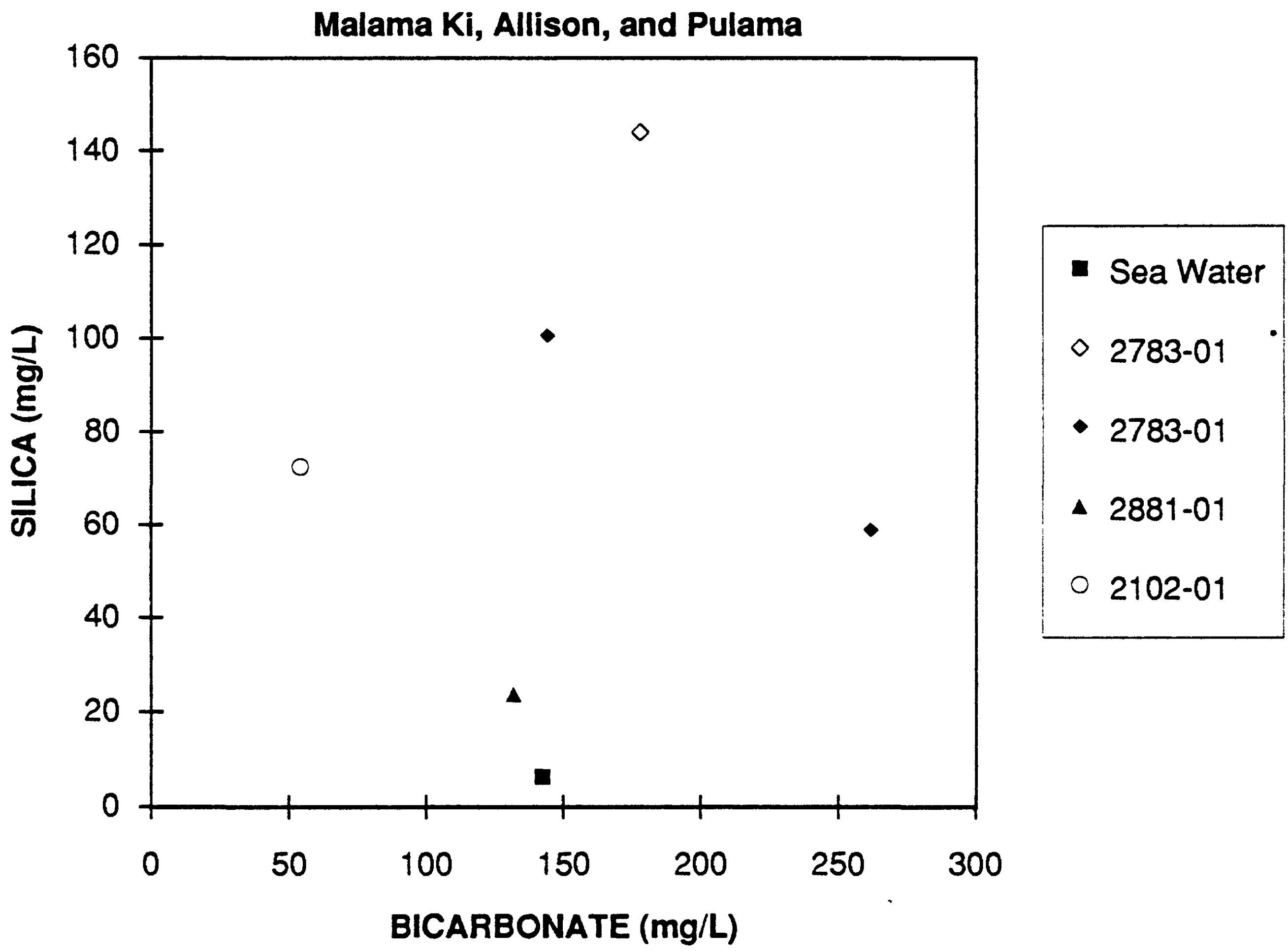

Figure 53. Silica versus bicarbonate for samples of Figure 49 and repeat samplings of Malama Ki (filled diamond).

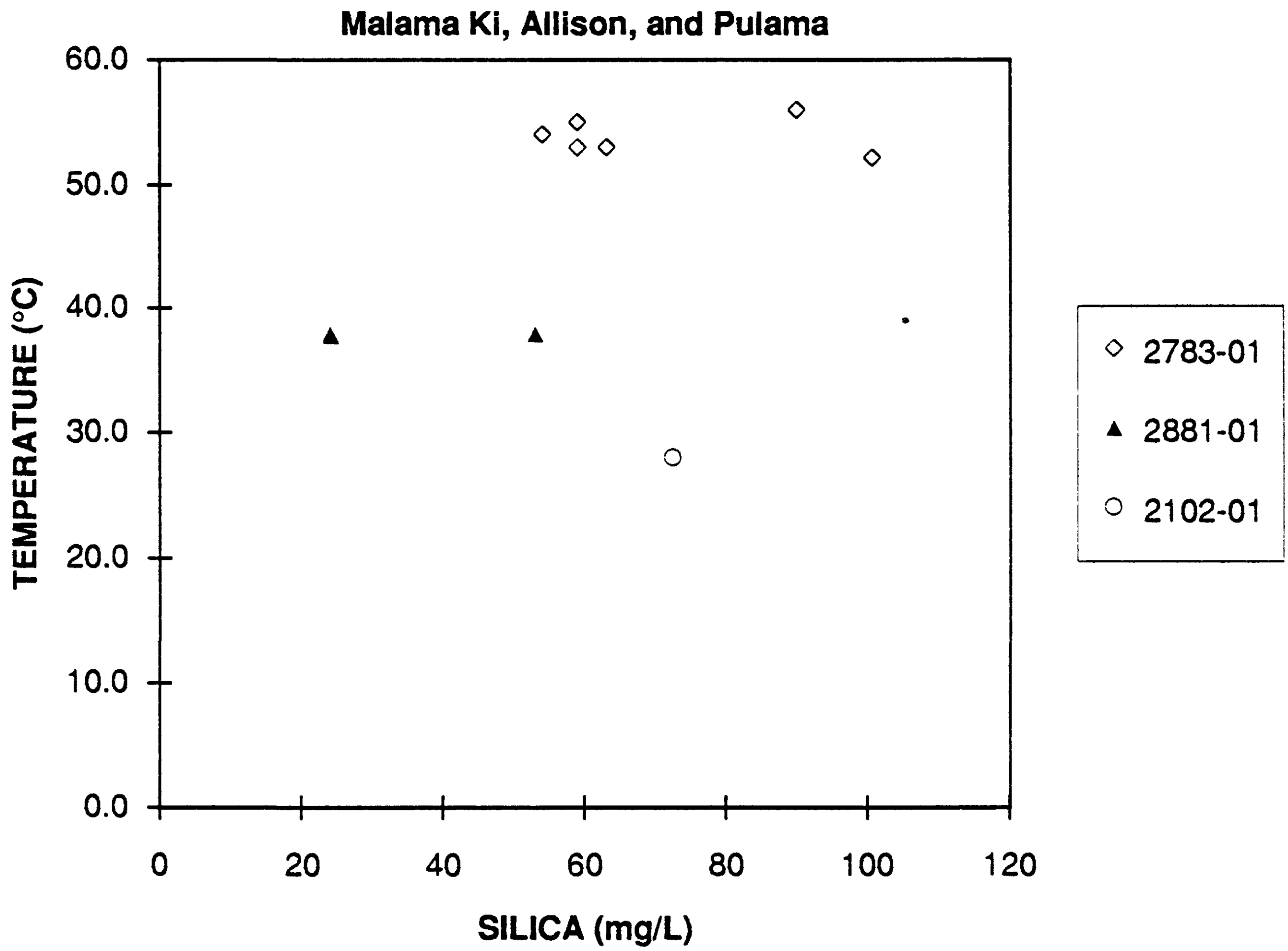

Figure 54. Temperature versus silica for samples of Figure 49, repeat samplings of Malama Ki (open diamond), and McMurtry and others (1977) sample for Allison.

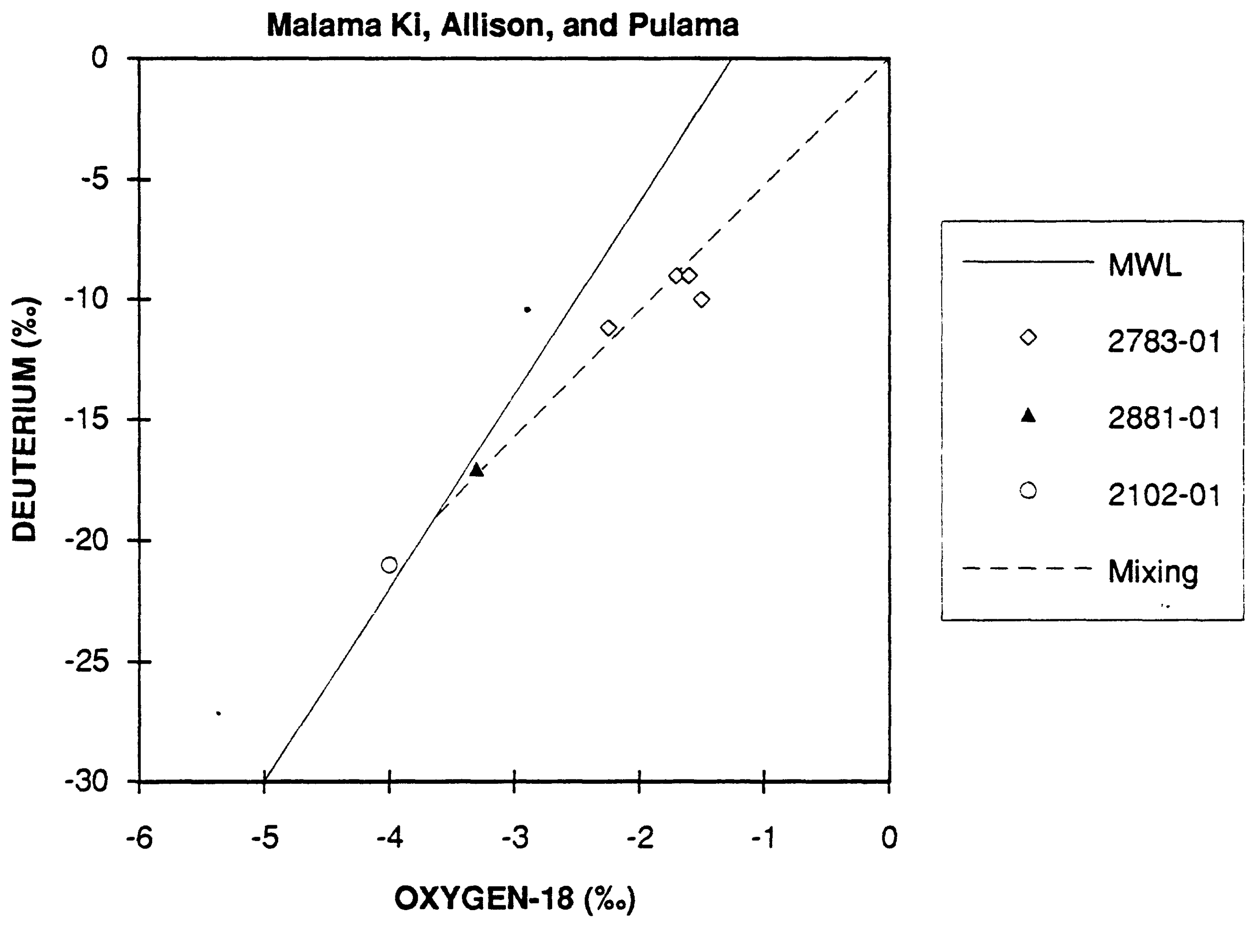

Figure 55. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for McMurtry and others (1977) samples for wells of Figure 49. Global meteoric water line is from Craig (1961).

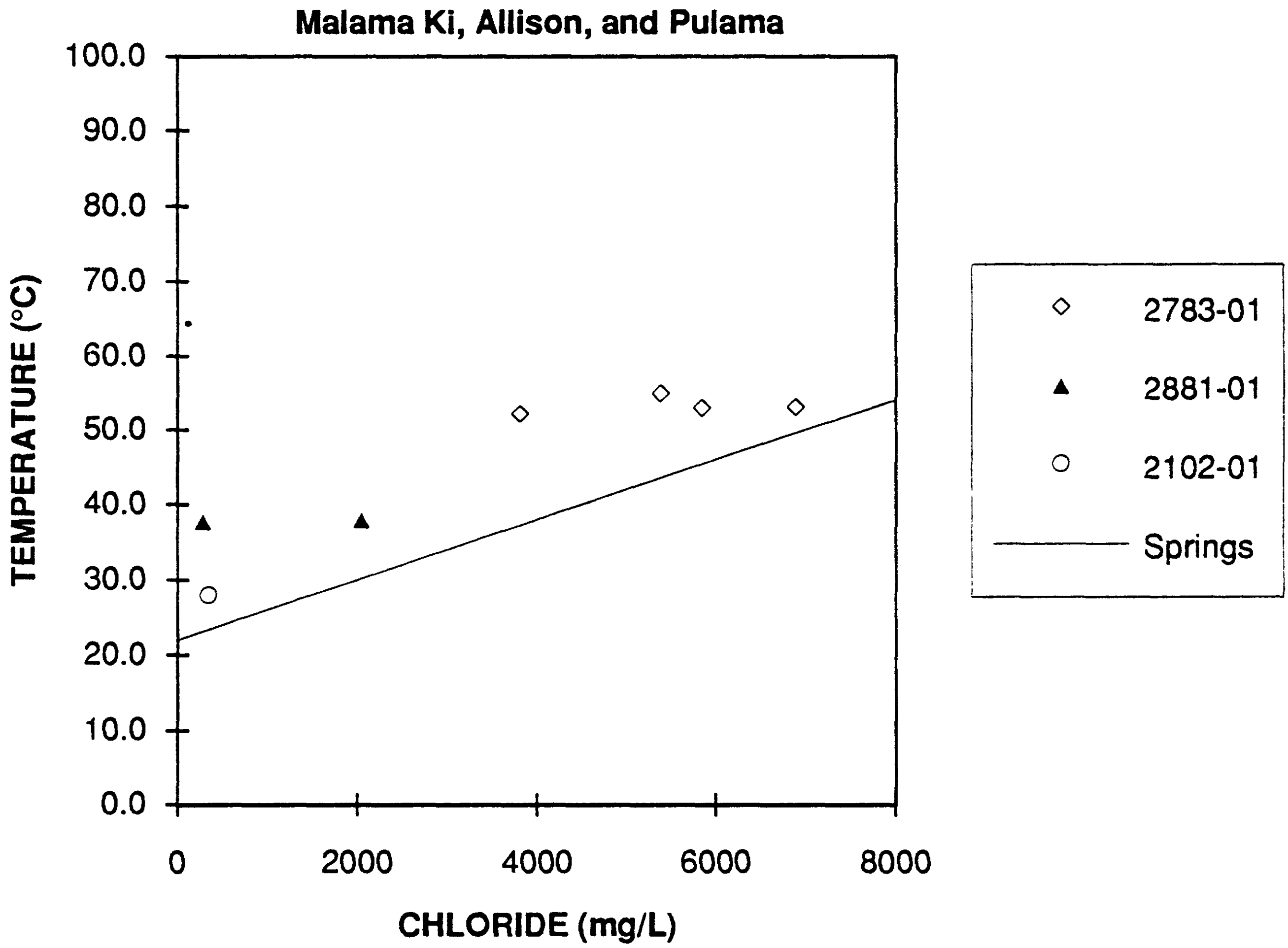

Figure 56. Temperature versus chloride for samples of Figure 49 with repeat samplings shown. Line is for mixing relation of temperature (actually enthalpy) versus chloride for coastal springs south of east rift.

