

Western U.S. Digital Geothermal Maps and Databases

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ABSTRACT

The Idaho National Engineering and Environmental Laboratory (INEEL) has produced digital geothermal resource maps for the U.S. Department of Energy (DOE). They were produced for the DOE GeoPowering the West Activity. The geothermal maps consist of the 13 western states were prepared for the general public to be used as an educational tool, promote the use of geothermal resources, show general trends and geothermal occurrences in the western U.S., and provide other information of interest such as land use, direct-use applications, etc. The information

for these maps were gathered from many different sources, but due to time and funding limitation they do not represent an exhaustive search for geothermal data for each state. The Geo-Heat Center contributed several databases that were used to produce the maps. A brief description of the information included in the maps and how they were produced will be presented.

1. INTRODUCTION

Low- and moderate-temperature geothermal resources are widely distributed throughout the western and central U.S. as can be seen in Figure 1. There are also a few low-temperature geothermal resources that occur in the eastern states.

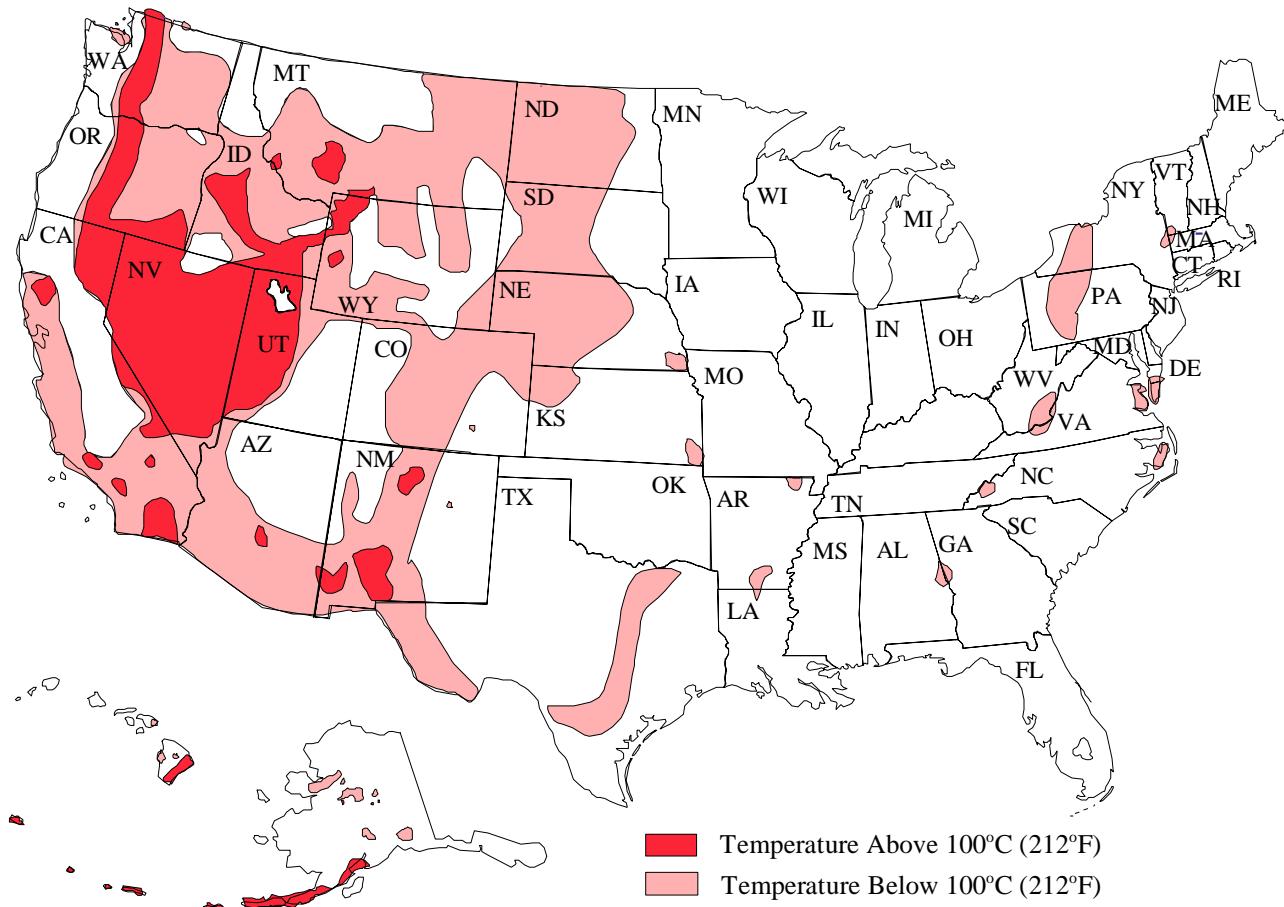


Figure 1: Geothermal Resource Area of the United States.

