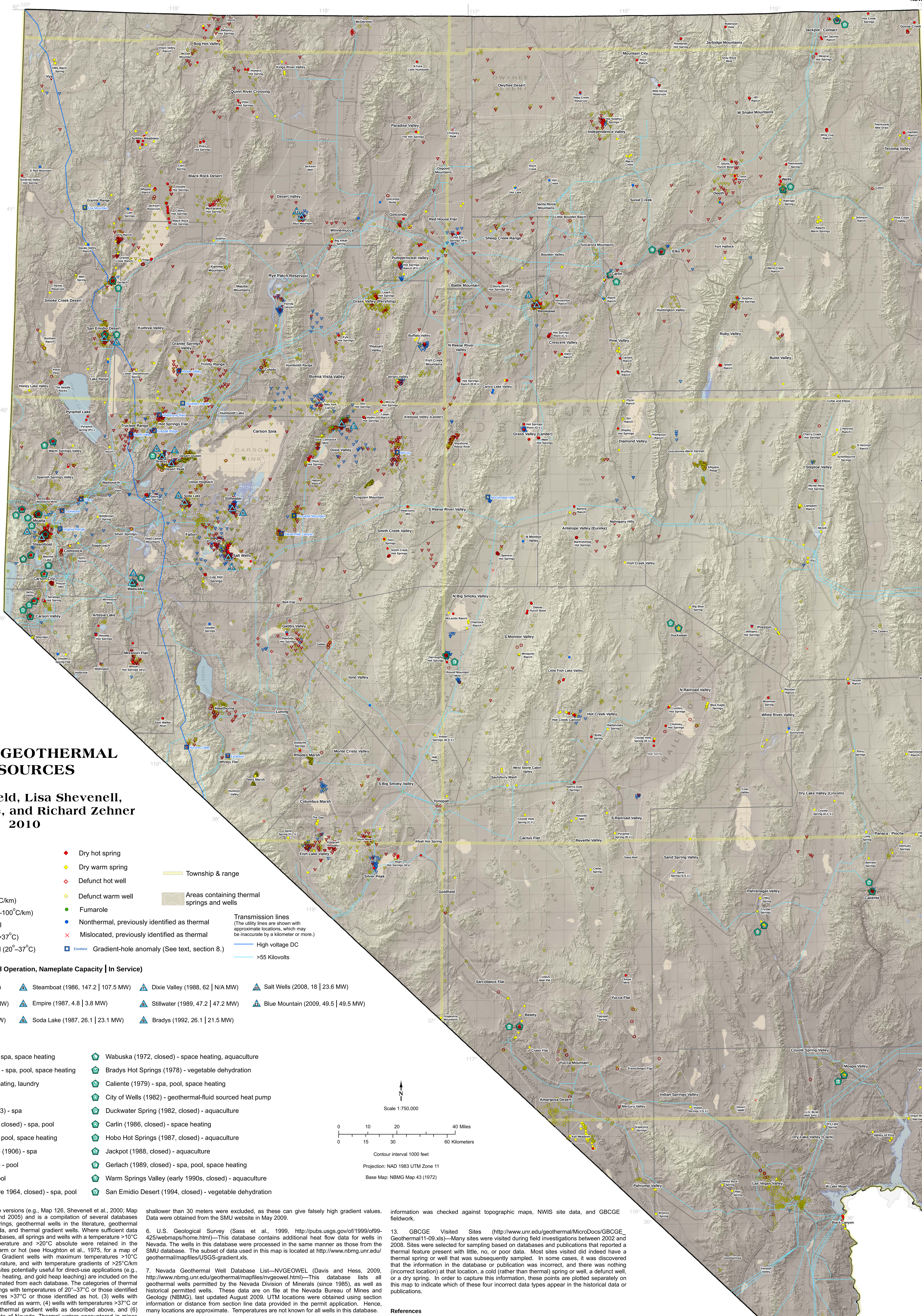

NEVADA GEOTHERMAL RESOURCES

Robin Penfield, Lisa Shevenell, Larry Garside, and Richard Zehner

2010

- Hot spring (>37°C)
- Warm spring (20°–37°C)
- Hot well (>37°C)
- Warm well (20°–37°C)
- Hot heat-flow well (>100°C/km)
- Warm heat-flow well (25°–100°C/km)
- Permitted geothermal well
- Hot shallow survey well (>37°C)
- Warm shallow survey well (20°–37°C)
- Dry hot spring
- Dry warm spring
- Defunct hot well
- Defunct warm well
- Fumarole
- Nonthermal, previously identified as thermal
- Mislocated, previously identified as thermal
- Excelsior Gradient-hole anomaly (See text, section 8.)
- Township & range
- Areas containing thermal springs and wells

Transmission lines
(The utility lines are shown with approximate locations, which may be inaccurate by a kilometer or more.)
- High voltage DC
- >55 Kilovolts

