DOE/RA/50075--T9

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GEOHERMAL RESOURCE AREA 6

Lander and Eureka Counties

Area Development Plan

DOE/RA/50075--T9

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SUMMARY

Geothermal Resource Area 6 includes Lander and Eureka Counties. There are several different geothermal resources ranging in temperature from 70° F. to in excess of 400° F. within this two county area. Eleven of these resources are considered major and have been selected for evaluation in this Area Development Plan.

The various potential uses of the energy found at each of the 11 resource sites were determined after evaluating the study area's physical characteristics, land ownership and land use patterns, existing population and projected growth rates, and transportation facilities. These were then compared with the site specific resource characteristics. The uses considered were divided into five main categories: electrical generation, space heating, recreation, industrial process heat, and agriculture. Within two of these categories certain subdivisions were considered separately.

The following summarizes the findings about each of the geothermal sites considered:

Spencer Hot Springs

Spencer Hot Springs, located at the northern end of the big Smokey Valley, have an estimated reservoir temperature of 216° F. Animal husbandry, greenhousing, and industrial processing are believed to hold the greatest development potential. District space heating and electrical generation hold the least.

Smith Creek Valley

There are several warm and hot springs in this area, the hottest being Smith Creek Valley Springs with a temperature of about 212° F. Industrial processing, greenhousing, and the aquacultural raising of prawns and fish hold the greatest potential for successful development.

Buffalo Valley Hot Springs

The Buffalo Valley Hot Springs are located about five miles southwest of Battle Mountain. The springs have a recorded temperature of 174° F. and an estimated reservoir temperature of 257° F. Animal husbandry and aquaculture are believed to have high development potential. Residential-commercial space heating, greenhousing, and industrial processing have moderate development potential.

Hot Springs Ranch

The geothermal anomaly at the Hot Springs Ranch has a reported temperature of 129° F. It is located about 35 miles south of Battle Mountain. Aquaculture has the highest development potential followed by animal husbandry, greenhousing, and industrial processing.

Beowawe Geysers

The Beowawe Geysers geothermal resource is located in the southwestern part of Whirlwind Valley. This is the highest temperature anomaly found in the study area having a measured temperature of 414° F. and an estimated temperature of 444° F. Because of the high temperature of the resource, electrical generation, and industrial processing are believed to hold the greatest potential for successful development.

Hot Springs Point

The Hot Springs Point geothermal anomaly is located about 10 miles southeast of Beowawe Geysers. The maximum reported temperature of this resource is 166° F. Aquaculture and animal husbandry have a high development potential. Residential-commercial space heating and greenhousing have moderate development potential.

Walti Hot Springs

Walti Hot Springs are the third hottest resource in Eureka County having measured temperatures of 165° F. Animal husbandry, aquaculture, residential-commercial space heating, greenhousing, and low temperature industrial processing are considered to have high to moderate development potential at this site.

Klobe Hot Springs

Klobe Hot Springs are located near the north end of the Monitor Range. Temperatures at this site have been reported up to 158° F. Animal husbandry has the highest development potential based on site and resource characteristics. Recreation, electrical generation, and district space heating have the lowest development potential.

Horseshoe Ranch Springs

The Horseshoe Ranch Springs geothermal anomaly has a temperature of 136°F. It is located about one mile northeast of the community of Beowawe. Aquaculture is considered to have the greatest development potential followed by industrial processing and animal husbandry.

Bruffey's Hot Springs

Bruffey's Hot Springs resource is one of several hot springs occurring along the east side of the Sulfur Springs Range. It has a maximum temperature of 152° F. Animal husbandry, aquaculture, residential space heating, and greenhousing are considered to be application types that could feasibly make use of the resource.

Shipley Hot Springs

Shipley Hot Springs are a moderately low temperature (106° F.) resource with high natural flow rates (6,700 gallons per minute). Aquaculture is considered to have the highest development potential at this site followed by animal husbandry and greenhousing.

I. INTRODUCTION

Geothermal Resource Area 6 covers all of the land in both Lander and Eureka Counties. There are many different geothermal anomalies known within this area. Eleven of these are considered major and are evaluated in this document. These include: Spencer Hot Springs; Smith Creek Valley; Buffalo Valley Hot Springs; Hot Springs Ranch; Beowawe Geysers; Hot Springs Point, Warti Hot Springs; Klobe Hot Springs; Horseshoe Ranch Springs; Bruffey's Hot Springs; and Shipley Hot Springs.

It is the purpose of this document to provide the public and private decision makers with information that will facilitate the development of the various geothermal resources found in Lander and Eureka Counties. To further this goal, this Area Development Plan was prepared to provide information concerning the geothermal resources, the physical and socio-economic setting of the study area, and the potential for developing this so far underutilized resource.

This report has been divided into three major sections to enable the reader to more easily interpret the information presented. The first section describes Geothermal Resource Area 6 in terms of its physical and socio-economic characteristics. The second describes the resource itself based on the best currently available information. The third describes the potential uses for the resources based on a study of the geothermal resource characteristics, land use, and various other factors.

II. THE AREA

A. Physical Characteristics

1. Location and Relief

The geothermal resource area covering Lander and Eureka Counties has a total land area of 9,801 square miles or about eight percent of the total land area in the State of Nevada. The area is located in central Nevada and is bordered on the north by Humboldt and Elko Counties, on the east by White Pine County, on the south by Nye County, and on the west by Churchill and Pershing Counties.

The Lander and Eureka County area is characterized by alternating, linear mountains and valleys. The more notable mountains in the area are the Shoshone Range, Fish Creek Range, Toiyabe Range, Cortez Range, Simpson Range, Fish Creek Range, and Monitor Range. Major valleys include Antelope Valley, Reese River Valley, Monitor Valley, and Pine Valley. Elevations range from a high of 10,900 feet in the Toiyabe Range to a low of 4,500 feet found in the northern part of the Reese River Valley (Figure 1).

2. Climatic Conditions

The climatic conditions in the Lander and Eureka County area are quite variable due to the large physical size and the great relief of the area. Detailed climatological information is available for the area at two meteorological stations: Austin, elevation 6,543 feet; and Battle Mountain, elevation 4,513 feet. Tables 1 and 2 give these climatological summaries.

The continental arid climate found in the study area is affected by both the Sierra Nevada and Rocky Mountains. Cold arctic air masses are forced eastward onto the Great Plains

FIGURE 1

FIGURE 2

TOPOGRAPHICAL AND PHYSICAL FEATURES OF LANDER AND EUREKA COUNTIES

by the Rocky Mountains as they travel out of Canada. This prevents extended periods of cold from settling in over central Nevada. Pacific storm systems lose much of their water content when passing over the towering Sierra's so that when they finally cross into central Nevada very little moisture remains. At lower elevations precipitation quantities in the five to seven inch range are common. At higher elevations precipitation quantities between 12 to 15 inches can be found.

Summer is short and pleasant. Because of the low humidity, high percentage of sunshine, and temperatures in the 80's (F.) the area is quite comfortable. Temperatures in the evening drop quickly down into the 50's (F.) and the upper 40's (F.) providing excellent nighttime conditions and creating a daily temperature range of over 42° F. Although the maximum average temperature is normally in the low 90's, a record high temperature of 112° F. has been recorded. July, August, and September are rather dry months, each averaging around 0.3 inch of precipitation. Precipitation is evenly distributed throughout the rest of the year with each month receiving about 0.7 inch.

Winter is typified by cool days, cold nights, and little snow. The average season receives 17 inches; however, one exceptional season recorded 63 inches. The little snow that does fall is about one-third of the total winter precipitation. Afternoon temperatures in the low 40's (F.) and night temperatures in the teens give a winter temperature range of 20° F. to 25° F. The coldest temperature recorded was -40° F.

Temperature characteristics at other locations in the Lander and Eureka County area may be inferred by applying the environmental lapse rate of an increase or decrease of 3-1/2° F. per 1,000 vertical feet lower or higher than the recording station. Care must be taken, however, in using these calculated temperatures as local conditions may influence exact temperature readings.

Table 1

LATITUDE 40° 39' N
LONGITUDE 116° 36' W
ELEV. (GROUND) 4513 feet

CLIMATOLOGICAL SUMMARY

STATION Battle Mountain, Nevada

Means: 1936-1965

Extremes: 1936-1968

MEANS AND EXTREMES FOR PERIOD

Month	Temperature (°F)								Mean degree days	Precipitation Totals (Inches)								Mean number of days						Month
	Means				Extremes					Mean	Greatest daily	Year	Snow, Sleet					Precip. .10 inch or more	Temperatures					
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Mean					Maximum monthly	Year	Greatest daily	Year	Max.		Min.					
																				90° and above	32° and below	32° and below	below 0° and below.	
(a)	30	30	30	33		33		16	30	33		30	33		30		30	30	30	30				
Jan	39.4	13.6	26.5	64	1953	-40	1937	1148	0.71	0.55	1962	3.9	28.5	1937	6.0	1952	3	0	7	29	6	Jan		
Feb	45.5	20.7	33.1	69	1951	-25	1949	882	0.67	0.90	1936	3.0	10.0	1936	9.0	1936	2	0	2	26	1	Feb		
Mar	52.6	24.3	38.5	79	1966	-3	1948	831	0.66	0.73	1937	3.2	18.0	1967	5.0	1963	2	0	*	27	0	Mar		
Apr	63.1	31.5	47.3	88	1936	9	1948	548	0.75	0.63	1941	1.5	16.0	1965	12.0	1965	3	0	0	18	0	Apr		
May	72.6	37.9	55.3	97	1954	14	1959	322	0.92	1.40	1946	*	5.0	1965	3.0	1965	2	1	0	7	0	May		
Jun	81.5	44.6	63.1	104	1961	24	1945	114	0.85	1.15	1941	0	T	1954+	T	1944	2	8	0	1	0	Jun		
Jul	93.4	51.0	72.2	107	1936	31	1948	5	0.30	0.85	1946	0	0	--	0	--	1	25	0	0	0	0	Jul	
Aug	91.3	47.0	69.2	106	1940	28	1960	29	0.22	0.75	1965	0	0	--	0	--	1	20	0	*	0	0	Aug	
Sep	81.2	37.8	59.5	102	1950	16	1954	170	0.32	1.11	1959	0	T	1948+	T	1948+	1	6	0	7	0	0	Sep	
Oct	68.9	30.3	49.6	92	1963	6	1958	466	0.71	2.27	1963	*	5.2	1949	2.4	1949	2	*	0	19	0	0	Oct	
Nov	52.3	21.2	36.8	77	1965	-9	1964	850	0.66	1.09	1950	1.2	10.0	1964	6.0	1964	2	0	1	26	*	0	Nov	
Dec	42.9	16.8	29.9	68	1939	-22	1948	1111	0.69	1.00	1942	4.3	16.0	1968	5.2	1951	2	0	4	27	2	0	Dec	
Year	65.4	31.4	48.4	107	July 1936	-40	Jan 1937	6476	7.46	2.27	Oct 1963	17.1	28.5	Jan 1937	12.0	April 1965	23	60	14	187	9	Year		

(a) Average length of record, years.

+ Also on earlier dates, months, or years.

T Trace, an amount too small to measure.

* Less than one half.

