



Analyses of Gas, Steam and Water Samples Collected in and Around Lassen Volcanic National Park, California, 1975–2002

By Cathy J. Janik and Deborah Bergfeld



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Cover: Big Boiler. Photograph by Patrick Muffler

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1927 (NAVD 27).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L).

Specific conductance is given in milisiemens per centimeter at 25 degrees Celsius (mS/cm at 25 °C).

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Abstract

This report contains physical and chemical data from gas, steam, and water samples collected between July 1975 and September 2002 from locations in and around Lassen Volcanic National Park, California. Data are compiled as tables in Excel spreadsheets and are organized by locale. Most data are keyed to 1 of 107 site codes that are shown on local- and regional-scale maps. Brief descriptions of terminology, sampling, and analytical methods are provided.

Introduction

A large number of gas, steam, and water samples were collected during U.S. Geological Survey (USGS) investigations in the Lassen Volcanic Center between July 1975 and September 2002. Information on sample parameters and results of bulk chemical and isotope analyses are presented in this report. Some of the stable isotope data have previously been shown in figures 2 and 3 of Janik and others (1983), and some of the water chemistry data were published by Thompson (1985). A recent publication by Janik and McLaren (2010) presents much of the gas chemistry and stable isotope data given here, but does not present location data for the samples. This report contains all available physical, chemical, and isotopic data for the samples presented in these earlier papers and includes other unpublished data.

Data in each table are organized into groups that correspond primarily to the six main areas of hydrothermal activity in and around Lassen, plus one group of “other” features. Each sample is keyed to a site code that is given in UTM coordinates that are referenced to the NAD 27 datum (table 1). Many of the samples were collected prior to the onset of handheld global positioning system (GPS) instrumentation, and the coordinates were originally estimated from topographic maps. Table 2 contains gas

chemistry data for 10 gas samples whose locations were not recorded. Those data are identified with an asterisk and a brief description.

Figure 1 shows all of the sample locations across the entire collection area. Five main collection areas are within the boundaries of Lassen Volcanic National Park and include Bumpass Hell (fig. 2), Boiling Springs Lake (fig. 3), Devils Kitchen (fig. 4), Little Hot Springs Valley (fig. 5), and Sulphur Works (fig. 6). The Boiling Springs Lake grouping includes samples collected from springs and gas vents at Boiling Springs Lake, the Drakesbad Resort, Terminal Geyser, and the Walker Well. The sixth collection area is about 3–4 km south of the park boundary and includes sample sites at Morgan and Growler hot springs along Mill Creek (fig. 7). The remaining 19 locations include sites at Cold Boiling Lake, Pilot Pinnacles, and 16 springs that are geographically scattered about the area (fig. 1). In tables 1 through 5, data for these locations are grouped under the heading of “other”.

Each site code in table 1 lists all the types of features that were sampled at the site during the course of the investigation. Attempts were made to sample the same feature during each visit, but at Lassen it is common for features to change in character, and a location where a degassing spring existed in one year may have had a roiling mud pot or a dry steam vent in a different year. Sites where the sample features changed are shown with a star symbol that is labeled as “mixed” in figures 2 through 6. Fumaroles were targeted for gas collection as they typically provide gas samples with the least amount of air-contamination, however, safe access was not always possible, and at times a secondary feature was selected.

Terminology Used in Tables

The types of features sampled during this investigation include fumaroles, lakes with drowned gas vents, frying pans, pools, thermal and nonthermal springs, mud pots, and a well. We identify thermal springs (TS) as those having collection temperatures $\geq 17^{\circ}\text{C}$, applying the definition of Meinzer (1923) as thermal water having a temperature appreciably higher than the local mean annual air temperature. The mean annual air temperature at an elevation of 2,500 m on Lassen Peak for the 2005 water year was about 7°C (data from the California Department of Water Resources), and we consider 10°C as being an appreciably higher temperature. All other spring waters are herein defined as nonthermal (NTS).

Fumaroles (FM) are features where steam and gas issue from a discrete area, such as a crack or fracture, and often have sampling temperatures near or above the local boiling point. At elevations typical of the thermal areas within the park, boiling would occur at 92–93 degrees Celsius. At lower-elevation sites, such as the Morgan and Growler hot springs area, boiling would occur around 95 degrees Celsius. Many fumarole samples in table 2 have temperatures in excess of the local boiling point and are described as superheated. Gas emissions associated with superheated fumaroles at Lassen often have large, highly visible plumes of steam, and the sound of the escaping gas is very loud.

Gas from all other features was collected from the surface of a body of water. Gas from lakes (L) issues from drowned vents where the gas source is submerged under the water. Frying pans (FP) are features where gas issues from a pool of boiling water that is

no deeper than a few centimeters. Frying pans are characterized by splashing water, similar to the action of water poured onto a hot pan. Gas bubbles at pools (P) and thermal springs at Lassen rise through variable depths of water, generally less than 0.5 m. All pools in this study contained thermal water and are distinguished from thermal springs by the lack of a visible outflow channel. Mud pots (MP) are degassing features found in areas of extreme acid alteration; they contain viscous, muddy water and often have no outflow channel.

Collection Methods and Analytical Information

Details about gas-bottle preparation, sampling, and analytical methods are given in Fahlquist and Janik (1992). Gas samples were collected into evacuated glass bottles containing 4 N sodium hydroxide (caustic) by using silicone tubing to connect the collection device to the sample bottle. At fumaroles, the gas was collected using a titanium tube, and at other features gas was collected using an inverted funnel placed over the rising bubbles. At all sites, atmospheric components were purged from the collection system prior to sample collection. Steam samples from fumaroles were typically collected by cooling the sample tubing and pouring the condensed steam into a bottle. A few steam samples for isotope analyses were collected directly into evacuated bottles.

Waters collected for chemical analyses were poured into pre-rinsed plastic bottles after passing the sample through a 0.45 μm acetate-membrane filter. Other raw (nonfiltered) waters were collected in glass and plastic bottles for stable isotope and tritium analyses, respectively. For most samples, pH was determined in the field using paper indicator strips, but for some samples it was determined by using a calibrated meter in the field or in the laboratory. Samples were preserved for cation analyses by drop-wise addition of high-purity nitric acid to a pH less than 2.

Table 2 lists analytical results for 129 gas samples analyzed at the USGS Volcanic Gas Geochemistry laboratory in Menlo Park, California. Head-space gas concentrations (H_2 , He, Ar, O_2 , N_2 , and CH_4) were measured using two gas chromatographs with He or Ar carrier gases and equipped with thermal-conductivity and flame-ionization detectors. Dissolved-gas concentrations were determined by analysis of the caustic solution. NH_3 concentrations were obtained using an ion-selective probe. Until 1987, H_2S and CO_2 concentrations were determined by gravimetry using hydrogen peroxide to oxidize the sulfur and barium chloride and strontium chloride to precipitate dissolved sulfur and carbon as BaSO_4 and SrCO_3 , respectively. All sulfur in the caustic solution was assumed to be derived from H_2S . Splits of the BaSO_4 and SrCO_3 solids were used to determine the $\delta^{34}\text{S}$ and $\delta^{13}\text{C}$ composition of the gas following the methods of Thode and others (1961) and McCrea (1950). After August 1987, CO_2 concentrations were determined by direct measurement of evolved CO_2 on a vacuum-extraction line, following acidification of the caustic solution using phosphoric acid. A split of the evolved CO_2 was used for carbon isotope analysis following the standard procedure of McCrea (1950). Stable isotope analyses were performed at USGS laboratories in Menlo Park, California, and Reston, Virginia.

Chemical analyses of 68 waters collected before 1983 were performed at USGS laboratories in Menlo Park, California, (table 3) following methods outlined in Thompson

(1985). After 1995, an additional 32 water samples were analyzed at the EES-6 laboratory at Los Alamos National Laboratory, Los Alamos, New Mexico, (table 4) following procedures outlined in Goff and others (2001). Some samples were collected solely for isotopic analyses, and these results are shown in table 5. Tritium analyses (tables 2 through 5) were performed at the University of Miami Tritium Lab, Rosenstiel School of Marine and Atmospheric Science, using the methods of Ostlund (1962).

Acknowledgments

A number of researchers produced the data that are reported here. We acknowledge the work of Dale Counce, Lynn Fahlquist, Mark Huebner, Linda Johnson, Andy Ouimette, Mike Thompson, and Doug White. Without their efforts this report would not be possible. Joel Robinson (USGS Menlo Park) produced the base maps used for the figures.