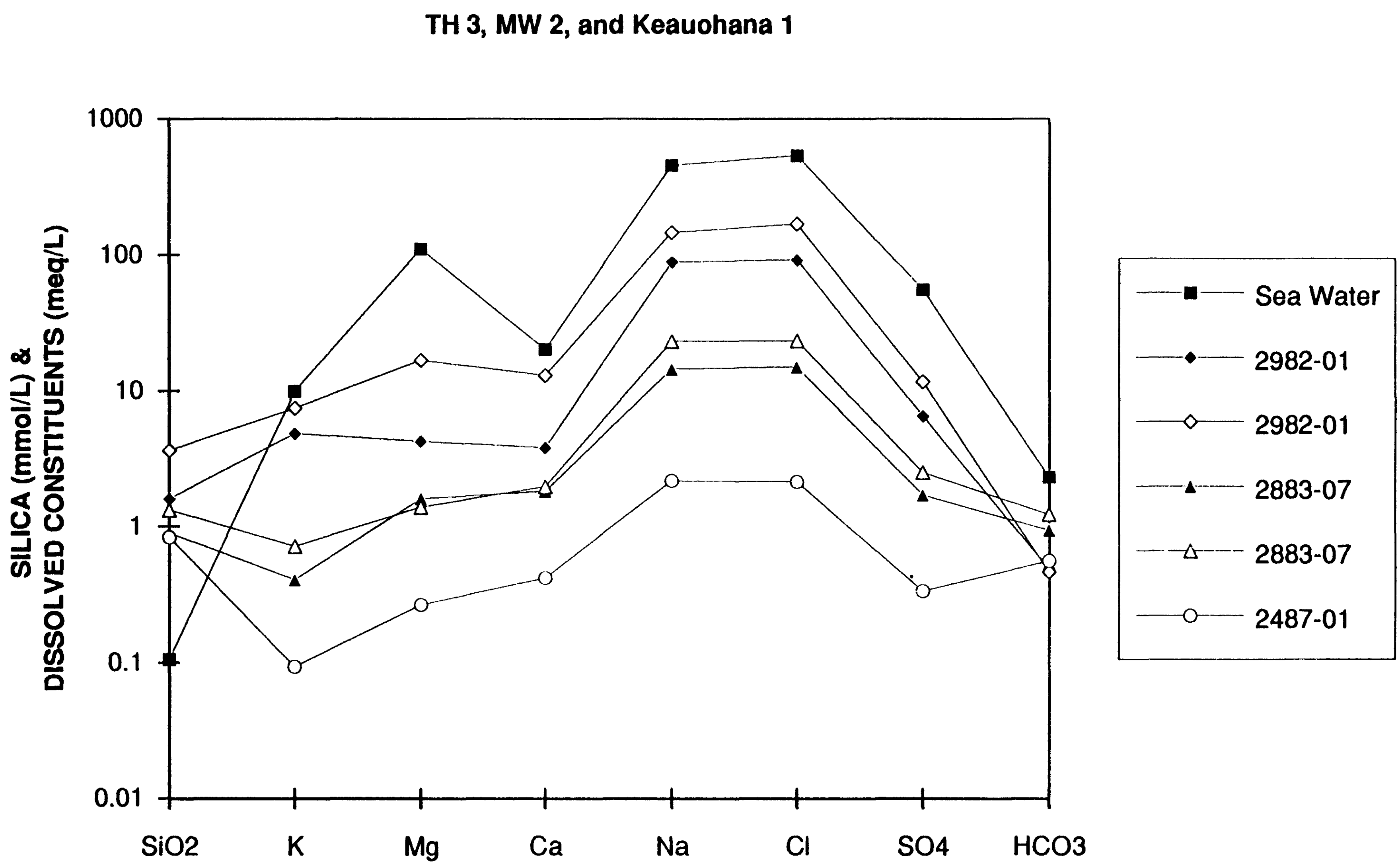

Figure 57. Modified Schoeller diagram for samples from the second group of wells between the east rift and the coast: The second group is Puna Thermal TH 3 (2982-01), Puna Geothermal MW 2 (2883-07), and Keauohana 1 (2487-01).

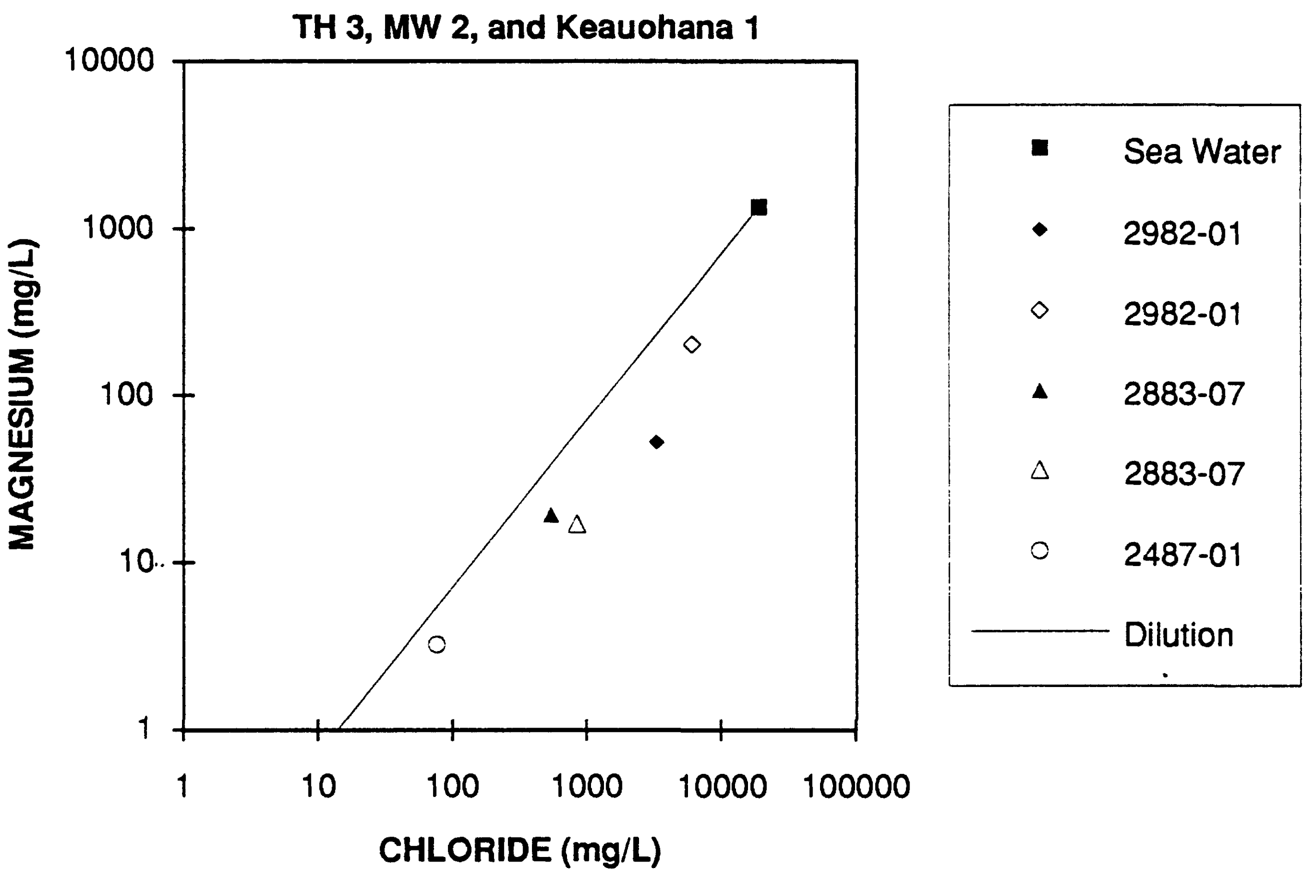

Figure 58. Magnesium versus chloride for samples of Figure 57. Dilution line shown differs from mixing line at low concentrations.

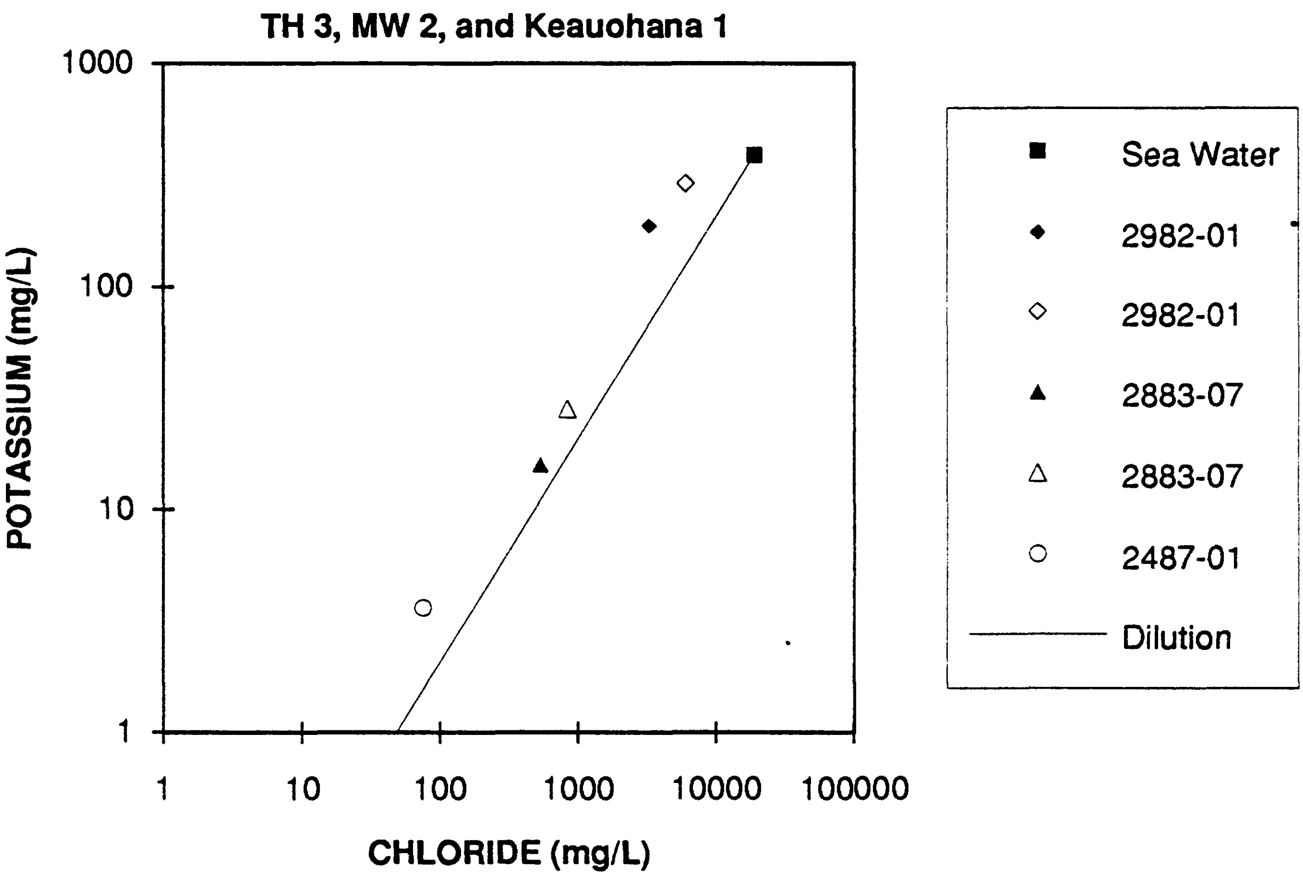

Figure 59. Potassium versus chloride for samples of Figure 57. Dilution line shown differs from mixing line at low concentrations.

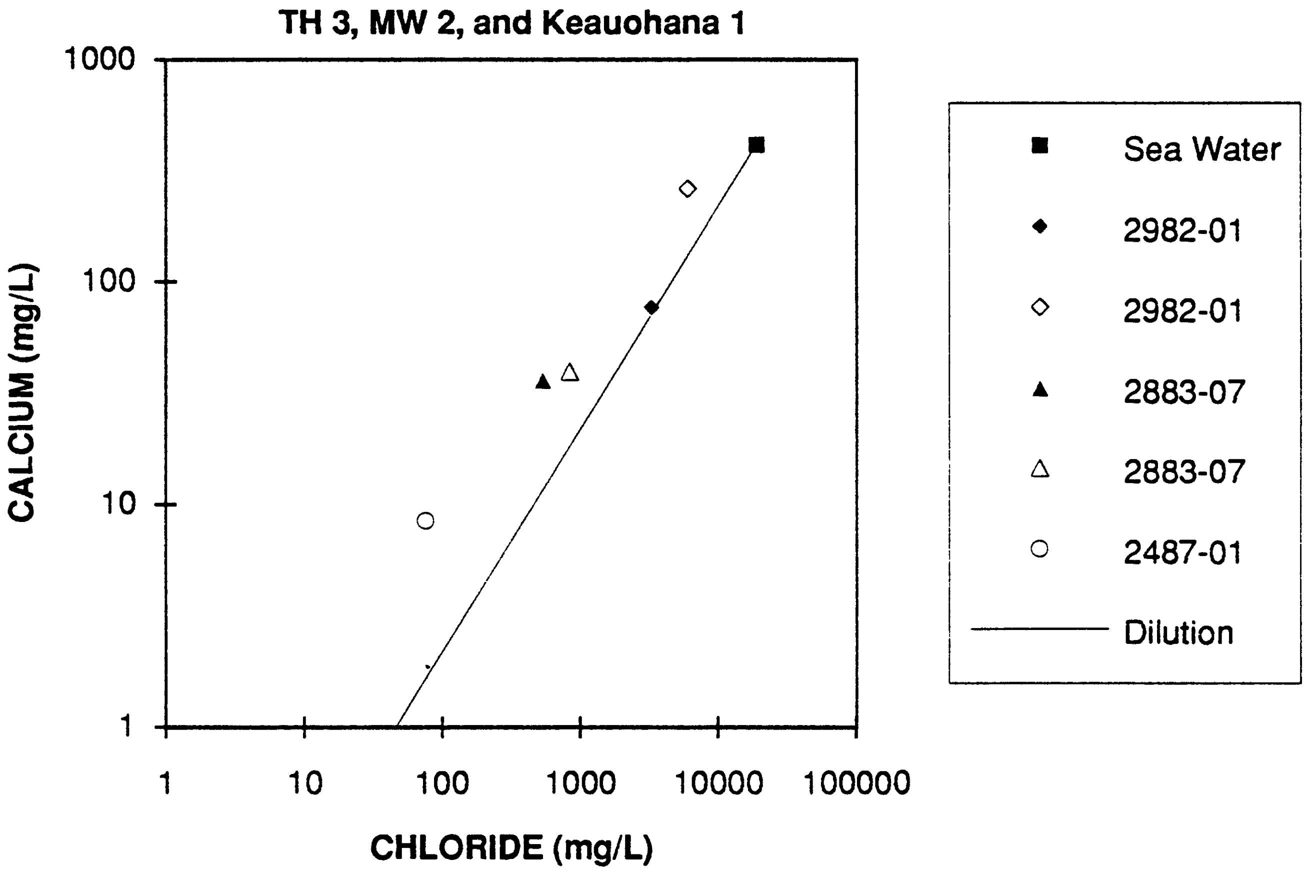

Figure 60. Calcium versus chloride for samples of Figure 57. Dilution line shown differs from mixing line at low concentrations.

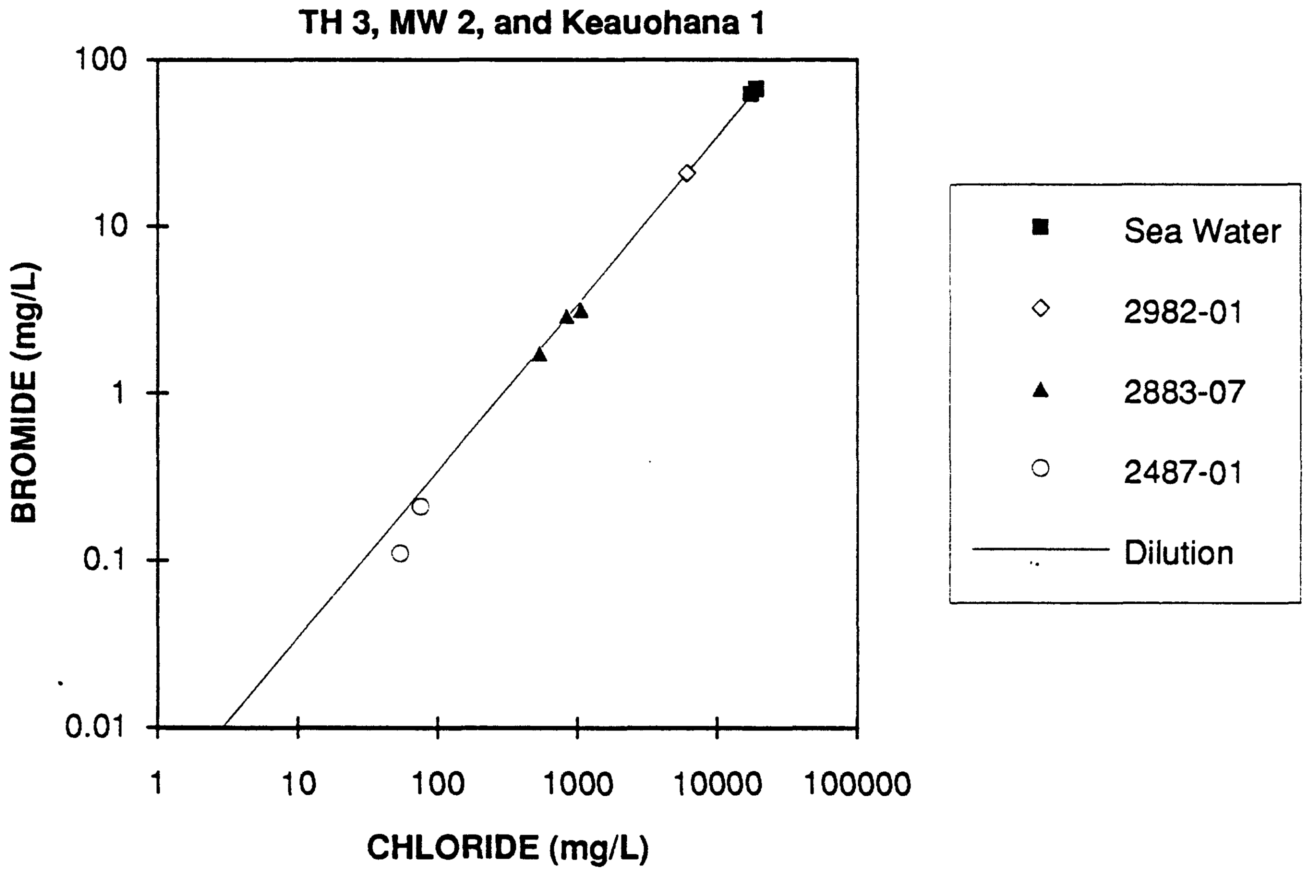

Figure 61. Bromide versus chloride for samples of Figure 57. Dilution line shown differs from mixing line at low concentrations.

