A PRELIMINARY PLAN FOR THE DEVELOPMENT OF GEOTHERMAL ENERGY IN THE TOWN OF GABBS, NEVADA

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1.0 INTRODUCTION

Hydrothermal energy or natural hot water has long been used in the town of Gabbs, Nevada, but not for its heat content. Rather, it has been and is the source of the town's domestic water supply. Because Gabbs was known to have this hydrothermal resource underlying it, it was considered to be a prime candidate for development of this alternate energy. As part of its program to assess the geothermal potential, the Nevada Department of Energy contracted with Geothermal Development Associates to prepare a plan for geothermal utilization for the City of Gabbs. To lay the groundwork for a plan, the potential for development is first analyzed, and a set of required procedures identified. This report describes the results of the analyses as well as a plan for geothermal development. It identifies the major findings and specific barriers to development that would have to be addressed.

In Section 2.0 of the report, characteristics of the site significant to the prospect for geothermal development are described. These characteristics include physiography, demography, economy, and the goals and objectives of the citizens as they would relate to geothermal development.

Section 3.0 describes the geothermal resource evaluation. Based on available information, the reservoir is generally described, defining the depth to the reservoir, production rates of the existing water wells, water quality, and the resource temperature.

Uses of the energy that seem appropriate to the situation both now and in the foreseeable future at Gabbs are described in Section 4.0 of the report. The amounts and types of energy currently consumed, by end-user, are estimated. From this information, a conceptual engineering design and cost estimates are presented. Finally in this section, the results of a life cycle analysis of the economic feasibility are discussed. A time-line chart shows the tasks, the time estimated to be required for each and the interrelationships among the activities.

Section 5.0 of the report discusses the essential institutional requirements for geothermal energy development. These include the financial, environmental, legal and regulatory requirements.

The last section of the report summarizes the main resource, engineering, and institutional considerations involved in a geothermal district heating system for Gabbs.

2.0 SITE DESCRIPTION

2.1 Physiography

The City of Gabbs is located in Nye County in central Nevada. It lies between Gabbs Valley to the west and the Paradise Range just to the east. Gentle slopes of 15 percent or less characterize most of the city (Figure 2.1), but the land rises sharply at the eastern municipal boundary, where 30 percent slopes are common. Elevations vary from 4,560 to 4,760 feet in the populated regions, and from 4,530 to 5,600 feet overall (Nevada State Land Use Planning Agency, 1980). Three canyons provide drainage for the city. Each is considered a potential flood hazard, but none directly endangers the inhabited areas (Figure 2.2).

Climatic data have never been officially recorded for Gabbs. The nearest recording station is 40 miles away in Mina. There, 5,082 heating-degree-days are experienced, under slightly milder conditions. January is Gabb's coldest month, with an average high of 46.6°F and an average low of 20.0°F (National Oceanic and Atmospheric Administration, 1978). Precipitation in Gabbs is estimated to be 5 to 6 inches per year (Nevada State Land Use Planning Agency, 1980).

Mineral resources in the region are abundant, with silver, lead, tungsten, fluorspar, iron ore, magnesite and brucite having been commercially mined.