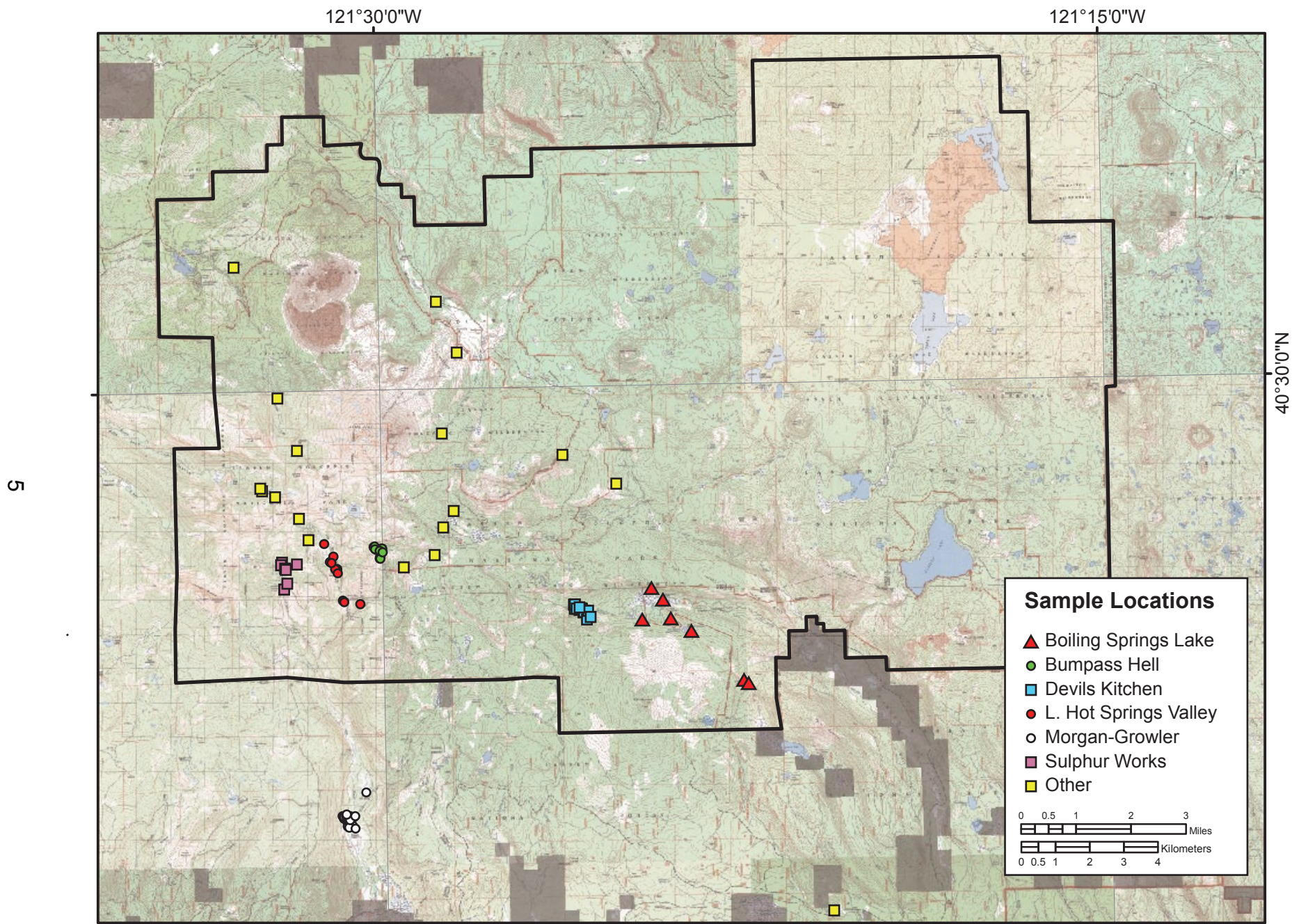


Figure 1. Topographic map showing locations for all samples collected in the Lassen region, California.

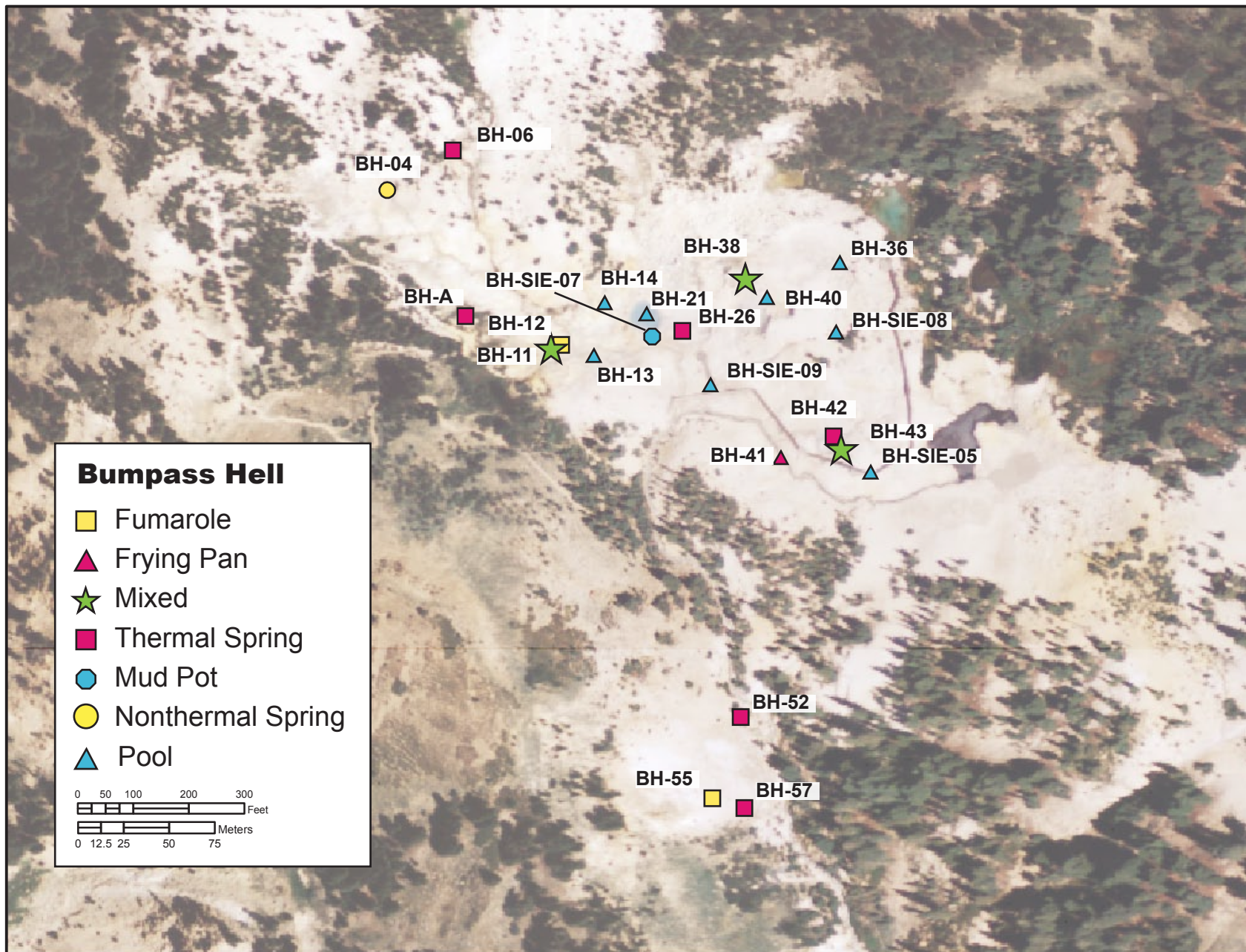


Figure 2. Locations for samples collected in the Bumpass Hell area within Lassen Volcanic National Park, California, shown on an air-photo base from the National Agriculture Imagery Program.

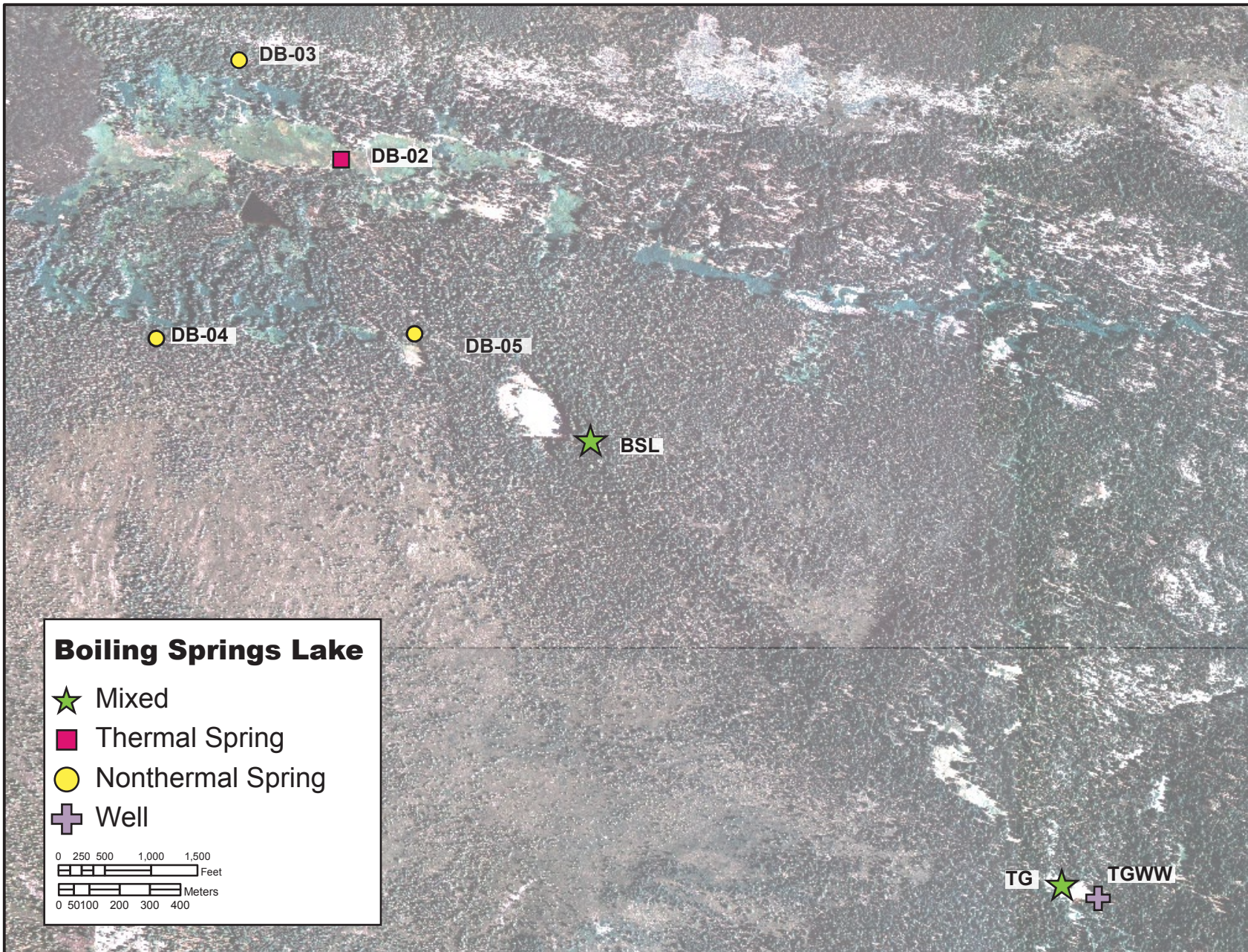


Figure 3. Locations for samples collected in the Boiling Springs Lake area within Lassen Volcanic National Park, California, shown on an air-photo base from the National Agriculture Imagery Program.