** Base 65°F

Table 2

LATITUDE 39° 30' N
LONGITUDE 117° 05' W
ELEV. (GROUND) 6543

CLIMATOLOGICAL SUMMARY

STATION Austin, Nevada

(Means 1936-1965)

MEANS AND EXTREMES FOR PERIOD 1936-1968 (Extremes 1936-1968)

Month	Temperature (°F)								Mean degree days	Precipitation Totals (Inches)								Mean number of days						Month
	Means				Extremes					Mean	Greatest daily	Year	Snow, Sleet					Precip. .10 inch or more	Temperatures					
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Mean					Maximum monthly	Year	Greatest daily	Year	Max.		Min.					
																	90° and above		32° and below	32° and below	0° and below			
(a)	30	30	30	33		33			30	33		30	33	Year	30	Year	30	or more	90° and above	32° and below	32° and below	0° and below		
Jan	40.4	18.1	27.2	65	1951	-15	1963	1069	1.06	.85	1940	11.5	28.0	1949	7.0	1949	3	0	6	29	2	Jan		
Feb	42.3	19.9	31.1	67	1951	-13	1962	916	1.12	1.00	1936	10.4	17.0	1943	10.0	1947	4	0	4	26	1	Feb		
Mar	47.1	23.4	35.3	74	1966	- 3	1939	920	1.51	1.85	1946	15.9	59.8	1946	19.0	1946	5	0	2	27	*	Mar		
Apr	56.3	30.2	43.3	80	1936	3	1936	636	1.49	1.34	1960	9.2	43.0	1967	6.0	1946	5	0	1	18	0	Apr.		
May	65.2	37.3	51.3	88	1954	12	1938	426	1.33	1.44	1965	1.5	11.0	1950	6.0	1955+	4	0	0	9	0	May		
Jun	75.0	44.1	59.6	97	1959+	25	1950	170	1.13	1.14	1965	*	5.5	1944	2.9	1944	3	2	0	2	0	Jun		
Jul	86.7	53.4	70.0	102	1959	38	1955+	10	.56	1.63	1937	0	0	--	0	--	1	10	0	0	0	Jul		
Aug	84.7	51.8	68.3	98	1960+	30	1943	21	.51	1.07	1965	0	T	1968+	T	1937	1	7	0	0	0	Aug		
Sep	76.1	45.1	60.6	97	1950	18	1965	159	.47	.96	1939	*	9.0	1948	9.0	1948	1	1	0	2	0	Sep		
Oct	64.2	36.2	50.1	86	1959+	13	1943	398	1.07	2.04	1946	3.1	14.0	1943	7.0	1946	3	0	*	10	0	Oct		
Nov	49.6	26.0	37.9	74	1950	- 5	1938	771	.93	1.18	1965	7.9	24.1	1944	13.0	1944	3	0	3	22	0	Nov		
Dgc	42.9	21.5	32.2	67	1939	- 7	1961	995	1.08	1.05	1961	10.4	35.0	1936	11.0	1961	4	0	5	27	*	Dec		
Year	60.9	33.9	47.2	102	July 1959	-15	Jan 1963	6491	12.26	2.04	Oct 1946	70.1	59.8	Mar 1946	19.0	Mar 1946	37	20	21	172	3	Year		

(a) Average length of record, years.

+ Also on earlier dates, months, or years.

T Trace, an amount too small to measure.

* Less than one half.

** Base 65°F

3. Geologic Setting(17, 19, 20)

Lander and Eureka Counties are located in the central portion of the Basin and Range Geomorphic Province. The area has a character more or less typical of the Province with elongate mountains separated by long alluvial filled valleys.

The study area contains rocks that range in age from early Paleozoic to Recent. These include sedimentary, igneous and metamorphic rocks. Lower Paleozoic strata consist of two different rock facies brought together by thrust faulting. These two facies consist of: 1) rocks referred to as the carbonate and transitional assemblage consisting of limestone and dolomite with minor amounts of shale and quartzite; and 2) rocks referred to as the siliceous and volcanic assemblages consisting of chert and clastic sedimentary rock with interbedded volcanic flows and pyroclastic deposits. The carbonate and transitional assemblages were believed to have been laid down in the eastern portion of the huge, trough-like, Cordillern Geosyncline and the siliceous and volcanic assemblages in the western portion of the geosyncline.

During the late Devonian and early Mississippian time, the lower Paleozoic rocks were folded and faulted as part of the Antler Orogeny. The siliceous and volcanic rocks were thrust eastward for possibly as much as 90 miles over carbonate assemblages rocks. Following the Antler Orogeny and throughout the remainder of the Paleozoic and the Triassic, thick sequences of carbonate and clastic rocks were deposited with some inter-bedded lava flows and pyroclastics.

Scattered outcrops of Jurassic and Cretaceous intrusive igneous rocks occur throughout the area. The Tertiary is represented by various types of intrusive rocks, lava flows, volcanic breccias, and ash flow tuffs. The youngest Quaternary and Recent rocks consist primarily of alluvial and lacustrine sediments covering most of the valley floors.

The Basin and Range topography characteristic to the study area has developed on all rock types. This topography has

developed because of the characteristic fault block structure of the Province which is caused by normal faulting and is expressed as long north-south trending mountains and valleys. The Great Basin portion of the Basin and Range Province is an area of internal drainage and has many large ephemeral lakes.

The geothermal resource in the study area is associated with the long north-south trending normal faults characteristic to the Basin and Range Province. Water, originating as rainfall, sinks deep into the earth where it is heated by contact with a geothermal heat source. This heat source may be either a cooling magmatic body or just rock heated by the earth's geothermal gradient. The heated water then rises to the surface along the deep faults which offer permeable conduits for fluid movement. If these faults cut the earth's surface, hot springs and other surface expressions of geothermal energy may appear. It should be noted that geothermal resources may be present without such surface indications. One of the goals of modern exploration geology is to locate these "hidden" resources.

4. Hydrology(8, 9)

Geothermal Resource Area 6 contains portions of two major hydrographic regions found in Nevada. These regions are the Central Region and the Humboldt River Basin.

The Central Region covers much of the southern portion of the study area. This area is characterized by long, narrow valleys with small intermittent streams emptying into the valley bottoms where the flows either evaporate or infiltrate into the groundwater. The perennial streams are usually only a few miles long. There are no large standing bodies of water even though the area is characterized by internal drainage.

The Humboldt River Basin is found throughout much of Lander County and in the northern portion of Eureka County. This region is the drainage basin for the Humboldt River. The Humboldt is a slow meandering river beginning near the town of Wells in Elko County. The river meanders over 300 miles to the west before it

finally enters the Humboldt Sink where evaporation consumes virtually all of the remaining water. During the years of extremely high flow, runoff water will flow into the Carson Sink, which is about 20 feet lower.

The hydrology of the area can be described as being typical of that occurring in high desert environments. Precipitation is seasonal, some occurring in the summer as thundershowers, but mostly occurring in the winter as snow. Streamflows are equally seasonal with peak flows occurring in the late spring as the result of snowmelt. Typically, runoff reaches a peak flow in the late spring and has a minimal flow in the late summer or early fall. Approximately 50 percent of the annual runoff occurs in May and June with two to four percent occurring in September and October.

This wide range in flow creates multiple problems. Seasonal high flows often result in flood damage, with serious erosion and sedimentation. Low flows limit agricultural production and cause high water temperatures. Both sedimentation and high water temperatures impact adversely on fish life and general water quality.

The Nevada State Engineer has designated three out of twenty-one ground water basins in the Lander and Eureka County study area. These designated groundwater basins are those in which more groundwater has been allocated than is believed to be annually recharged as often occurs in a populated area. These designated groundwater basins are:

Diamond Valley (Basin Number 153)

Upper Reese River Valley (Basin Number 56)

Middle Reese River Valley (Basin Number 58)

Because the study area's geothermal resources are the water dominated type, any use of those resources may affect local groundwater conditions. This may impact historical use of groundwater in those areas and may raise questions concerning water rights and water allocation. It should be noted that geothermal development is considered a preferred use of groundwater. Any

developer of geothermal energy resources is encouraged to contact the State Water Engineer early in the project planning process to insure that all such water related questions are answered.

B. Land Ownership and Land Use(14)

The study area is a total of about 8,801 square miles in size. This is approximately eight percent of the total land area of the state. Table 3 shows the land ownership pattern found in Lander and Eureka Counties.

Table 3

LAND OWNERSHIP PATTERNS IN LANDER AND EUREKA COUNTIES

	Acres	Percent
<u>Lander County</u>		
Public Land		
Federal	3,303,906	91.82
State	259	0.01
County	3,850	0.11
Total Public	3,308,015	91.94
Private Land		
Indian	721	0.02
Tax Roll	289,425	8.04
Total Private	290,146	8.06
<u>Eureka County</u>		
Public Land		
Federal	2,188,044	81.75
State	0	0
County	2,080	0.08
Total Public	2,190,124	81.83
Private Land		
Indian	162	0.01
Tax Roll	486,194	18.16
Total Private	486,356	18.17

FIGURE 3
LAND OWNERSHIP IN
LANDER AND EUREKA
COUNTIES

Existing land use patterns in the Lander and Eureka County area are based primarily on proximity to the major population centers of Battle Mountain, Austin, and Eureka. Away from these centers the land has historically been used for agriculture, ranching, mining, wildlife management, and open space. The Bureau of Land Management has classified much of the 5,048,635 acres of the public land it administers as being for multiple use. This classification includes all types of uses from recreation, wildlife management, watershed management, livestock grazing, and timber production on the more heavily forested portions of the land. Other federal agencies holding title to land in the study area such as the U.S. Forest Service and the Bureau of Reclamation, are also managing their lands according to the multiple use concept where possible.

There are four BLM Wilderness Study Areas in Geothermal Resource Area 6: Augusta Mountains, De Soto Mountains, Simpson Park Range, and Roberts Creek Mountains.(24)

These study areas are those which the BLM believes meets the following criteria:

1. Size--must have at least 5,000 or more acres of contiguous public land to be of a size to make practical its preservation and use in an unimpaired condition;
2. Naturalness--must be substantially natural or generally appear to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable.
3. Outstanding solitude or recreation--must have either outstanding opportunities for solitude or a primitive and unconfined type of recreation;
4. Supplemental values--must have supplemental values, which include ecological, geological, or other natural features of scientific, educational, scenic, or historical value.

These four Wilderness Study Areas will continue to be managed under special guidelines directed by Congress to preserve the

wilderness values until a final determination of wilderness suitability is made. There are no known geothermal resources within the boundaries of any of the potential wilderness areas. Should any be located in the future, the development of those resources will be subject to the BLM wilderness area management policy.

Larger urban communities develop various zoning classifications to segregate various land uses within the community to those which are deemed compatible. Such uses include residential, commercial, governmental/institutional, various types of industrial, and agricultural. Geothermal development must be compatible with existing development in these zoned areas.

C. Population(16)

The population of the Lander and Eureka County area has fluctuated greatly in the past. The population of Eureka County was four percent lower in 1980 than it was in 1920. Population increases or decreases in the county of between 40 and 60 percent in any one ten year period were not uncommon. In Lander County the population growth has been more steady over the same 56 year period. There was only one ten year period in which the county experienced a population decrease. Between 1920 and 1980 Lander County experienced an overall population growth of 109 percent. Table 4 illustrates the past growth trend in Lander and Eureka Counties.

Table 4
PAST AND PROJECTED POPULATION TRENDS IN
IN LANDER AND EUREKA COUNTIES

Eureka County				Lander County			
Year	Population	Year	Population	Year	Population	Year	Population
1920	1,350	1972	800	1920	1,484	1972	2,300
1930	1,333	1973	800	1930	1,714	1973	2,719
1940	1,361	1974	1,000	1940	1,745	1974	2,800
1950	896	1975	1,100	1950	1,850	1974	2,800
1960	767	1976	1,096	1960	1,566	1976	3,246
1961	809	1977	1,119	1961	1,635	1977	3,293
1962	825	1978	1,181	1962	1,655	1978	3,325
1963	830	1979	1,242	1963	1,686	1979	3,357
1964	811	1980	1,304	1964	1,822	1980	3,389
1965	946	1981	1,322	1965	2,032	1981	3,415
1966	940	1982	1,339	1966	2,211	1982	3,411
1967	782	1983	1,357	1967	2,583	1983	3,467
1968	852	1984	1,374	1968	2,451	1984	3,493
1969	914	1985	1,392	1969	2,615	1985	3,519
1970	948	1990	1,445	1970	2,666	1990	3,686
1971	900	1995	1,594	1971	2,600	1995	3,870
		2000	1,707			2000	4,043

The existing population of the Lander and Eureka County area is not evenly distributed but is localized in distinct population centers with only scattered persons in the rural areas. There are only four communities found in the Lander and Eureka County area. The largest community is Battle Mountain, followed by Austin, Beowawe, and Eureka.

The State Planning Coordinator's Office anticipates each of these four communities will grow somewhat in the next 40 years, although none of them extensively. Table 5 illustrates the anticipated growth in the study area based on known, existing conditions. Should any development of new, unanticipated development occur, these projections may be invalidated.

Table 5
POPULATION PROJECTIONS FOR THE MAJOR COMMUNITIES IN
LANDER AND EUREKA COUNTIES TO THE YEAR 2020

City	1980	1990	2000	2010	2020
LANDER COUNTY					
Battle Mountain	2,270	2,500	2,810	3,150	3,500
Austin	350	360	370	380	390
EUREKA COUNTY					
Eureka	600	650	750	830	930
Beowawe	300	350	400	490	530

D. Transportation Facilities(5, 6, 7)

Two major highways in Nevada pass through the Lander and Eureka County area. U.S. 50 is an east-west route connecting the towns of Ely, Eureka, Austin, Fallon, and Carson City. Interstate 80 is one of about 12 major east-west interstate routes in the United States. It connects the towns of Elko, Carlin, Battle Mountain, Winnemucca, Lovelock, Fernley, Wadsworth, Sparks, Reno, and Verdi.

