Site Description

Reno

(updated 2010)

Geologic setting:

Geothermal features: The Truckee Meadows area (figure) includes the Reno-Sparks urban area between Peavine Mountain (N), Steamboat Hills (S), and the Carson and Virginia Ranges on the west and east, respectively. Geothermal fluids are found at several localities. These vary from slightly anomalous water temperatures in shallow domestic wells to high-temperature geothermal resources which are utilized for electric-power generation. We describe Truckee Meadows geothermal areas in more detail below.

Hidden Valley

Huffacker Hills

There is little information on the localized thermal groundwater that Bateman and Scheibach (1975, fig. 4) reported northeast of Huffaker Hills (see figure). Groundwater temperatures are reported between 20°C and 30°C (Bateman and Scheibach, 1975, fig. 4), too low for most space-heating or related uses, and we know of no present geothermal applications.

Lawton Hot Springs

On April 10, April 14, and April 29, 2008, UNR samplers visited the abandoned River Inn site along the Truckee River to revisit well temperatures. The Mogul Earthquake Swarm had been active for 2 weeks prior to sampling. We found the well temperatures similar to their 2006 values (44 – 46°C), and relatively unchanged over the 2.5 week sampling period. The westernmost well varied from 44.5 to 44.2 to 44.6 °C over the three visits, and the well 5m east varied from 43.5 to 43.4 to 44.5 °C. The two wells are not stagnant, but neither flows beyond the lateral replacement rate (and could

not be sampled). We opened the metal lids of the concrete well casings and temperature-tested water 3m below surface level. The water level is at/close to the Truckee River water table.

Moana Hot Springs (Map)

The Moana Hot Springs, located in NE¼ Sec. 26, T19N, R19E, in southwestern Reno, support the largest low-to-moderate temperature, direct-use development in Nevada. The springs have not flowed at the surface since the early 1980s; however, some of the wells drilled in the surrounding area maintain an artesian head. The springs were the discharge point for an area of thermal groundwater that has been used for a spa, swimming pool, and home heating for nearly 100 years. Recent use for home space heating began in the 1960s. The area today is predominantly residential. We estimate that the area of thermal groundwater encompasses at least 9 km^2. Depths to the resource range from <50 to 240 m (e.g., McKay and others, 1995). In this area there are more than 250 wells, ranging in depth from 3 to 304.8 m, that access geothermal fluids for space heating. More than 300 residences are heated either by use of individual wells or a distrct heating system. Also heated are churches, apartments, a county swimming pool, and a casino. Residential and commercial development is concentrated in Sections 23 through 27, T19N, R19E (Flynn, 2001). (figure).

The Moana Hot Springs were formerly the site of a spa that could be reached from downtown Reno by a streetcar line built in 1907 (Nevada State Journal, January 2, 1977). The swimming pool was also supplied for a long time with heated water from a well in the vicinity, and water was mixed directly with city water to maintain a specified pool temperature. This operation was terminated because of production problems with the well and water quality. Several homes in the area have used the thermal waters for over 60 years, although the number of wells increased markedly in the 1970s and 80s as the Reno residential area expanded. Numerous homes and three commercial establishments now use the geothermal waters for space heating; other uses include the heating of domestic hot water and water for swimming pools. Most of the systems use down-hole heat exchangers, and circulate city water through finned-tube baseboard heaters. Thermostatically controlled pumps are installed in most systems. Of the 162 lots that have access to the district heating systems in Manzanita and Warren Estates, 110 residences have paying customers, with the other homeowners declining the use of the resource. Fluid is delivered to the residences at 140 to 160°F (pers. comm. with Dennis Trexler, summer 2006). Bateman and Scheibach (1975) discuss the early use of the Moana geothermal waters in more detail, and maps by Garside (1983) and in Trexler and others (1982) show the area of geothermal development to that time. Jacobson and Johnson (1991) presented a more recent summary of the geohydrology.