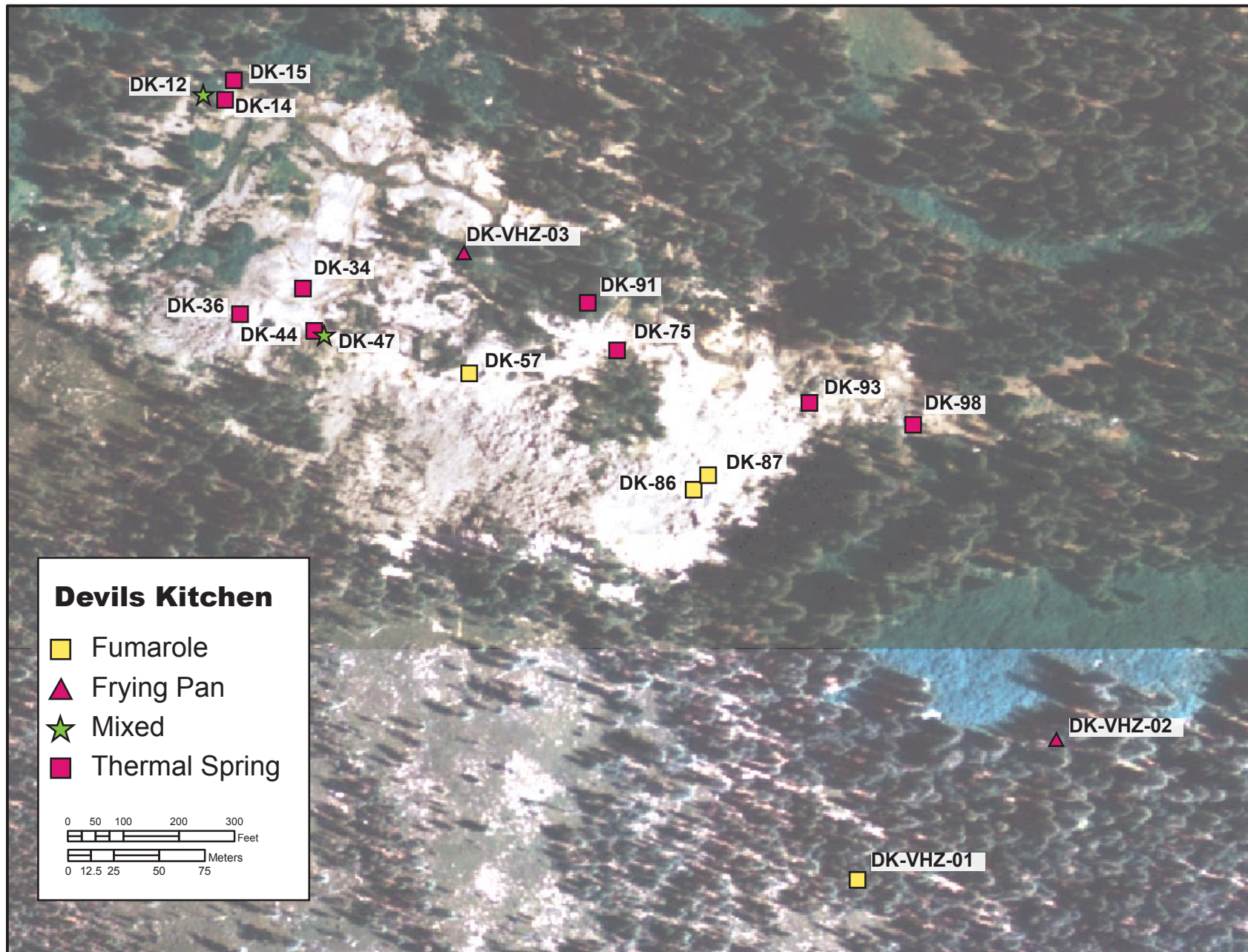


Figure 4. Locations for samples collected in the Devils Kitchen area within Lassen Volcanic National Park, California, shown on an air photo base from the National Agriculture Imagery Program.

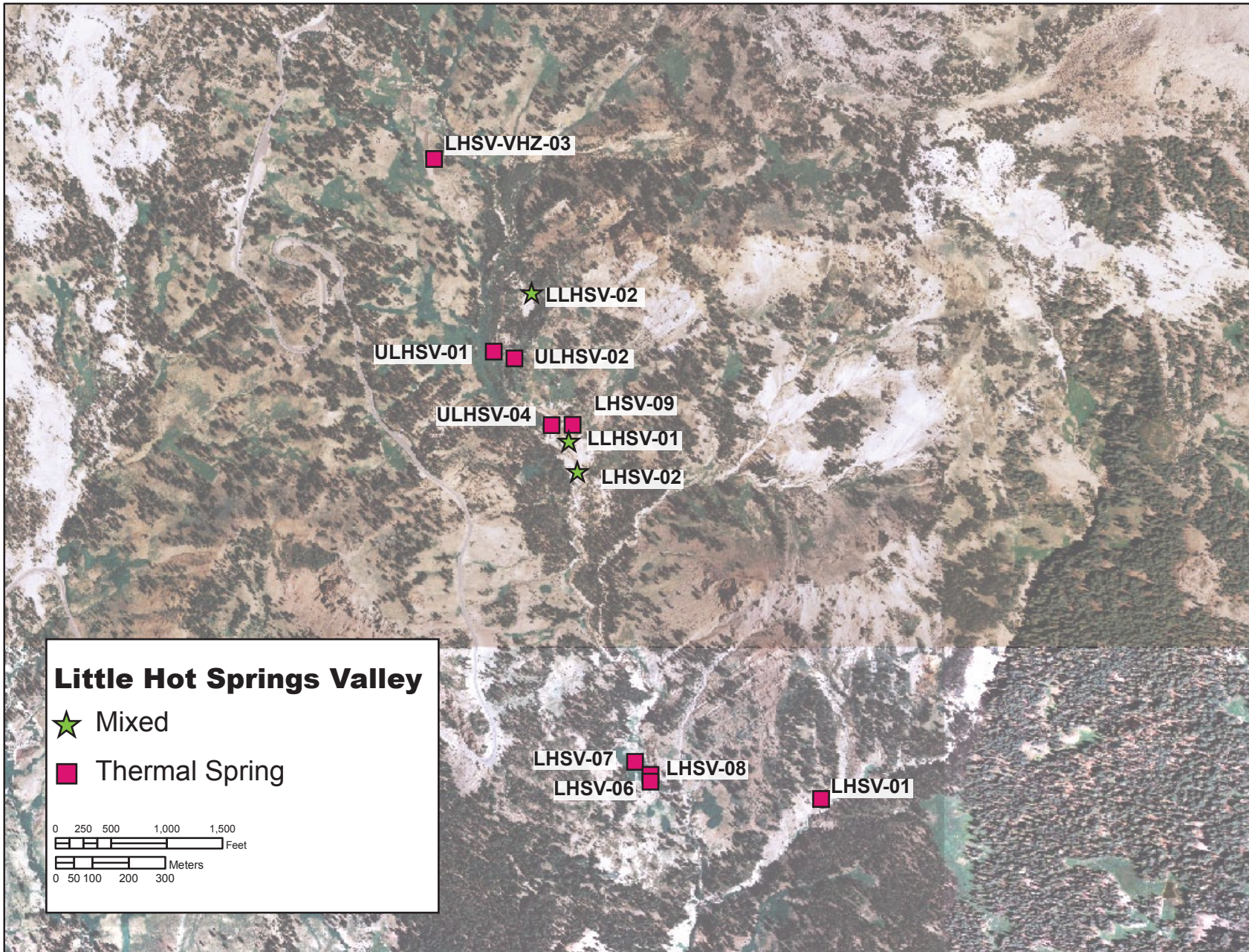


Figure 5. Locations for samples collected in the Little Hot Springs Valley area within Lassen Volcanic National Park, California, shown on an air-photo base from the National Agriculture Imagery Program.

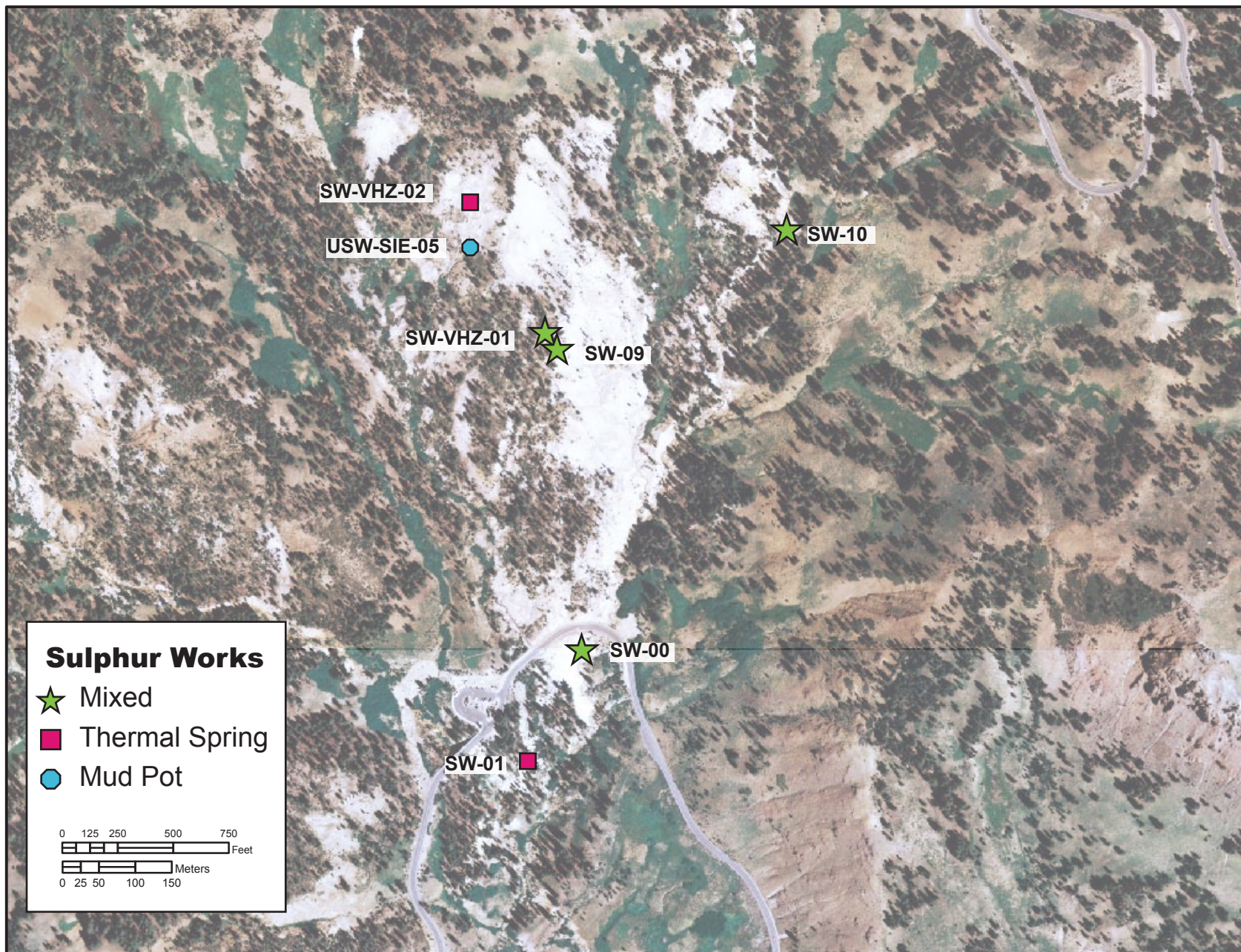


Figure 6. Locations for samples collected in the Sulphur Works area within Lassen Volcanic National Park, California, shown on an air-photo base from the National Agriculture Imagery Program.