Power Plants (Year of Initial Operation, Nameplate Capacity | In Service)

1. Wabuska (1984, 2.4 | 2.1 MW)
2. Beowawe (1985, 16.6 | 17.7 MW)
3. Desert Peak (1985, 23 | 19 MW)
4. Steamboat (1986, 147.2 | 107.5 MW)
5. Empire (1987, 4.8 | 3.8 MW)
6. Soda Lake (1987, 26.1 | 23.1 MW)
7. Dixie Valley (1988, 62 | N/A MW)
8. Stillwater (1989, 47.2 | 47.2 MW)
9. Bradys (1992, 26.1 | 21.5 MW)
10. Salt Wells (2008, 18 | 23.6 MW)
11. Blue Mountain (2009, 49.5 | 49.5 MW)

Direct Use Applications

A. Steamboat Springs (1860) - spa, space heating
B. Walleys Hot Springs (1862) - spa, pool, space heating
C. Elko (1868) - pool, space heating, laundry
D. Carson City (1880) - pool
E. Darroughs Hot Springs (1883) - spa
F. Lawtons Hot Springs (1886, closed) - spa, pool
G. Moana Hot Springs (1905) - pool, space heating
H. Baileys Hot Springs (Beatty) (1906) - spa
I. Ash Springs (1960s, closed) - pool
J. Bowers Mansion (1962) - pool
K. Moapa Warm Springs (before 1964, closed) - spa, pool
L. Wabuska (1972, closed) - space heating, aquaculture
M. Bradys Hot Springs (1978) - vegetable dehydration
N. Caliente (1979) - spa, pool, space heating
O. City of Wells (1982) - geothermal-fluid sourced heat pump
P. Duckwater Spring (1982, closed) - aquaculture
Q. Carlin (1986, closed) - space heating
R. Hobo Hot Springs (1987, closed) - aquaculture
S. Jackpot (1988, closed) - aquaculture
T. Gerlach (1989, closed) - spa, pool, space heating
U. Warm Springs Valley (early 1990s, closed) - aquaculture
V. San Emidio Desert (1994, closed) - vegetable dehydration

N

Scale 1:750,000

0 10 20 40 Miles
0 15 30 60 Kilometers

Contour interval 1000 feet

Projection: NAD 1983 UTM Zone 11

Base Map: NBMG Map 43 (1972)

This map is a revision of previous map versions (e.g., Map 126, Shevenell et al., 2000; Map 141, Shevenell and Garside, 2003 and 2005) and is a compilation of several databases containing information on thermal springs, geothermal wells in the literature, geothermal wells permitted by the State of Nevada, and thermal gradient wells. Where sufficient data were available from the individual databases, all springs and wells with a temperature >10°C above average annual surface temperature and >20°C absolute were retained in the database, as were those noted as warm or hot (see Houghton et al., 1975, for a map of mean annual surface temperatures). Gradient wells with maximum temperatures >10°C above average annual surface temperature, and with temperature gradients of >25°C/km were retained in the database. Thus, sites potentially useful for direct-use applications (e.g., onion drying, aquaculture, spas, space heating, and gold heap leaching) are included on the map. Questionable records were eliminated from each database. The categories of thermal sites included on the map are (1) springs with temperatures of 20°–37°C or those identified as warm, (2) springs with temperatures >37°C or those identified as hot, (3) wells with temperatures of 20°–37°C or those identified as warm, (4) wells with temperatures >37°C or those identified as hot, (5) selected thermal gradient wells as described above, and (6) geothermal wells permitted by the State of Nevada. Thermal waters encountered in mines are indicated with the well symbol. The databases plotted on this map were obtained from the following sources:

1. Garside (1994) (http://www.nbmg.unr.edu/geothermal/geochemdata/ ofr94_2/ofr94-2.htm)—This dataset includes selected spring and well locations and chemical analyses for most of Nevada's geothermal areas. The sources for this dataset are selected entries from Garside and Schilling (1979), GEOTHERM, and National WATer Data STOrage and REtrieval System (WATSTORE).

2. GEOTHERM (for Nevada) and other unpublished NBMG data, including locations digitized from 7.5' topographic maps (http://www.nbmg.unr.edu/geothermal/geochemdata/ geotherm.htm). GEOTHERM is a U.S. Geological Survey database, active until 1983, designed to host the geology, geochemistry, and hydrology of geothermal sites. Map 161 includes wells and springs identified as thermal in GEOTHERM, as well as thermal features digitized on 7.5' topographic maps. Thermal gradients could not be calculated for many of the well records, but records were retained if the well temperature was >10°C above average annual surface temperature.