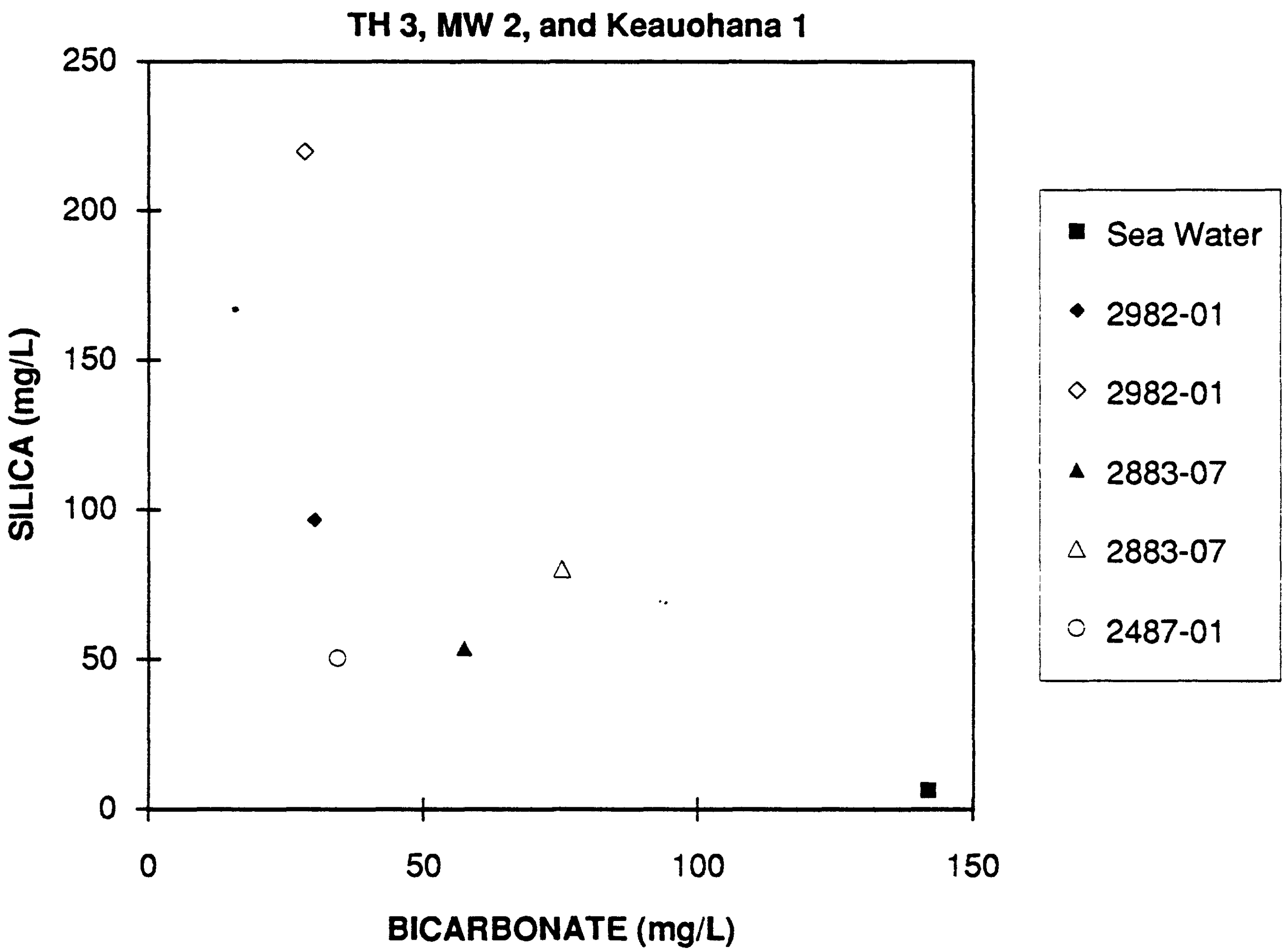

Figure 62. Silica versus bicarbonate for samples of Figure 57.

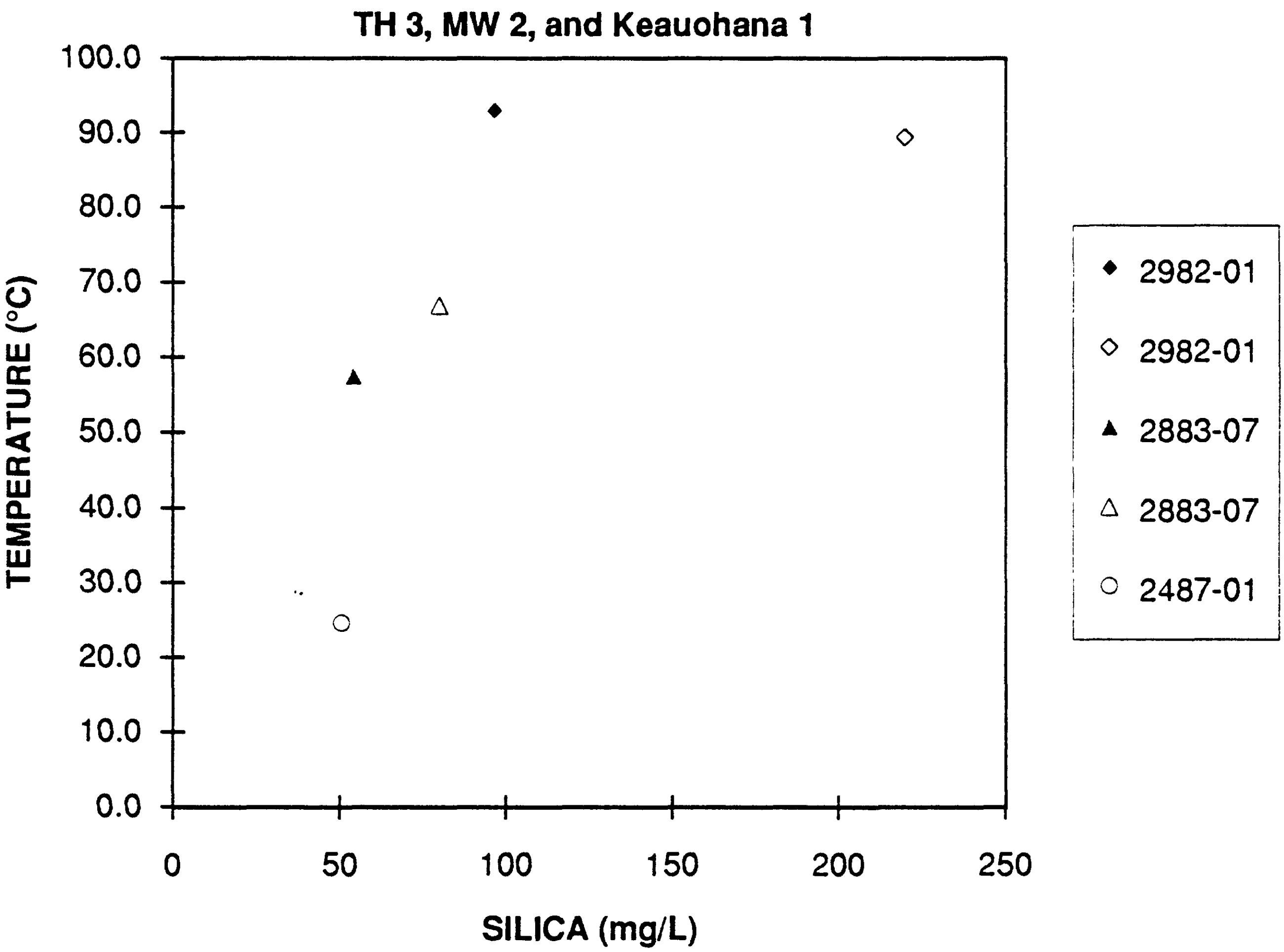

Figure 63. Temperature versus silica for samples of Figure 57.

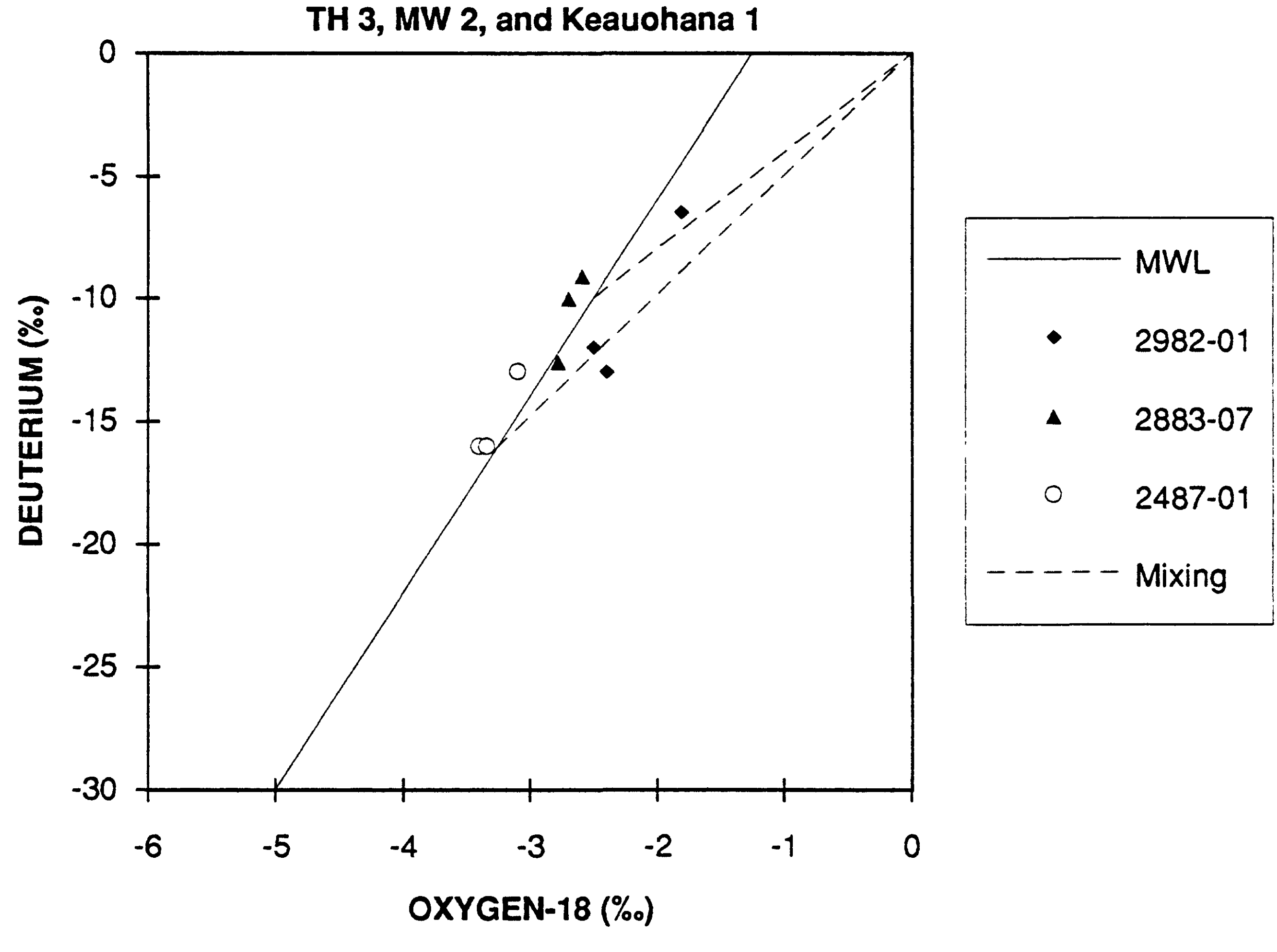

Figure 64. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples for wells of Figure 57. Data for repeat samplings shown. Global meteoric water line is from Craig (1961). Mixing lines are from sea water and passing through deuterium at zero chloride from the deuterium versus chloride for 1991-92 data and through deuterium versus oxygen-18 for data from McMurtry and others (1977).

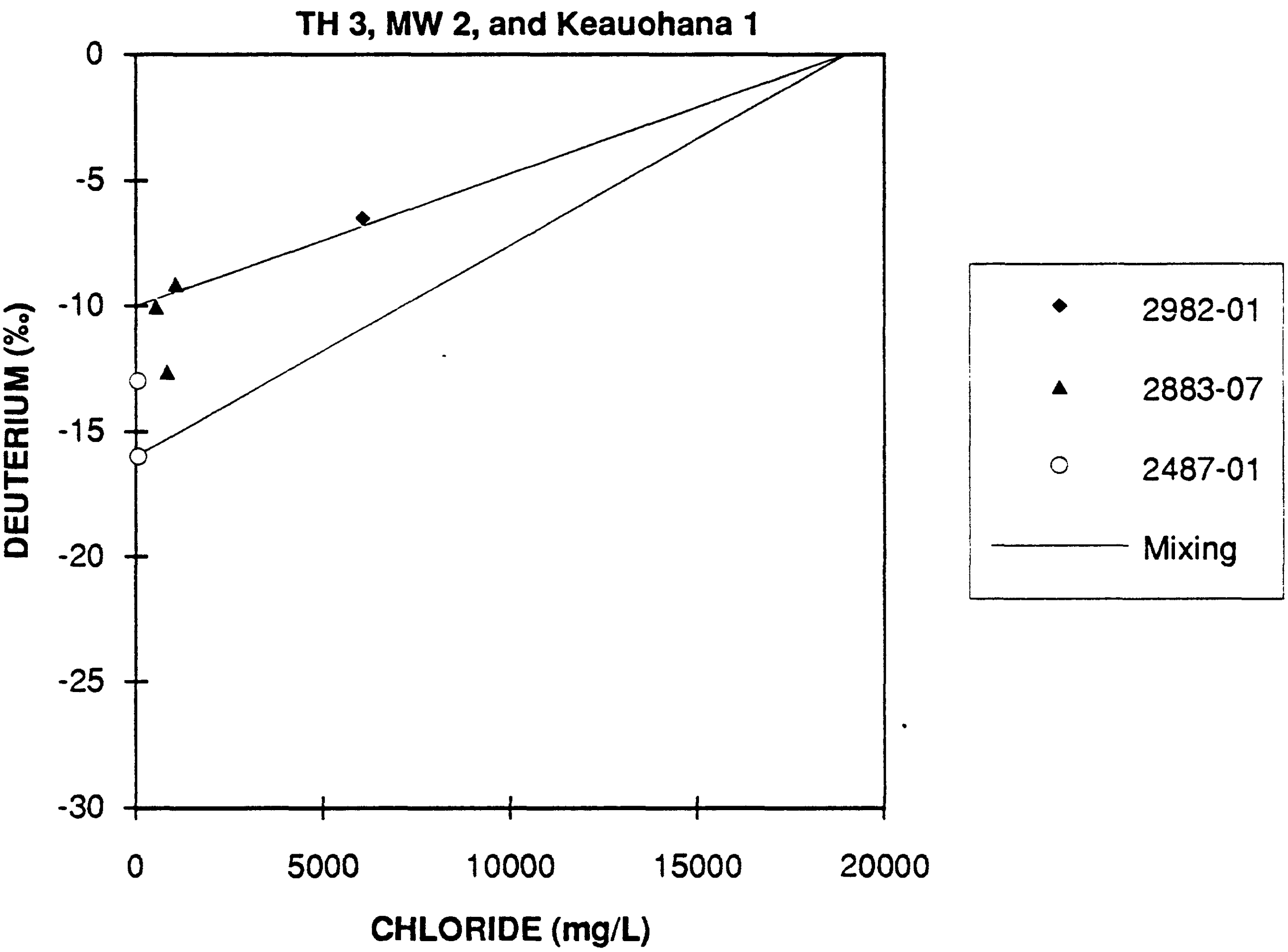

Figure 65. Deuterium versus chloride for samples of Figure 57. Upper mixing line obtained from this plot and lower mixing line from deuterium versus oxygen-18 plot.

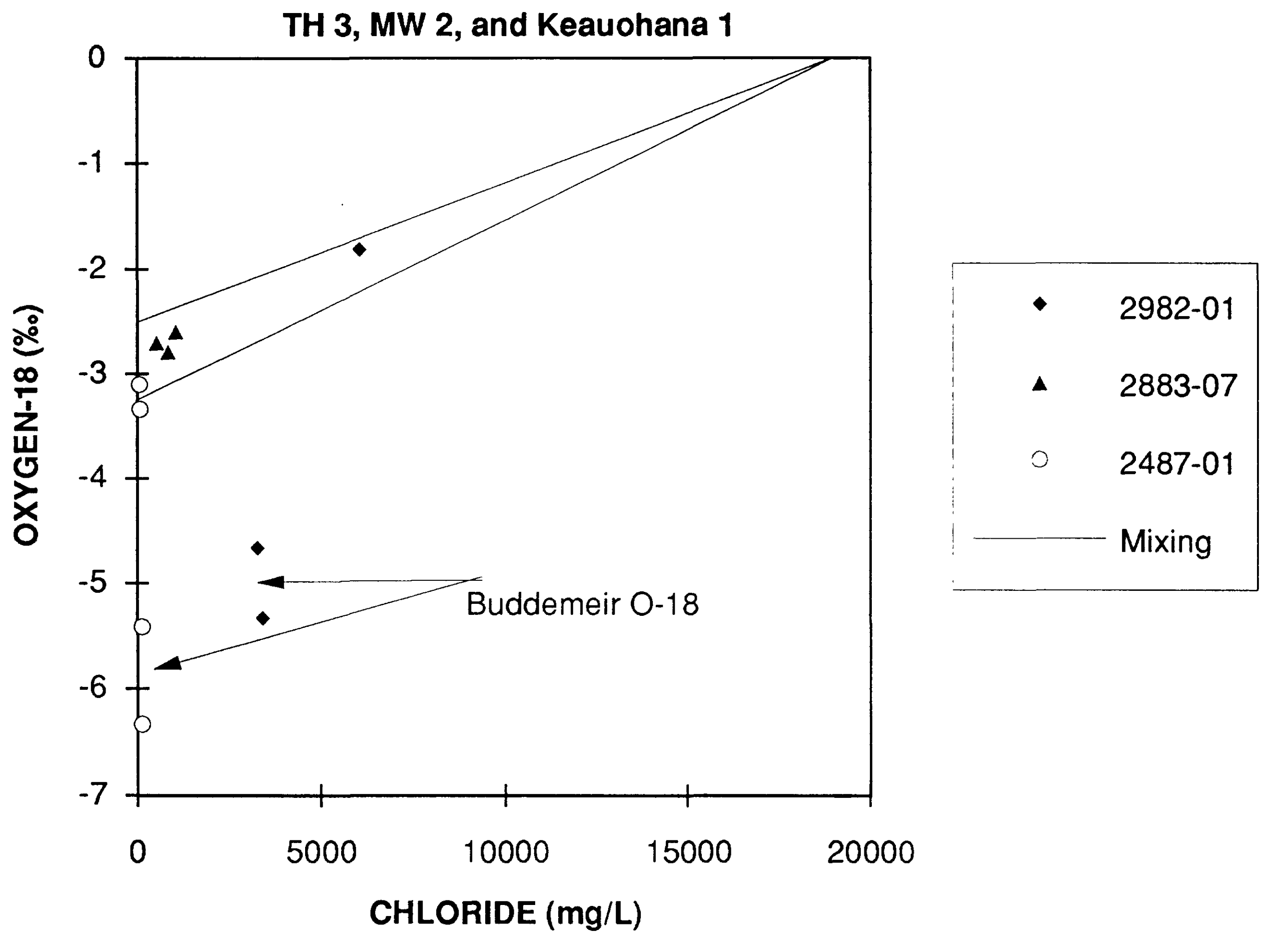

Figure 66. Oxygen-18 versus chloride for samples of Figure 57. Data for repeat samplings shown. Upper mixing line is from assumed sea water and passes through value calculated using the global meteoric water line and intercept from Figure 65, and lower mixing line is from deuterium versus oxygen-18 plot. Data of Buddemeier and others is from Shupe and others (1976).