There have been several major efforts in assessing the potential for low-to-moderate temperature geothermal resources in the U.S. The first major effort in the 1980s included 17 states that resulted in geothermal resource maps, prepared by the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (NOAA). This was the first time that geothermal resources were shown on a map. These maps were produced as "public" maps. They were designed to be useful to a wide range of people such as entrepreneurs, developers, lawmakers, ranchers, students, etc. They were also expected to be of use to a geothermal specialist (Grim, et al., 1980). The maps had a fairly well standardized format.

These maps showed the location of springs (diamonds) and wells (circles) located in each state with red symbols representing temperatures above 50°C and blue symbols representing temperatures below 50°C. Known or potential geothermal resources areas (KGRA) (PGRA) were also located on the maps. The scales for the maps ranged from 1:500,000 to 1:2,500,000 depending on the size of the state. The original states were Alaska, Arizona, California, Hawaii, Idaho, Kansas, Montana, Nebraska, North Dakota, New Mexico, Nevada, Oregon, Oklahoma, Texas, Utah, Washington and Wyoming. An example of one of the maps can be seen in Figure 2. Most of these maps are now out of print.

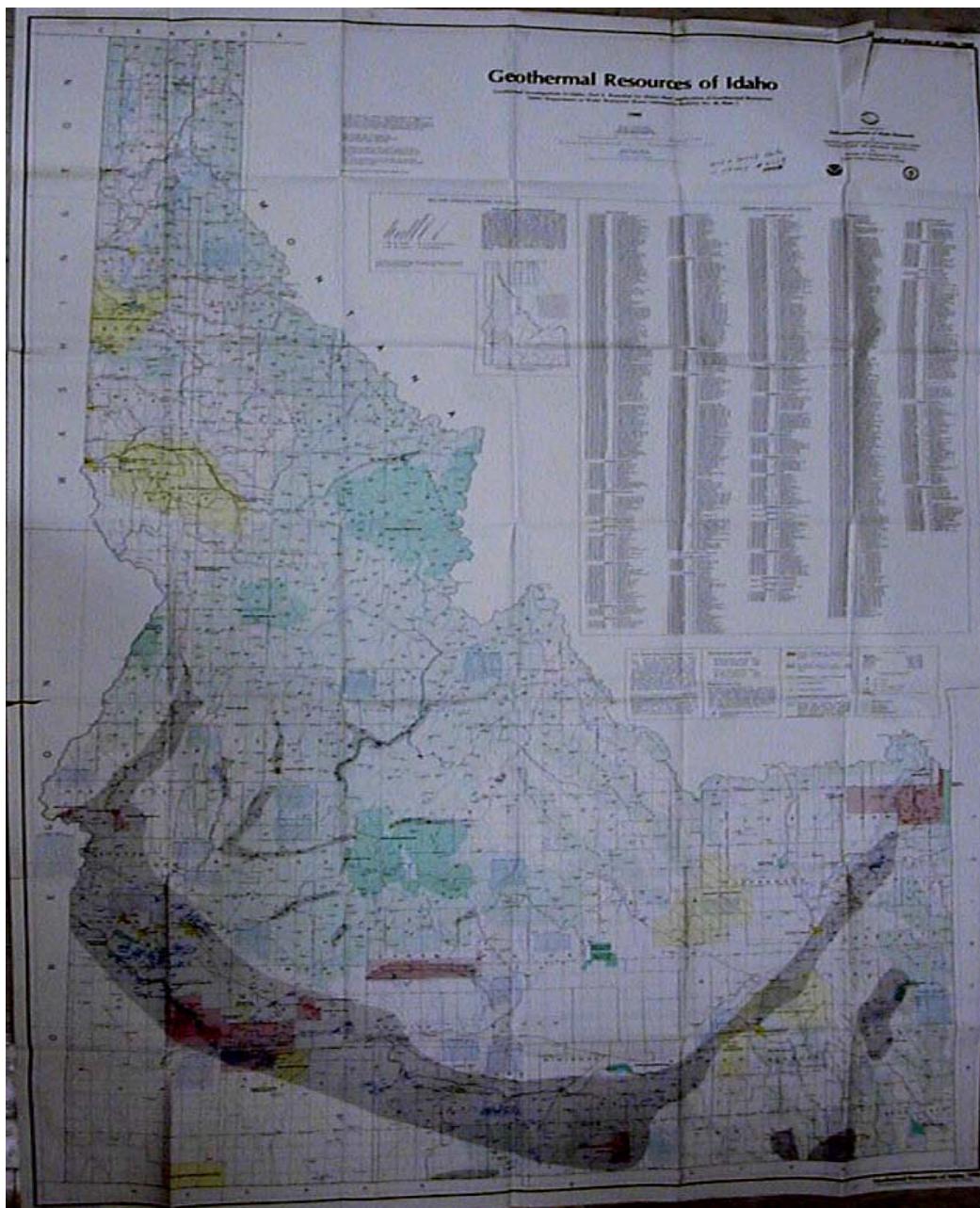


Figure 2: Idaho NOAA map.

The next effort, which included 10 of the 17 original states, was in the early-1990s, and resulted mainly in individual digital databases of all known geothermal wells and springs for a total of over 9,000 wells and springs. The 10 states were: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington (Lienau and Ross, 1996). Most of the states also produced maps, but each state used their own format.

The Geo-Heat Center was recently tasked through a contract with the U.S. Department of Energy (DOE) to complete a state resource database, including collocated communities, for six more states in the west. These states are: Alaska, Nebraska, North Dakota, South Dakota, Texas and Wyoming. The Geo-Heat Center was further tasked to include the original state databases into a standard format for ease of use. Research for the databases included finding reports and other information on wells and springs for those states, and also to ask knowledgeable people in those states where to obtain additional information. This work produced the Western States Geothermal Database CD.

The latest effort, completed by Idaho National Engineering and Environmental Laboratory (INEEL), produced thirteen western U.S. digital geothermal maps as part of DOE's GeoPowering the West activity. The following states were included Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming.

They are prepared for the general public to be used as an education tool much like the NOAA maps. These maps show trends and geothermal occurrences in the western U.S., provides information of interest such as, location of wells and springs, land use and direct use applications, which provides a starting point for people interested in identifying geothermal resources. These resource maps are a starting point for educating individuals, energy professionals, economic development associations, and businesses – about locating, developing and using potential geothermal energy resources. Geothermal working groups, established in several states including Nevada, Idaho, Oregon, Utah, Arizona, New Mexico and Washington, have used these maps to generate interest and initiate actions to develop their respective geothermal resources.