The area has a total of about 4,127 miles of roadway. There are 379 miles on the federal aid system, 256 miles on the state system, 3,483 miles on the county system, and 10 on city or local systems. The area has a total of 3,648 miles of unpaved road and 481 miles of roadway paved to various standards.

Transportation services are rather limited in the area. Truck service is available on a limited basis. No trucking terminal facilities are available. The nearest such facilities are located 170 miles west in Reno. Limited air service is available from the small airport facilities in Eureka, Austin, and Battle Mountain. Charter service is available but the nearest full service airport in the region is Cannon International Airport in Reno. Two railroads, Western Pacific and Southern Pacific, have railroad lines that cross through the northern part of the study area. Western Pacific usually runs two trains per day while Southern Pacific has about 20 trains per day. All of these trains are for freight only. The only passenger service is AMTRAK which serves Battle Mountain and the northern portion of the study area twice per day. Two interstate bus lines serve other passenger transportation needs.

FIGURE 4

MAJOR TRANSPORTATION FACILITIES IN LANDER AND EUREKA COUNTIES

E. Economic Activities

1. Lander County

a. Background(14)

The growth and development of Lander County is characteristic of the surrounding areas. The county was first visited by immigrants traveling west on the California Emigrant Trail. Later the population grew as rich mines were opened.

Lander County originated from the first rearrangement of territorial county lines in 1862. It was created from areas of Humboldt and Churchill counties. The county was named after General Frederick W. Lander who was in charge of building a wagon road across the state for the federal government which later became a state and pony express route.

In the early days of the county's existence, Austin was the main town and center of a vast mining region. The lack of transportation soon threatened the area's economy and resulted in the construction of the Nevada Central Railroad from Battle Mountain to Austin. As mining diminished, cattle raising flourished. Today, both agriculture and a rapidly growing mining industry provide the basis of the county's economy. Currently there are 48 distinct mining operations in Lander County producing barite, gold, silver, turquoise, copper, sand and gravel. A directory of mining operations in Lander County is available through the State Inspector of Mines Office.

b. Employment and Income(11)

Lander County's leading business activity is mining which represented 46 percent of the labor force in 1979. Government and trade are the second and third largest employment category. The county's unemployment rate decreased from 5.1 percent in 1977 to 1.8 percent in 1978 at which time it was the state's lowest.

In 1979 it rose to 3.8 percent or fourth lowest rate in the state.

Per capita income increased 16 percent from 1973 to 1977. In 1977 it was the state's fifth lowest at \$5,961. The estimated median income for a family living in Lander County in 1978 was \$13,200.

Table 6

1979 EMPLOYMENT PATTERNS -- LANDER COUNTY(11)

Industry	Number of Firms	Number of Employees	Percent of Employees	Total Wages	Percent of Wages
Mining	21	810	46	13,990,788	56
Construction	7	66	4	1,753,870	7
Manufacturing	1	8	<1	128,953	<1
Trans., Comm., and Util.	6	31	2	476,342	2
Wholesale & Retail Trade	36	307	17	2,213,047	9
Fin., Ins., and Real Estate	4	19	1	226,402	1
Service Industries*	2	161	9	1,411,397	6
Government	13	362	20	4,595,636	19
TOTAL	90	1,764	100	24,796,435	100

*Includes Agricultural Services and Firms not Elsewhere Classified

2. Eureka County

a. Background(14)

Eureka County was established in 1873. Its lands were derived from the now existing counties of Elko, Lander, and White Pine. The final boundaries which today define Eureka's true area were constituted in 1881. The town of Eureka, settled in 1865, was made the county seat. The county's early development was closely linked to various mining strikes such as Ruby Hill and Mineral Hill. It was the second largest mineral producer in the state through much of the 1800's. But as with other mineral booms, the depletion of ore soon brought these areas into decay. Today, mining again is playing an important role in the economy of Eureka County. There are currently 24 mining operations in the county with that number expected to increase as the price of precious metals increases.

b. Employment and Income(11)

Mining dominates Eureka County's economy accounting for 48 percent of the employment in 1979. Government was the second largest reported employment category with 18 percent of the total labor force.

Unemployment was 6.1 percent in 1972. It has decreased every year except 1976, when it rose from 3.7 percent to 5.0 percent. Unemployment was estimated to be 1.9 percent in 1978 rising to 2.1 percent in 1979.

Per capita income in Eureka County is the state's seventh highest. In 1977 it was \$6,793.

Table 7

1979 EMPLOYMENT PATTERNS -- EUREKA COUNTY(11)

Industry	Number of Firms	Number of Employees	Percent of Employees	Total Wages	Percent of Wages
Mining	14	356	63	6,052,344	71
Construction	4	56	10	**	**
Manufacturing	**	**	**	**	**
Trans., Comm., and Util.	**	**	**	20,607	<1
Wholesale & Retail Trade	13	36	6	**	**
Fin., Ins., and Real Estate	**	**	**	48,044	<1
Service Industries*	7	20	4	171,281	2
Government	7	92	16	839,900	10
TOTAL	47	566	-	8,540,771	-

*Includes Agricultural Services and Firms not Elsewhere Classified

**Less than 3 Firms or 10 Employees

***Cumulative total includes all county information, even if not specified above

F. Design Information(1)

No engineering design characteristics are available for any community in either Lander or Eureka County. The two closest communities where such information available are Elko and Winnemucca.

The design characteristics for these communities are as follows:

	Elko	Winnemucca
Latitude	40°50'	40°54'
Longitude	115°47'	117°48'
Elevation	5,075 Ft.	4,301 Ft.
Winter Design Dry-Bulb Temperature		
99%	-8° F.	-1° F.
97.5%	-2° F.	3° F.
Summer Design Dry-Bulb and Mean Coincident Wet-Bulb Temperature		
1%	94°/59° F.	96°/60° F.
2.5%	92°/59° F.	94°/60° F.
5%	90°/58° F.	92°/60° F.
Mean Daily Temperature Range	42° F.	42° F.
Design Wet-Bulb Temperature		
1%	63° F.	64° F.
2.5%	62° F.	62° F.
5%	60° F.	61° F.
Degree-Heating Days	7,397	6,255
Degree-Cooling Days	283	529

Degree-heating and degree-cooling day information is available on the following communities in Lander and Eureka Counties:

	Elevation	Degree-Heating Days	Degree-Cooling Days
Austin	6,605	6,491	398
Battle Mountain	4,530	6,476	522
Fish Creek	6,050	8,061	75

G. Energy Information

The energy situation in Geothermal Resource Area 6 is typical of that occurring in northern Nevada. Electricity and natural gas are the prime sources of energy used in the urban areas with electricity, propane, and distillate fuels being the primary source of energy in the rural areas. These fuels are supplemented with various quantities of coal, wind, hydro, and other alternative energy sources.

Electrical energy in much of Lander and Eureka Counties is supplied by Sierra Pacific Power Company and Mount Wheeler Power Company. In some of the more rural areas, however, commercially generated power is not available. Developments in these areas must use individual diesel fuel generating systems.

The electrical energy supplied by Sierra Pacific Power Company tends to be more costly than electricity supplied by most other power companies in Nevada. The primary reason is that Sierra Pacific's only generation facilities, the Tracy and Fort Churchill Powerplants, use oil or natural gas as a fuel. Approximately 60 percent of the natural gas used comes from Canada, and nearly all of the oil is imported from neighboring states or foreign countries. Substantial price increases for both of these fuels in the years since the 1973-1974 Arab Oil Embargo have caused rapid escalation in costs to electrical users.

Mount Wheeler Power Company supplies much of electricity in southern Eureka County. The source of much of this power are hydroelectric projects on the Colorado River. This electricity tends to be very reasonable in cost as hydropower is much less expensive to produce because there are no costs for high priced fossil fuels. Other electricity in the Mount Wheeler system is supplied from coal fired generating facilities in Utah.

Southwest Gas Company supplies natural gas to the community of Battle Mountain. The company also has authority to service areas within one mile of its main transmission pipeline. The costs of the natural gas obtained through southwest Gas is steadily rising because most of the gas purchased for northern Nevada is from Canada. Substantial price increases have been imposed on this gas in the last few years.

Natural gas is not available throughout much of the study area. Consumers in these areas must rely on electricity, liquified petroleum gas (LPG), or other petroleum products to satisfy their energy demands. In remote rural areas, the costs of importing these fuels can become extremely expensive. Energy costs for petroleum products have more than doubled in the last few years.

Coal is another energy source that has seen some limited use in the study area. The amount in relation to other energy sources is believed very small and consists mostly of residential applications.

Other potential alternative energy sources that have some development possibilities in the near future include solar and wind systems. The Nevada Department of Energy is actively encouraging these as well as all types of geothermal development.

Given the existing mix of energy resources that are presently used it is obvious that the potential for developing geothermal energy is very good. To assess the role of geothermal energy in supplying energy requirements in the study area, the NDOE has been working with the New Mexico Energy Institute (NMEI) to evaluate the potential of geothermal energy development through the year 2020. Using a computer model developed by NMEI, projections have been made of the amount of geothermal energy that can be economically developed through the next 40 year period. Two primary classes of development are evaluated: residential and industrial applications by municipal developers and residential and industrial applications by private developers. Tables 8 and 9 show the projections that were developed. For comparison the amount of geothermal energy which could be developed is shown in BTUs and in the equivalent amount of oil and electricity.

Based on these projections it is estimated that by the year 1990 1.09×10^{11} BTUs of energy could economically be developed by municipal developers and 1.08×10^{11} BTUs could be developed by private developers. By the year 2000 this increases to 1.20×10^{11} BTUs for municipal developers and 1.17×10^{11} BTUs for private developers. By 2019, it increases to 1.43×10^{11} BTUs for municipal and to 1.41×10^{11} BTUs for private developers. It should be noted that these projections represent an idealized situation where all the resources are developed

to their maximum economic potential. Due to the location and physical characteristics of the resources in the study area this probably will not happen.

It has been estimated, using data from the publication Energy in Nevada, that anticipated energy consumption for non-transportation needs in 1990 would be 1.09×10^{11} BTUs. In 2000 it would be about 1.20×10^{11} BTUs. These figures indicate that under ideal conditions approximately 11 percent of the energy demand in the study area could be met by geothermal energy in the year 1990 and over 12 percent could be met by 2000. Because of the location of the population base in relation to the geothermal resources found in the study area, it is not anticipated that the resources will be developed to their greatest potential in this time period. However, if only a portion of the resources were developed, there could be a significant impact on the consumption of fossil fuels, new industry development, and new jobs for the people living in the study area.

Energy costs for fossil fuels such as natural gas and oil are going to continue to rise in the foreseeable future. This is primarily due to two factors: First, the source of much of this energy is outside of the United States and hence beyond the physical control of the country. Second, domestic sources of energy will be deregulated in cost by 1985. Both of these factors make coal and geothermal energy attractive alternatives to existing energy sources. Coal, one of the major non-renewable energy resources found in abundance in the United States, can be processed into synthetic fuels. The cost of this coal, whether for production of synthetic fuels or for combustion in an electrical powerplant, is also high. Additionally, strip mining of coal and the air pollution created when it is burned pose serious environmental questions.

Geothermal energy, on the other hand, is relatively clean, less expensive to use, and attractive to many types of developers. Geothermal technology is becoming more available to manage geothermal reservoirs to obtain maximum production over the longest

period of time and to make use of very difficult fluid types. Thus, the development of the geothermal resources in Lander and Eureka Counties should be encouraged wherever and whenever possible. This development would benefit both Nevada's citizens and industries, and would assist in the development of energy independence in this country.