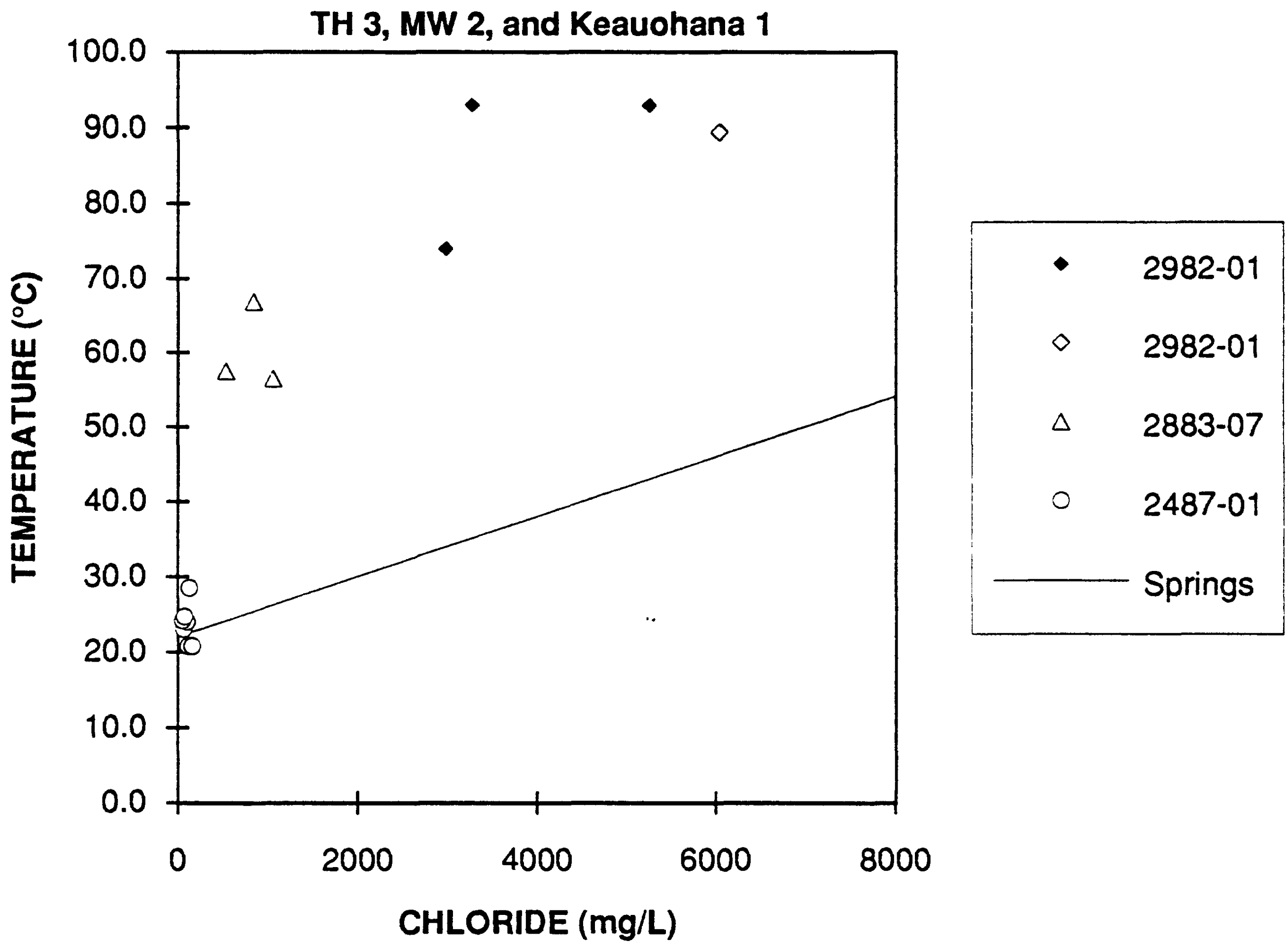

Figure 67. Temperature versus chloride for samples of Figure 57. Repeat samplings shown. Line is for mixing relation of temperature (actually enthalpy) versus chloride for coastal springs south of east rift.

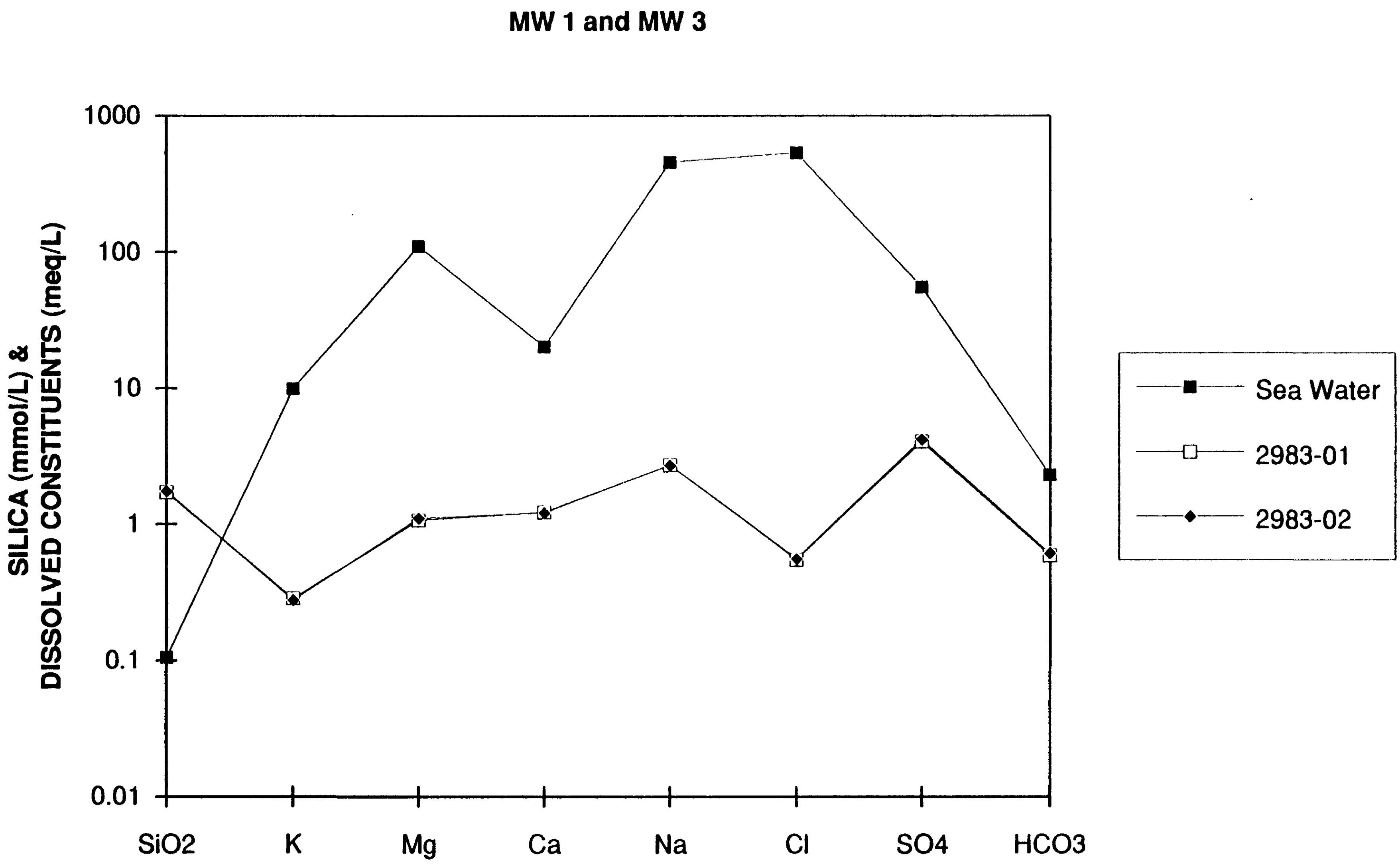

Figure 68. Modified Schoeller diagram for samples from Puna Geothermal MW 1 (2983-01) and MW 3 (2983-02) wells.

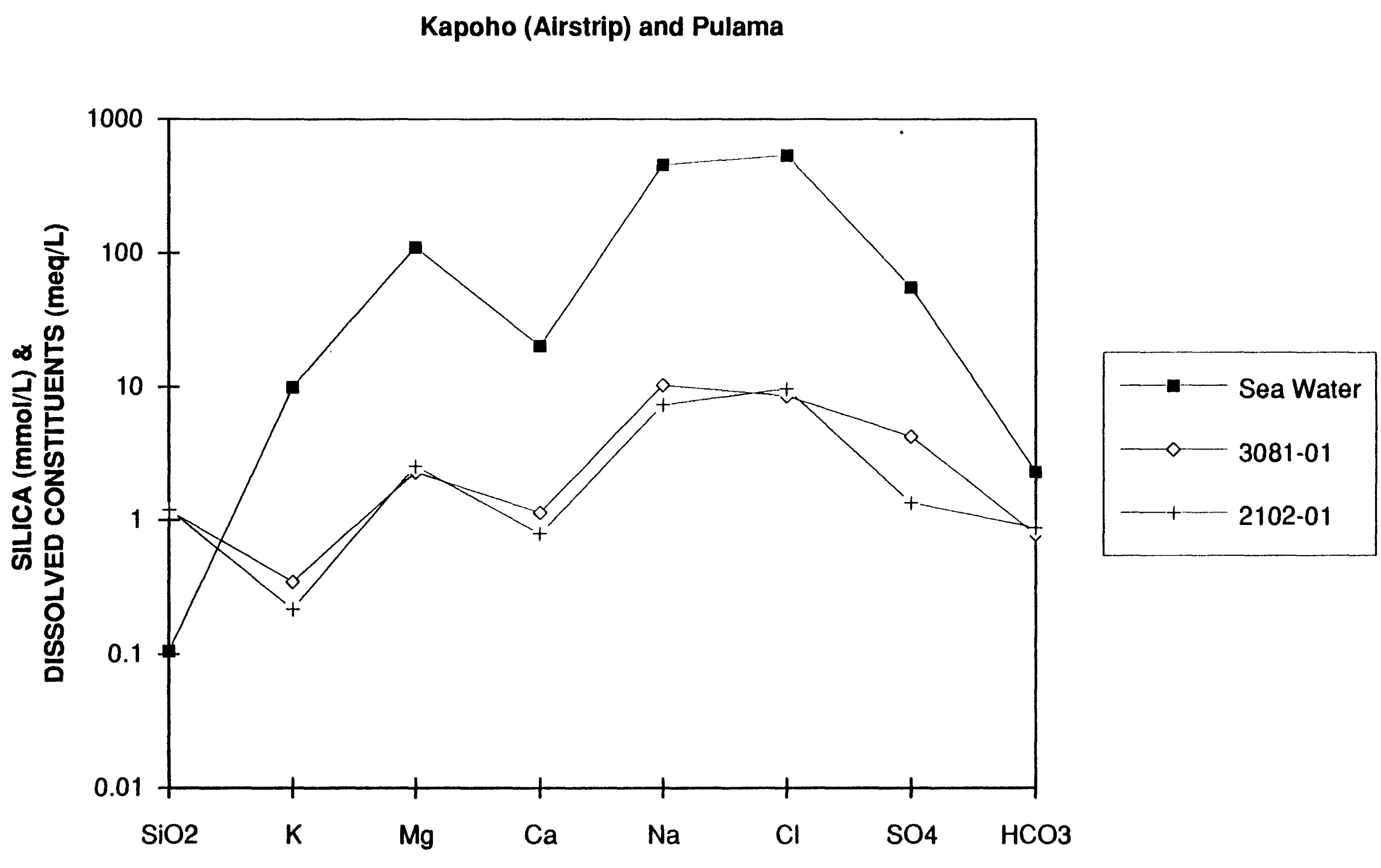

Figure 69. Modified Schoeller diagram for samples from Kapoho (Airstrip) (3081-01) and Pulama (2102-01) for comparison.

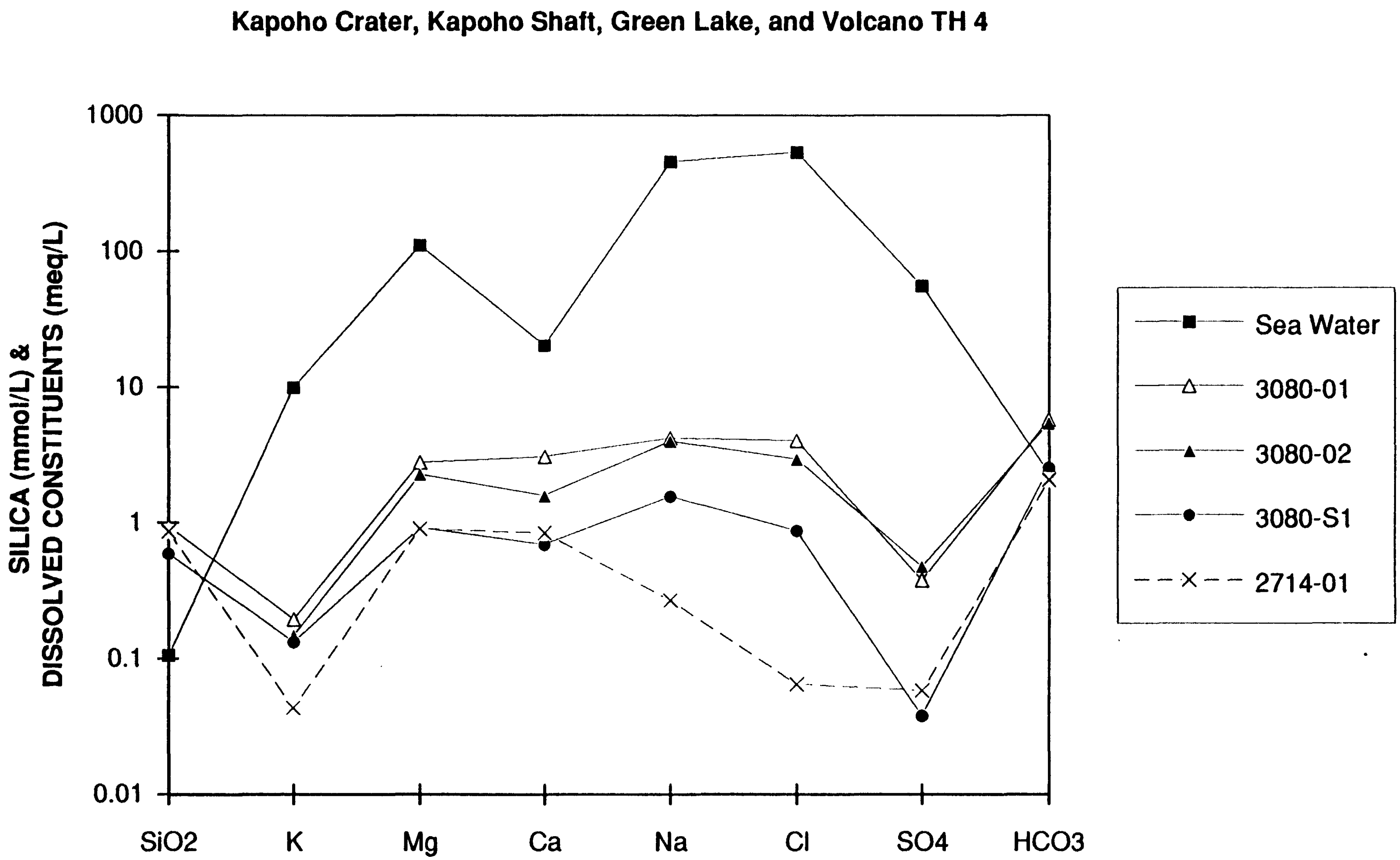

Figure 70. Modified Schoeller diagram for samples from Green Lake (3080-S1), Kapoho Crater (3080-01) and Kapoho Shaft (3080-02) with Volcano TH-4 (2714-01) for comparison.