The regional geothermal resource map and the maps for each of the thirteen western states (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington and Wyoming) plus documentation are available on the Internet at <http://geothermal.id.doe.gov/maps-software>.

2. WESTERN STATES GEOTHERMAL DATABASE CD (BOYD, 2003)

The Geothermal State Resources CD can contain up to five databases for the 16 states as stated above. The five databases are:

Well and Springs - Which contains all the known wells and spring for that state with a temperature typically $> 20^{\circ}\text{C}$ (68°F);

Chemistry - This database contains the most common fluid chemistry for the sites listed in the *Wells and Springs* database. There are a couple states where no chemistry information was available (Texas and Nebraska);

Other Information - This database contains additional information found in the original databases but did not fit in the original two categories;

Direct-Use Sites - This database contains known locations of existing direct-use sites for each state. The states of Arkansas, Georgia, Hawaii, New York and Virginia are also included since they all have direct-use; and

Collocated Sites - Contains information on population centers located within 8 km (5 miles) of a known resource with a temperature above 50°C (122°F).

The databases are available in three different formats for use over a wide range of spreadsheets and database programs. The three formats are listed below.

QuattroPro 8 extension *.wb3

Microsoft Excel 97 extension *.xls

Comma delimited Text extension *.csv

Background information on each state database can be found in the "Information" file. This file includes the source of the information, a summary of each database included for the state (such as how many entries in the wells and springs database), a listing of the column headings for each database, and which of the column headings has no information for that state.

There are two more white paper files that may be available for each state. The first one is the original state team report for the 10 original states. Seven of the original reports are available online at the website DOE Information Bridge <<http://www.osti.gov/bridge/>>. As the other state reports become available, they will also be placed on the CD. The second white paper file contains a listing of references that provides more information for each state.

To be able to view these white paper files, you must be able to view an Adobe PDF file. If a person does not have the program Adobe Reader or similar program to read the white papers files, the installation files have been included on the CD in the directory Adobe. The files are available for both Windows and Mac computers.

The databases, which can be obtained in part or as a whole set on a CD, are available through the Geo-Heat Center. The cost for information for one state is \$10, and for all 16 of the western states is \$25. To obtain a copy of the CD, contact the Geo-Heat Center by phone (541-885-1750), fax (541-885-1754), email (geoheat@oit.edu), or mail (Geo-Heat Center, 3201 Campus Drive, Klamath Falls, OR 97601).