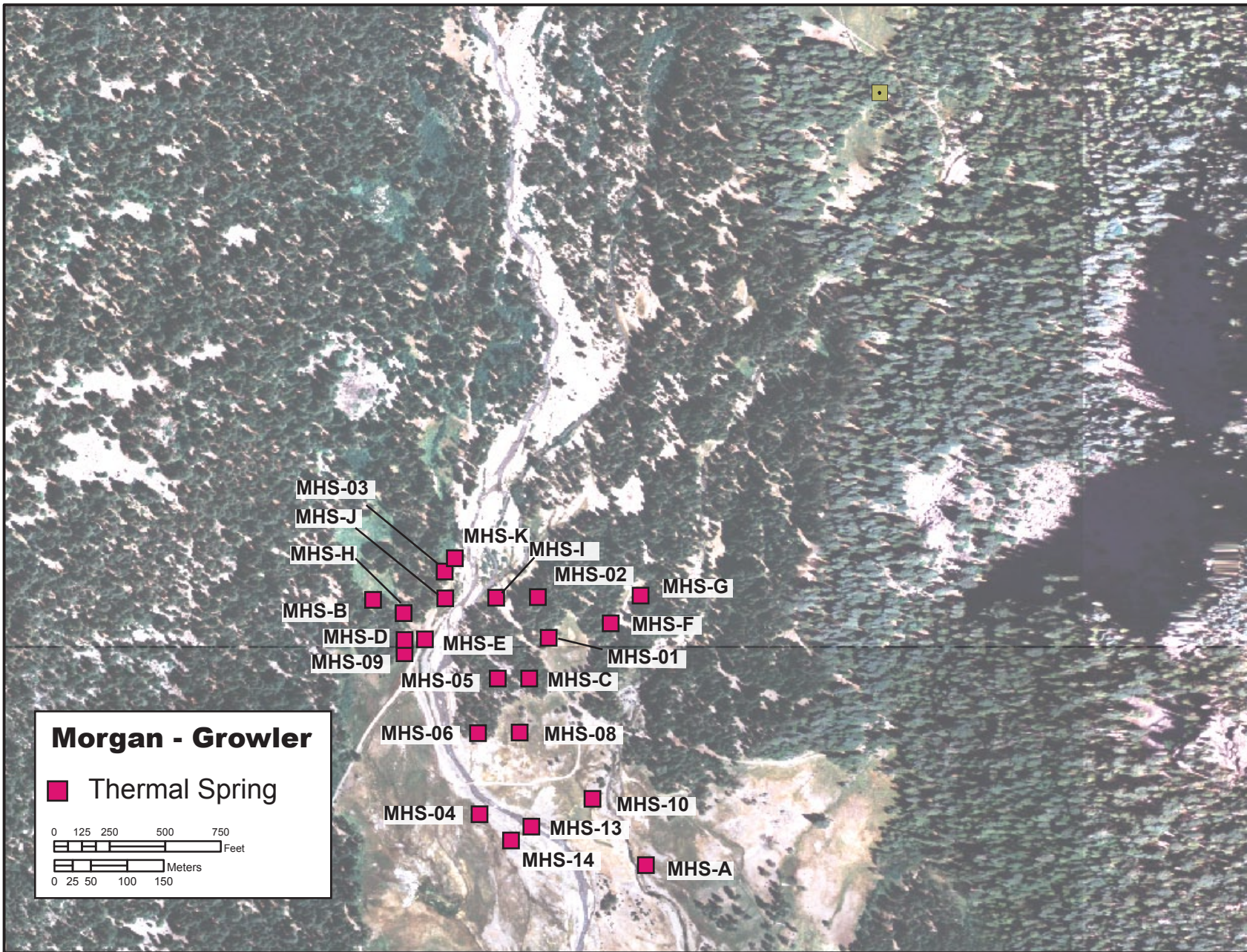


Figure 7. Locations for samples collected in the Morgan and Growler hot springs area south of Lassen Volcanic National Park, California, shown on an air-photo base from the National Agriculture Imagery Program.

Table 1. Site codes, feature types and sample location data given in UTM coordinates in relation to the NAD 27 datum, Lassen Volcanic National Park, California. Location accuracy is given as 5 m for sites located using GPS measurements and 10 m for sites located using a map. Features at some locations may no longer be active. FM, fumarole; FP, frying pan; L, lake; NTS, nonthermal spring; P, pool; TS, thermal spring.

Table 2. Gas chemistry, tritium concentrations, and stable isotope values for gas and steam collected within and around Lassen Volcanic National Park, California. Temperature is reported in degrees Celsius ($^{\circ}\text{C}$). Gas concentrations are reported in mol-%, and tritium concentrations are in tritium units (TU). Stable isotope values are reported in per mil (‰) relative to PDB ($\delta^{13}\text{C}$), CDT ($\delta^{34}\text{S}$) and SMOW (δD and $\delta^{18}\text{O}$). Feature abbreviations are as shown in table 1; nr, not recorded. Detection limits were not available. A blank cell indicates that a value was below the detection limit or that an analysis was not attempted.

Table 3. Water chemistry, tritium concentrations and stable isotope values for waters collected within and around Lassen Volcanic National Park, California, between July 1975 and October 1982. Temperature is reported in degrees Celsius ($^{\circ}\text{C}$). Analyte concentrations are in mg/kg, and tritium values are in tritium units (TU). Stable isotope values of water are reported in per-mil (‰) relative to SMOW (δD and $\delta^{18}\text{O}$). The pH was measured in the field using indicator paper (p), or in the laboratory using a meter (Lm). Feature abbreviations are as shown in table 1; nr, not recorded. Samples collected from fumaroles are condensed steam. Detection limits were not available for some samples. A blank cell indicates that a value was below the detection limit or that an analysis was not attempted.

Table 4. Water chemistry, tritium concentrations, and stable isotope values for waters and steam collected within and around Lassen Volcanic National Park, California, between September 1996 and September 2002. Temperature is reported in degrees Celsius ($^{\circ}\text{C}$). Analyte concentrations are in mg/kg, and tritium values are in tritium units (TU). Stable isotope values of water are reported in per-mil (‰) relative to SMOW (δD and $\delta^{18}\text{O}$). The pH was measured in the field using indicator paper (p) or a meter (mF), or in the laboratory using a meter (Lm). Feature abbreviations are as shown in table 1. Samples collected from fumaroles are condensed steam. Detection limits were not available for some samples. A blank cell indicates that a value was below the detection limit or that an analysis was not attempted.

Table 5. Tritium concentrations and stable isotope values for steam, water, and CO_2 collected from features within and around Lassen Volcanic National Park, California. Temperature is reported in degrees Celsius ($^{\circ}\text{C}$). Stable isotope values are reported in per-mil (‰) relative to SMOW (δD and $\delta^{18}\text{O}$) and PDB ($\delta^{13}\text{C}$). Tritium concentrations are reported as tritium units (TU). Isotope data for steam samples that are identified with an "E" were collected directly into an evacuated bottle. A blank cell indicates that an analysis was not attempted.

Table 1. Site codes, feature types, and sample location data, within and around Lassen Volcanic National Park, California.

Site code	Easting NAD27	Northing NAD 27	±/±	Feature type
BUMPASS HELL				
BH-04	626931	4479529	5	NTS
BH-06	626967	4479550	5	TS
BH-11	627026	4479444	5	FM
BH-12	627021	4479442	5	FM/FP/TS
BH-13	627044	4479438	5	P
BH-14	627050	4479467	5	P
BH-21	627073	4479465	5	FM
BH-26	627093	4479451	5	TS
BH-36	627179	4479489	5	P
BH-38	627127	4479480	5	FM/FP
BH-40	627139	4479470	5	P
BH-41	627147	4479382	5	FP
BH-42	627176	4479391	5	TS
BH-43	627181	4479387	5	FP/P
BH-52	627125	4479239	5	TS
BH-55	627109	4479195	5	FM
BH-57	627127	4479189	5	TS
BH-A	626974	4479459	5	TS
BH-SIE-05	627196	4479374	5	P
BH-SIE-07	627076	4479449	5	MP
BH-SIE-08	627177	4479451	5	P
BH-SIE-09	627108	4479422	5	P
BOILING SPRINGS LAKE - DRAKESBAD - TERMINAL GEYSER				
BST	636207	4477040	5	FM/FP/L/P/TS
DB-02	635384	4477977	5	TS
DB-03	635051	4478302	5	NTS
DB-04	634779	4477387	5	NTS
DB-05	635628	4477402	5	NTS
TG	637758	4475588	5	FM/FP/P
TG WW	637875	4475543	10	W
DEVILS KITCHEN				
DK-12	632787	4477845	5	FP/TS/MP
DK-14	632799	4477842	5	TS
DK-15	632804	4477853	5	TS
DK-34	632842	4477739	5	TS
DK-36	632807	4477725	5	DK
DK-44	632848	4477713	5	TS
DK-47	632853	4477713	5	P/TS
DK-57	632933	4477692	5	FM
DK-75	633014	4477705	5	TS
DK-86	633056	4477628	5	FM
DK-87	633064	4477636	5	FM
DK-91	632998	4477731	5	TS
DK-93	633119	4477676	5	TS
DK-98	633176	4477664	5	TS
DK-VHZ-01	633146	4477414	5	FM
DK-VHZ-02	632555	4477491	5	FP
DK-VHZ-03	632930	4477758	5	FP
LITTLE HOT SPRINGS VALLEY				
LHSV-01	626548	4477860	10	TS
LHSV-02	625881	4478756	10	FM/FP/MP
LHSV-06	626038	4477962	10	TS
LHSV-07	626081	4477926	10	TS
LHSV-08	626081	4477908	10	TS
LHSV-09	625867	4478885	10	TS
LHSV-VHZ-03	625488	4479613	10	TS
LLHSV-01	625856	4478840	10	FM/FP
LLHSV-02	625756	4479246	10	FP/TS
ULHSV-01	625651	4479085	5	TS
ULHSV-02	625708	4479067	5	TS
ULHSV-04	625810	4478884	5	TS
SULPHUR WORKS				
SW-00	624409	4478454		FM/FP/EM/TS
SW-01	624335	4478304	5	TS
SW-09	624375	4478368	5	FM/FP/MP/P
SW-10	624691	4479032	10	FP/TS
SW-VHZ-01	624359	4478890	5	FP/P
SW-VHZ-02	624256	4479071	5	TS
USW-SIE-05	624255	4479008	5	MP
MORGAN-GROWLER				
GHS	626726	4472348	5	TS
MHS-01	626272	4471600	10	TS
MHS-02	626257	4471656	10	TS
MHS-03	626129	4471691	10	TS
MHS-04	626177	4471358	10	TS
MHS-05	626202	4471544	10	TS
MHS-06	626175	4471469	10	TS
MHS-08	626232	4471470	10	TS
MHS-09	626074	4471579	10	TS
MHS-10	626332	4471379	10	TS
MHS-13	626248	4471341	10	TS
MHS-14	626220	4471322	10	TS
MHS-A	626405	4471288	10	TS
MHS-B	626051	4471652	10	TS
MHS-C	626245	4471544	10	TS
MHS-D	626074	4471597	10	TS
MHS-E	626102	4471598	10	TS
MHS-F	626357	4471620	10	TS
MHS-G	626398	4471658	10	TS
MHS-H	626073	4471634	10	TS
MHS-I	626200	4471655	10	TS
MHS-J	626130	4471654	10	TS
MHS-K	626143	4471709	10	TS
OTHER (COLD BOILING LAKE - PILOT PINNACLE - REGIONAL SPRINGS)				
O-CBL	628715	4479303	5	L
O-PP-01	624751	4480347	5	TS
O-PP-02	625032	4479741	10	TS
O-REG-CCS	624701	4482360	10	NTS
O-REG-CS	632466	4482239	10	NTS
O-REG-CVS	627821	4478953	5	NTS
O-REG-DILIRON	623620	4481260	5	NTS
O-REG-DILSOU	623662	4481173	5	NTS
O-REG-DILTHERM	623602	4481234	5	TS
O-REG-DS	640415	4468907	5	NTS
O-REG-KCCS	628956	4480110	5	NTS
O-REG-KCNS	629266	4480583	5	NTS
O-REG-LORH	629375	4483220	5	NTS
O-REG-MCTS	624123	4483872	5	NTS
O-REG-MS	622825	4487698	5	NTS
O-REG-OBS	628746	4486710	5	NTS
O-REG-SLLS	624048	4480987	5	NTS
O-REG-SLTS	634029	4481371	10	NTS
O-REG-UHCS	628931	4482860	10	NTS