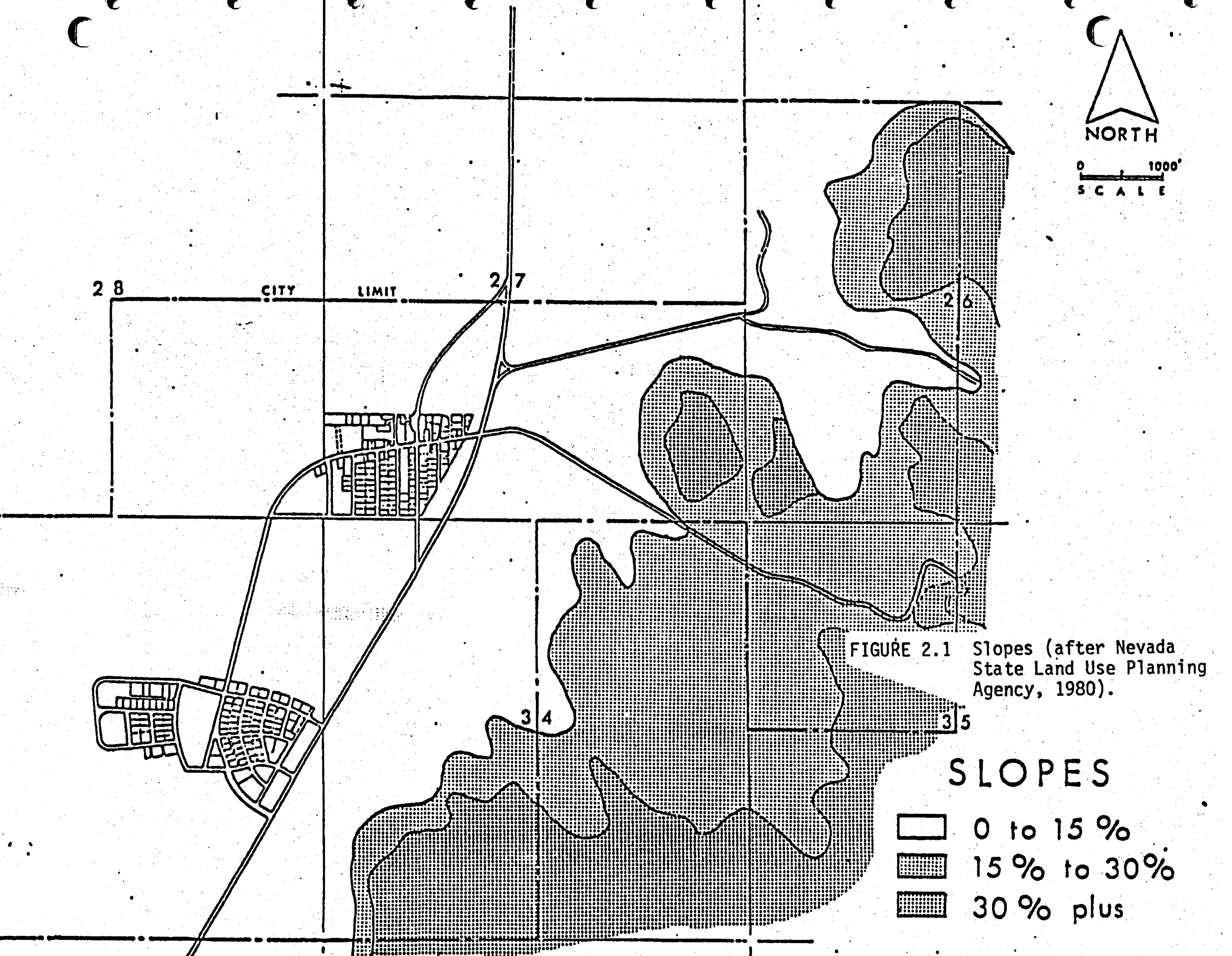

FIGURE 2.1 Slopes (after Nevada State Land Use Planning Agency, 1980).