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Location of the Moana thermal system is thought to be controlled by northerly striking faults that parallel the front of the Carson Range to the west (Flynn and Ghusn, 1984; Bateman and Scheibach, 1975; Bonham and Bingler, 1973). Several faults in this area cut glacial outwash deposits of Illinoian age (E.C. Bingler, oral commun., 1977). It has also been noted that there is a striking north-south alignment of those wells with artesian head (past and present) and that the alignment may mark a fault trace (Bateman and Scheibach, 1975).

Although thermal groundwater has been encountered in wells over an area of several square kilometers (figure), the highest temperatures, as well as the area of maximum use for space and domestic hot water heating, is concentrated in an area slightly over 5 km^2. (figure). The wells in the Sweetwater Drive-Manzanita Lane area (SE¼ NE¼ Sec. 26, Tl9N, R19E) are usually 30-90 m deep and many have temperatures of 71-85°C. The resource temperature of the Warren Properties district heating system is reported to be 99°C (Rafferty, 1989). To both the north and west of this area, it has been necessary to drill deeper wells to encounter thermal waters. Since 1995, well drilling has all but stopped due to depressed cost of natural gas and the expenses associated with drilling and the completion of both production and injection geothermal wells, but there has been a renewed interest in geothermal direct use with a recent rise in the cost of natural gas (Flynn, 2001, p. 7).

There are few indications of subsurface hot water north of Virginia Lake, although subsurface temperatures of 48°C were found at the Veterans Hospital 1.5 km northeast of Virginia Lake (Nork, 1985). In the Moana area, the hot waters encountered in drilling are associated with a "blue" clay zone that directly overlies the Tertiary bedrock units here and may be up to 46 m thick. The hot water is not generally found above this "blue" clay zone (Bateman and Scheibach, 1975). Flynn and Ghusn (1984) reported that the blue clay, a smectite clay, represents hydrothermal alteration of Tertiary rhyodacite. If the water moves upward through faults in the bedrock, this clay zone may act as a relatively impermeable cap, forcing the water to diffuse laterally (and vertically) away from the fault zone. Noticeable increases in water temperature were observed when certain wells were drilled through the contact between the clay and underlying bedrock. The existence of an artesian head only in wells drilled along a certain alignment, presumably a fault, may further support this theory of near-surface operation of the system. Wells drilled into or through the clay at some distance from such an input zone would tend not to display artesian conditions due to the hydraulic head loss involved in moving water laterally through the clays and andesite.

Water temperatures encountered at depths greater than 30 m range from 75 to 96°C. Deeper wells do not in general have the highest temperatures, suggesting that temperatures deep within the system may not be appreciably greater than those encountered nearer to the surface. This figure shows temperature profiles of several wells within the area. Although variable, the pattern of a leveling off of temperature with depth can be clearly observed (Bateman and Scheibach, 1975).

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Steamboat Hot Springs (Maps)

Steamboat Hot Springs are located about 14 km south of downtown Reno, just south of the junction of U.S. Highway 395 and State Route 27 (Sec. 33, T18N, R20E). The springs have a long history as a resort and health spa. They were first located in 1860 by Felix Monet. They are so named because, when discovered, escaping steam reportedly produced a noise resembling the puffing of a steamboat. The area had several owners and developments before 1871, when the Virginia and Truckee Railroad was completed to this point and a small town sprang up (Hummel, 1888). A post office was established in 1880 and exists to this day. Some of the resorts have used the names Reno Hot Springs, Mount Rose Hot Springs, or Radium Hot Springs. The deposits of sulfur and cinnabar were first opened up in 1876, and numerous attempts have since been made to mine these deposits (Overton, 1947). The spa on the site, the Steamboat Villa Hot Springs Spa, was restored in the mid-1990s and is currently in use (Williams, 1996, p. 27).