Table 2. Gas chemistry, tritium concentrations and stable isotope values for features within and around Lassen Volcanic National Park, California.

Site code	Feature type	Sample #	Date	Temp. (°C)	Gas/steam	CO ₂	H ₂ S	NH ₃	H ₂	O ₂	CH ₄	H ₂	Ar	N ₂	N/Ac	δ ¹³ C-CO ₂ (‰)	δ ³⁴ S-H ₂ S (‰)	δ ³⁴ S-steam (‰)	δ ¹⁸ O-steam (‰)	δ ² H-water (‰)	δ ¹⁸ O-water (‰)	Tritium (TU)
BIFFSPASS HELL																						
BH1-11	FM	101-001	10/06/93	124	0.0043	85.4	6.2	0.1754	0.0004	0.0103	0.2173	2.6340	0.1071	4.70	45	-0.4	-0.4					
BH1-11	FM	84-01	07/29/94	114	0.0048	83.7	7.0	0.3500	0.0004	0.0103	0.1083	1.0810	0.0419	2.06	50	-2.4	-0.4					
BH1-12	FM	176-02	07/19/76	108	0.0035	94.2	3.6	0.2000	0.0004	0.0089	0.0900	0.0180	0.81	45	-10.7	-3.1						
BH1-12	FM	187-06	09/22/87	97	0.0036	88.0	6.8	0.2796	0.0004	0.0046	0.0685	1.440	0.0809	3.67	45	-10.3						
BH1-12	FM	188-01	08/15/88	100	0.0035	89.2	6.3	0.2485	0.0003	0.0027	0.1150	0.0403	2.31	46	-10.4							
BH1-12	FM	189-06	08/16/89	121	0.0038	90.0	6.6	0.0827	0.0003	0.0014	0.0839	1.240	0.0452	2.11	47	-9.4						
BH1-12	FM	191-02	08/21/91	92.2	0.0052	89.5	6.6	0.0684	0.0004	0.0028	0.0694	0.7430	0.0602	3.09	51	-9.6						
BH1-12	FM	193-04	08/11/93	85	0.0051	61.0	0.0063	0.0003	0.0000	0.0020	0.9662	0.0531	2.33	44	-9.4							
BH1-26	FM	186-05A	09/02/86	88.6	0.0022	5.4	0.0021	0.0003	0.0012	0.0650	0.3300	0.0420	1.99	49	-9.3							2.8
BH1-38	FM	176-01	07/19/76	133	0.0019	91.8	4.3	0.1900	0.0000	0.0100	1.4000	0.0600	0.80	52	-9.7							
BH1-38	FM	176-01B	07/19/76	133	0.0039	91.8	4.3	0.1900	0.0000	0.0100	1.4000	0.0600	0.80	52	-9.7							
BH1-38	FM	176-07	09/02/76	139	0.0085	92.5	5.9	0.0770	0.0000	0.0510	0.3700	0.0130	1.10	85	-11.2	-2.6						-10.9
BH1-38	FM	176-11	10/02/76	136	0.0071	92.0	5.9	0.2000	0.0000	0.0100	1.6000	0.0410	1.38	87	-10.5	-2.4						
BH1-38	FM	176-23	10/27/76	135	0.0035	91.4	5.3	0.2000	0.0000	0.0100	1.3000	0.0300	1.21	40	-10.8	-3.1						
BH1-38	FM	179-08B	08/23/79	145.6	0.0040	91.3	6.5	0.0980	0.0003	0.0120	0.0840	1.0300	0.0220	0.97	44	-9.6	-2.9					-11.0
BH1-38	FM	179-08C	08/23/79	145.6	0.0046	90.0	5.4	0.1800	0.0004	0.0000	0.9000	0.9760	3.37	44	-9.6	-2.9						
BH1-38	FM	179-08D	08/23/79	145.6	0.0041	91.4	5.4	0.1400	0.0002	0.0070	0.6500	0.0150	1.67	48	-9.6	-2.9						
BH1-38	FM	185-02	09/27/85	boiling	0.0101	91.2	6.1	0.0052	0.0000	0.0068	0.2720	0.0400	2.28	46	-10.2							
BH1-38	FM	187-03	09/22/87	110	0.0037	88.4	6.6	0.1546	0.0002	0.0025	0.0945	1.0640	0.0798	3.57	45	-10.2						
BH1-38	FM	188-07(2)	08/17/88	161.4	0.0042	85.7	6.2	0.0499	0.0003	0.0020	0.0664	0.9208	0.1186	6.88	58	-10.1	-9.2					
BH1-38	FM	188-07(3)	08/17/88	161.4	0.0041	85.6	6.8	0.1195	0.0002	0.0012	0.0970	1.0480	0.0790	3.51	44	-9.9						
BH1-38	FM	188-13	08/19/88	161.4	0.0048	91.0	7.2	0.2313	0.0000	0.0014	0.0905	0.7010	0.0728	3.50	47	-9.4						
BH1-38	FM	190-08	08/02/90	96	0.0045	90.8	6.2	0.0990	0.0038	0.0050	0.0910	0.4861	0.0509	2.35	46	-9.1						
BH1-38	FM	194-01(1)	07/26/94	148	0.0041	89.7	6.3	0.1016	0.0001	0.0062	0.9765	0.0599	2.69	45	-9.2							
BH1-38	FM	195-33	09/16/96	143.9	0.0035	94.1	5.8	0.0651	0.0004	0.0069	0.0852	1.5756	0.0257	1.77	60	-9.1						
BH1-41	FM	176-14	10/02/76	93	0.0105	91.7	4.3	0.1400	0.0000	0.0070	1.2100	0.0200	1.00	47	-9.4							
BH1-41	FM	186-08	09/03/86	93.1	0.0105	91.7	4.3	0.1400	0.0000	0.0067	0.9970	0.0100	1.200	5.38	45	-10.9	-2.4					
BH1-43	FM	186-07A	09/03/86	88.2	0.0049	23.0	0.0019	0.0000	0.0000	0.0010	0.9900	0.0430	1.99	46	-9.4							
BH1-43	FM	186-07B	09/03/86	88.2	0.0048	22.9	4.4	0.0025	0.0003	0.0060	0.4100	0.0480	2.15	45	-9.4							
BH1-43	FM	176-08	09/02/76	94	0.0033	91.4	5.3	0.1300	0.0000	0.0020	0.9710	1.5800	0.0230	4.40	56	-9.9	-2.3					
BH1-43	FM	186-03	09/02/86	94	0.0027	5.7	0.0510	0.0004	0.0035	0.0700	0.2800	0.0230	1.20	32.2	-10.2							
BOILING SPRINGS LAKE - DRAKESBAD - TERMINAL GEYSER																						
BSL	FM	176-16	10/02/76	96	0.0041	61.5	2.3	0.2300	0.0000	2.26	0.2000	0.3900	30.80	79	-21.5	-4.6						
BSL	FM	184-09A	09/13/84	96	0.0014	88.1	2.9	0.0343	0.0000	0.0043	0.2460	0.1770	8.28	47	-9.7							
BSL	FM	190-05	07/31/90	96	0.0025	87.6	4.5	0.0010	0.0000	0.0062	0.2754	0.3418	0.1222	7.25	85	-9.1						
BSL	FM	193-18	08/25/93	95	0.0025	89.8	4.8	0.0045	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	80	-9.6						
BSL	FM	198-01	09/15/98	96.6	0.0019	86.8	2.6	0.0126	0.0010	0.0272	0.0907	0.8894	0.1850	9.39	51	-9.0	-5.4					
IG	FM	197-04	09/20/75	95	0.0044	84.4	1.9	0.0200	0.0000	0.0380	0.1030	0.2700	11.60	43	-13.6	-6.7						
IG	FM	176-08	09/01/76	96	0.0038	89.9	6.8	0.0000	0.0000	0.0000	0.0000	0.0000	21.80	52	-10.7							
IG	FM	180-11	08/19/89	107	0.0002	23.9	10.7	0.7970	0.0018	0.0135	0.0402	0.1317	0.1643	22.63	44	-10.7	-1.0					
IG	FM	193-15	08/14/93	96	0.0002	69.7	8.3	0.0120	0.0000	0.0092	0.0440	0.1163	0.5022	21.23	42	-10.5	-1.0					
IG	FM	196-01	09/16/96	30	0.0027	0.0	0.0000	0.0000	0.0002	0.2209	0.0313	0.0001	0.0256	0.98	38.4	-10.3						
DEVILS KITCHEN																						
DK-12	FM	100-05	08/07/00	93.9	0.0050	94.0	2.3	0.0160	0.0008	0.0136	0.1155	0.3413	0.0614	3.20	52	-8.7						
DK-14	FM	188-19	08/21/88	96	0.0056	92.1	5.3	0.0000	0.0006	0.0096	0.5016	0.0310	2.04	66	-9.2							
DK-34	FM	188-18	08/18/88	88	0.0019	89.9	6.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	80	-9.6						
DK-36	FM	197-05	09/20/75	84	0.0035	21.0	0.0064	0.0000	0.0000	0.0070	0.3800	0.0700	3.64	53	-9.0	-5.4						
DK-47	FM	187-08	09/23/87	93.5	0.0082	92.2	4.3	0.0045	0.0005	0.0017	0.0859	0.3385	0.0587	3.08	52	-9.0						
DK-47	FM	188-10	08/18/88	95.8	0.0029	89.5	4.8	0.1203	0.0005	0.0013	0.0901	0.3805	0.1042	5.04	48	-9.5						
DK-57	FM	100-03	08/07/00	93	0.0033	91.7	4.0	0.0713	0.0006	0.0015	0.0739	0.5429	0.0586	7.75	64	-9.1						
DK-56	FM	187-10	09/23/87	93.5	0.0047	91.6	3.9	0.0417	0.0004	0.0075	0.1077	0.4732	0.0370	3.76	51	-9.0						
DK-87	FM	188-11	08/18/88	104.8	0.0030	89.8	4.1	0.0279	0.0006	0.0005	0.1064	0.4863	0.1101	5.35	49	-9.7						
DK-87	FM	188-18	08/18/88	104	0.0031	84.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	80	-9.6						
DK-87	FM	189-09	08/18/89	114	0.0033	92.3	3.7	0.1012	0.0003	0.0020	0.1056	0.5709	0.0388	3.09	53	-9.0						
DK-87	FM	190-04	07/31/90	98	0.0068	96.0	2.0	0.0233	0.0002	0.0008	0.0445	0.1929	0.0340	1.71	50	-8.8						
DK-93	FM	197-02	08/27/77	93	0.0455	84.9	1.8	0.0470	0.0000	0.0000	0.5400	0.0330	2.58	78	-10.6	-4.8						