Table 8

NEW MEXICO ENERGY INSTITUTE--GEOTHERMAL DIRECT USE ENERGY PROJECTIONS--
 COMBINED INDUSTRIAL AND RESIDENTIAL APPLICATION WITH MUNICIPAL
 DEVELOPER -- LANDER AND EUREKA COUNTIES

Year	Projected geothermal energy on line (BTUs)	Gallons of oil replaced	Kilowatt hours of electricity replaced
1980	-0-	-0-	-0-
1981	-0-	-0-	-0-
1982	-0-	-0-	-0-
1983	2.52 x 10 ¹⁰	182,609	7.38 x 10 ⁶
1984	5.41 x 10 ¹⁰	392,029	1.58 x 10 ⁷
1985	1.05 x 10 ¹¹	760,869	3.08 x 10 ⁷
1986	1.05 x 10 ¹¹	760,869	3.08 x 10 ⁷
1987	1.06 x 10 ¹¹	768,116	3.11 x 10 ⁷
1988	1.07 x 10 ¹¹	775,362	2.71 x 10 ⁷
1989	1.08 x 10 ¹¹	782,609	2.81 x 10 ⁷
1990	1.09 x 10 ¹¹	789,855	2.88 x 10 ⁷
1991	1.10 x 10 ¹¹	797,102	2.93 x 10 ⁷
1992	1.11 x 10 ¹¹	804,348	3.02 x 10 ⁷
1993	1.12 x 10 ¹¹	811,594	3.08 x 10 ⁷
1994	1.13 x 10 ¹¹	818,841	3.14 x 10 ⁷
1995	1.14 x 10 ¹¹	826,087	3.16 x 10 ⁷
1996	1.15 x 10 ¹¹	826,087	3.22 x 10 ⁷
1997	1.16 x 10 ¹¹	840,580	3.28 x 10 ⁷
1998	1.17 x 10 ¹¹	847,826	3.34 x 10 ⁷
1999	1.19 x 10 ¹¹	862,319	3.40 x 10 ⁷
2000	1.20 x 10 ¹¹	869,565	3.43 x 10 ⁷
2001	1.21 x 10 ¹¹	876,812	3.49 x 10 ⁷
2002	1.22 x 10 ¹¹	844,058	3.55 x 10 ⁷
2003	1.23 x 10 ¹¹	891,304	3.60 x 10 ⁷
2004	1.24 x 10 ¹¹	898,551	3.66 x 10 ⁷
2005	1.25 x 10 ¹¹	905,797	3.72 x 10 ⁷
2006	1.27 x 10 ¹¹	920,290	3.75 x 10 ⁷
2007	1.28 x 10 ¹¹	927,536	3.81 x 10 ⁷
2008	1.29 x 10 ¹¹	934,783	3.90 x 10 ⁷
2009	1.30 x 10 ¹¹	942,029	3.96 x 10 ⁷
2010	1.32 x 10 ¹¹	956,522	4.01 x 10 ⁷
2011	1.33 x 10 ¹¹	963,768	4.07 x 10 ⁷
2012	1.35 x 10 ¹¹	971,015	4.19 x 10 ⁷
2013	1.35 x 10 ¹¹	978,261	4.19 x 10 ⁷
2014	1.37 x 10 ¹¹	992,754	4.28 x 10 ⁷
2015	1.38 x 10 ¹¹	1,000,000	4.34 x 10 ⁷
2016	1.39 x 10 ¹¹	1,007,246	4.40 x 10 ⁷
2017	1.41 x 10 ¹¹	1,021,739	4.48 x 10 ⁷
2018	1.42 x 10 ¹¹	1,028,986	4.54 x 10 ⁷
2019	1.43 x 10 ¹¹	1,036,232	4.63 x 10 ⁷

Table 9

NEW MEXICO ENERGY INSTITUTE--GEOTHERMAL DIRECT USE ENERGY PROJECTIONS--
 COMBINED INDUSTRIAL AND RESIDENTIAL APPLICATION WITH PRIVATE
 DEVELOPER -- LANDER AND EUREKA COUNTIES

Year	Projected geothermal energy on line (BTUs)	Gallons of oil replaced	Kilowatt hours of electricity replaced
1980	-0-	-0-	-0-
1981	-0-	-0-	-0-
1982	-0-	-0-	-0-
1983	2.52 x 10 ¹⁰	182,609	7.38 x 10 ⁶
1984	2.55 x 10 ¹⁰	183,783	7.47 x 10 ⁶
1985	2.59 x 10 ¹⁰	187,681	7.59 x 10 ⁶
1986	2.63 x 10 ¹⁰	190,580	7.71 x 10 ⁶
1987	2.67 x 10 ¹⁰	193,478	7.82 x 10 ⁶
1988	1.06 x 10 ¹¹	768,116	3.11 x 10 ⁷
1989	1.07 x 10 ¹¹	775,362	3.14 x 10 ⁷
1990	1.08 x 10 ¹¹	782,609	3.16 x 10 ⁷
1991	1.08 x 10 ¹¹	782,609	3.16 x 10 ⁷
1992	1.09 x 10 ¹¹	789,855	3.19 x 10 ⁷
1993	1.10 x 10 ¹¹	797,101	3.22 x 10 ⁷
1994	1.11 x 10 ¹¹	804,348	3.25 x 10 ⁷
1995	1.12 x 10 ¹¹	811,594	3.28 x 10 ⁷
1996	1.13 x 10 ¹¹	818,841	3.31 x 10 ⁷
1997	1.14 x 10 ¹¹	826,087	3.34 x 10 ⁷
1998	1.15 x 10 ¹¹	833,333	3.37 x 10 ⁷
1999	1.16 x 10 ¹¹	840,580	3.40 x 10 ⁷
2000	1.17 x 10 ¹¹	847,826	3.43 x 10 ⁷
2001	1.18 x 10 ¹¹	955,072	3.46 x 10 ⁷
2002	1.20 x 10 ¹¹	869,565	3.52 x 10 ⁷
2003	1.21 x 10 ¹¹	876,812	3.55 x 10 ⁷
2004	1.22 x 10 ¹¹	884,058	3.57 x 10 ⁷
2005	1.23 x 10 ¹¹	891,304	3.60 x 10 ⁷
2006	1.24 x 10 ¹¹	898,550	3.63 x 10 ⁷
2007	1.25 x 10 ¹¹	905,797	3.66 x 10 ⁷
2008	1.27 x 10 ¹¹	920,290	3.72 x 10 ⁷
2009	1.28 x 10 ¹¹	927,536	3.75 x 10 ⁷
2010	1.29 x 10 ¹¹	934,783	3.78 x 10 ⁷
2011	1.30 x 10 ¹¹	942,029	3.81 x 10 ⁷
2012	1.31 x 10 ¹¹	949,275	3.84 x 10 ⁷
2013	1.33 x 10 ¹¹	963,768	3.90 x 10 ⁷
2014	1.34 x 10 ¹¹	971,014	3.93 x 10 ⁷
2015	1.35 x 10 ¹¹	978,261	3.96 x 10 ⁷
2016	1.37 x 10 ¹¹	992,754	4.01 x 10 ⁷
2017	1.38 x 10 ¹¹	1,000,000	4.04 x 10 ⁷
2018	1.39 x 10 ¹¹	1,07,2466	4.07 x 10 ⁷
2019	1.41 x 10 ¹¹	1,021,739	4.13 x 10 ⁷

III. THE RESOURCE

A. General Information

There are approximately 11 geothermal sites in Geothermal Resource Area 6 with the potential for commercial development. The most major of these include: Beowawe Geysers, Spencer Hot Springs, and Hot Springs Point. In addition to these three sites, there are several other sites in the study area where thermal water has been encountered. The following portion of this report includes a discussion of each of the 11 major geothermal areas in Geothermal Resource Area 5.

Evaluation of the geothermal reservoir at these sites is difficult because of the limited information currently available. To estimate the size of the geothermal reservoir and the heat energy stored in it, either the methodology presented in U.S.G.S. Circular 790 was used or the information obtained from Geothermal Direct Heat Use Market Potential. Using methodologies contained in these reports, the potential heat energy found in the geothermal reservoir is calculated using such known factors as: surface area, depth, temperature, and the specific heat of rock. The formula used for this calculation is:

$$q_r = p_c * a * d (t - t_{ref})$$

where:

q_r = reservoir thermal energy in BTUs

p_c = volumetric specific heat of rock plus water (40.284 BTU/ft³/°F.)

a = reservoir area

d = reservoir thickness

t = reservoir temperature

t_{ref} = reference temperature (59° F.)

Existing technology is not capable of extracting all of the energy from the geothermal reservoir. To give a more realistic value to the energy obtainable, an assumption of 25 percent of total reservoir capacity is used. This value should be considered an estimate and may or may not be representative of actual reservoir conditions.

FIGURE 5

LOCATIONS OF GEOTHERMAL RESOURCES IN LANDER AND EUREKA COUNTIES

It should be emphasized that the information presented about each geothermal reservoir is based on the best information currently available. The actual conditions in the reservoir may be considerably different than indicated. Any party investigating the development of any of these resources is urged to contact the Nevada Department of Energy for additional resource information and to engage the services of a reputable, experienced consulting firm in assessing the geothermal reservoir.

B. Lander County

1. Spencer Hot Springs

a. Description(13)

Spencer Hot Springs are located at the northern end of the Big Smokey Valley in southeastern Lander County. There is an approximately one mile long travertine terrace developed at the site. Six individual hot springs have been identified. The main spring has in the past been used to supply hot water to a bath house. No other uses are known at this time.

b. The Reservoir

The following parameters are believed to describe the Spencer Hot Springs geothermal reservoir:

Volume(31)

0.79 $\pm$ 0.2 cubic mile

Temperature(31)

Reported temperature-----144° F.

*Na-K-Ca, Mg-corrected geothermometer-----190° F.

*Chalcedony geothermometer-----203° F.

*Quartz conductive geothermometer-----253° F.

Mean reservoir temperature-----216° F. $\pm$ 4° F.

*Use any geothermal temperatures with caution. Local conditions may give invalid temperature estimates.

Discharge(13)

12 gallons per minute

Water Chemistry(13)

Three water chemistry analyses for water from Spencer Hot Springs are reproduced in Appendix 1A. These analyses indicate that water from Spencer Hot Springs meets most standards for safe drinking water. The standard for iron and total dissolved solids is, however, violated in most cases.

Energy Content

Potential heat energy found in the reservoir----- 7.4×10^{10} BTUs

Heat energy extractable with existing technology--- 1.8×10^{10} BTUs

2. Smith Creek Valley

a. Description(13)

There are four widely scattered geothermal resources in Smith Creek Valley. The first of these is at Peterson's Mill south of the New Pass Range. These springs have a reported temperature of 85° F. and are located just down gradient from a northeast trending fault in the alluvium. Another hot spring is reported about 10 miles southwest of the Peterson's Mill Springs. No temperature information is available about these warm springs.

Smith Creek Valley Springs are located in the central part of Smith Creek Valley about five miles north of SR-2. There are 20 springs in this area which have temperatures reported near the boiling point. The Smith Creek Valley Springs appear to be associated with recent faulting in the alluvium. About six miles north of these springs another hot spring has been reported. The temperature of this spring is 187° F. Various geothermometers have suggested that the temperature of this thermal reservoir is between 289° and 315° F.

b. The Reservoir

There are two distinct hot spring areas in Smith Creek Valley: Peterson's Mill and those springs around the Smith Creek Valley Spring area. For evaluation purposes, these two spring areas are considered to represent two distinct geothermal reservoirs though, in fact, there may be one or several distinct reservoirs present. Future site specific analysis is necessary to either confirm or dispute this assumption. The following parameters are believed to define these two reservoirs:

Volume(13, 29)

Peterson's Mill-----	0.24 cubic mile
Smith Creek Valley Springs-----	0.79 cubic mile

Temperature(13)

Peterson's Mill-----	reported temperature----	85° F.
Smith Creek Valley Springs--	reported temperature----	boiling
	geothermometer-----	315° F.

Discharge(13)

Peterson's Mill-----	no information available
Smith Creek Valley Springs--	125 gallons per minute

Water Chemistry (13)

Water chemistry information for two wells from Smith Creek Valley are reproduced in Appendix 1A. These analyses indicate that water from both areas in Smith Creek Valley meets most standards for safe drinking water set by the State of Nevada.

Energy Content(31)

Peterson's Mill

Potential heat energy found in the reservoir-----	3.7×10^{13} BTUs
Heat energy extractable with existing technology--	9.3×10^{12} BTUs

Smith Creek Valley Springs

Potential heat energy found in the reservoir----- 7.2×10^{14} BTUs

Heat energy extractable with existing technology-- 1.8×10^{14} BTUs

3. Buffalo Valley Hot Springs

a. Description(13)

Buffalo Valley Hot Springs are located about 45 miles southwest of Battle Mountain. Water with a reported temperature of 174° F. issues from about 11 springs that cover an area of about three acres. Based on various geothermometers a reservoir temperature of 257° F. has been estimated. Thermal water with temperatures up to 193° F. has been encountered in shallow test holes covering a two square mile area.

The Buffalo Valley Hot Springs are a roughly circular assemblage of numerous springs with low flows. The spring area is a small mound of travertine that stands only a few feet higher than the surrounding area. Travertine is deposited at a few of the hotter springs, but most are too cool or have too low a flow to cause any deposits to accumulate.