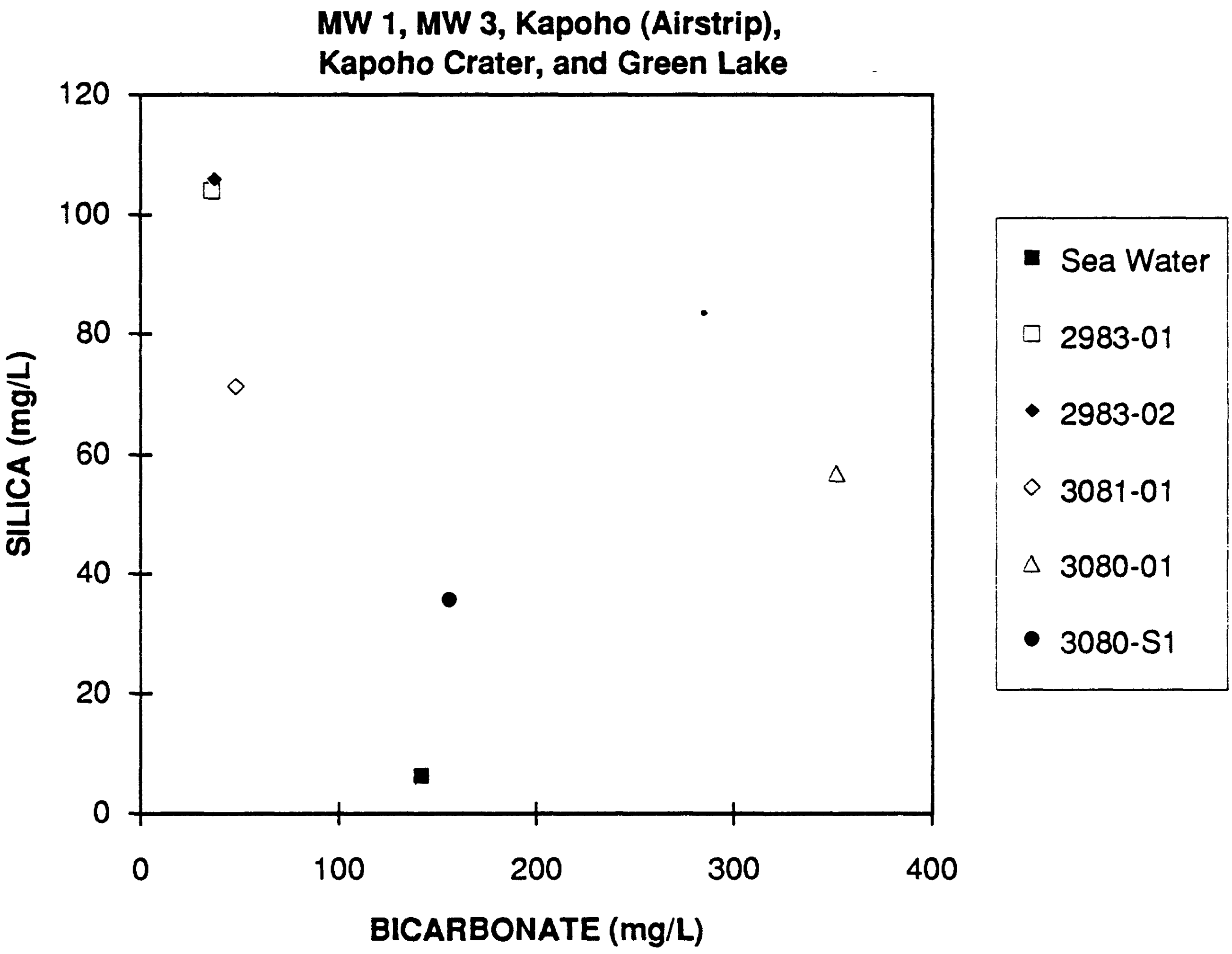

Figure 71. Silica versus bicarbonate for samples of Figures 68, 69, and 70.

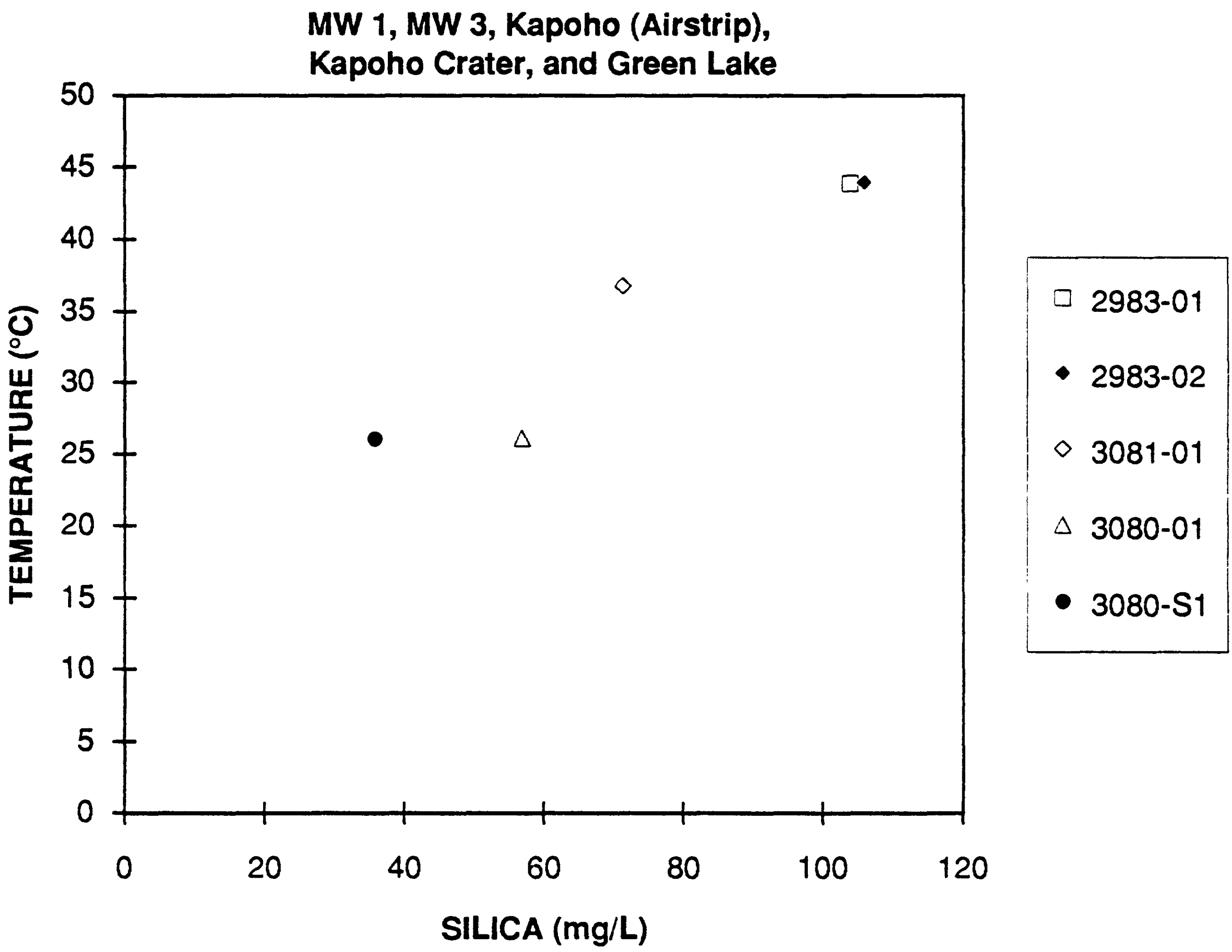

Figure 72. Temperature versus silica for samples of Figures 68, 69, and 70.

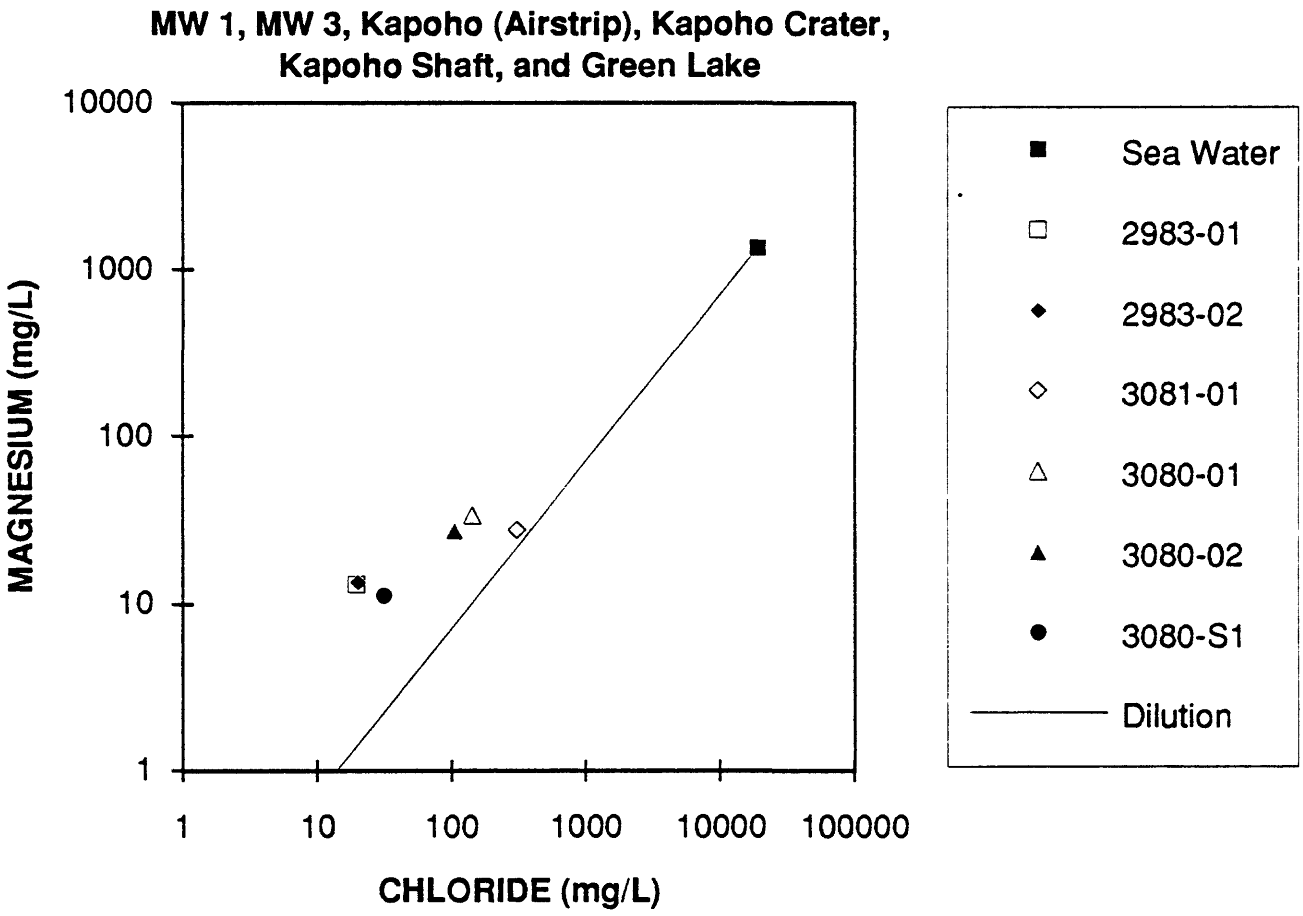

Figure 73. Magnesium versus chloride for samples of Figures 68, 69, and 70. Dilution line shown differs from mixing line at low concentrations.

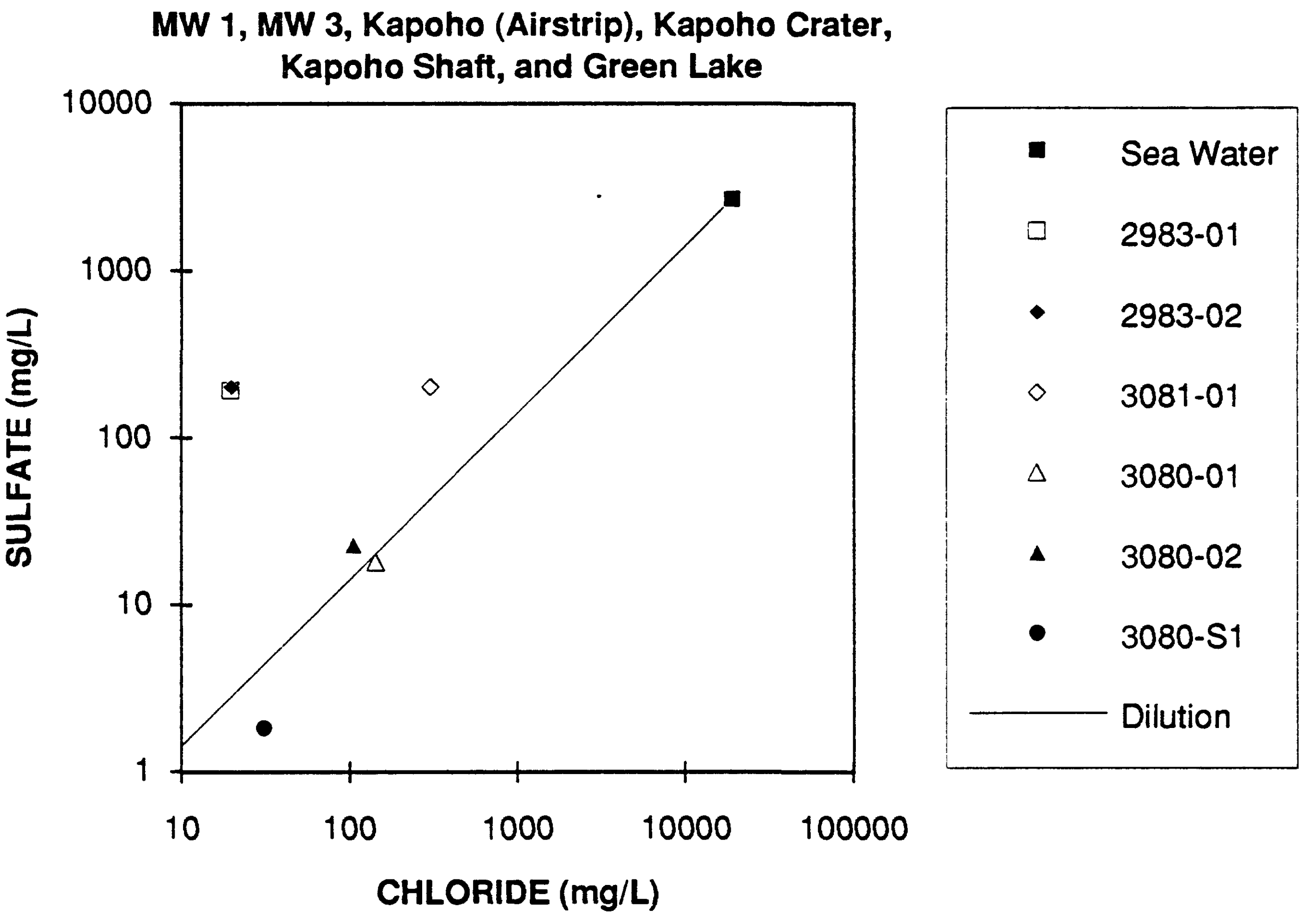

Figure 74. Sulfate versus chloride for samples of Figures 68, 69, and 70. Dilution line shown differs from mixing line at low concentrations.

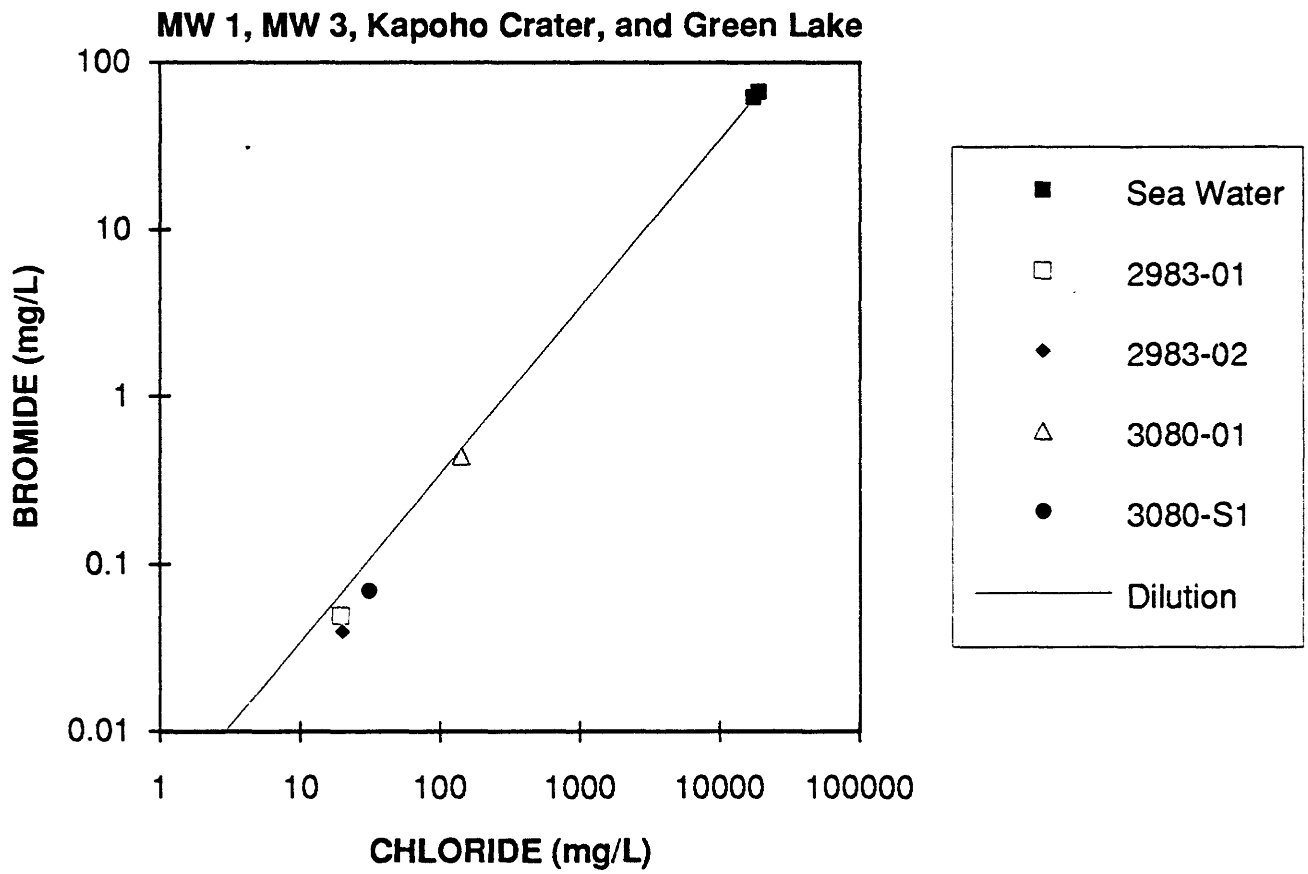

Figure 75. Bromide versus chloride for samples of Figures 68, 69, and 70. Dilution line shown differs from mixing line at low concentrations.