2.1 Information included on the Maps

Idaho National Engineering and Environmental Laboratory (INEEL) prepared these maps, using Geographical Information System (GIS) technology, to show areas with potential for geothermal electricity production and direct use – as well as known geothermal wells and springs, existing geothermal power plants and direct-use applications, land ownership, and other information. The maps have also been consolidated into a western United States geothermal resources regional map (Figure 3) to provide a broader view of regional potential for power and direct-use applications.

GIS technology, using “layers” of digitized spatial information and linking databases, provides great flexibility in manipulating and presenting this information. This improved database allows for improved data visualization and analysis (USDOE, 2003).

The new maps have a greater variety of information than the NOAA maps depending on the users needs. The main information shown on the map is geothermal wells and springs, direct use applications (space heating, greenhouses, aquaculture, spa, district heating), electrical generation, land ownership, KGRAs or PGRAs, cities/towns, county boundaries, rivers and streams, lakes and reservoirs.

The primary source of information on the wells and springs and direct-use applications were obtained from the Geo-Heat Center’s “Western States Geothermal Databases” CD. Some information came from personal communications with researchers in various states. The wells and springs are represented as symbols that identifies as either a well or spring, and if the temperature is greater than 50°, and a temperature between 20 and 50°C. Some of the direct-use applications were not located on the maps for they lacked adequate location information (Latitude/Longitude or

Section/Township/Range) necessary to be plotted on the maps. Also some of the direct-use applications may no longer be in operation. The applications of geothermal resources is constantly changing and is difficult to accurately track.

Land status and geopolitical information has been incorporated into the new maps to show where the resources are and what type of land use is in the area. The types of land ownership shown are private lands, Bureau of Land Management (BLM) or other federal lands, state lands, Native American lands and U.S. forest service lands. Hawaii has what is mentioned as Hawaii Home Lands. If a resource is located with in a national forest or a national park chances are that it will not be available for development. If the resource were located in an area of primarily Bureau of Land Management land, then they would have to take into consideration what steps are needed to apply for leasing of the property.

The KGRA and PGRA areas have been digitized off the NOAA maps and incorporated into the INEEL maps.



Figure 3: Western United States geothermal resources regional map.

3. OTHER DATABASES OR MAPS THAT ARE NOW AVAILABLE

The GeoPowering the West (http://www.eere.energy.gov/geothermal/deployment_gpw.html) initiative has also producing several fact sheets available for downloading. The states that have been completed to date are Nevada, Idaho and New Mexico.

The Idaho Department of Water Resources (<http://idahogeothermal.org>) has produced a website for Idaho Geothermal Resources. Their website includes information such as an overview, technical report and references, an interactive geothermal map and special regulatory information.

The Utah Geological Survey (<http://www.ugs.state.ut.us/>) just completed the CD "Geothermal Resources of Utah, a Digital Atlas of Utah's Geothermal Resources" which was compiled by Robert E. Blackett and Sharon I. Wakefield. This CD includes the summation of many years of data collection, geothermal reports, maps and a bibliography that can be viewed in PDF format, several spreadsheet formats of the thermal wells and springs, and maps that can be view in either ArcExplorer and ArcView. Designed for GIS work, this CD can also be used by casual readers interested in Utah's geothermal regime.

The Division of Oil, Gas and Geothermal Resources and the California Geological Survey, under the Department of

Conservation, produced a new "Geothermal Map of California." The map includes digital layers for a wide range of geothermal data including geothermal fields and power plants. To order a map, contact the California Division of Oil, Gas and Geothermal Resources, 801 K Street, MS 20-20, Sacramento, CA 95814-3530. Phone: (916) 445-9686.

4. REFERENCES

INEEL, 2004, Maps & Software – Geothermal – INEEL, <http://geothermal.id.doe.gov/maps-software.shtml>

Grim, P. J.; Berry, G. W.; Theberge, Lt. Cmdr. A., 1980, NOAA Progress Report on Geothermal Mapping for State Coupled Program, Resource Assessment / Commercialization Planning Meeting Minutes, p 153-154.

Boyd, Tonya L., 2003, Western States Geothermal Databases CD, Multiple Integrated Uses of Geothermal Resources Proceedings, International Geothermal Conference, Reykjavik, Iceland, September 2003, SO4 page 8 – 14.

U.S. Department of Energy, 2003, "New Maps Reveal Expanded Geothermal Energy Potential," http://www.eere.energy.gov/geothermal/docs/geo_maps_pressrelease.doc.