Buffalo Valley is a closed graben. North-south trending Basin and Range faults occur along the west side of the valley at the base of the Tobin Range. Similar range bounding faults are not conspicuous on the eastern side of the valley near the hot springs, although a recognizable fault does extend north of the springs along the western edge of the Fish Creek Mountains. Probably associated with this, or another, basin-and-range fault is a series of Quaternary basalt cinder cones and flows. These are aligned parallel with the west slope of the Fish Creek Mountains for about 12 miles.

b. The Reservoir

The following parameters are believed to describe the Buffalo Valley Hot Springs geothermal reservoir:

Area(31)

1.37 $\pm$ 4.8 cubic mile

Temperature(31)

Reported temperature-----197° F.
Chalcedony geothermometer-----207° F.
Na-K-Ca, Mg corrected geothermometer-----275° F.
Sulfate water isotope geothermometer-----284° F.
Mean reservoir temperature-----255° F.

Discharge(13)

10 gallons per minute

Water Chemistry(13)

Two water chemistry analyses from the Buffalo Valley Hot Springs are reproduced in Appendix 1A. These analyses indicate that water from this geothermal reservoir meets most standards for safe drinking water, violating only the standard for total dissolved solids.

Energy Content(31)

Potential heat energy found in the reservoir-----1.6 x 10¹⁵ BTUs
Heat energy extractable with existing technology----4.0 x 10¹⁴ BTUs

4. Hot Springs Ranch

a. Description

Hot Springs Ranch is located along SR-8A between the Fish Creek and Shoshone Mountains. Springs at this site have temperatures ranging between 122° and 129° F. The springs are believed

to be associated with deep circulation of water along a fault running through the area. There are at least 11 springs in the assemblage at Hot Springs Ranch.

b. The Reservoir

The following parameters are believed to describe the Hot Springs Ranch geothermal reservoir:

Volume(31)

0.79 cubic mile

Temperature(31)

Reported temperature-----129° F.

Silica geothermometer-----198° F.

Discharge

No information available

Water Chemistry(13)

Two water chemistry analyses for samples taken from springs on the Hot Springs Ranch are reproduced in Appendix 1A. These samples indicate that water from this geothermal reservoir meets all standards for safe drinking water except for total dissolved solids.

Energy Content(31)

Potential heat energy found in the reservoir----- 3.2×10^{14} BTUs

Heat energy extractable with existing technology----- 8.1×10^{13} BTUs

Special Note: Hot Springs Ranch is located in a designated groundwater basin and hence is subject to special regulation by the State Water Engineer's Office.

C. Eureka County

1. Beowawe Geysers

a. Description(13)

Beowawe Geysers are located in the southwestern portion of Whirlwind Valley, about six miles from the community of Beowawe. This geothermal area has the highest reported subsurface temperature in the study area.

Surface manifestations of the geothermal reservoir include hot springs, fumaroles, and geysers. Temperatures in these areas range from 202° to 204° F. At one time, several geysers were known to exist on the main sinter terrace, although today, probably due to the drilling of geothermal exploration wells, none exist. Geysers on the valley floor west of the terrace are surprisingly much more thermally active now than before exploration activity began in 1932.

The main terrace at the Beowawe Geysers is an enormous, conspicuous, symmetrical spring-sinter deposit that stands about 250 feet high. Flowing springs on top of this terrace are today depositing opal around some of the pools.

The Geysers geothermal field is located along a major fault system that extends between 35 and 70 miles in length. These east-northeast trending faults are intersected by several northwest trending faults and lineaments. The geothermal manifestations are found in these intersection zones.

Beowawe Geysers has been the subject of much interest by geothermal developers. There were about 17 exploratory geothermal wells drilled at Beowawe during the period 1959 through 1980. The companies primarily responsible for these wells include: Magma Power Company, Vulcan Thermal Power Company, Sierra Power Company, and Chevron USA, Inc. Several of the wells have gone over 5,000 feet in depth and have encountered temperatures in excess of 414° F.

b. The Reservoir

The following parameters are believed to describe the Beowawe Geysers geothermal reservoir:

Volume(31)

1.97 cubic mile

Temperature(31)

Reported temperature-----414° F.

Quartz adiabatic geothermometer-----439° F.

Sulfate-water isotope geothermometer-----484° F.

Mean reservoir temperature-----444° F.

Discharge(13)

Total discharge of the Geysers area is unknown. Some wells have, however, produced at least 400,000 to 500,00 lbs/hr of fluid with 10 to 15 percent steam flashover. The Vulcan Number 4 well has been reported to have approximately 1.5 million lbs/hr of fluid with 41,5000 lbs/hr of that being steam.

Water Chemistry(13)

Four water chemistry analyses for water from the Beowawe Geysers area are reproduced in Appendix 1B. These analyses indicate that water from this geothermal reservoir violates only the total dissolved solid and iron standards for safe drinking water as set by the State of Nevada.

Energy Content(31)

Potential heat energy found in the reservoir----- 4.5×10^{15} BTUs

Heat energy extractable with existing technology----- 1.1×10^{15} BTUs

2. Hot Springs Point (Crescent Valley)

a. Description(13)

Hot Springs Point is located about 10 miles southeast of Beowawe Geysers in the central portion of Crescent Valley. There are at least five hot springs found in this assemblage having temperatures ranging from between 122° and 138° F. The springs issue from alluvium and bedrock along a 1.5 mile long line associated with the Dry Hills Fault. Several areas along the fault in the hot springs are known to have deposits of native sulfur and cinnabar.

There has been some exploration activity at the Hot Springs Point area. Magama Power drilled a 410 foot well which encountered fluids with temperatures up to 166° F.

b. The Reservoir

The following parameters are believed to describe the Hot Springs Point geothermal reservoir:

Area(31)

0.79 cubic mile

Temperature(31)

Reported temperature-----166° F.

Chalcedony geothermometer-----189° F.

Quartz conductive geothermometer-----241° F.

Mean reservoir temperature-----198° F.

Discharge(31)

About 35 gallons per minute

Water Chemistry(13)

Two water chemistry analyses for water from the Hot Springs Point geothermal reservoir are reproduced in Appendix 1B. These

analyses indicate water from this area violates both the iron and the total dissolved solids standards set by the State of Nevada for safe drinking water.

Energy Content(31)

Potential heat energy found in the reservoir----- 6.5×10^{14} BTUs
Heat energy extractable with existing technology----- 1.6×10^{14} BTUs

3. Walti Hot Springs

a. Description(13)

Walti Hot Springs are located on the western flank of the Simpson Park Range in Grass Valley. These springs, with surface temperatures of about 165° F., are the third hottest geothermal resource in Eureka County. The spring area, where a large deposit of siliceous sinter has been deposited, lies on a major range bounding fault along the western side of the Simpson Park Range.

b. The Reservoir

The following parameters are believed to describe the Walti Hot Springs geothermal reservoir:

Volume(29)

0.72 cubic mile

Temperature(13)

Measured temperature-----165° F.

Estimated temperature-----239° F.

Discharge

No information available

Water Chemistry(13)

Water chemistry analyses for two samples from Walti Hot Springs are reproduced in Appendix 1B. These analyses indicate that water from this geothermal resource meets all standards set by the State of Nevada for safe drinking water.

Energy Content(31)

Potential heat energy found in the reservoir----- 7.7×10^{14} BTUs

Heat energy extractable with existing technology----- 1.9×10^{14} BTUs

4. Klobe Hot Springs

a. Description(13)

Klobe Hot Springs are located in the central part of Antelope Valley near the north end of the Monitor Range. Temperatures in these springs have been reported to be as high as 156° F. Wells drilled near the hot spring area have encountered 158° F. water. There are at least two springs and two wells in the Klobe Hot Springs area. Water from these sources is currently being used for stock watering.

b. The Reservoir

The following parameters are believed to describe the Klobe Hot Springs geothermal reservoir:

Volume(29)

0.72 cubic mile

Temperature(13)

Reported temperature-----158° F.

Estimated reservoir temperature-----165° F.

Discharge

No information available

Water Chemistry(13)

Two water chemistry analyses for fluids from Klobe Hot Springs are reproduced in Appendix 1B. These analyses indicate that the water from this geothermal resource meets all standards for safe drinking water. The iron standards may, however, occasionally be violated.

Energy Content(31)

Potential heat energy found in the reservoir-----6.3 x10¹⁴ BTUs

Heat energy extractable with existing technology-----1.6 x10¹⁴ BTUs

5. Horseshoe Ranch Springs

a. Description(13)

The Horseshoe Ranch Springs area, about one mile northeast of Beowawe, has two distinct warm springs having temperatures up to 136° F. Water from the springs is currently being used for bathing and irrigation. The Horseshoe Ranch Springs are probably located on an extension of a fault running along the south side of Whirlwind Valley.

b. The Reservoir

The following parameters are believed to describe the Horseshoe Ranch Springs geothermal reservoir:

Volume(29)

0.36 cubic mile-----This volume may be very inaccurate. Horseshoe Ranch Springs are located along the same fault which localizes the surface geothermal activity at Beowawe Geysers, some seven miles to the south. It is thus possible that there is some underground connection between the two geothermal systems greatly enlarging the volume of the reservoir.

Temperature(13)

Measured temperature-----136° F.

Discharge

No information available

Water Chemistry(13)

Examples of two water chemistry analyses for water from the Horseshoe Ranch Springs are reproduced in Appendix 1B. These analyses indicate that the water from this geothermal reservoir meets the standards for safe drinking water. Occasionally, however, the total dissolved solid standard is violated.

Energy Content(31)

Potential heat energy found in the reservoir----- 1.6×10^{14} BTUs

Heat energy extractable with existing technology----- 4.1×10^{13} BTUs

6. Bruffey's Hot Springs

a. Description(13)

Bruffey's Hot Springs are one of several hot springs occurring along a major range bounding fault on the east side of the Sulfur Springs Range. These springs have the highest temperatures of any of the springs along this fault trace with temperatures of 152° F. being recorded. Prominent calcareous sinter terraces have been developed.

b. The Reservoir

The following parameters are believed to describe the Bruffey's Hot Springs geothermal reservoir:

Volume(29)

0.36 cubic mile

Temperature(13)

Reported temperature-----152° F.

Discharge

No information available

Water Chemistry(13)

Only one water chemistry analysis for water from Bruffey's Hot Springs is available. This analysis is reproduced in Appendix 1B. Though information is rather limited, it appears that the water quality for water from this reservoir is excellent, meeting all standards for safe drinking water set by the State of Nevada.

Energy Content(31)

Potential heat energy found in the reservoir----- 2.0×10^{14} BTUs

Heat energy extractable with existing technology----- 5.0×10^{13} BTUs

Special Note: Bruffey's Hot Springs are in a designated groundwater basin and are hence subject to special regulation by the State Water Engineer's Office.

7. Shipley Hot Springs

a. Description(13)

Shipley Hot Springs are the second hottest resource located along the range bounding fault on the east side of the Sulfur Springs Range. These springs have temperatures up to 106° F. and have high discharge rates.

b. The Reservoir

The following parameters are believed to describe Shipley Hot Springs geothermal reservoir:

Volume(29)

0.36 cubic mile

Temperature(13)

Reported temperature-----106° F.

Discharge(31)

3,000 to 6,700 gallons per minute have been reported

Water Chemistry(13)

Two water chemistry analyses for water from Shipley Hot Springs are reproduced in Appendix 1B. These analyses indicate that water from Shipley Hot Springs meets all standards set for safe drinking water.

Energy Content(31)

Potential heat energy found in the reservoir-----1.0 x 10¹⁴ BTUs

Heat energy extractable with existing technology-----2.5 x 10¹³ BTUs

8. Other Warm Springs in Eureka County

There are several other warm springs in Eureka County that deserve mentioning. Carlotti Ranch Springs, Siri Ranch Springs, Flynn Ranch Springs and possibly Sulfur Springs are located along the same fault line as Bruffey's Hot Springs and Shipley Hot Springs. These four warm spring areas have temperatures ranging from a low of 69° F. up to a high of 102° F. Other sites with temperatures above 70° F. include: Thompson Ranch Spring, Hot Creek Springs, and the Raine Ranch Springs. It should be noted that Hot Creek Springs and Carlotti Ranch Springs are believed to be located in a designated groundwater basin, and are hence regulated by special provisions of the Water Engineer's Office.