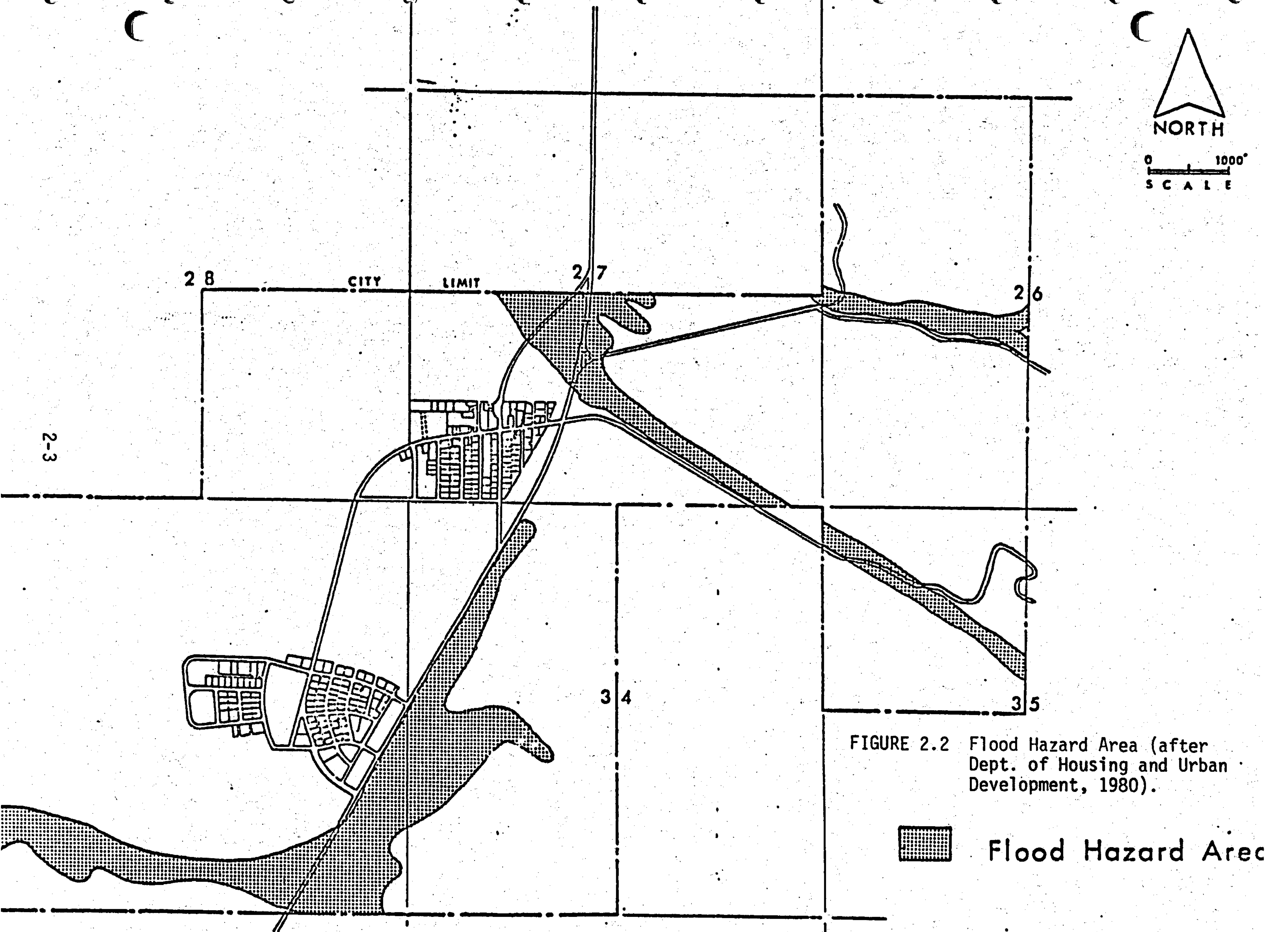

FIGURE 2.2 Flood Hazard Area (after Dept. of Housing and Urban Development, 1980).

2.2 Population

Gabbs was initially settled during the World War II era when emergency mining and milling operations were undertaken by the Federal government to extract magnesium. Basic, Inc. took over the facilities in 1948 and the growing settlement incorporated soon thereafter.

Preliminary 1980 census data shows a population of 809 (U.S. Bureau of the Census, 1980). The median age of the residents is 26.3, and 97 percent are under the age of 65. Fifty-four percent are male. Since about 80 percent of the workforce is employed by Basic, Inc., future population growth will depend largely upon the strength of the company's mining activities. Basic anticipates minor employment increases in the near future due to expanded operations. The proposed MX missile system would bring immigration to the eastern portion of the state, but would not be expected to affect Gabbs directly (Nevada State Land Use Planning Agency, 1980).

2.3 Water System

The city's water system is owned and operated by a subsidiary of Basic, Inc. Users are provided water service at no charge. Six wells are used (Figure 2.3), which have a total capacity of 1,200 gallons per minute