3. National Water Information System (NWIS) / National WATer Data STOrage and REtrieval System (WATSTORE) (http://waterdata.usgs.gov/nwis)—U.S. Geological Survey chemical data for groundwater. This database incorporates recent and historical measurements of temperature, geochemistry, conductivity, etc. Thermal gradients could not be calculated for many of the well records, but they were retained in the database if the well temperature was >10°C above average annual surface temperature. Data were obtained from the USGS website in August 2005.

4. Trexler et al. (1983) map—Any sites not captured by the previous four databases were digitized from this map.

5. Southern Methodist University (SMU) (David Blackwell and Maria Richards, http://www.smu.edu/geothermal)—This dataset includes geothermal temperature and gradient data from exploration drill holes and heat flow holes. These data are maintained by the Geothermal Laboratory at Southern Methodist University. Wells with a gradient of 25°–100°C/km are considered warm on Map 161, and those ≥100°C/km are hot. Drill holes shallower than 30 meters were excluded, as these can give falsely high gradient values. Data were obtained from the SMU website in May 2009.

6. U.S. Geological Survey (Sass et al., 1999, http://pubs.usgs.gov/of/1999/of99-425/webmaps/home.html)—This database contains additional heat flow data for wells in Nevada. The wells in this database were processed in the same manner as those from the SMU database. The subset of data used in this map is located at http://www.nbmg.unr.edu/ geothermal/mapfiles/USGS-gradient.xls.

7. Nevada Geothermal Well Database List—NVGEOWEL (Davis and Hess, 2009, http://www.nbmg.unr.edu/geothermal/mapfiles/nvgeowel.html)—This database lists all geothermal wells permitted by the Nevada Division of Minerals (since 1985), as well as historical permitted wells. These data are on file at the Nevada Bureau of Mines and Geology (NBMG), last updated August 2009. UTM locations were obtained using section information or distance from section line data provided in the permit application. Hence, many locations are approximate. Temperatures are not known for all wells in this database.

8. GeothermEx (http://www.energy.ca.gov/pier/project_reports/500-04-051.html)—This dataset gives the common names for gradient hole anomalies within Nevada. For Map 161, gradient hole anomalies are assigned to regions identified by GeothermEx that were not otherwise included in the map. For instance, the Fox Mountain geothermal region is not identified by database wells or springs—the name (and anomaly) are sourced from the GeothermEx database.

9. Nevada Bureau of Mines and Geology (NBMG) (http://www.nbmg.unr.edu/ dox/mi/09.pdf)—The Nevada Mineral Industry 2009 report (Shevenell et al., in preparation) and NV Energy (2010) include power plant nameplate (gross) generating capacity and the MW reported by NV Energy (2010) as in service in 2009. Nameplate capacity is the manufacturer's rating of equipment output capacity as reported to the Nevada Division of Minerals by the plant operators (as of February 2010) and does not necessarily reflect the capability of the currently developed resource. These nameplate capacities are estimates, and several different values can be found in the literature. Generator nameplate capacity refers to the generator size, but not the turbines or actual capacity of the power plant. There are no public documents breaking down nameplate capacity of the turbines or gross power, so these numbers may not adequately reflect actual generation (Dan Fleischmann, pers. comm., June 2010).

10. Great Basin Center for Geothermal Energy (GBCGE) Direct Use (http://www.unr.edu/geothermal/MicroDocs/ Map161_DirectUse.xls)—The Great Basin Center for Geothermal Energy has compiled all known direct use locations, year of initial operation, and usage (unpublished data, L. Garside, L. Shevenell, and R. Penfield).

11. GBCGE Shallow Temperature Surveys (http://www.unr.edu/geothermal/ tgrad.html)—This dataset contains shallow (2 meters depth) thermal anomaly data for five study areas: Desert Queen, Desert Peak, Rhodes Marsh, Teels Marsh, and Tungsten Mountain. Only temperatures >20° C are shown on Map 161 as anomalies.

12. GBCGE Great Basin Groundwater Geochemical Database (http://www.unr.edu/geothermal/GeochemDB.htm) —The Great Basin Center for Geothermal Energy made changes to locations and names in the above datasets (Garside, 1994; Trexler et al., 1983; NWIS / WATSTORE; and GEOTHERM), based on a variety of criteria. Site information was checked against topographic maps, NWIS site data, and GBCGE fieldwork.

13. GBCGE Visited Sites (http://www.unr.edu/geothermal/MicroDocs/GBCGE_ Geothermal11-09.xls)—Many sites were visited during field investigations between 2002 and 2008. Sites were selected for sampling based on databases and publications that reported a thermal feature present with little, no, or poor data. Most sites visited did indeed have a thermal spring or well that was subsequently sampled. In some cases, it was discovered that the information in the database or publication was incorrect, and there was nothing (incorrect location) at that location, a cold (rather than thermal) spring or well, a defunct well, or a dry spring. In order to capture this information, these points are plotted separately on this map to indicate which of these four incorrect data types appear in the historical data or publications.

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