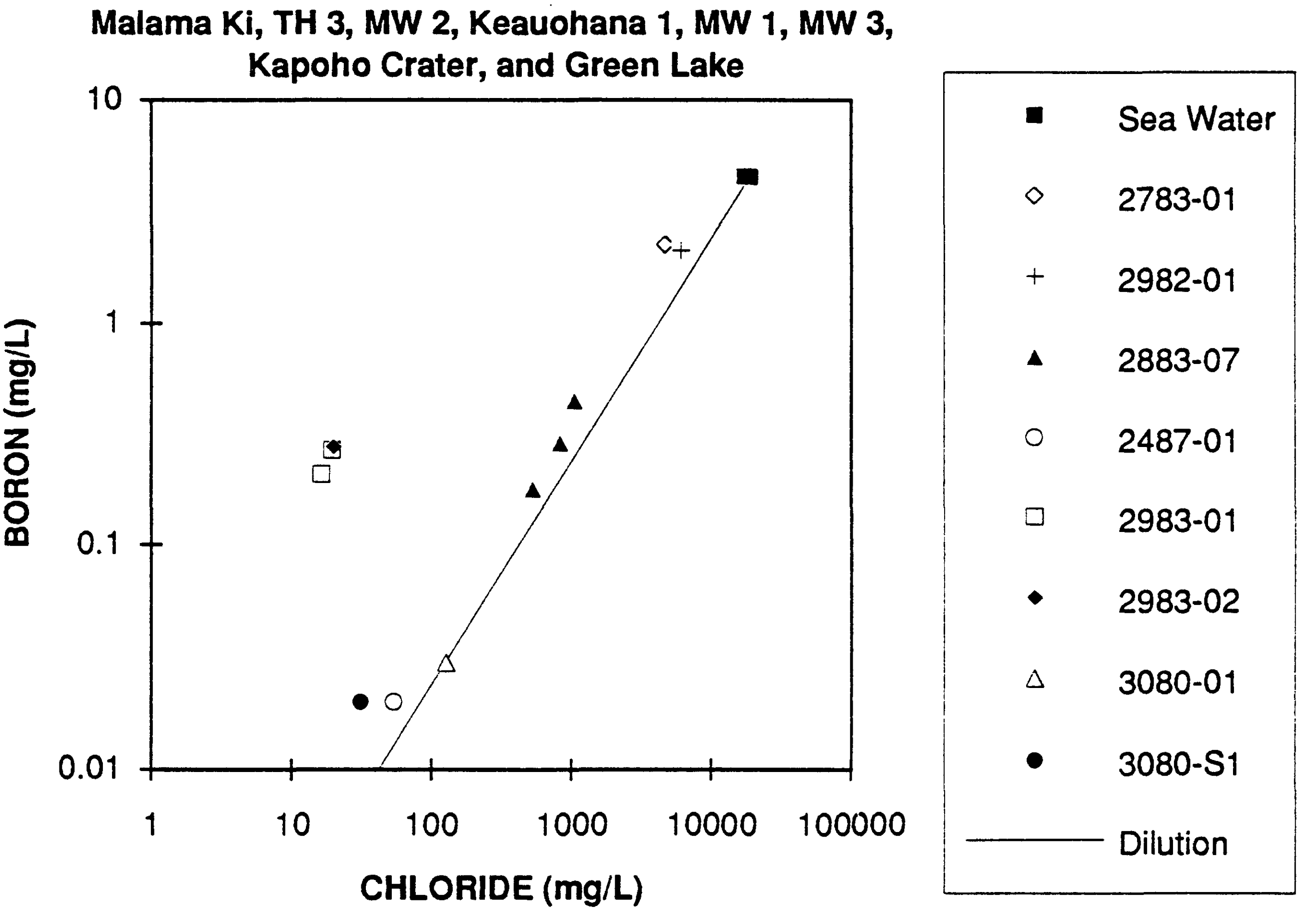

Figure 76. Boron versus chloride for samples with boron data of Figures 49, 57, 68, 69, and 70: Malama Ki (2783-01), Puna Thermal TH 3 (2982-01), Puna Geothermal MW 2 (2883-07), Keauohana 1 (2487-01), Puna Geothermal MW 1 (2983-01), Puna Geothermal MW 3 (2983-02), Kapoho Crater (3080-01), and Green Lake (3080-S1). Symbols are the same as in previous plots except for Puna Thermal TH 3 (2982-01) shown here with a plus rather than a diamond. Repeat samplings (not shown) of 2487-01 and 3080-01 are at boron detection limit of <0.02 mg/L.

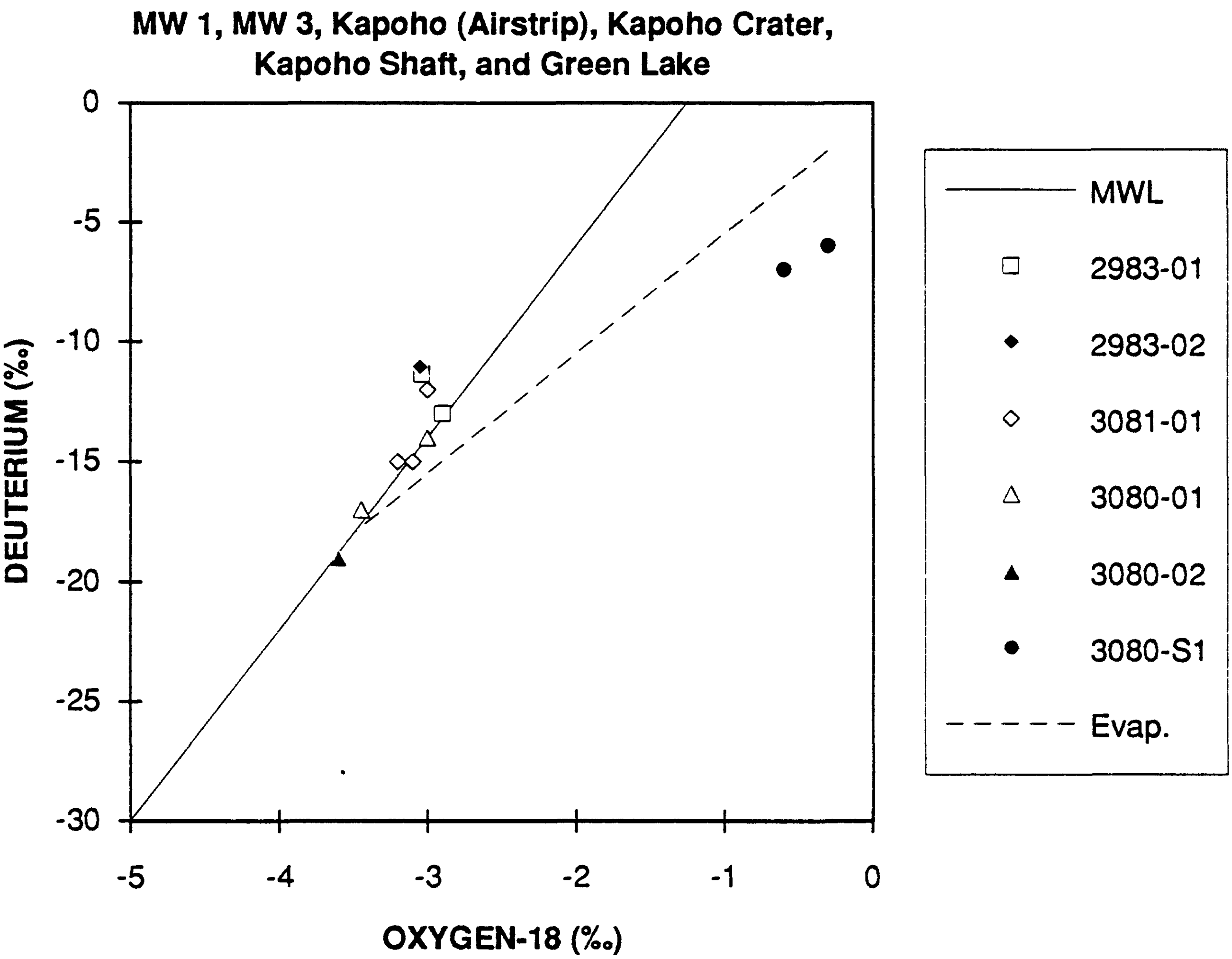

Figure 77. Deuterium (δD) versus oxygen-18 ($\delta^{18}O$) in parts per thousand (‰) for samples for wells of Figures 68, 69, and 70. Data for repeat samplings shown. Global meteoric water line is from Craig (1961). Evap. line uses empirical slope of 5 from Craig (1961).

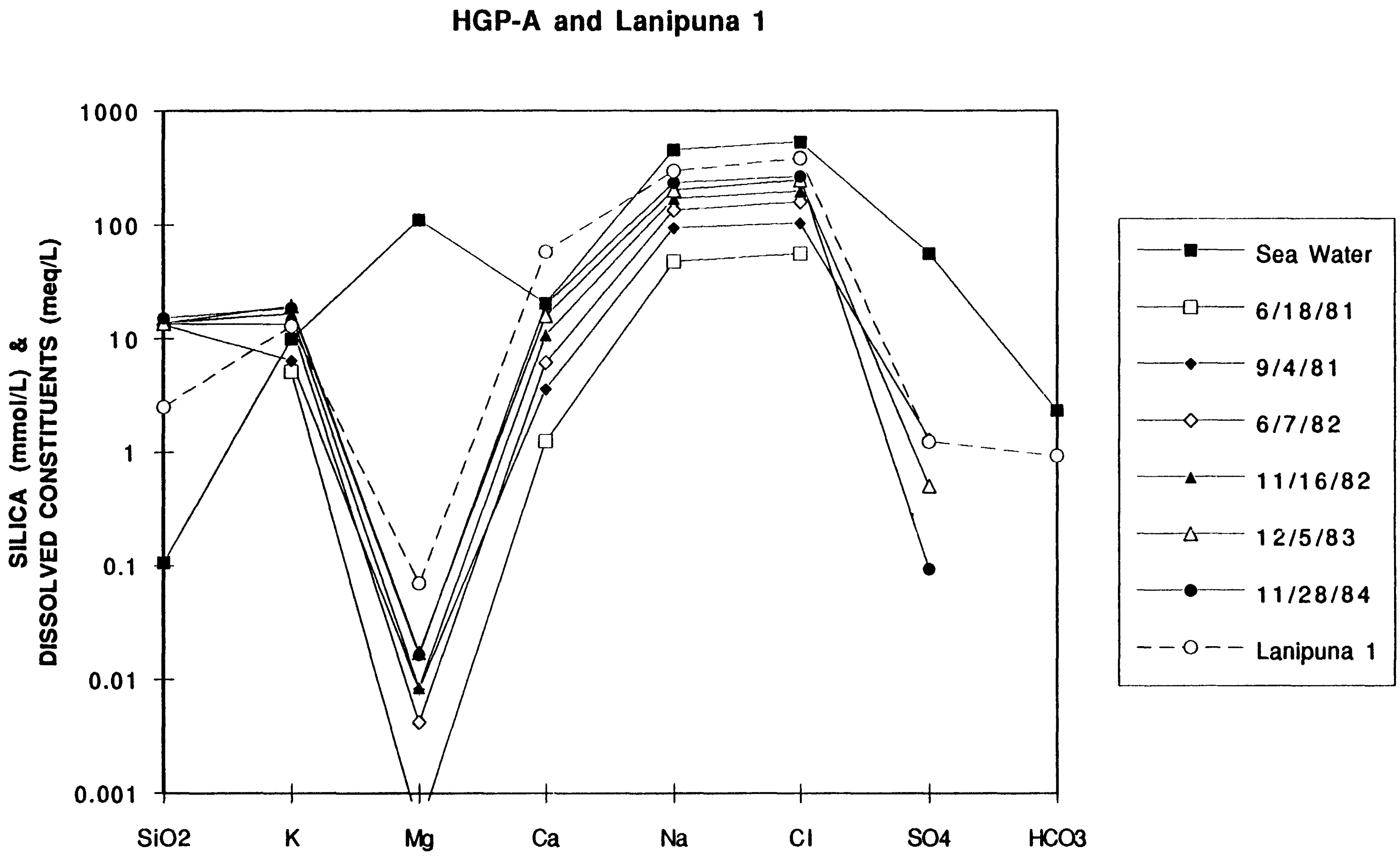

Figure 78. Modified Schoeller diagram for selected samples from HGP-A during two periods of flow and for Lanipuna 1.

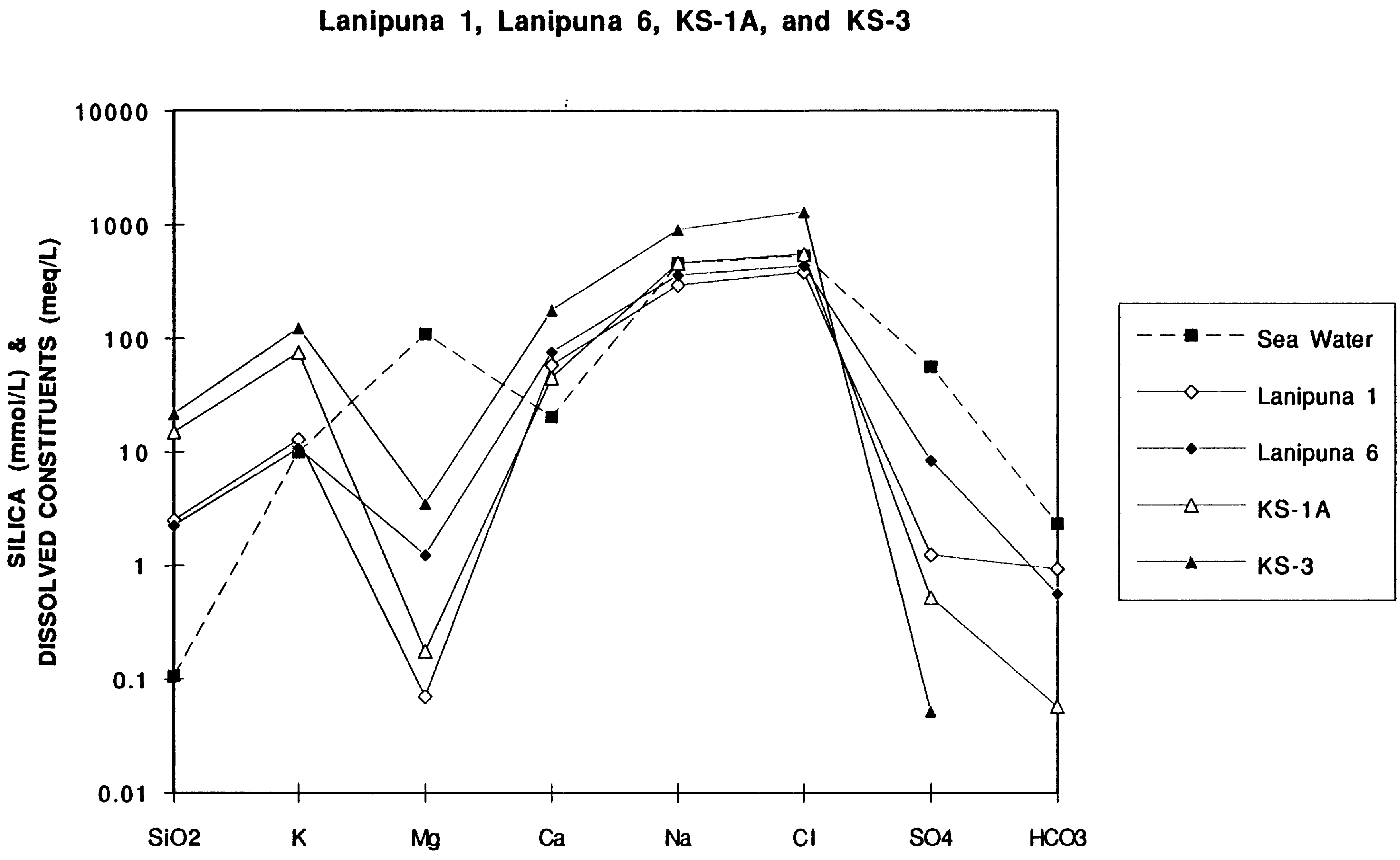

Figure 79. Modified Schoeller diagram for Lanipuna 1 and other deep wells in the vicinity of HGP-A.