IV. THE USES

A. General Information

Uses for geothermal energy fall into two broad categories: electrical generation and direct use of the hot water. Electrical generation on a practical commercial scale requires both a high temperature resource and a large geothermal reservoir. It appears that several of the geothermal areas in Geothermal Resource Area 6 meet these criteria.

Direct uses of geothermal energy are more varied and can economically use both lower temperature and less extensive resources. In addition, hot water from geothermal electrical generation facilities can be used for other applications after the initial use. Figure 6 illustrates the various types of uses for geothermal energy and the temperature requirements for each use.

For the purpose of this study, direct applications have been divided into four major categories: space heating, recreation, industrial process heat, and agriculture. Space heating has further been divided into district and residential-commercial systems. Agriculture has been divided into greenhousing, animal husbandry, and the aquacultural raising of fish and prawns. Appendix 2A describes and illustrates the procedure developed by the Nevada Department of Energy to evaluate these uses in reference to a particular geothermal resource site. The reader is encouraged to read this appendix before reading the following "Uses" section. The purpose in developing the geothermal method described in Appendix 2A was to be able to give some quantification to statements made about the development potential of a particular site. As with any method of this type, there are problems. The major problem with this method is that it considers only five major site characteristic parameters. There are obviously many more that must be considered by any developer of geothermal resources. At best, the methods used in this document can give only a good idea of the potential of a certain type of application. Before any

FIGURE 6

GEOHERMAL USE TEMPERATURES IN LANDER AND EUREKA COUNTIES

* Temperatures indicated are based in part on various geothermometers.

development occurs, it is suggested that the developer look at detailed site specific information to evaluate the resource and its applicability to the proposed use.

B. Lander County

1. Spencer Hot Springs

Spencer Hot Springs are located about 15 miles southeast of Austin along SR-83. Water from these springs is currently being piped to a concrete-lined pool, probably for livestock use. Geothermal Use Evaluation Table 10 evaluates potential applications of the hot water from Spencer Hot Springs. An analysis of this table leads to the following sequence of potential application development feasibility:

<u>Application</u>	<u>Development Feasibility</u>
Animal Husbandry.....	High
Greenhousing.....	High
Industrial Process Heat.....	High
Aquaculture.....	Medium
Residential-Commercial Space Heating.....	Medium
Recreation.....	Medium
District Space Heating.....	Low
Electrical Generation.....	Low

This ranking system is useful in assessing the potential for different kinds of geothermal applications. Those applications with development numbers higher than 200 probably have the highest potential for successful development. Those applications with development numbers between 125 and 200 have moderate potential and those with development numbers less than 124 are considered to have low potential. However, characteristics of the geothermal resource not considered in this ranking system may make the potential application more or less feasible than indicated. Detailed, site specific information must be gathered before any development of the resource occurs.

The area of Spencer Hot Springs is historically a ranching area. For this reason both animal husbandry and greenhousing development can be considered to fit nicely into the current economic base of the area and hold high potential for development.

Industrial processing, though somewhat limited by the temperature of the resource, also has high development potential. Other applications such as aquaculture, residential space heating, and recreation have moderate development potential. The feasibility of these types of applications at this time are, however, somewhat less than optimal. District space heating and electrical generation are not considered feasible developments at this time based on resource characteristics or existing land use patterns.

It should be noted that the area around Spencer Hot Springs and the community of Austin is experiencing a resurgence in the mining industry. Should such a resurgence continue, the development of various space heating and low temperature industrially related applications should be considered as a beneficial use of the energy at Spencer Hot Springs. Should such development occur, the economic base of the Lander County area could be greatly strengthened and broadened.

Table 10

Geothermal Use Evaluation--Spencer Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	2	6	
Land Factors	27	1.6	43.2	61
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	2	2	
Land Factors	3	1.6	4.8	187
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	2	2	
Land Factors	3	1.6	4.8	79
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	27	
Water Chemistry	1	2	2	
Land Factors	9	2	18	134
Population Centers	81	1	81	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	2	162	
Water Chemistry	9	2	18	
Land Factors	27	1.6	43.2	229
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	2	162	
Water Chemistry	9	2	18	
Land Factors	1	2	2	236
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	2	6	
Land Factors	1	2	2	197
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	2	6	
Land Factors	9	2	18	240
Population Centers	1	0	0	
Depth to Resource	27	2	54	

2. Smith Creek Valley

There are two major hot spring areas in Smith Creek Valley: Peterson's Mill and Smith Creek Valley Springs. The northern most of the two areas, Peterson's Mill is a low temperature geothermal resource. Development of this site is limited to those applications not requiring temperatures much in excess of 85° F. These types of applications include space heating and cooling using heat pumps, soil warming, the aquacultural raising of fish and prawns, and similar such applications.

Geothermal Use Evaluation Table 11 has evaluated potential applications for the Smith Creek Valley Springs area. This evaluation has lead to the development of the following sequence of potential applications:

<u>Application</u>	<u>Development Feasibility</u>
Industrial Process Heat.....	High
Greenhousing.....	High
Aquaculture.....	Medium
Animal Husbandry.....	Medium
Electrical Generation.....	Medium
Residential-Commercial Space Heating.....	Low
Recreation.....	Low
District Space Heating.....	Low

This evaluation indicates that the most appropriate applications for the Smith Creek Valley Springs are industrial processing, greenhousing, and aquaculture. These applications are not overly dependent on proximity to a population base. Both agricultural types are, however, dependent on climate. The Lander and Eureka County area does have fairly harsh winter temperatures. The resource appears, however, to be high enough in quality to compensate for this adverse climate. Other applications such as residential space heating, district space heating, and electrical generation appear to have moderate to low development potential because of resource characteristics, existing land use characteristics, or existing population patterns.

Table 11

Geothermal Use Evaluation--Smith Creek Valley Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	1	81	
Water Chemistry	3	1	3	
Land Factors	27	1.6	43.2	145
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	1	1	
Land Factors	3	1.6	4.8	105
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	3	1.5	4.5	78
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	2	18	79
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	2	162	
Water Chemistry	9	1	9	
Land Factors	27	2	54	231
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	2	162	
Water Chemistry	9	1	9	
Land Factors	1	2	2	227
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1.5	4.5	
Land Factors	1	2	2	196
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	1	3	
Land Factors	9	2	18	156
Population Centers	1	0	0	
Depth to Resource	27	2	54	

3. Buffalo Valley Hot Springs

Buffalo Valley Hot Springs are located about 45 miles southwest of Battle Mountain in the remote Buffalo Valley. These springs are about 50 miles from the nearest paved road, although a good quality dirt road does lead into the area.

Buffalo Valley Hot Springs were evaluated according to the standard methodology. This evaluation leads to the following sequence of potential applications:

<u>Application</u>	<u>Development Feasibility</u>
Animal Husbandry.....	High
Aquaculture.....	Medium
Residential-Commerical Space Heating.....	Medium
Greenhousing.....	Medium
Industrial Process Heat.....	Medium
District Space Heating.....	Low
Recreation.....	Low
Electrical Generation.....	Low

One application is considered to have high potential for successful development at this time. Animal husbandry activities, historically a dominant economic activity in this region, could make excellent use of the geothermal resource.

Four other applications are considered to have moderate potential for successful development: small space heating systems, greenhousing, and industrial process heat. Low known discharges from these springs may limit the types of developments that may occur. Wells that may potentially be drilled may be able to supply sufficient quantities of water for different uses. Detailed site specific analyses must be done on these springs to make certain that the resource is capable of supplying water of both high enough temperature and quantity to make the development economically feasible.

Three types of development--district space heating, recreation, and electrical generation--are considered to have low development potential. The low potential evaluation is based primarily on the resource's temperature, location, and distance from any substantial population base. Should the basic demography of the region change, or the technology to handle lower temperature geothermal fluids be developed, Buffalo Valley Hot Springs should be looked at in much greater detail as a potential site to supply energy needs.

Table 12

Geothermal Use Evaluation--Buffalo Valley Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	1.3	4	
Land Factors	27	1.3	35	57
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	1.3	1.3	
Land Factors	3	1.3	4	185
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	1.3	1.3	
Land Factors	3	.5	1.5	75
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	1	9	70
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1.3	12	
Land Factors	27	1.3	35	134
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1.3	12	
Land Factors	1	1	1	148
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1.5	4.5	
Land Factors	1	1	2	196
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	1.3	4	
Land Factors	9	1	9	229
Population Centers	1	0	0	
Depth to Resource	27	2	54	

4. Hot Springs Ranch

The geothermal resource at Hot Springs Ranch is located immediately west of SR-8A approximately 35 miles south of Battle Mountain. The resource is represented by 11 surface hot springs having temperatures between 122° and 129° F. Geothermal Use Evaluation Table 13 evaluates the potential applications of energy from the Hot Springs geothermal area. The following sequence of potential applications has been determined by summarizing the information in that table:

<u>Application</u>	<u>Development Feasibility</u>
Aquaculture.....	High
Animal Husbandry.....	Medium
Greenhousing.....	Medium
Industrial Process Heat.....	Medium
Residential-Commerical Space Heating.....	Low
Recreation.....	Low
Electrical Generation.....	Low
District Space Heating.....	Low

Based on the standard evaluation methodology, one application is considered to have high development potential. However, due to the lack of information regarding spring discharge and the harsh climate of the area, the potential may not be as high as the initial evaluation indicates. Aquacultural development requires that the ponds be maintained at an optimum temperature of 80° to 85° F. for best prawn and fish development. This may not be possible with the Hot Springs Ranch resource.

Animal husbandry, greenhousing, and industrial process heat applications are considered to have moderate potential for successful development. The area of the Hot Springs Ranch is historically a ranching and agricultural area. Any such development of the geothermal resource along these lines will greatly broaden the economic base of the agricultural community as well as the county in general.

Four types of applications are considered to have low development potential: both types of space heating, recreation and electrical generation. The resource is too cool and remote to be successfully developed into these applications.

Table 13

Geothermal Use Evaluation--Hot Springs Ranch

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	1	3	
Land Factors	27	1.6	43	64
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	1	1	
Land Factors	3	1	3	103
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	0	0	
Water Chemistry	1	1	1	
Land Factors	3	2	6	25
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	2	18	79
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1	9	
Land Factors	27	1.6	43.2	139
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1	9	
Land Factors	1	2	2	146
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	2	54	
Water Chemistry	3	1	3	
Land Factors	1	2	2	221
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	1	3	
Land Factors	9	1.6	14.4	152
Population Centers	1	0	0	
Depth to Resource	27	2	54	

C. Eureka County

1. Beowawe Geysers

The Beowawe Geysers geothermal resource is the largest and the hottest geothermal resource in the study area. These springs, located about six miles from the small community of Beowawe, have been extensively explored. Currently, however, no development has occurred at the site although several different types of uses have been considered.

Geothermal Use Evaluation Table 14 evaluates potential applications at Beowawe Geysers. The following sequence of potential applications is derived from that table:

<u>Application</u>	<u>Development Feasibility</u>
Electrical Generation.....	High
Industrial Process Heat.....	High
Aquaculture.....	Medium
Animal Husbandry.....	Medium
Greenhousing.....	Medium
Residential-Commerical Space Heating.....	Low
District Space Heating.....	Low
Recreation.....	Low

The evaluation of the potential applications at Beowawe Geysers indicates that those types of applications requiring higher temperatures are most feasible at this time. Both electrical generation and industrial process heat are considered to have high development potential. Other applications requiring hot water, but not necessarily a nearby population base, such as aquaculture, animal husbandry, and greenhousing are considered to have moderate development potential. All of these applications would fit nicely into the historical character of the area which is primarily ranching. Those types of applications requiring a large population base, such as district space heating and recreation, are not considered to be feasible for development at this time.

Table 14

Geothermal Use Evaluation--Beowawe Geysers

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	2	162	
Water Chemistry	3	1	3	
Land Factors	27	2	54	237
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	1	1	
Land Factors	3	1.6	5	105
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	3	1.5	4.5	78
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	27	
Water Chemistry	1	1	1	
Land Factors	9	2	18	52
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	2	162	
Water Chemistry	9	1	9	
Land Factors	27	2	54	231
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1	9	
Land Factors	1	2	2	146
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1	3	
Land Factors	1	2	2	194
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	1	3	
Land Factors	9	2	18	156
Population Centers	1	0	0	
Depth to Resource	27	2	54	

2. Hot Springs Point

The Hot Springs Point geothermal resource is located about 10 miles southeast of Beowawe Geysers and about five miles from the main paved road through the area. Although some exploration has occurred in the area, no development has taken place.