The Steamboat Hot Springs area is the best known and most extensively studied geothermal area in Nevada, and one of the better known thermal areas of the world. The geology and geochemistry have been described in detail by White and others (1964). Other references on the geology of the hot springs area and the surrounding vicinity include: White and others (1946), White (1952, 1953), Thompson and White (1964), Bateman and Scheibach (1975), Bingler (1975), and Tabor and Ellen (1975). The rock alteration has been reported in the following articles: White (1947, 1954), Sigvaldason and White (1962), Schoen and White (1965, 1967), Ehrlich and Schoen (1967). The geochemistry (including isotope geochemistry) and heat flow have been discussed by the following: Brannock and others (1948), White and Brannock (1950a, b), Craig (1953), White and others (1957), White and Craig (1959), White (1957, 1968), and Silberman and White (1975). The mercury, antimony, silver, and gold mineralization has been described in a number of publications, including: Phillips (1871, 1879), Le Conte (1883), Becker (1888, 1889), Lindgren (1905), Jones (1914), Bailey and Phoenix (1944), Gianella and White (1946), White and others (1949), and White (1974) Other references include: Bonham and Bell (1993), Combs and Goranson (1995), Desormier (1983), Finger and others (1994), Flynn and others (1994), Koenig (1989), Mariner and Janik (1995), Nehring (1980), Rose and others (1999), Goranson and Combs (2000), Goranson (2001), Henry and Perkins (2001), Skalbeck and others (2002), Sorey and Colvard (1992), White (1980, 1983), Johnson and Hulen (2005). Geophysical studies are reported in White and others (1964), Hoover, Batzle and Rodriquez (1975), Hoover, O'Donnell, Batzle, and Rodriquez (1975), Long and Brigham (1975b), Peterson (1975), Abbott and Louie (2000), and Skalbeck (2001).

Much of the following geologic description is summarized from White (1968), White and others (1964), Thompson and White (1964), and Bateman and Scheibach (1975). Bonham's (1969) summary of White and others (1964) has also been extensively quoted in the following:

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The oldest rocks in the Steamboat Springs area are metamorphosed sedimentary rocks that have been intruded by granodiorite (figure). The sedimentary rocks are largely metamorphosed water-laid volcanic tuffs with intercalated beds of sandstone, conglomerate, and limestone. They are probably Triassic in age. Much of the Steamboat Springs area is underlain by granodiorite of probably Cretaceous age. The granodiorite has been hydrothermally altered over most of the area, and near-surface bleaching is prevalent in and adjacent to the thermal areas.

Flows of andesite, correlated with the Tertiary Alta Formation, crop out at a few localities in the district and have also been recognized in several of the drill holes located within the thermal area. The andesite overlies granodiorite. Two small erosional remnants of an andesite flow are the only rocks of the Kate Peak Formation that crop out in the district. Rocks of the Kate Peak Formation, however, crop out over extensive areas immediately adjacent to the Steamboat Springs district.

Basaltic andesite flows extend over much of the southern and eastern parts of the Steamboat Springs district. The flows overlie granodiorite and alluvial deposits. These pre-basaltic andesite pediment gravels and alluvium are present over much of the district. They rarely crop out, because they are usually concealed beneath younger rocks, but they have been encountered in a number of the drill holes. The oldest deposits of hot-spring sinter are also of pre-basaltic andesite age. Several areas of this early hot-spring sinter are present in the district.

The Steamboat thermal area lies on a line connecting several rhyolite domes that occur to the southwest and northeast of the thermal area and are named the Steamboat Hills Rhyolite. The emplacement of the large dome that lies southwest of Steamboat Springs was preceded and accompanied by extensive pyroclastic eruptions that mantled much of the adjacent area with a layer of rhyolite pumice. White and others (1964) have proposed that another rhyolite intrusive may underlie the hot-spring area.

White and others (1964) have differentiated several different types of Quaternary deposits in the Steamboat Springs district, including pre-Lahontan alluvium, post-basaltic andesite sinter, opaline hot-spring sinter, alluvium of Lahontan age, and Recent alluvium and hot-spring deposits. Their detailed mapping of these Quaternary deposits has contributed greatly to an understanding of the history of the Steamboat Springs area.