Table 3. Water chemistry, tritium concentrations and stable isotope values for waters collected from features within and around Lassen Volcanic National Park, California, between July 1975 and October 1982

Site code	Feature type	Sample #	Date	Temp. (°C)	pH (p)	pH (Lm)	As	B	Ba	Br	Ca	Cl	Cs	F	Fe	HCO ₃ -K	Li	Mg	Mn	Na	NH ₄	Rb	SiO ₂	SO ₄	Sr	δD-water (‰)	δ ¹⁸ O-water (‰)	Tritium (TU)		
BUMPASS HELL																														
BH-A	TS	075-04	07/16/75	93	2.0	2.36	-0.04	0.7			7.09	-0.5		0.3		0	3.9	-0.01	2.5	0.12	8	1.6		96.36	458		-75	-7.1		
BH-42	TS	075-05	07/16/75	90	1.7	1.95		-0.1			1.1	-0.5		-0.1		0	4.1	-0.01	1.8	0.2	4	1.4		195			-62	-2.0		
BOILING SPRINGS LAKE - DRAKESBAD - TERMINAL GEYSER																														
BSL	TS	079-02	07/31/79	94	1.9	2.31		1.7			21.6	13		0.55	63	0	1.25	0	15.2		6.5			242	710		-68	-3.8		
DB-02	TS	076-03	09/01/76	65.5	6.8	8.13		0.6	0.5		38.6	0.9	0.06	0.15	-0.04	130	10.3	0.03	9.6	0.06	41	0.10	144	132	0.6	91	-11.4			
DB-02	TS	LM76-232	Aug. 1976	65	6.5	7.11		1.4	0.4		38	3.0	0.07	0.15		129	10.9	0.03	9.1		45	0.12	142	140	0.4	-90.5	-11.42			
ITG	FM	076-06	09/01/76	92		4.50		1.57			8.2	1.6		0		33	3	0	1.9		8			465	48		-87	-10.5		
TG WW	W	LJ82-23	10/23/82	86		7.45		2.7			43.1	1100		2.06		84	77.8	2.83	2.4		681			107	129		-97	-12.1		
TG WW	W	LJ82-24	10/23/82	86		2.45		2.64			367.7	6650		4.94		0	319	19.4	5.3		3230			33	180		-92	-9.5		
TG WW	W	LJ82-25	10/23/82	86		7.60	10.4	55.0		6.25	77.9	1760	0.8	4.17		84	102	5.53	1.78		1030	0.73	145	99		-96	-10.8			
TG WW	W	LJ82-26	10/23/82	86		7.44	9.9	62.0		7.60	60.8	2180	1.29	3.85		95	162	7.01	2.98		1220	1.34	133	81		-93	-9.7			
TG WW	W	LJ82-27	10/23/82	86		7.76	8.9	51.0		6.25	76.4	1770	0.81	3.94		111	99	5.28	0.83		1010	0.72	141	105		-97	-10.5			
DEVILS KITCHEN																														
DK-12	TS	075-07	07/17/75	94	7.0			0.73			610	0.3		0.33		23.7	4.4	0	141		23.5			114	43.1		-86	-10.4		
DK-14	TS	079-05	07/31/79	92		6.12		1.5			9.26	11		0.31	0.1	46	3.96	0.05	0.9	0.07	35.3	2.6		166	64		-77	-7.1		
DK-15	TS	079-04	07/31/79	94	6.8			0			14.7	3		0.22		62	1.07	0	3.41		12.0			60	78		-94	-12.6		
DK-34	TS	075-08	07/17/75	95	4.5			0.59			9.1	1.7		0.32		0	1.22	0			0			41.5	57.9		-87	-11.0		
DK-75	TS	075-08	07/17/75	95.5	1.9	7.81		1.4			45	-0.5		0.31		32.4	13.2	-0.01	4.0		24.3	1		213	237		-82	-9.8		
DK-91	TS	076-01	09/01/76	68	2.5	3.26		0.3			10.5	0.5		0.17	6.1	0	7.2	0.015	6.5	0.08	2			171	226		-83	-10.3		
DK-98	TS	076-02	09/01/76	73	5.6	7.88		1.4			12.2	1.4	0.07	0.32	-0.04	234	17.4	0.04	13.2	0.08	34	0.15	183	18		-90	-12.5			
LITTLE HOT SPRINGS VALLEY																														
LHSV-01	TS	076-10	09/02/76	95	4.8	8.32		0.3	1.2		114	1.4	0.08	0.3	-0.02	182	15.8	0.025	8.7	0.65	93	0.08	133	429	1.4	-88	-11.6			
LHSV-01	TS	077-07	08/27/77	nr				0.13			59.2	4.3		0.22		87	14	0	6.53		90.7			172	373					
LHSV-06	TS	LM76-162 (J76-08)	09/02/76	93	4.5			5.13			23	3		0.75		41	14.2	0.01	3.35		96			115	294		-77	-7.9		
LHSV-07	TS	076-09	09/02/76	94	3.8			0.48			44.3	0.6		0.7		0	11	0.085	14.9		98			162	511		-76	-8.3		
LHSV-08	TS	079-09	08/01/79	93	5.5			4.2			25.7	6		0.84		19	11.93	0	4.09		86.9	4.2		123	301		-76	-7.7		
LHSV-08	TS	LM76-169	09/02/76	91	5.0	6.83		1.0			39	2		-0.1		24	20.9	0.01	3.6		74			117	330		-81	-9.4		
LHSV-09	TS	079-10	08/01/79	88	5.6	6.19		0.2			39.7	3.3		0.35	-0.04	12	15.35	-0.05	4.0	0.16	55.3	1.2		152	220		-83	-9.7		
ULHSV-01	TS	076-04	09/02/76	66.5	6.7	7.74		0.1	2.4		208	0.9	0.06	0.54		351	15.5	0.025	14.5	0.4	70	0.09	100	487	3.1	-92	-12.9			
ULHSV-02	TS	076-05	09/02/76	69				0			255	1.2		0.57		275	14.8	0.025	15.8		65			91	517		-93	-13.0		
ULHSV-04	TS	079-11	08/01/79	55.5	6.7	7.02		-0.1			102	6.2		0.5	1.4	425	9.14	-0.05	5.6		67.6	5.3		133	101		-91	-12.5		
SULPHUR WORKS																														
SW-01	TS	LM76-116	09/02/76	83	6.5	7.72		1.2	1.6		159	2		0.52	-0.02	267	14.4	0.02	38.0	0.4	70			154	494	3	-86	-11.7		
SW-10	TS	LM76-76 (J76-12)	09/03/76	88	7.2	8.25		-0.1	1.3		115	0.5		0.77	0.1	230	2.7	-0.01	28.2	0.8	3			39	246	0.32	-92.4	-12.51		
MORGAN-GROWLER																														
GHS	TS	075-01	07/16/75	95	8.3			105			80	2390		2.3		648	203	11.2	0.05		1450			231	75		-93	-9.3		
GHS	TS	079-14	08/02/79	95		7.45		83.5			81.2	2400		2.3		55	173	0.63	0.067		1340			272	110		-95	-2.3		
GHS	TS	LJ82-01	09/03/82	95.5	8.0	7.79	12.7	71	0.62	8.00	59.8	2430	2.09	2.03	0.16	66	185	7.70	0.01	0.01	1380	3.0	1.61	274	90	0.98	-94	-9.3	0.2	
MHS-01	TS	076-15	09/03/76	96.5	7.1			81.7			85.5	2590		2.5		76	173	7.4	1.4		1470			189	99		-95	-9.7		
MHS-01	TS	079-16	08/24/79	95		7.25		70			100	3240		2.5		68	162	0.6	0.866		1260			285	123		-95	-9.6		
MHS-01	TS	079-15	08/24/79	96				74			94.4	2330		2.6		50	155	7.09	0.31		1240			122	101		-95	-9.6		
MHS-02	TS	076-14	09/03/76	94	7.1			95			85.5	2335		2.7		61	182	7.94	0.47		1460			172	98		-95	-9.8		
MHS-02	TS	079-18	08/02/79	93	6.9			24.8			91.9	2300		2.9		63	166	0.64	0.4		1280			200	72		-95	-9.4		
MHS-02	TS	079-14	08/24/79	94				74			88.1	2300		2.5		70	159	7.08	0.32		1260			126	113		-95	-9.4		
MHS-02	TS	LJ82-02	09/03/82	89	7.0	7.17	10.7	69	0.41	7.75	68.4	2380	2.1	2.08	0.06	69	157	7.50	0.34	0.02	1340	1.5	1.47	201	96	1.17	-95	-9.6		
MHS-03	TS	076-02	07/16/75	85	7.2			90			92	2300		3		43.6	165	8.2	0.45		1380			101	122.7		-95	-9.7		
MHS-03	TS	LJ82-03	09/03/82	77	6.5	6.88	19.2	65	0.64	7.60	68.8	2200	2.06	2.25	0.13	45	142	6.96	0.45	0.13	1290	11.2	1.34	215	111	1.04	-96	-9.8		
MHS-04	TS	076-16	09/03/76	89	7.4			85.5			86	2350		2.5		66	179	7.5	0.11		1520			170	99		-93	-9.3		
MHS-05	TS	079-17	08/24/79	85				72			111	2240		2.5		108	149	6.71	0.69		1180			162	107		-94	-9.5		
MHS-06	TS	079-18	08/24/79	82				81			128	2160		2.5		134	140	6.45	3.71		1140			150	113		-95	-9.6		
MHS-08	TS	0716/75	88.5	7.2				72			90	2270		2.8		62.3	165	8	0.8		1370			177	98		-94	-9.5		
MHS-08	TS	079-19	08/24/79	88				72			99.8	2290		2.6		46	141	6.69	0.57		1190			146	104		-94	-9.5		
MHS-09	TS	079-16	08/24/79																											