Geothermal Use Evaluation Table 15 evaluates potential developments in the Hot Springs Point area. Based on this evaluation the following sequence of uses has been determined:

<u>Application</u>	<u>Development Feasibility</u>
Animal Husbandry.....	High
Aquaculture.....	High
Residential-Commercial Space Heating.....	Medium
Greenhousing.....	Medium
Industrial Heat Process.....	Low
Recreation.....	Low
Electrical Generation.....	Low
District Space Heating.....	Low

This ranking goes along quite well with the historical character of the region. Ranching and similar agricultural industries are very important to this region. Thus, the development of various animal husbandry applications using the energy from Hot Springs Point geothermal area could greatly add to the economic stability of the industry.

Aquaculture appears to have fairly good potential though the region tends to have cold winters, a problem that could also hamper the development of greenhousing facilities. Individual space heating and low temperature industrial process applications heat could also make use of the energy from this resource site.

Three types of applications--recreation, electrical generation, and district space heating--are not considered feasible at this time because of resource characteristics or the distance of the resource from any substantial population base.

Table 15

Geothermal Use Evaluation--Hot Springs Point

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	0.66	2	
Land Factors	27	2	54	74
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	0.6	0.66	
Land Factors	3	2	6	187
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	1	27	
Water Chemistry	1	0.66	0.66	
Land Factors	3	1.5	4.5	50
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	2	18	79
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1	9	
Land Factors	27	0.6	16	112
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	0.6	5	
Land Factors	1	2	2	142
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1.5	4.5	
Land Factors	1	2	2	196
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	0.6	5	
Land Factors	9	2	2	223
Population Centers	1	0	0	
Depth to Resource	27	2	54	

3. Walti Hot Springs

Walti Hot Springs are located in the remote area of Grass Valley along the Lander/Eureka County line. These springs are the third hottest geothermal resource in the Eureka County area. Hot water from these springs has been used for several years to heat ranch buildings and supply water for irrigation.

Geothermal Use Evaluation Table 16 evaluates potential uses for the energy at the hot springs. The following sequence was determined from that table:

<u>Application</u>	<u>Development Feasibility</u>
Animal Husbandry.....	High
Aquaculture.....	Medium
Residential-Commercial Space Heating.....	Medium
Greenhousing.....	Medium
Industrial Process Heat.....	Medium
Recreation.....	Low
Electrical.....	Low
District Space Heating.....	Low

Those uses of the Walti Hot Springs geothermal resource that are considered to have good to moderate development potential are agricultural applications and space heating. Several of the ranch facilities currently are using the resource for space heating. This should be continued as future buildings are added at the ranch. Consideration should be given to the development of aquacultural ponds and greenhouses as both supplying the needs of individual ranch residents and potentially supplying additional produce for market. Walti Hot Springs have historically been used for various space heating and irrigation needs at a small ranch development. Encouragement should be given to both continued use and expanded use of the resource on the ranch.

Several types of applications are not considered feasible at this time: district space heating, electrical generation, recreation, and industrial process heat. The characteristics of the resource and the remote location of the site probably preclude such development.

Table 16

Geothermal Use Evaluation--Walti Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	1.3	4	
Land Factors	27	1	27	49
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	1.3	1.3	
Land Factors	3	1	3	184
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	1	27	
Water Chemistry	1	1.3	1.3	
Land Factors	3	0.5	1.5	48
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	1	9	70
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1.3	12	
Land Factors	27	1	27	126
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1.3	12	
Land Factors	1	1	1	148
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1.5	4.5	
Land Factors	1	1	1	195
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	1.3	4	
Land Factors	9	1.5	1	234
Population Centers	1	0	0	
Depth to Resource	27	2	54	

4. Klobe Hot Springs

Klobe Hot Springs are located about eight miles south of U.S. 50 in Antelope Valley. This geothermal reservoir is represented by two springs and several wells with temperatures of approximately 158° F. Water from Klobe Hot Springs is currently being used for stock watering.

Various potential applications for the springs were evaluated in Table 17. Ranking those applications by their development numbers leads to the following sequence:

<u>Application</u>	<u>Development Feasibility</u>
Animal Husbandry.....	High
Aquaculture.....	Medium
Residential-Commercial Space Heating.....	Medium
Greenhousing.....	Medium
Industrial Process Heat.....	Medium
Recreation.....	Low
Electrical Generation.....	Low
District Space Heating.....	Low

The development feasibility derived for various applications using the standard methodology given in Appendix 2A are believed to fairly well describe the feasibility of those applications. Animal husbandry activities have been the historic use of the resource. Such use should continue and, if possible, be expanded. Aquaculture, small space heating applications, and greenhousing could all be jointly developed on a small ranch adding to the profitability of the operation as well as supplying some local produce needs. Industrial processes not requiring very high temperatures potentially could be developed, probably in association with the ranching facilities.

Recreation, electrical generation, and district space heating are not considered feasible applications at this time because of the character of the resource and its remote location.

Table 17

Geothermal Use Evaluation--Klobe Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	1.6	5	
Land Factors	27	1.6	43	66
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	1.6	1.6	
Land Factors	3	2	6	188
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	1	27	
Water Chemistry	1	1.6	1.6	
Land Factors	3	1.5	4.5	51
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	1	9	70
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1.6	14.4	
Land Factors	27	1.6	43.2	145
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1.6	14.4	
Land Factors	1	1.5	1.5	151
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1	3	
Land Factors	1	2	3	194
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	1.6	5	
Land Factors	9	1.5	13.5	235
Population Centers	1	0	0	
Depth to Resource	27	2	54	

5. Horseshoe Ranch Springs

Horseshoe Ranch Springs are located about six miles east of Beowawe Geysers along SR-21. The water from these springs is reportedly used for bathing and irrigation.

Various uses of the energy found at the Horseshoe Ranch Springs were evaluated according to the standard methodology. Based on development numbers the following sequence was determined:

<u>Application</u>	<u>Development Feasibility</u>
Aquaculture.....	High
Industrial Process Heat.....	Medium
Animal Husbandry.....	Medium
Greenhousing.....	Low
Residential-Commercial Space Heating.....	Low
Recreation.....	Low
Electrical Generation.....	Low
District Space Heating.....	Low

As evidenced by the overall lower development potential at this site, the feasibility of development is not considered too high. Aquaculture, the only application with a high development potential, may not be feasible when information on the amount of water available at the site becomes known. Another limiting factor on this type of development may be the harsh winter climate, making the maintenance of the ponds at 80° F. difficult.

Other applications of this resource do not appear to have much potential at this time. Applications such as recreation, space heating, and electrical generation probably could not be developed at the Horseshoe Ranch Springs site because of the temperature characteristics of the resource, the location of the resource some distance from any substantial population base, and the proximity of the resource to the much higher temperature resource at Beowawe Geysers.

Table 18

Geothermal Use Evaluation--Horseshoe Ranch Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	1.3	4	
Land Factors	27	1.3	35	57
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	1.3	1.3	
Land Factors	3	1.3	4	104
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	0	0	
Water Chemistry	1	1.3	1.3	
Land Factors	3	2	6	25
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1.5	1.5	
Land Factors	9	2	18	80
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1.3	12	
Land Factors	27	1.3	35	134
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1.3	12	
Land Factors	1	1.5	1.5	122
Population Centers	3	0	0	
Depth to Resource	27	1	27	
-Aquaculture				
Temperature	27	2	54	
Water Chemistry	3	2	6	
Land Factors	1	2	2	224
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	1.3	4	
Land Factors	9	1.5	13.5	126
Population Centers	1	0	0	
Depth to Resource	27	2	27	

6. Bruffey's Hot Springs

Bruffey's Hot Springs are the northernmost of six thermal springs on the margin of the Sulfur Springs Range. This hot spring site is located about five miles east of SR-51 and 35 miles south of Carlin. Bruffey's Hot Springs are the hottest in this series of springs having temperatures of 152° F. Potential applications for the geothermal energy found at Bruffey's Hot Springs were evaluated in Table 19. The following was determined from that table:

<u>Application</u>	<u>Development Feasibility</u>
Animal Husbandry.....	High
Aquaculture.....	Medium
Residential-Commerical Space Heating.....	Medium
Greenhousing.....	Medium
District Space Heating.....	Low
Industrial Process Heat.....	Low
Electrical Generation.....	Low
Recreation.....	Low

Four different types of geothermal applications are considered to hold some potential for development at Bruffey's Hot Springs: three types of agricultural developments and residential space heating. These types of applications are ideal for development in a ranching area. Supplemental greenhousing and aquacultural/development could both supply the immediate needs of the ranch but also supply additional produce for market sales. Although the development of all four different use categories together could be considered the ideal, the development of even one could be economically productive. There are, however, potential problems seen at this time with the development of either a greenhousing or an aquacultural industry. The site is located in northern Nevada where the harsh winter climate may make it difficult to maintain proper growing temperatures either in greenhouses or aquaculture ponds. Lack of site specific information on spring and well discharges makes it difficult to evaluate the potential of such development.

Four types of applications are not considered feasible: electrical generation, district space heating, recreation, although industrial process heat require either resource characteristics or a population base not associated with the resource. Should technology become available to use these lower temperature fluids or a population base be developed nearby, these applications should be reevaluated.

Table 19

Geothermal Use Evaluation--Bruffey's Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	2	6	
Land Factors	27	1.3	35	59
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	2	2	
Land Factors	3	1.3	4	186
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	2	2	
Land Factors	3	1.5	4.5	79
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	2	
Water Chemistry	1	2	2	
Land Factors	9	1.5	13.5	24
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	1	
Water Chemistry	9	2	18	
Land Factors	27	1.3	35	60
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	2	18	
Land Factors	1	1.5	1.5	155
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	2	6	
Land Factors	1	1.5	1.5	197
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	2	6	
Land Factors	9	1.5	13.5	236
Population Centers	1	0	0	
Depth to Resource	27	2	54	

7. Shipley Hot Springs

Shipley Hot Springs are the second hottest in the series of springs along the margin of the Sulfur Springs Range. The site is about 50 miles south of Carlin and six miles east of SR-51.

Geothermal Resource Evaluation Table 20 shows how the of potential uses at this site were evaluated. The following sequence was developed from that table:

<u>Application</u>	<u>Development Feasibility</u>
Aquaculture.....	Medium
Animal Husbandry.....	Medium
Greenhousing.....	Medium
Industrial Process Heat.....	Medium
Residential-Commercial Space Heating.....	Low
Recreation.....	Low
Electrical Generation.....	Low
District Space Heating.....	Low

Shipley Hot Springs hold moderate potential for several types of applications: aquaculture, animal husbandry, and greenhousing. Water flow rates from the springs are known to be fairly large and could be sufficient to supply the needs of an aquacultural industry needing to maintain growing ponds at 80° F., though the climate of the area does have harsh winters. Similar comments could be made on animal husbandry and green housing. Industrial Process Heat may have low temperature applications, but 106° F. water, though applicable in some processes probably could not induce developers to locate in the area when higher temperature resources are available in the immediate area.

Those applications requiring either a large population base or a higher temperature resource such as electrical generation and district space heating are not considered feasible at this time.

Table 20

Geothermal Use Evaluation--Shipley Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	2	6	
Land Factors	27	1	27	51
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	2	2	
Land Factors	3	1	3	104
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	0	0	
Water Chemistry	1	2	2	
Land Factors	3	1.5	4.5	24
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	2	2	
Land Factors	9	1.5	13.5	76
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	2	18	
Land Factors	27	1	27	132
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	2	18	
Land Factors	1	1.5	1.5	154
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	2	6	
Land Factors	1	1.5	1.5	196
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	2	6	
Land Factors	9	1.5	13.5	155
Population Centers	1	0	0	
Depth to Resource	27	2	54	

8. Other Warm Springs in Eureka County

There are about seven other warm springs in Eureka County with temperatures below 100° F. These warm springs were not evaluated according to the standard methodology because the types of potential applications at these sites is somewhat limited. The development of an aquacultural industry is possible should the temperature and flow characteristics of the site be sufficient to maintain the growing ponds at about 80° F. year around. Space heating applications using the geothermal fluid as a heat source for heat pumps should also be considered. The warm fluid could be used to heat the ground in greenhouses and maybe supply preheat for any associated boilers.