The hot-springs system formed in the early Pleistocene, prior to the eruption of the basaltic andesite flows in the Steamboat area. The basaltic andesites have been dated at about 2.5 Ma, and the rhyolite domes have given K-Ar ages of 1.15 to 1.52 Ma. Also, hydrothermal potassium feldspar, which replaces basaltic andesite, gave an age of 1 Ma (Silberman and White, 1975). Thus, the hot-spring system is seen to have been active, possibly intermittently, for over 2.5 million years. The source of

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the energy for the thermal convective system may be the rhyolitic magma chamber from which the rhyolitic domes were emplaced (Silberman and White, 1975), although of the rhyolite may be too old to be a continued heat source for the system. It has been estimated that about 0.001 km3 of new magma would have to be provided each year to supply the heat at Steamboat at the present rate of heat loss, and no evidence is available to suggest such an addition. Perhaps the Steamboat system is similar to other Basin and Range systems where heat is derived through deep circulation of fluids in an extensional environment. Studies are ongoing to better understand the heat source at this site.

The thermal waters contain small amounts of metals, including mercury, antimony, silver, and gold and have deposited small amounts of stibnite, gold, and silver, and larger amounts of cinnabar in both hot-spring sinter and in the altered wall rocks adjacent to the hot-spring vents. The waters at Steamboat are high in Na, Cl, HCO_3, and SiO_2, and have a significant Li content. Also, they are anomalous in As, Sb, Hg, Cs, and B. Mercury vapor is commonly detected in the steam from springs and wells. The relative abundance of these highly soluble elements which have a low crustal abundance, coupled with the long life of the geothermal system, creates great problems with maintaining the supply of these elements by rock leaching. White (1974) suggested that the spring waters include a continuing small supply of magmatic water enriched in the previously mentioned constituents. Oxygen isotope data show that there could be no more than 11% magmatic water supplied to the hydrothermal system, and it is probably less than 5%.

All of the wall rocks in the thermal area have been altered. Near-surface acid bleaching is the most obvious visible effect at the surface, and it has strongly affected the granodiorite and the basaltic rocks. The near-surface acid bleaching extends to depths of 30 m or more. Below this zone the rocks adjacent to the channelways of migrating thermal waters have been hydrothermally altered. A type of propylitic alteration is prevalent in this zone.

The main terrace at Steamboat Hot Springs is made up of siliceous spring deposits, primarily opaline sinter. It is believed that with time this will change to chalcedonic sinter. A large area of chalcedonic sinter is present in Pine Basin to the southwest of the main terrace and is believed to be the most extensive chalcedonic hot-spring sinter known in the world. It contains disseminated cinnabar. Also, small amounts of siliceous sinter are present about 2.4 km south of Steamboat Hot Springs in C NE¼ Sec. 5, T17N, R20E, and a small deposit of spring travertine is located in SW¼ SW¼ SW¼ Sec. 5, Tl7N, R20E on the southeast flank of Steamboat Hills about 30 m above the floor of Pleasant Valley (Thompson and White, 1964).

The springs at Steamboat are near boiling, and early exploration steam wells reported temperatures as high as 187°C. One well encountered temperatures of up to 138°C at only 49 m (White, 1968). The hot water is reported to have 5-10% steam flashover (Koenig, 1970). Preferred estimated

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reservoir temperatures from chemical geothermometers were about 201°C (Silica) to 208°C (Na-K-Ca) (Mariner and others, 1974). Six steam wells, ranging in depth from 218 to 558 m were drilled in the late 1950s and early 1960s by Nevada Thermal Power Co. Also, the U.S. Geological Survey drilled eight core holes for a total of 1,011 m, and, in the past, several other wells have been drilled in the area for spas. In the 1970s, the hot water from one steam well was used as a flameless source of heat for the manufacture of plastic explosives.