Table 4. Water chemistry, tritium concentrations and stable isotope values for waters collected from features within and around Lassen Volcanic National Park, California, between September 1996 and September 2002.

Site code	Feature type	Sample #	Date	Temp. (°C)	pH (p)	pH (mF)	pH (Lm)	Cond. (mS/cm)	Al	As	B	Ba	Be	Br	Ca	Cl	F	Fe	HCO ₃	K	Li	Mg	Mn	Na	NH ₄	NO ₃	PO ₄	SiO ₂	SO ₄	Sr	Ti	V	Zn	TDS	δD-water (‰)	δ ¹⁸ O-water (‰)	Tritium (TU)		
BUMPASS HELL																																							
BH-SIE-05	P	BH05-00	07/21/00	78.7		1.20	1.83	6.3	96.4	0.0031	9.49	0.063	0.002	<0.04	14.5	<0.05	<0.04	55.1	0	7.21	0.016	19.1	0.52	15.5	26.4	0.27	0.49	396	1880	0.038	0.059	0.11	0.11	2522	-58	0.8			
BH-SIE-07	MP	BH07-00	07/21/00	94.6		1.68	2.39	1.7	15.3	0.0029	1.07	0.043	<0.001	<0.02	25.1	0.10	<0.02	16.3	0	3.17	0.002	7.24	0.25	30.6	3.02	0.37	<0.05	255	471	0.032	0.013	0.053	0.42	829	-76	-5.4			
BH-SIE-08	P	BH08-00	07/21/00	85.2		1.72	2.32	1.8	10.7	0.0095	0.024	0.078	<0.001	0.05	3.01	0.09	<0.02	4.76	0	1.92	0.002	1.15	0.041	1.76	1.53	0.33	0.14	257	355	0.028	0.010	0.015	0.23	638	-65	-2.2			
BH-SIE-09	P	BH09-00	07/21/00	73		1.43	1.95	4.4	54.5	0.031	0.18	0.077	<0.001	<0.02	2.92	<0.05	<0.02	40.8	0	4.86	0.019	2.43	0.071	7.83	0.02	0.34	1.00	293	1082	0.13	0.008	0.083	0.022	1491					
BOILING SPRINGS LAKE - DRAKESBAD - TERMINAL GEYSER																																							
BSL	L	L96-02	09/16/96	50.0	2.0		2.24		18.8	0.0002	0.21			<0.02	5.35	0.04	0.22	24.4	0	0.35	<0.01	4.81	0.17	2.45	1.00	<0.02	<0.05	116	593	0.018				767	-59	-0.7	1.56		
DB-03	NTS	L97-19	08/07/97	11.0		7.31	6.32	0.079	<0.02	0.013	0.016	0.005	<0.002	<0.02	5.77	0.21	0.03	<0.01	44.4	2.44	<0.01	2.12	<0.002	6.38	<0.02	<0.05	47.1	1.71	0.045	<0.002	0.008	<0.01	147	-94	-13.3				
DB-04	NTS	L97-17	08/07/97	6.6	6.0		6.08	0.055	<0.02	0.0003	0.005	<0.002	<0.002	<0.02	4.39	0.16	0.05	<0.01	32.5	2.14	<0.01	1.95	<0.002	3.92	<0.02	<0.05	34.9	0.35	0.028	<0.002	0.009	<0.01	107	-94	-13.3				
DB-05	NTS	L97-18	08/07/97	5.3			5.96	0.052	<0.02	0.0001	0.005	<0.002	<0.002	<0.02	4.45	0.12	0.05	<0.01	31.0	2.06	<0.01	1.81	<0.002	3.24	<0.02	0.08	32.5	0.29	0.025	<0.002	0.009	<0.01	101	-93	-13.2				
DEVILS KITCHEN																																							
DK-12	FP	L00-05	08/05/00	93.3		1.23	1.83	8.32	157	0.0025	0.24	0.048	0.003	<0.04	62.2	1.08	<0.04	60.8	0	24.5	0.033	29.2	1.18	75.0	29.6	<0.04	1.17	387	3065		0.025	0.18	0.20	3895	-70	-6.1			
LITTLE HOT SPRINGS VALLEY																																							
LHSV-02	FM	L96-09	09/19/96	131.4			4.85		0.01	0.010	3.41			<0.02	0.06	0.03	0.13	0.09	12.6	<0.01	<0.01	0.01	<0.01	<0.01	4.21	0.15	<0.05	1.01	1.06	<0.002					23				
LHSV-02	FM	L00-07	08/06/00	122.7			4.96	0.058	0.018	0.0003	3.70	<0.001	<0.001	<0.02	0.07	0.09	<0.02	0.06	<0.8	0.03	<0.001	0.02	<0.001	0.08	3.95	<0.02	<0.05	0.41	6.65	<0.001	<0.001	0.020		21					
LHSV-VHZ-03	TS	L02-07	09/17/02	62.0			7.74		0.015	<0.0002	0.057	0.060	0.0001	<0.02	268	0.67	0.50	<0.01	400	14.7	0.021	17.6	0.57	71.2	1.31	<0.02	<0.05	99.7	620	4.33	0.021	<0.001	0.001	1499					
SULPHUR WORKS																																							
SW-09	MP	L00-02	08/04/00	87.4		2.55	2.71	2.13	3.41	0.095	4.94	0.026	<0.001	<0.02	20.5	0.42	0.66	119	0	9.42	0.007	19.5	0.64	15.8	137	<0.02	<0.05	143	887	0.020	0.034	0.094	0.14	1362	-56	-4.2			
USW-SIE-05	MP	L00-03	08/04/00	86.2		2.21	2.46	2.56	29.3	0.0092	0.49	0.013	<0.001	<0.02	8.40	1.23	0.58	108	0	5.93	0.008	10.1	0.31	8.06	134	<0.02	<0.05	195	1151	0.006	0.003	0.089	0.43	1657	-52	-2.5			
OTHER [COLD BOILING LAKE - PILOT PINNACLE - REGIONAL SPRINGS]																																							
O-CBL	L	L96-07	09/18/96	11.0	5.5		5.69		0.12	0.0018	0.007			<0.02	2.85	0.18	<0.02	0.18	22.9	0.60	<0.01	1.73	<0.01	3.87	0.13	<0.02	<0.05	3.34	1.29	0.031				37	-62	-7.5			
O-CBL	L	L97-21	08/08/97	24	4.5		5.73	0.031	0.07	<0.0001	0.006	<0.002	<0.002	<0.02	2.41	0.14	0.02	0.12	15.2	0.42	<0.01	1.19	0.005	3.30	<0.02	<0.05	0.5	0.87	0.011	<0.002	0.003	0.01	37	-56	-4.3				
O-REG-CCS	NTS	L97-11	08/05/97	3.0		6.54	5.70	0.020	0.03	0.0001	0.006	<0.002	<0.002	<0.02	1.40	0.11	0.02	<0.01	10.5	0.87	<0.01	0.65	<0.002	1.29	<0.02	<0.05	17.8	1.04	0.008	<0.002	0.006	<0.01	42	-97	-13.6				
O-REG-CS	NTS	L97-02	08/04/97	2.9	5.9		5.91	0.053	<0.02	0.0004	0.007	<0.002	<0.002	<0.02	5.24	0.15	0.01	<0.01	32.0	0.40	<0.01	2.18	<0.002	1.73	<0.02	<0.05	16.4	0.67	0.021	<0.002	<0.002	<0.01	85	-95	-13.5				
O-REG-CVS	NTS	L97-22	08/09/97	6.4	5.7		5.70	0.032	<0.02	<0.0001	<0.002	<0.002	<0.002	<0.02	3.14	0.11	0.01	<0.01	17.7	0.53	<0.01	1.10	<0.002	1.69	<0.02	<0.05	16.1	0.83	0.030	<0.002	<0.001	56	-94	-13.3					
O-REG-DILIRON	NTS	L97-10	08/05/97	7.0		5.91	6.97	0.762	<0.02	0.0005	0.018	0.013	<0.002	<0.02	20.7	0.18	0.03	2.38	12.7	5.64	<0.01	32.6	2.09	28.2	<0.02	<0.05	56.9	308	0.71	<0.002	<0.002	<0.01	875	-94	-13.4				
O-REG-DILSOU	NTS	L97-08	08/05/97	5.4		4.31	4.10	0.278	2.54	<0.0001	0.004	0.010	<0.002	<0.02	29.0	0.13	0.19	<0.01	0	2.01	<0.01	3.07	0.23	9.87	0.29	<0.05	52.6	144	0.15	<0.002	<0.002	0.03	244	-95	-13.5				
O-REG-DILTHERM	TS	L97-09	08/05/97	17.0		4.45	3.89	0.405	0.3	0.0003	0.009	0.029	<0.002	<0.02	43.3	0.64	0.18	3.72	0	2.41	<0.01	6.28	1.06	11.8	<0.02	<0.05	48.2	200	0.22	<0.002	<0.002	0.03	318	-91	-12.5				
O-REG-DS	NTS	L96-08	09/18/96	9.1	5.5		7.09		0.02	0.043	0.41			0.03	8.46	13.1	0.02	<0.01	56.6	2.77	0.04	3.59	<0.01	12.1	0.04	0.02	<0.05	40.2	0.49	0.069			138	-92	-13.1				
O-REG-DS	NTS	L02-13	09/20/02	9.3		5.70	7.45		0.039	0.037	0.45	0.010	<0.0001	0.04	8.56	15.5	0.03	<0.01	58.0	3.24	0.054	3.65	<0.001	13.7	<0.02	0.08	0.05	37.2	0.40	0.067	<0.001	0.003	0.003	141	-97	-13.6			
O-REG-KCCS	NTS	L97-05	08/04/97	3.7	5.3		5.77	0.028	<0.02	0.0010	0.007	0.027	<0.002	<0.02	2.02	0.22	0.03	<0.01	15.4	1.34	<0.01	0.76	<0.002	2.25	<0.02	<0.05	32.7	0.66	0.013	<0.002	0.005	<0.01	68	-97	-13.6				
O-REG-KCNS	NTS	L97-01	08/03/97	2.0	5.7		6.25	0.079	<0.02	0.0004	0.004	<0.002	<0.002	<0.02	7.72	0.30	0.01	<0.01	47.4	1.20	<0.01	3.11	<0.002	2.79	<0.02	<0.05	27.4	0.43	0.053	<0.002	0.004	<0.01	129	-96	-13.5				
O-REG-LOST	NTS	L97-14	08/06/97	6.1	5.7		5.97	0.070	<0.02	0.0006	0.016	0.003	<0.002	<0.02	7.19	0.27	0.02	<0.01	33.5	1.35	<0.01	2.19	<0.002	3.82	<0.02	<0.05	24.2	5.39	0.064	<0.002	0.007	0.02	105	-98	-13.6				
O-REG-MCTS	NTS	L97-12	08/05/97	4.5		6.01	7.11	0.173	<0.02	0.0007	0.024	0.004	<0.002	<0.02	21.2	0.53	0.02	<0.01	97.5	2.27	<0.01	5.39	0.002	6.45	<0.02	<0.05	45.2	8.72	0.16	<0.002	0.006	0.02	267	-98	-13.8				
O-REG-OBS	NTS	L97-13	08/06/97	5.2		6.62	6.51	0.103	<0.02	0.0004	0.012	0.003	<0.002	<0.02	11.0	0.25	0.02	<0.01	59.7	2.36	<0.01	2.74	<0.002	5.39	<0.02	<0.05	45.8	2.85	0.092	<0.002	0.009	<0.01	179	-102	-13.9				
O-REG-SLS	NTS	L97-07	08/05/97	4.8		6.11	5.19	0.055	<0.02	<0.0001	0.004	0.005	<0.002	<0.02	4.09	0.11	0.03	0.01	5.0	1.05	<0.01	0.94	<0.002	2.86	0.14	<0.05	36.4	18.0	0.041	<0.002	<0.002	<0.01	73	-98	-13.6				
O-REG-SLTS	NTS	L97-20	08/08/97	3.5	5.7		5.97	0.050	<0.02	0.0006	0.007	<0.002	<0.002	<0.02	5.54	0.13	0.01	<0.																					