V. CONCLUSION

Geothermal Resource Area 6 has several major geothermal resources that are believed capable of supporting development at this time. These resources could support a wide range of different applications. In addition to the more major sites, there are many smaller thermal areas around the study area that could supply the heating needs of a single residence or small development. Table 21 summarizes the development potential for various applications at 11 of the major resource sites. Based on the information presented in this Area Development Plan, the resources in the study area that appear more appropriate for each type of development have been identified. These are listed below:

Electrical Generation

Beowawe Geysers

Residential-Commercial Space Heating

Klobe Hot Springs
Hot Springs Point
Bruffey's Hot Springs
Buffalo Valley Hot Springs
Spencer Hot Springs
Walti Hot Springs

District Space Heating

None

Recreation

Spencer Hot Springs

Industrial Processing

Beowawe Geysers
Smith Creek Valley Springs
Spencer Hot Springs

Greenhousing

Spencer Hot Springs
Smith Creek Valley Springs

Aquaculture

Hot Springs Ranch
Horseshoe Ranch Springs

Animal Husbandry

Spencer Hot Springs
Buffalo Valley Hot Springs
Hot Springs Point
Walti Hot Springs
Klobe Hot Springs
Bruffey's Hot Springs

There are many different types of benefits to be derived from the development of the geothermal resources in Geothermal Resource Area 6. These include, but are not limited to:

1. Creation of new industry
2. Expanding old industry
3. Creation of new jobs
4. Adding additional spendable income to the region
5. Broadening both the economic and tax base of the region and the state
6. Displacing the use of expensive, diminishing fossil fuels for either direct use or for electrical generation

The development of the geothermal resources located in the study area is thusly considered to be beneficial to the local region, the state, and the nation. For these reasons, such development should be encouraged wherever and whenever possible.

TABLE 21--GEOTHERMAL USE EVALUATION-SUMMARY

Lander and Eureka Counties

Site	Electrical Generation	Space Heating		Recreation	Industrial Process Heat	Agriculture		
		Residential- Commercial	District			Green- Housing	Aqua- culture	Animal Husbandry
LANDER COUNTY								
Spencer Hot Springs	61	187	79	134	229	236	197	240
Smith Creek Valley Springs	145	105	78	79	231	227	196	156
Buffalo Valley Hot Springs	57	185	75	70	134	148	196	229
Hot Springs Ranch	64	103	25	79	139	146	221	152
EUREKA COUNTY								
Beowawe Geysers	237	105	78	52	231	146	194	156
Hot Springs Point	74	187	50	79	112	142	196	223
Walti Hot Springs	49	184	48	70	126	148	195	234
Klobe Hot Springs	66	188	51	70	145	151	194	235
Horseshoe Ranch Springs	57	104	25	80	134	122	224	126
Bruffey's Hot Springs	59	186	79	24	60	155	197	236
Shipley Hot Springs	51	104	24	76	132	154	196	155

VI. ADDITIONAL INFORMATION

Additional information on the occurrence, character, or development of Nevada's geothermal resources may be obtained by writing, calling, or visiting any of the following:

Museum of Natural History
Division of Earth Sciences
255 Bell
Reno, Nevada 89503
(702) 784-6151

Nevada Department of Energy
400 West King Street, Room 106
Carson City, Nevada 89710
(702) 885-5157

Nevada Department of Conservation
and Natural Resources
Nevada Division of Water Resources
201 South Fall Street
Carson City, Nevada 89710
(702) 885-4380

Nevada Bureau of Mines and Geology
University of Nevada-Reno
Reno, Nevada 89557
(702) 784-6691

U.S. Bureau of Land Management
Room 3008, Federal Building
300 Booth Street
Reno, Nevada 89509
(702) 784-5748

U.S. Geological Survey
District Geothermal Office
4600 Kietzke Lane
Reno, Nevada 89502
(702) 784-5676

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Appendix 1A -- Water Chemistry Analyses

Lander County (Parts per Million)

Identification	pH	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS
SPENCER HOT SPRINGS															
Spencer Hot Springs	-	34	0.2	57	188		197	646	12	52	28	-	0	-	208
Spencer Hot Springs	7.4	79	0.13	51	10.2	198	34	684	0	47	26	5.2		0.1	-
Springs	6.5	77	-	43	9.4	200	36	672	1	51	22	4.7	-	.6	-
SMITH CREEK VALLEY															
Well-north	8.4	-	-	42	20	-	-	180	8	74	19	-	-	-	-
Well-south	7.7	110	-	4.8	0.06	170	8.4	246	5	102	22	8.9	-	0.66	-
BUFFALO VALLEY HOT SPRINGS															
Springs	-	117	tr	30	tr		327	761	0	109	34	-	0	-	1032
Spring	6.5	80	-	45	4.9	250	34	813	1	110	29	4.8	-	2.3	-
HOT SPRINGS RANCH															
Spring	8.0	40	-	20	9	118	21	333	-	64	21	-	-	-	-
Spring	7.9	39	0.02	52	7.2	116	20	428	-	62	21	3.9	0.8	0.6	519
Nevada Safe Drinking Water Standards															
			0.03		125					250	250				500

Appendix 1B -- Water Chemistry Analyses

Eureka County
(Parts per Million)

Identification	pH	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS
BEOWAWE GEYSERS															
Nevada Thermal No. 2 Well	9.7	534	-	.8	.2	332	30	39	224	90	49	15	0	2.4	1200
Steam Well	9.9	458	.05	10	0	263	31	0	288	127	62	16	<.1	-	1256
Steam Well	9.4	500	-	1.3	.2	250	38	505	81	64	70	.05	-	2.5	-
Pool below terrace	9.5	373	.04	.8	0	230	16	116	149	89	30	15	.4	2.0	-
HOT SPRINGS POINT															
Crescent Valley Hot Springs	-	73	.03	53	43		319	980	-	117	44	5.9	0	.4	1440
Springs	6.8	72	.04	54	38	277	51	928	0	116	49	6.9	3.3	1.6	-
WALTI HOT SPRINGS															
Springs	6.9	75	.02	60	13	48	15	282	0	62	13	2.4	.1	.17	-
Springs	6.5	68	-	56	12	44	14	264	<1	64	12	2.5	-	.12	-
KLOBE HOT SPRINGS															
Springs	8.5	87	.02	2.2	1.7	6.5	.7	126	10	18	6.5	4	0	.08	-
Springs	9.4	82	.04	10.3	.002	66	1	66.4	40.5	16.2	11	4.8	<.1	-	304
Nevada Safe Drinking Water Standards															
			.03		125					250	250				500

Appendix 1B -- (continued)

Identification	pH	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS
HORSESHOE RANCH SPRINGS															
Springs	7.0	58	-	22	5.8	136	17	378	0	62	27	5.0	-	.81	-
Spring	-	-	-	28	tr	151	-	393	-	60	9	-	-	.9	-
BRUFFEY'S HOT SPRINGS															
Spring	7.0	.58	-	52	16	39	8.7	2.78	0	27	14	.7	.1	.25	-
SHIPLEY HOT SPRINGS															
Springs	7.2	40	.01	57	21	29	5.9	279	0	35	21	.2	0	.26	346
Spring	7.6	30	0	55	21	30	6	288	0	33	17	.5	.6	.1	330
Nevada Safe Drinking Water Standards															
			.03		125					250	250				500

2A. Methodology for Evaluating Geothermal Applications

A major problem in evaluating potential uses of Nevada's geothermal resources is its diverse character. Temperatures range from 60° F. to over 400° F. The total dissolved solids (TDS) found in the geothermal fluid can range from less than 150 parts per million to well over 6,000 parts per million. The resource may have surface discharge points or may be located over 5,000 feet in depth. It may be located in an urban environment or it may be many miles from the nearest community and inaccessible by land vehicles.

In order to develop any method of evaluating geothermal resources the following criteria must be met:

1. The method must be generally applicable.
2. The method must be sufficiently flexible to allow for future data input or changing priorities in resource requirements.
3. The method must be simple and yet produce semi-quantitative results.

To develop the method of evaluating geothermal resources used in this and in similar Area Development Plans, the Nevada Department of Energy borrowed and expanded the method developed by the Nevada Bureau of Mines and Geology. This method describes eight potential geothermal application categories: residential- commercial space heating, district space heating, recreation, electrical generation, industrial process heat, greenhousing, aquaculture, and animal husbandry. Most types of known geothermal applications fit into one of these categories.

Several different parameters can be used to describe the development potential of a particular geothermal resource. These parameters include, but are not limited to:

1. Temperature;
2. Rock type and age;
3. Depth to resource;
4. Population centers nearby;
5. Geophysical data;
6. Water chemistry;

7. Flow rate;
8. Permeability;
9. Recharge;
10. Economics;
11. Structural controls;
12. Environmental considerations; and
13. Land factors such as areal extent, accessibility, and existing land use and zoning.

Although all of these factors influence the development potential of a geothermal resource, data about several of the factors are insufficient to evaluate at this time. For this reason, the decision was made to evaluate only the following parameters in which data are generally available: temperature, water chemistry, land factors, population centers, and depth to the resource. It must be remembered however, that these represent only a portion of the total number of development parameters that make geothermal application successful and as such indicate only the potential of a site. Any actual developer must use this information only for preliminary purposes and must develop more site specific data before any development occurs.

These five parameters are of differing importance to different applications. After consulting with professionals in the specific applications, NDOE staff ranked the parameters according to their relative importance to the application. For example, in the electrical generation industry the temperature of the resource is the prime parameter followed by land factors, depth to resource, water chemistry, and population centers. Each rank is accorded a number based on decreasing powers of three. This method was selected because it preserves the established order of importance. Temperature in the electrical generation industry has a rank of 81 land factors 27; depth to resource 9; water chemistry 3; and population centers 1.

The second step in evaluating the resource is to assign weighting factors to the characteristics of the specific resource. A weighting factor of "2" indicates the most desirable range of the parameter; a weighting factor of "1" is an intermediate factor; and a weighting factor of "0" is considered least desirable. These weighting factors have been tailored for each particular

application. Appendix 2B and 2I illustrate the specific weighting factors assigned to specific resource characteristics for each potential application.

For each particular application all of the parameters are ranked and weighted. The development number for the application is obtained by adding all of the separate products. This number can be used in conjunction with the other seven development numbers to give a relative sequence of development potential. Those applications with the lower development numbers probably would have less potential for successful development than those with higher development numbers.

Appendix 2B - Electrical Generation Weighting Factors

Temperature	
less than 300° F.	0
300° - 350°	1
greater than 350° F.	2

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm

greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds

high	0
moderate	1
low	2

Land Factors--average all three categories for weighting factor

Areal extent--square miles	
less than .5	0
.5 to 1.5	1
greater than 1.5	2

Accessibility--miles from paved road

greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use

not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles

0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet

greater than 7000	0
3500 - 7000	1
0 - 3500	2

Appendix 2C - Residential-Commercial - Space Heating Weighting Factors

Temperature	
less than 86° F.	0
87° - 140° F.	1
140° - 250° F.	2
greater than 250° F.	1

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average all three categories for weighting factor

Areal extent--square miles	
less than .5	0
.5 to 1.5	1
greater than 1.5	2

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2

Appendix 2D - District - Space Heating Weighting Factors

Temperature	
less than 150° F.	0
150° - 200° F.	1
greater than 200° F.	2

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2

Appendix 2E - Recreation Weighting Factors

Temperature	
less than 70° F.	0
70° - 90° F.	1
90° - 200° F..	2
greater than 200° F.	1

Water Chemistry--average both categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 30 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 200	0
100 - 200	1
0 - 100	2

Appendix 2F - Industrial Process Heat Weighting Factors

Temperature	
less than 105° F.	0
106° - 212° F.	1
greater than 212° F.	2

Water Chemistry--average all three
categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average all three categories for weighting factor	
Areal extent--square miles	
less than .5	0
.5 to 1.5	1
greater than 1.5	2

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 7000	0
3500 - 7000	1
0 - 3500	2

Appendix 2G - Greenhousing Weighting Factors

Temperature	
less than 100° F.	0
100° - 200° F.	1
200° - 350° F.	2
greater than 350° F.	1

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2

Appendix 2H - Aquaculture Weighting Factors

Temperature	
less than 70° F.	0
70° - 110° F.	1
110° - 150° F.	2
greater than 150° F.	1
Water Chemistry--average both categories for weighting factor	
pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0
TDS-ppm	
greater than 2000	0
1000 - 2000	1
0 - 1000	2
Land Factors--average both categories for weighting factor	
Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2
Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2
Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2
Depth to Resources---feet	
greater than 400	0
200 - 400	1
0 - 200	2

Appendix 2I - Animal Husbandry Weighting Factors

Temperature	
less than 100° F.	0
100° - 150° F.	1
150° - 250° F.	2
greater than 250° F.	1

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2