The Steamboat Springs geothermal resource is now developed by two electric generating facilities. Both flash and binary power plants are now operational at the Steamboat Hills geothermal area. Following exploration drilling in the early 1980s, Yankee Caithness constructed a flash power plant that came on line in 1988, producing 14.4 MW from a 236°C resource. The Yankee Caithness holding at Steamboat is owned by Ormat Nevada, Inc. as of 2006. Other power plants are located about 3 km to the northeast in a cooler part of the system along an outflow plume where reservoir temperatures are 170°C. Thermal waters at both plants are believed to be related to a single high temperature fluid that rises from depth beneath the Steamboat Hills and cools along a path to the area of the Advanced Thermal Systems (formerly SB Geo) plant (Mariner and Janik, 1995). Advanced Thermal Systems operates binary power plants at the site, including Steamboat I/Ia that came on-line in 1986 and produces 7.1 MW, and Steamboat II/III, which came on-line in 1992 and produces 48 MW of electricity. The geothermal resource is also being used for spas and space heating.

The Advanced Thermal Systems wells produce >155°C fluid from fractured Cretaceous granodiorite along a north-northeast-striking fault zone. The granodiorite is overlain by 15-75 m of Quaternary material and 30-60 m of Tertiary volcanic rocks (Goranson, 1991). Submersible pump technology application studies at the plant are ongoing, and a high-efficiency turbine retrofit was completed in 2001. The U.S. Department of Energy has provided initial funds ($200,000) to Steamboat Envirosystems, LLC, to evaluate enhanced geothermal systems technology at Steamboat, and $270,000 for geothermal resource exploration and definition through the GeoPowering the West program (www.eren.doe.gov/geothermal/). SB Geo drilled a 610-m temperature slim hole (MTH 24-33) in fractured granodiorite on its Meyberg Property, 1.5 km south of the SB Geo plants in 2001. Maximum encountered temperatures were 162°C between 335 and 427 m in fractured granodiorite, with temperatures decreasing below this interval (Goranson, 2001).

The Yankee Caithness wells produce from hydrothermally altered granodiorite and metamorphic rock near the intrusive contact between the Cretaceous granodiorite and Triassic metasedimentary rocks. North- and northeast-striking faults predominate in the Steamboat Hills area, and probably provide the main conduits for fluid flow to the resource areas tapped by the two companies. A new well (24-5) with significant flow was brought into production in July 2000 at a temperature of

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248°C. Although the flow rate did not diminish, the production temperature had dropped to 219°C within one year, and the well currently produces 8 MW of electricity (De Rocher, 2002). The U.S. Department of Energy has provided $1.875 million over 3 years for resource exploration and definition as part of the U-boat project (www.eren.doe.gov/geothermal/). Ormat Nevada acquired the Yankee Caithness and Advanced Thermal Systems plants and additional adjacent private land in 2003 and 2004.

Recent work by Skalbeck (2001) modeling both gravity and magnetics data interpreted an altered granodiorite area to the southwest of the current Caithness plant to be a possible up-flow zone. This area may be targeted in the future to try to tap a higher temperature resource, and increase the resource area. Other work by Skalbeck and others (2002) evaluated the hydrology of the area and possible interactions between the produced geothermal resource and nearby potable water supplies tapped in the unconsolidated zone by Washoe County. Changes in water chemistry through time in previously nonthermal, and some mixed wells in the area indicate a connection between the two resources through north-trending faults. Greater amounts of thermal water through time have been found in some domestic wells near the outflow zone of the geothermal system.