HGP-A

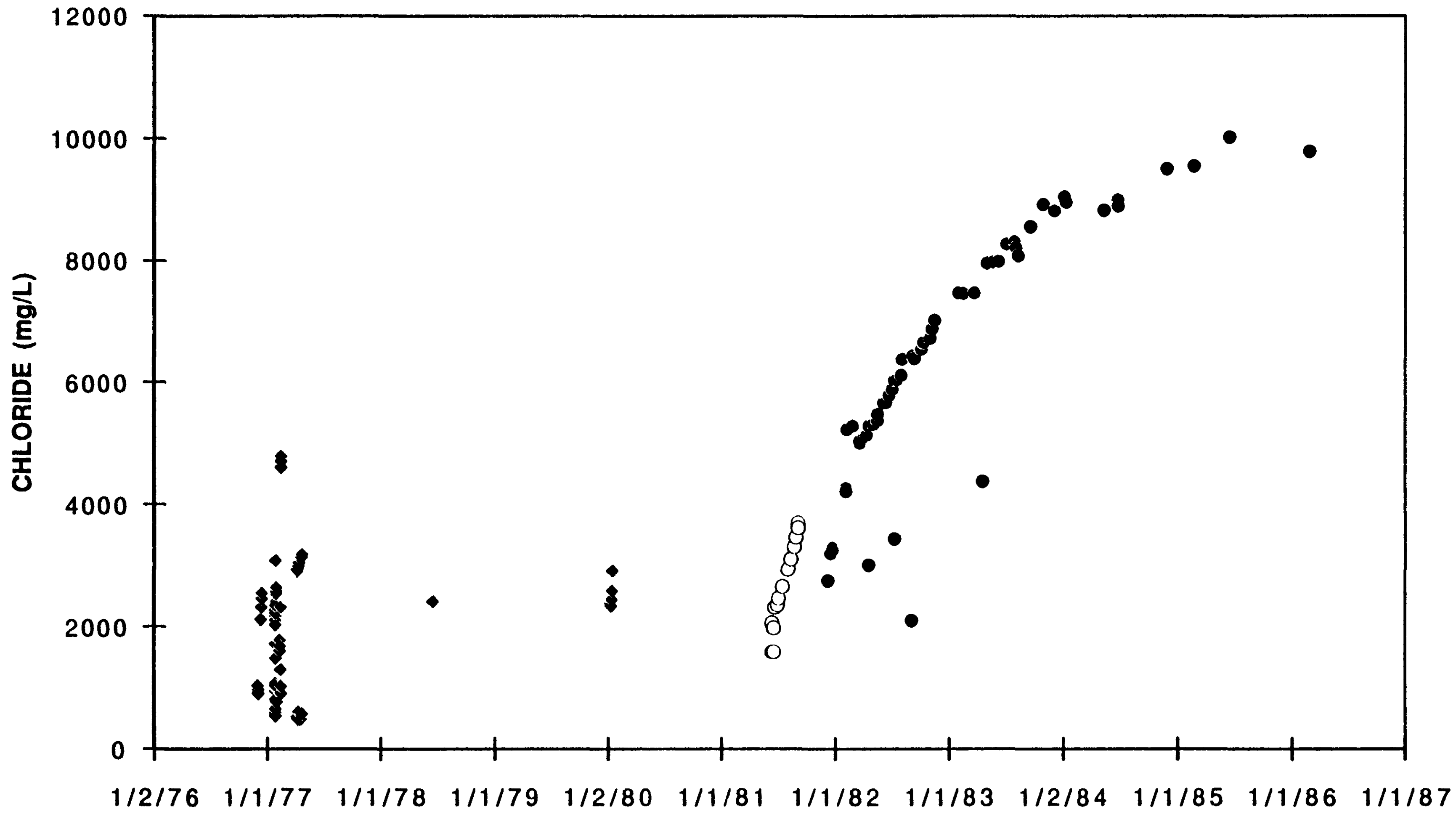

Figure 80. Chloride versus date for well HGP-A. Diamonds are early test samples, open circles are data for flow during 12 June - 4 September 1981, and filled circles are data for flow during period 11 December 1981 - 28 February 1986.

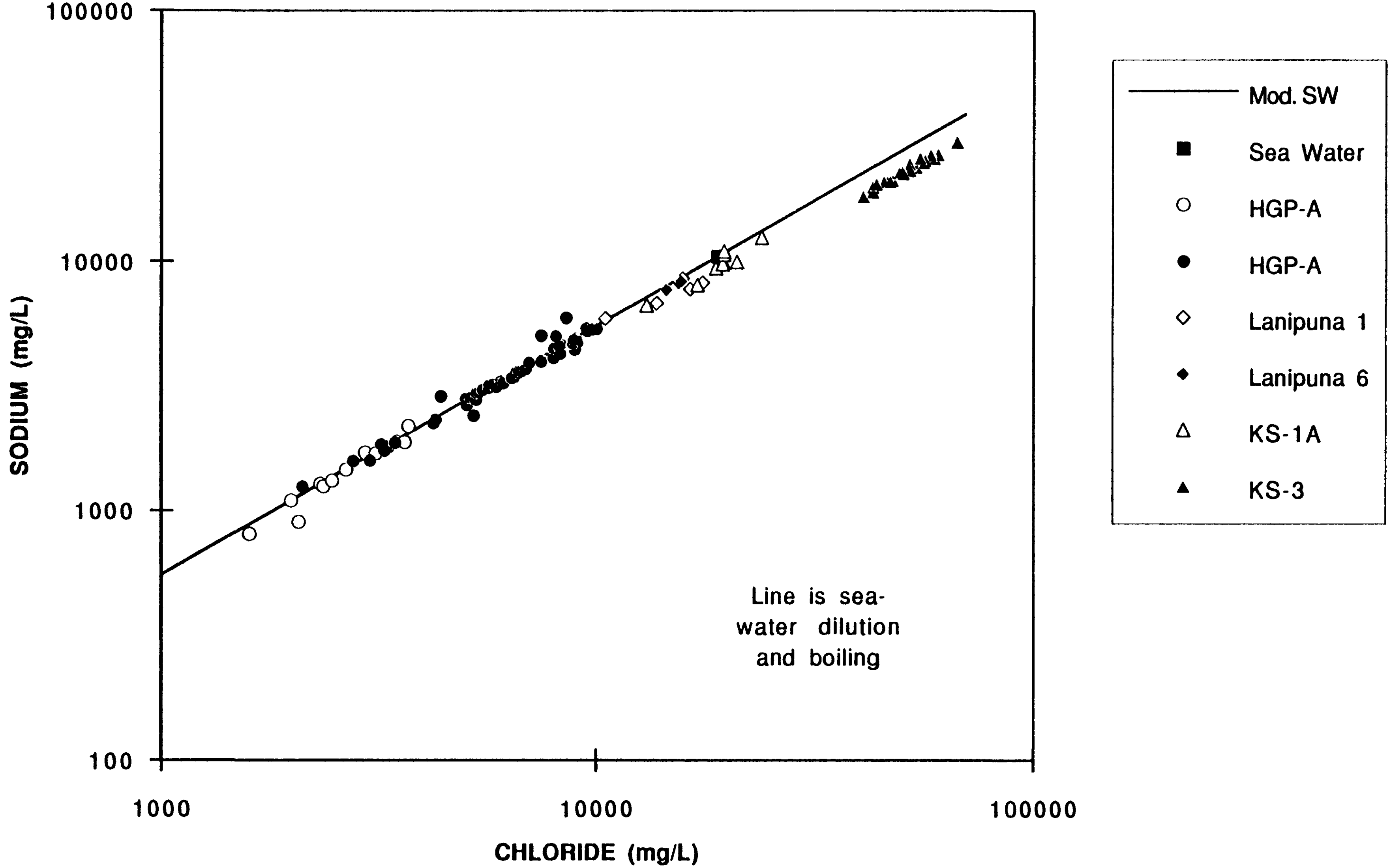

Figure 81. Sodium versus chloride for HGP-A during two periods of flow and for other deep wells in its vicinity. Line shown is for sea water dilution and boiling.

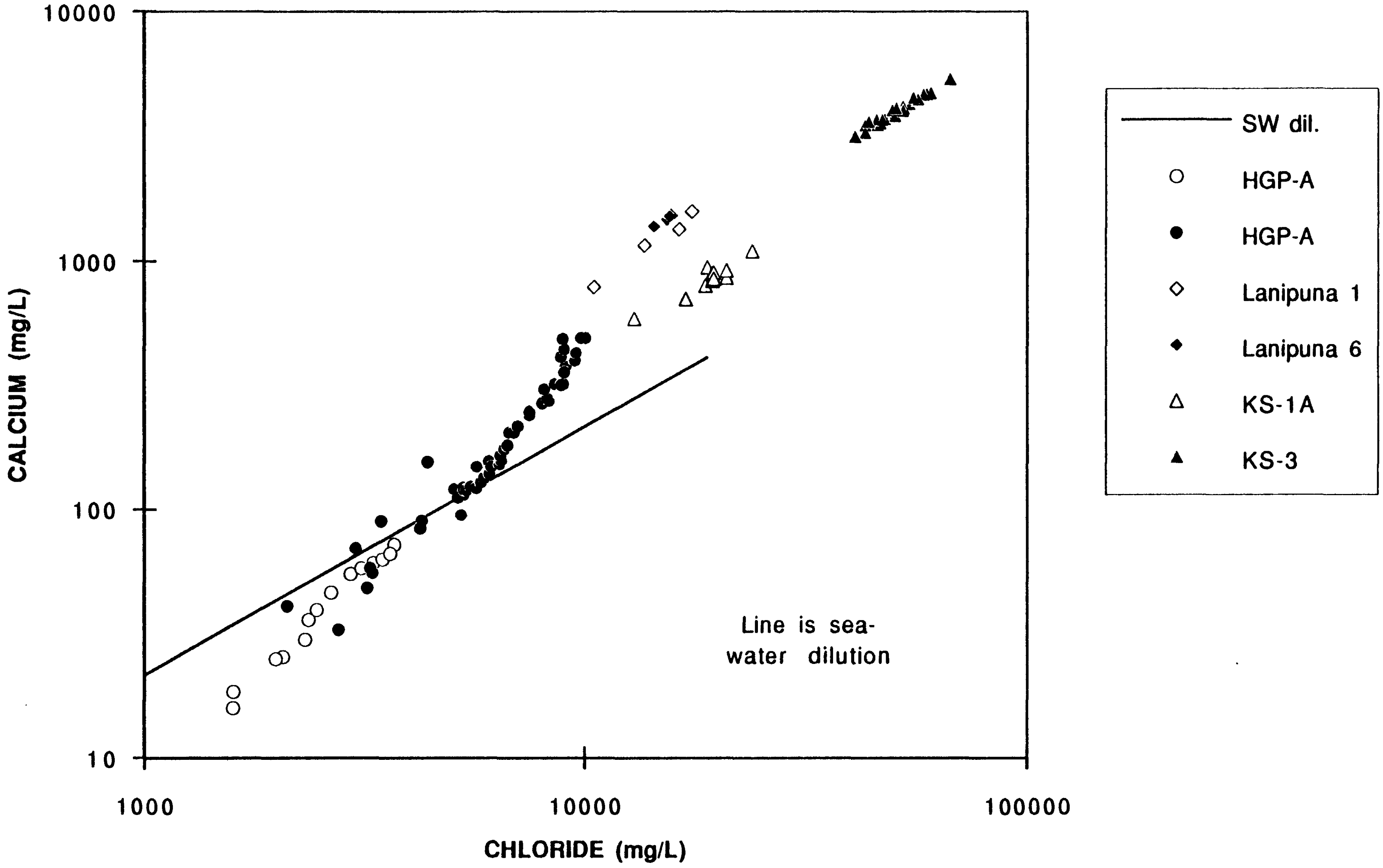

Figure 82. Calcium versus chloride for HGP-A during two periods of flow and for other deep wells in its vicinity. Line shown is for sea water dilution.

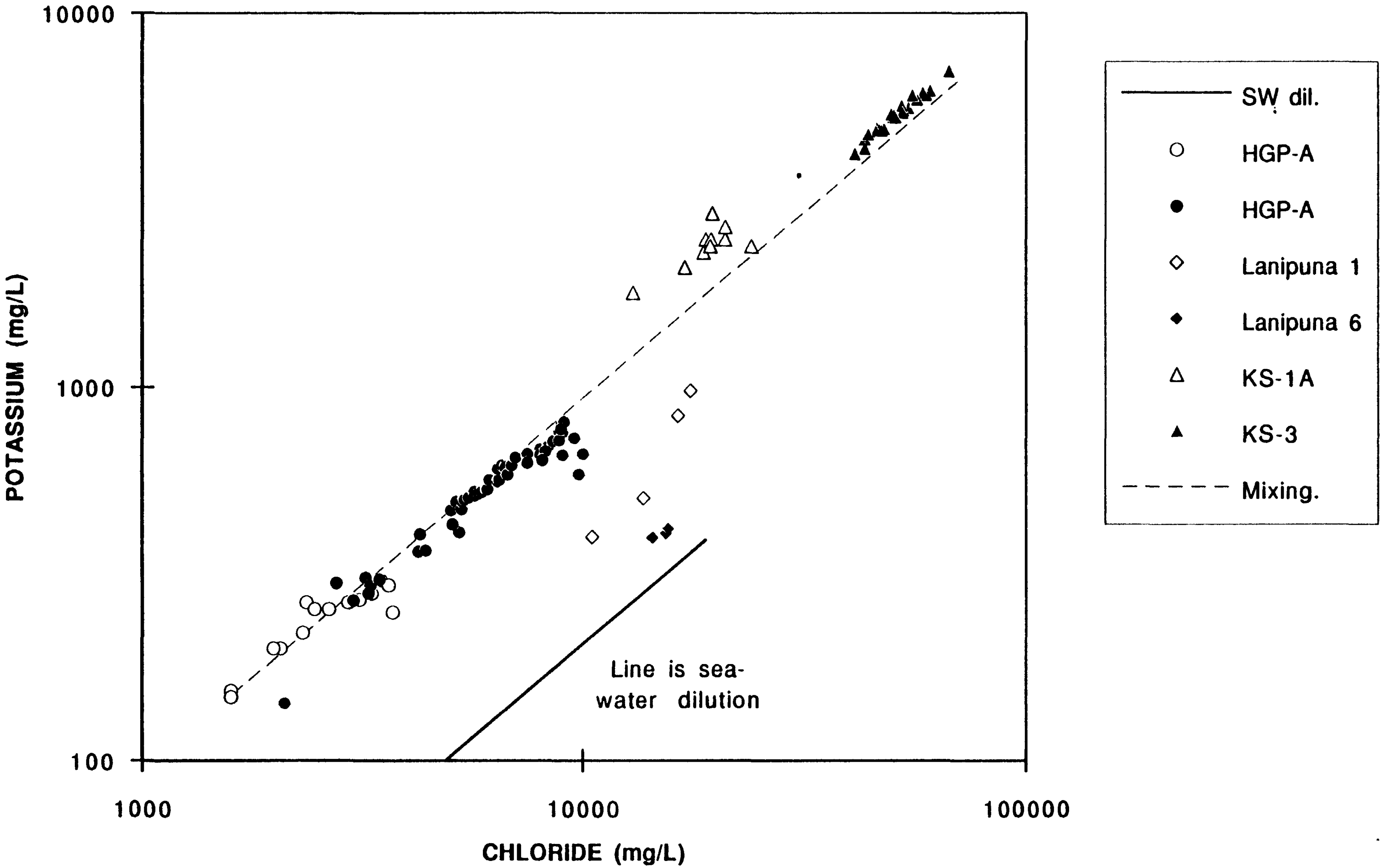

Figure 83. Potassium versus chloride for HGP-A during two periods of flow and for other deep wells in its vicinity. Solid line shown is for sea water dilution, and broken line is a mixing line based on HGP-A data.