Table 5. Tritium concentrations and stable isotope values for steam, water and CO₂ collected from features within and around Lassen Volcanic National Park, California.

Site code	Feature type	Sample #	Date	Temp. (°C)	pH (p)	pH (m)	Tritium (TU)	δD water (‰)	δ ¹⁸ O water (‰)	δD-steam (‰)	δ ¹⁸ O-steam (‰)	δD-steam (E) (‰)	δ ¹⁸ O-steam (E) (‰)	δ ¹³ C-CO ₂ (‰)	
BUMPASS HELL															
BH-04	NTS	L82-47	09/01/82	9.5	5.4		21.6	-91	-13.2						
BH-04	NTS	L85-01	09/27/85	7.8	5.7			-91	-13.0						
BH-04	NTS	L93-05	08/11/93	11		3.84		-96	-13.6						
BH-06	TS	L87-04	09/22/87	17.5	5.2			-89	-12.9						
BH-11	FM	T75-03	07/16/75	113						-93	-11.1				
BH-12	FP	L02-08	09/18/02	95.5										-9.5	
BH-13	P	P75-16	10/08/75	90	2.5			-74	-6.3						
BH-14	P	LC82-13	06/17/82	94	3.2			-75	-8.1						
BH-14	P	L82-17	08/26/82	94	3.3			-62	-2.6						
BH-21	P	P75-15	10/08/75	85	2.1			-83	-10.2						
BH-36	P	L83-02	09/21/83	64				-48	4.1						
BH-38	FM	L82-18	08/26/82	106			0.13			-92	-10.8	-93	-10.9		
BH-38	FM	L83-01	09/21/83	102						-96	-12.2				
BH-40	P	L83-03	09/21/83	88				-65	-4.2						
BH-52	TS	L89-07	08/17/89	50.6	2.0			-88	-10.6						
BH-57	TS	P75-23	10/08/75	94	2.1			-62	-4.0						
BOILING SPRINGS LAKE - DRAKESBAD - TERMINAL GEYSER															
BSL	L	L76-15	09/02/76	93	2.5			-72	-6.9						
BSL	TS	L82-38	08/30/82	93				-69	-5.9			-101	-11.6		
BSL	FP	L02-11	09/20/02	95.8										-10.4	
DB-02	TS	L82-23	08/27/82	67				-87	-10.9						
TG	P	T79-03	07/31/79	95	5.2			-84	-9.4						
TG	FM	L82-35	08/30/82	114			0.23					-106	-13.5		
DEVILS KITCHEN															
DK-14	TS	LC82-12	06/16/82	93	5.8			-79	-8.5						
DK-14	TS	L82-19	08/27/82	94.5	5.7			-77	-7.7	-86	-9.2				
DK-34	TS	L82-20	08/27/82	95	4.8			-80	-9.4						
DK-44	TS	L82-22	08/27/82	93.5	6.3			-89	-11.9						
DK-47	P	P75-14	10/05/75	84	6.5			-94	-12.6						
LITTLE HOT SPRINGS VALLEY															
LHSV-02	FP	L83-06	09/22/83	128			0.69					-89	-10.2		
LLHSV-01	FM	L82-30	08/29/82	98						-90	-9.8	-93	-10.4		
LLHSV-02	TS	L82-31	08/16/82	97.5				-60	-1.9	-91	-10	-92	-10.3		
ULHSV-01	TS	L88-17	09/20/88	70.2			0.32	-95	-12.9						
ULHSV-02	TS	L82-32	08/29/82	71	6.1		24.9	-92	-13.2						
SULPHUR WORKS															
SW-00	TS	L82-49	09/01/82	93	1.3			-60	-4.0	-86	-9.8				
SW-00	FM	L02-04	09/16/02	93.6										-8.4	
SW-01	TS	LC82-03	06/14/82	85	6.5			-86	-11.8						
SW-09	FM	L82-25	08/28/82	97						-83	-10.3	-89	-11.3		
SW-09	FM	L83-04	09/21/83	94						-89	-11.5				
SW-VHZ-01	FP	LC82-06	06/14/82	89	7.1			-80	-10.7						
SW-VHZ-01	P	L82-26	08/28/82	90.5	2.1		0.09	-93.3	-12.1						
SW-VHZ-01	FP	L02-01	09/16/02	93.1										-8.4	
SW-VHZ-02	TS	L85-11	09/28/85	90.4	2.5			-59	-2.4						
MORGAN-GROWLER															
GHS	TS	L76-20	10/03/76	96	7.0			-95	-9.2						
GHS	TS	LC82-16	06/18/82	96.5	8.0			-92	-10.0						
GHS	TS	L83-08	09/22/83	97				-93	-9.2			-129	-15.1		
GHS	TS	L84-07	09/12/84	95	8.0			-92	-9.2						
MHS-03	TS	L76-21	10/03/76	52	5.7			-94	-8.9						
MHS-04	TS	P75-07	09/24/75	92	7.5			-94	-8.7						
OTHER [COLD BOILING LAKE - PILOT PINNACLE - REGIONAL SPRINGS]															
O-CBL	L	L82-45	08/31/82	21.5	4.7			-73	-8.9						
O-PP-01	TS	L82-48	09/01/82	86	1.7			-81	-9.1						
O-REG-CS	NTS	L76-02	06/25/76	4.5	5.5			-98	-13.8						
O-REG-DS	NTS	L76-04	06/26/76	9.5	5.9			-95	-13.3						
O-REG-DS	NTS	L89-10	08/18/89	10	5.5		10.7	-95	-12.9						
O-REG-DS	NTS	L93-14	08/14/93	9		7.01		-95	-13.1						
O-REG-KCCS	NTS	L76-03	06/25/76	4	5.5			-97	-13.5						
O-REG-KCCS	NTS	L82-46.5	08/31/82	8			27.8	-92	-13.6						
O-REG-MS	NTS	L76-01	06/25/76	6	6.0			-100	-13.8						
O-REG-MS	NTS	T79-06	08/22/79	7			49.2	-100	-13.8						
O-REG-MS	NTS	L93-01	08/10/93	15		6.53		-99	-13.6						
O-REG-OBS	NTS	P75-06	10/04/75	14				-101	-13.7						
O-REG-OBS	NTS	T79-07	08/22/79	6			49.3	-102	-14.0						
O-REG-OBS	NTS	LC82-17	06/19/82	5				-102	-14.1						
O-REG-OBS	NTS	L82-28	08/28/82	8	6.0			-101	-14.0						
O-REG-OBS	NTS	L93-02	08/10/93	6		6.47		-101	-13.8						

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