Southeast of Steamboat Hot Springs the edge of the Steamboat geothermal groundwater anomaly is adjacent to land managed by the BLM. The anomalous temperatures in water wells in sec. 34, T18N, R20E range from 22°C to 70°C (Garside and Schilling, 1979, Appendix 1). To the south of this section, cool groundwaters are known from northern Steamboat Valley (Bateman and Scheibach, 1975, fig. 4). A small area of abnormal groundwater temperatures is known in southern Steamboat Valley (Bateman and Scheibach, 1975; unpub. data, Geothermal Services, Inc., 1980, in NBMG files). A geothermal gradient well located near the south edge of Sec. 4, T17N, R20E is reported to have a maximum temperature of 45°C (unpub. data, Geothermal Services, Inc., 1980). A few homes in the residential area east of Steamboat Hot Springs have been reported to use geothermal wells for space heating and swimming pools, and one or more spas have been active in the spring area since the 1860s. We know of no such uses in southern Steamboat Valley.

This area of anomalous groundwater temperatures does not extend to the south or east into the Virginia Range. Phillips Petroleum Co. drilled 8 temperature-gradient drill holes in 1981 in an area of the western Virginia Range about 7 km east of Steamboat Hot Springs (SMU; Sass and others, 1999). The drill holes are centered on an area about 1 km northwest of Castle Peak (GeothermEx, 2004). The holes have a maximum reported temperature of 29.4ºC in wells as deep as 275 m. Location: 39.42ºN, 119.66ºW.

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Leasing information: In May 2006 Sierra Pacific Resources and Ormat Technologies, Inc. jointly announced that Sierra Pacific Power Co., Sierra Pacific Resources northern Nevada utility, and ONRI 14 LLC, a subsidiary of Ormat Nevada, Inc., signed a 20-year 20-MW Power Purchase Agreement (PPA) for Galena No. 3, a new binary geothermal plant being built as part of the Galena Geothermal Project. This plant is expected to increase the output currently supplied from the Steamboat Hot Springs to Sierra Pacific Power Co. by between 15 and 25 MW. The design of the Galena No. 3 plant will be similar to the existing Richard Burdette Power Plant. This is the tenth PPA signed between Ormat and Sierra Pacific Power in Nevada and the fourth signed since Nevada's renewable energy portfolio standard has been enacted by the Nevada State Legislature in 2001 (Ormat press release, May 2006, and Bulletin Geothermal Resources Council, May/June 2006).

The Redfield Campus is located at the south end of Reno, adjacent to the Steamboat Springs geothermal area. Ormat Nevada, which operates the geothermal power plants at Steamboat Springs, has agreed to contribute one megawatt of electricity from geothermal energy, 600 gallons per minute of 180 F water for campus heating, and 100 gallons per minute of 300 F water at no cost, for research purposes. The Redfield Campus and the UNR Renewable Energy Center, a partnership between the University of Nevada, Reno, Truckee Meadows Community College, Desert Research Institute, the Regional Transportation Commission, Sierra Pacific Power, and Ormat Nevada, has the potential to become a world-class research facility in the field of renewable energy resources.

Verdi

Wedekind Mine

In 1903 the Wedekind shaft in the Wedekind mining district (SW¼ Sec. 28, T20N, R20E) encountered hot, acid water at 65 m. A 570-L/min pump was able to hold the water at the 100-foot (30.5 m) level. The water was heavily charged with H_2S, and several miners in the bottom of the shaft were overcome by heat and H_2S (Morris, 1903; Overton, 1947, p. 84). Warm water is reported in a 69-m-deep well in the same section and 88°C water was found in a 55-m-deep well located about 3 km to the southeast (SE¼ Sec. 34, T20N, R20E) (unpub. well driller's reports in the Office of the Nevada State Engineer). A second, shallower well at this later location had 46°C water in a 40-m well. Also, hot water was encountered in shallow drill holes slightly more than 3 km to the west, near the US 395–North McCarran intersection and just to the east at the intersection of North McCarran and Northtowne Lane (NW¼ Sec. 31, T20N, R20E (R. Kroll, written commun., 2004).

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Geothermal data are somewhat limited because few wells have been drilled in the area recently. Based on the available data, the area of potential geothermal resources in the vicinity of the Wedekind mining district is believed to be an elongate 1 km by 5 km zone in the northeastern Truckee Meadows.