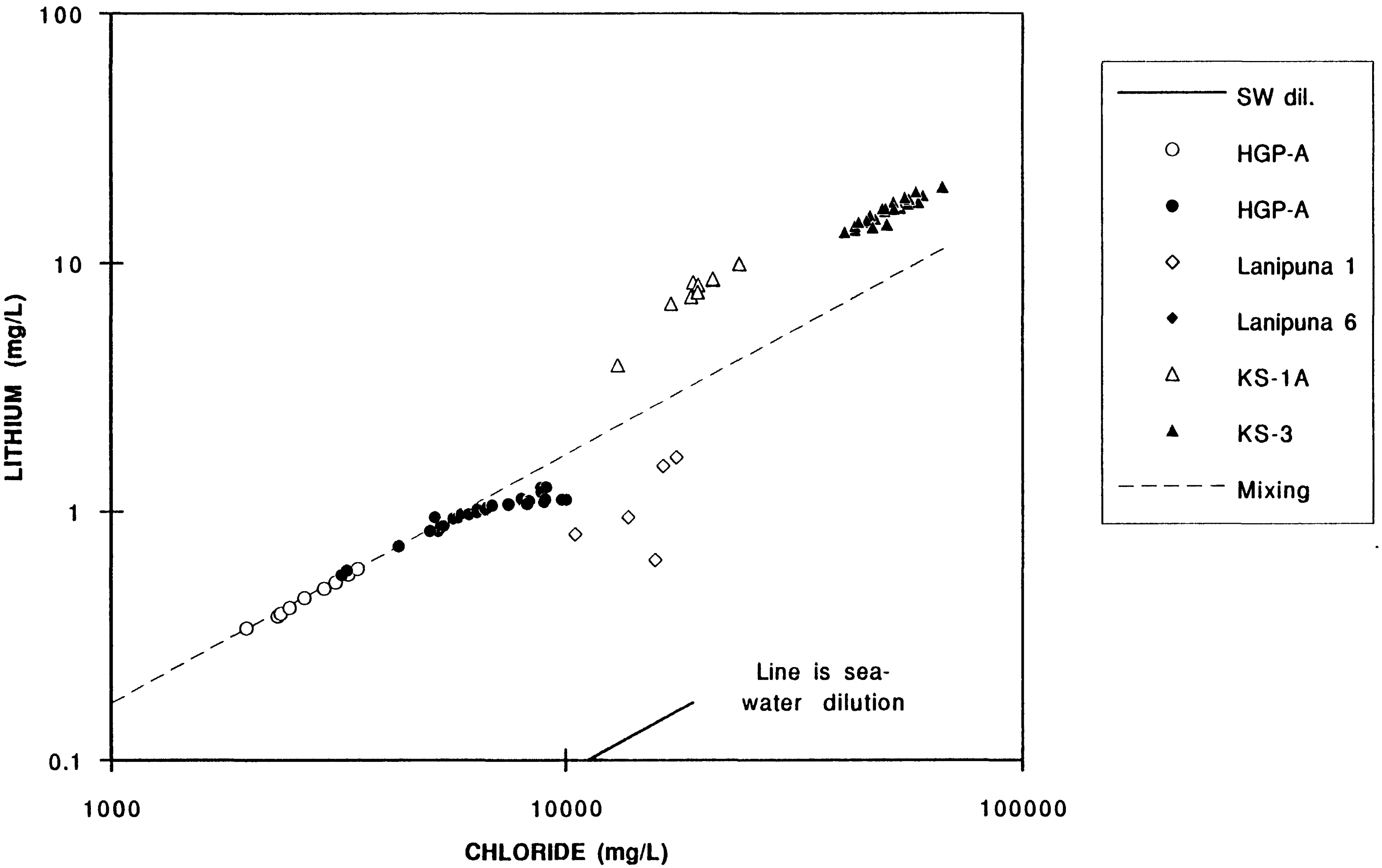

Figure 84. Lithium versus chloride for HGP-A during two periods of flow and for other deep wells in its vicinity. Solid line shown is for sea water dilution, and broken line is a mixing line based on HGP-A data.

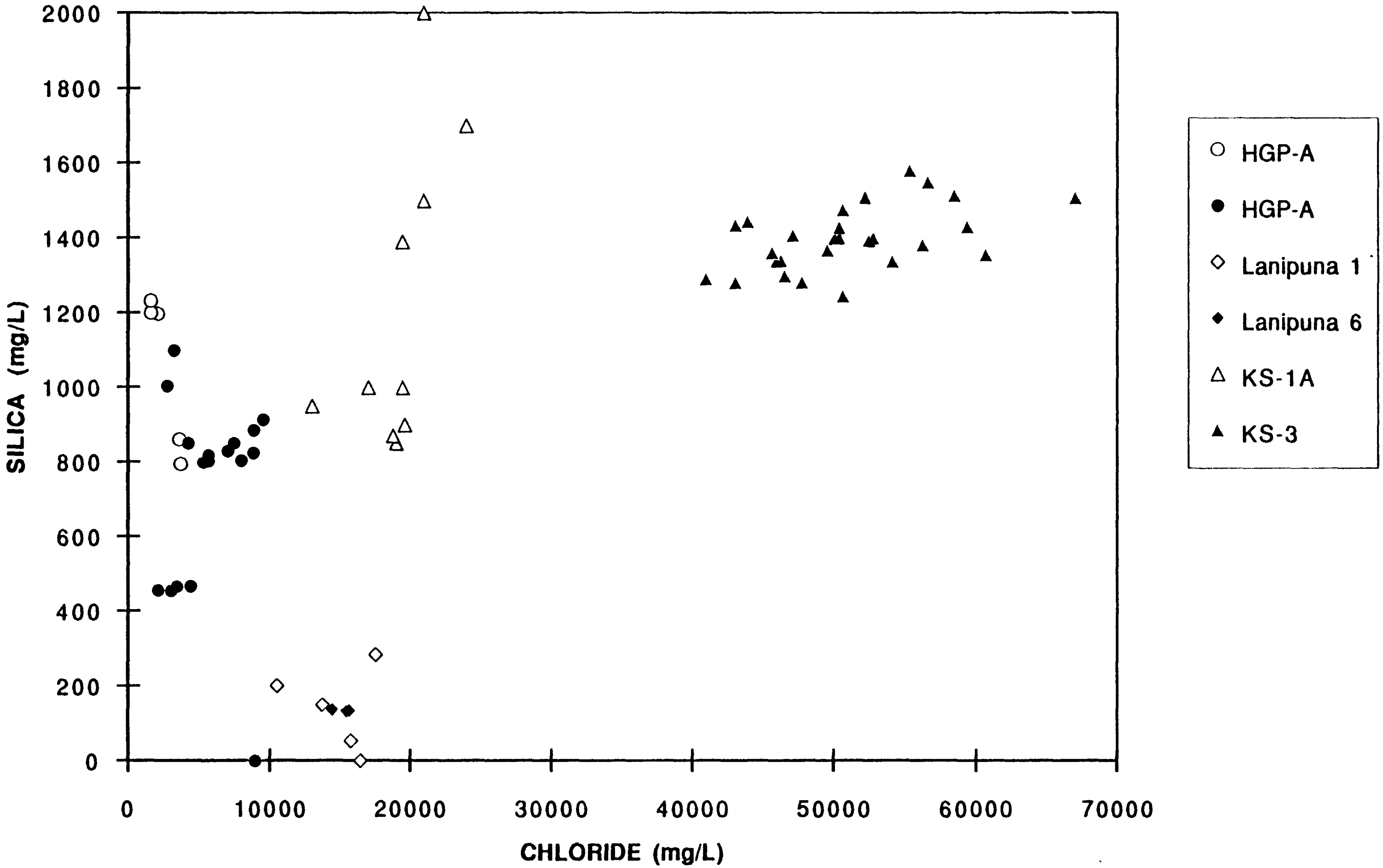

Figure 85. Silica versus chloride for HGP-A during two periods of flow and for other deep wells in its vicinity.

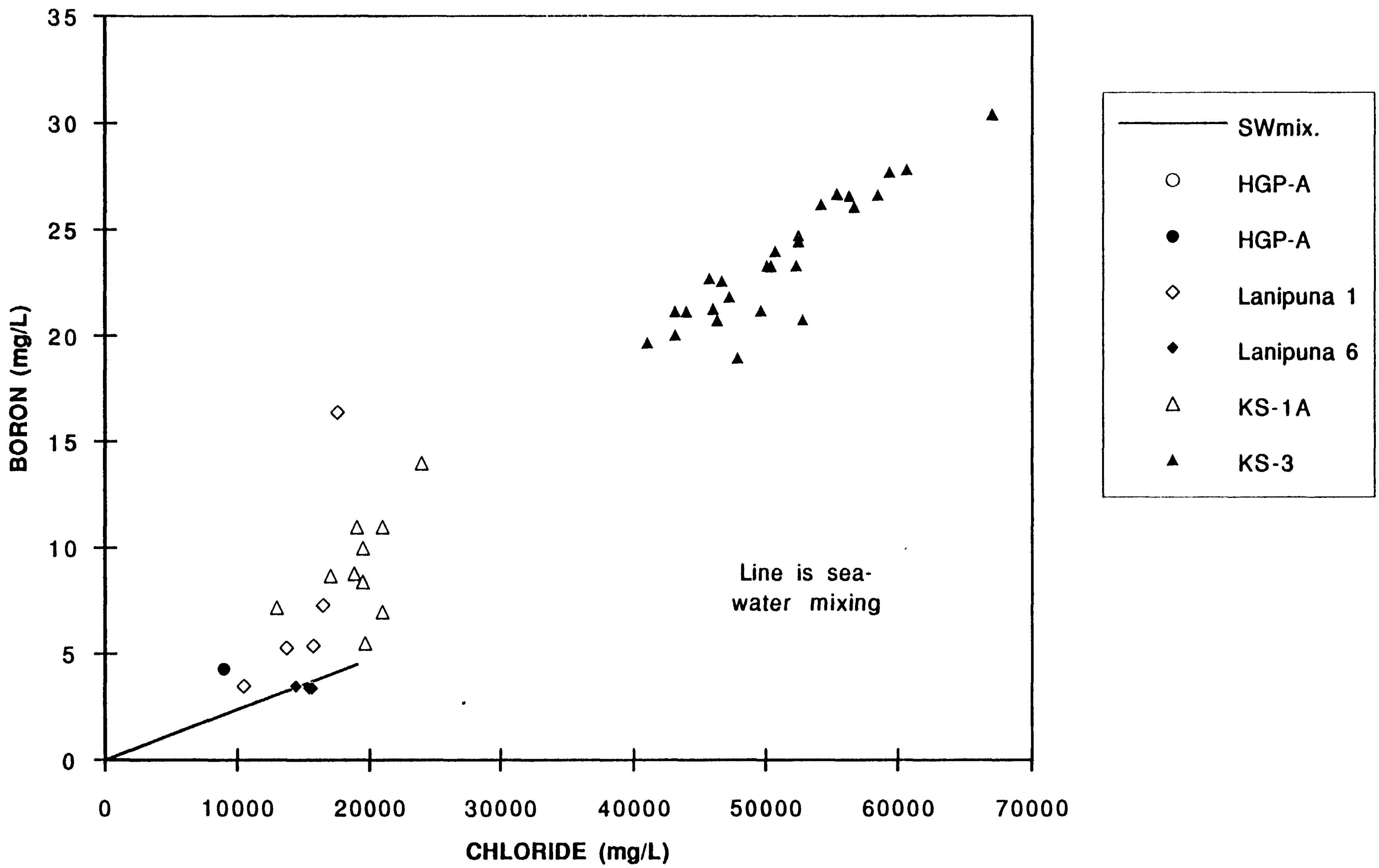

Figure 86. Boron versus chloride for HGP-A during two periods of flow and for other deep wells in its vicinity. Solid line shown is for sea water mixing.

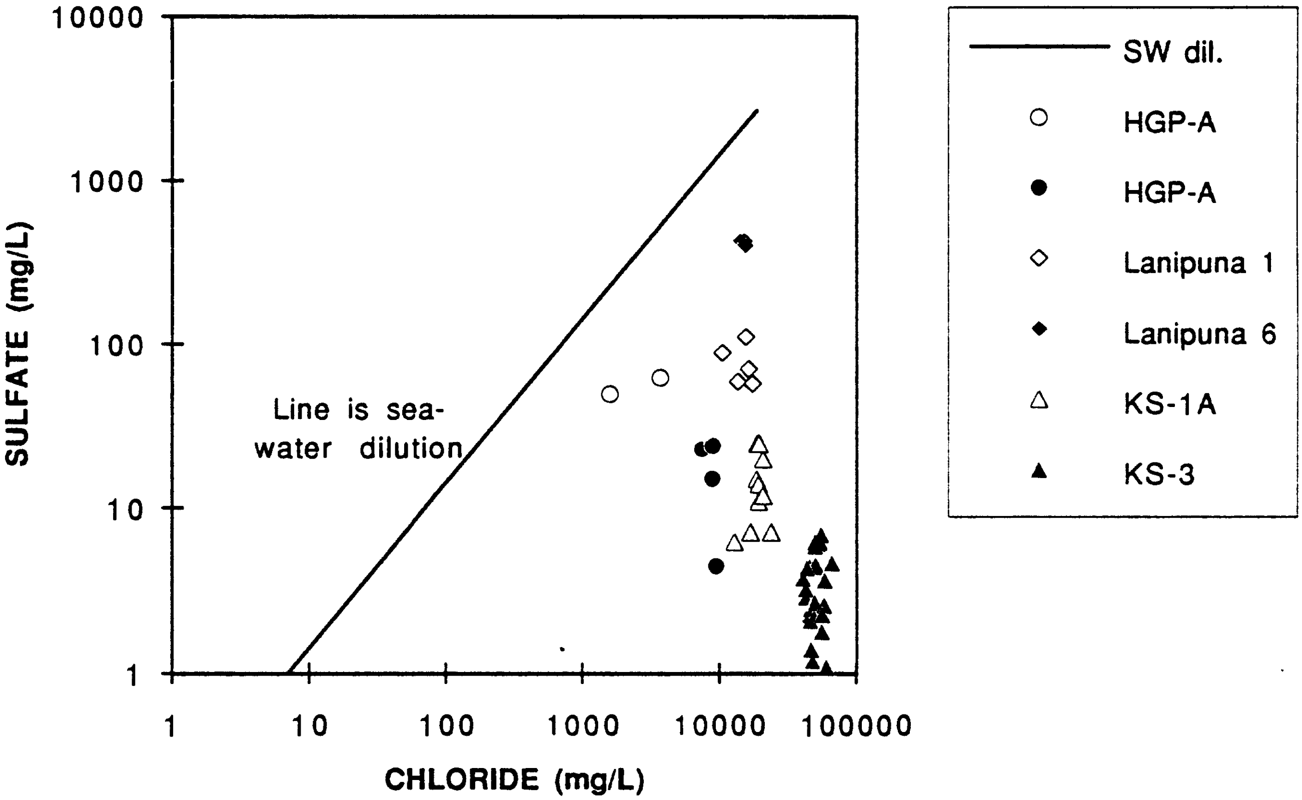

Figure 87. Sulfate versus chloride for HGP-A during a period of flow in 1984 and for other deep wells in its vicinity. Solid line shown is for sea water dilution.

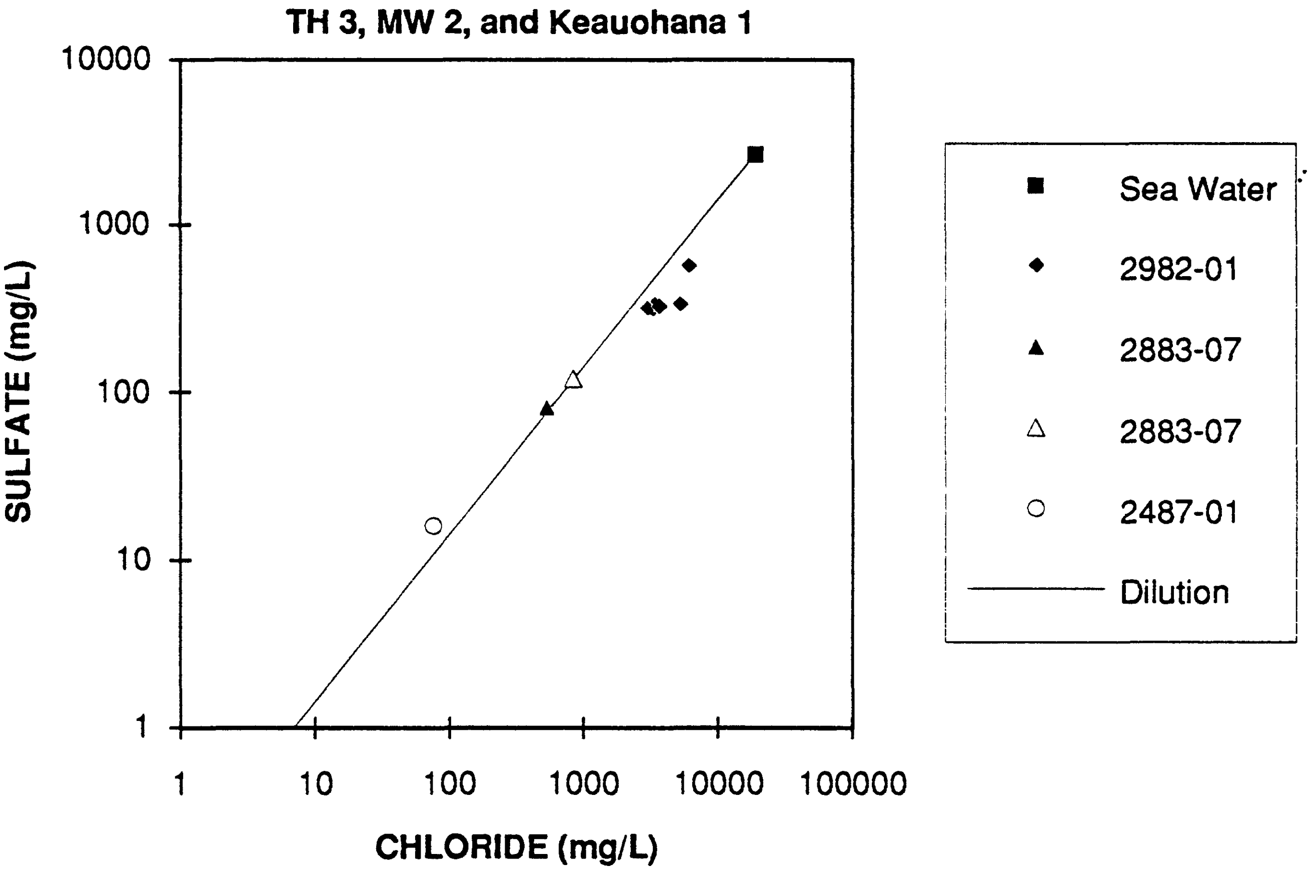

Figure 88. Sulfate versus chloride for wells of Figure 57. All data are shown for Puna Thermal TH 3 (2982-01).