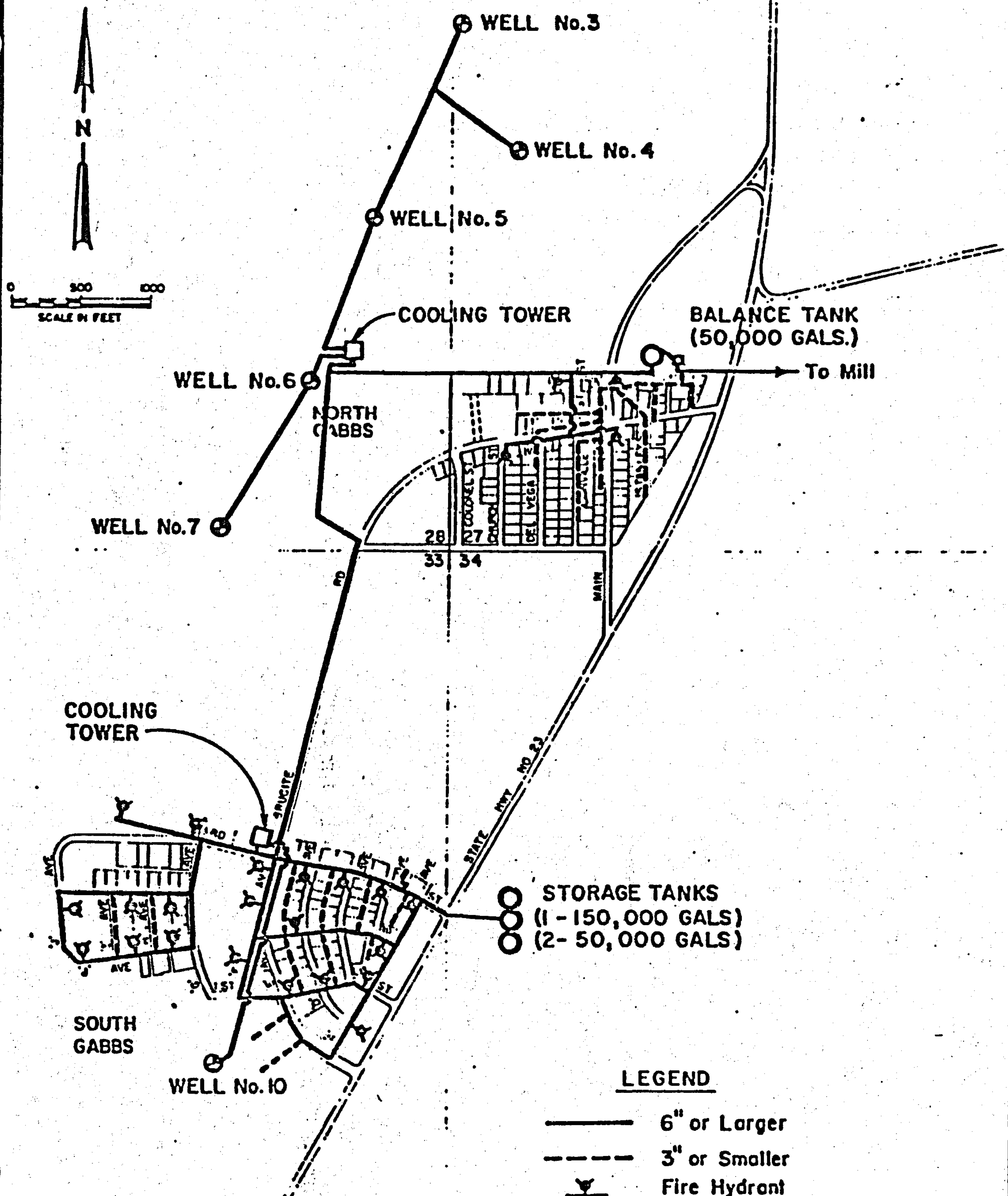

FIGURE 2.3 Existing Water Facilities (after W.F. Pillsburg, Inc., 1979).

(gpm). Basic is the primary user of the system; its peak use is 700 gpm compared to 300 gpm by the community (Pillsbury, 1979). City water use is broken down by month in Table 2.1.

The fluoride content of the city water is considered to be dangerously high. Nevada's standard is 1.8 milligrams per liter (mg/l), but typical concentrations have been 9 to 10 mg/l (Pillsbury, 1979).

High water temperatures have also proven troublesome to the residents. Well temperature readings vary from 118° F to 155°F. Two natural draft cooling towers are used to reduce the temperature to a comfortable level. The North Gabbs tower, with 750 gpm capacity has proven effective, but the 200 gpm South Gabbs tower has not. Tap water temperatures of 110°F are not uncommon in south Gabbs during the summer (Pillsbury, 1979).

2.4 Land Use

Agriculture is non-existent in and around Gabbs largely due to poor soil conditions. Industry consists primarily of the Basic mine and mill near the northeast corner of the city. The commercial district is almost entirely within North Gabbs (Figure 2.4). The road connecting North and South Gabbs is also zoned for business purposes (Figure 2.5). A land use survey conducted in 1979 is shown in Table 2.2. About one-half

TABLE 2.1 Community Monthly Water Consumption for 1978(a) (after W. Pillsbury, Inc. 1979).

	Consumption for Month in Gallons		
	North Gabbs	South Gabbs[b]	Total
January, 1978	1,008,000	1,670,000	2,678,000
February, 1978	1,023,000	1,714,000	2,737,000
March, 1978	1,484,000	2,010,000	3,494,000
April, 1978	1,394,000	2,219,000	3,613,000
May, 1978	1,864,000	4,080,000	5,944,000
June, 1978	2,279,000	6,101,000	8,380,000
July, 1978	2,993,000	6,822,000	9,815,000
August, 1978	3,409,000	7,625,000	11,034,000
September, 1978	2,373,000	3,746,000	6,119,000
October, 1978	2,455,000	4,094,000	6,549,000
November, 1978	2,319,000	2,892,000	5,211,000
December, 1978	1,965,000	4,695,000	6,660,000
TOTAL	24,566,000	47,668,000	72,234,000

(a) All figures based on records kept by Basic.

(b) Figures for South Gabbs are corrected to exclude 12% diversion to Basic and 13% evaporation loss.

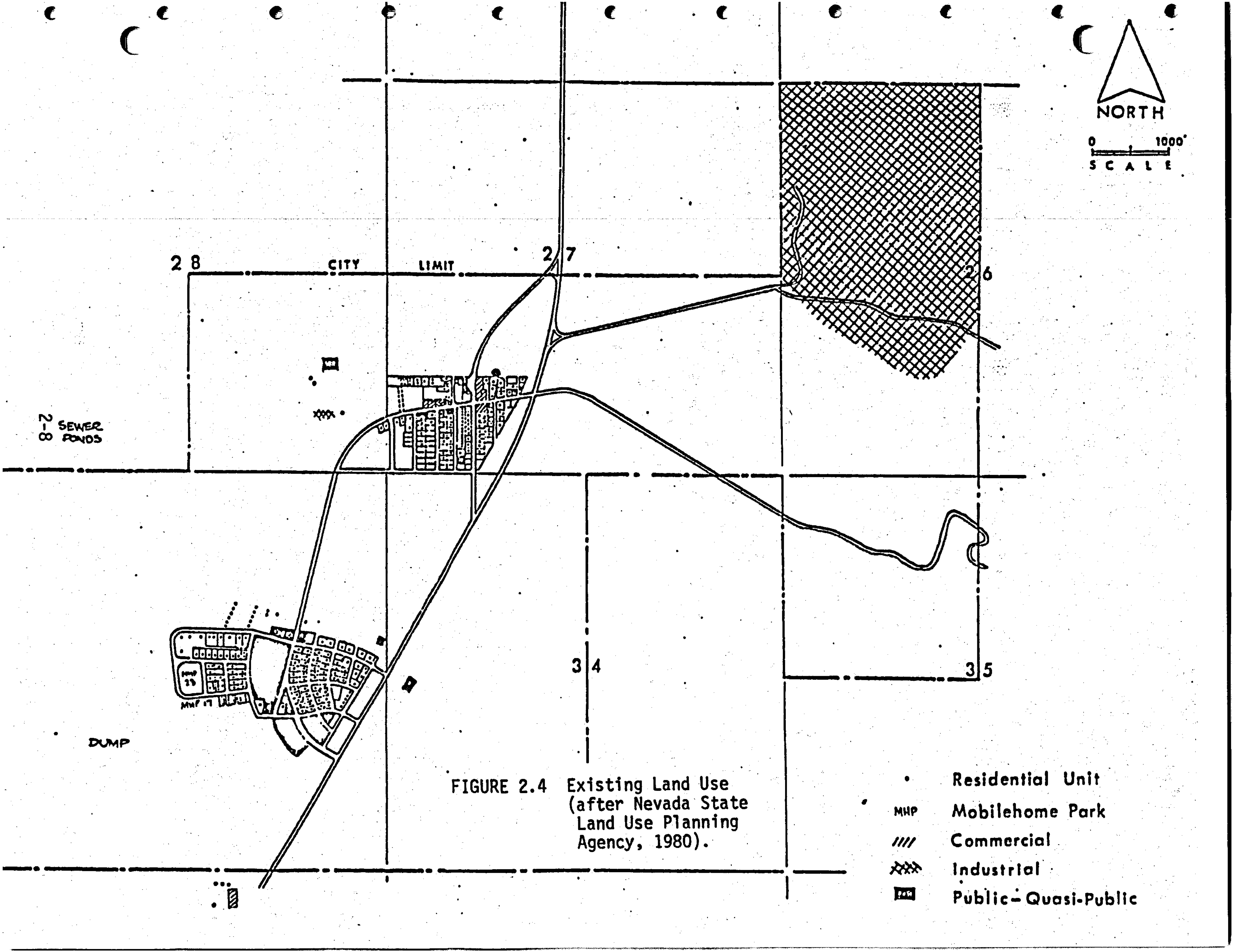

FIGURE 2.4 Existing Land Use (after Nevada State Land Use Planning Agency, 1980).

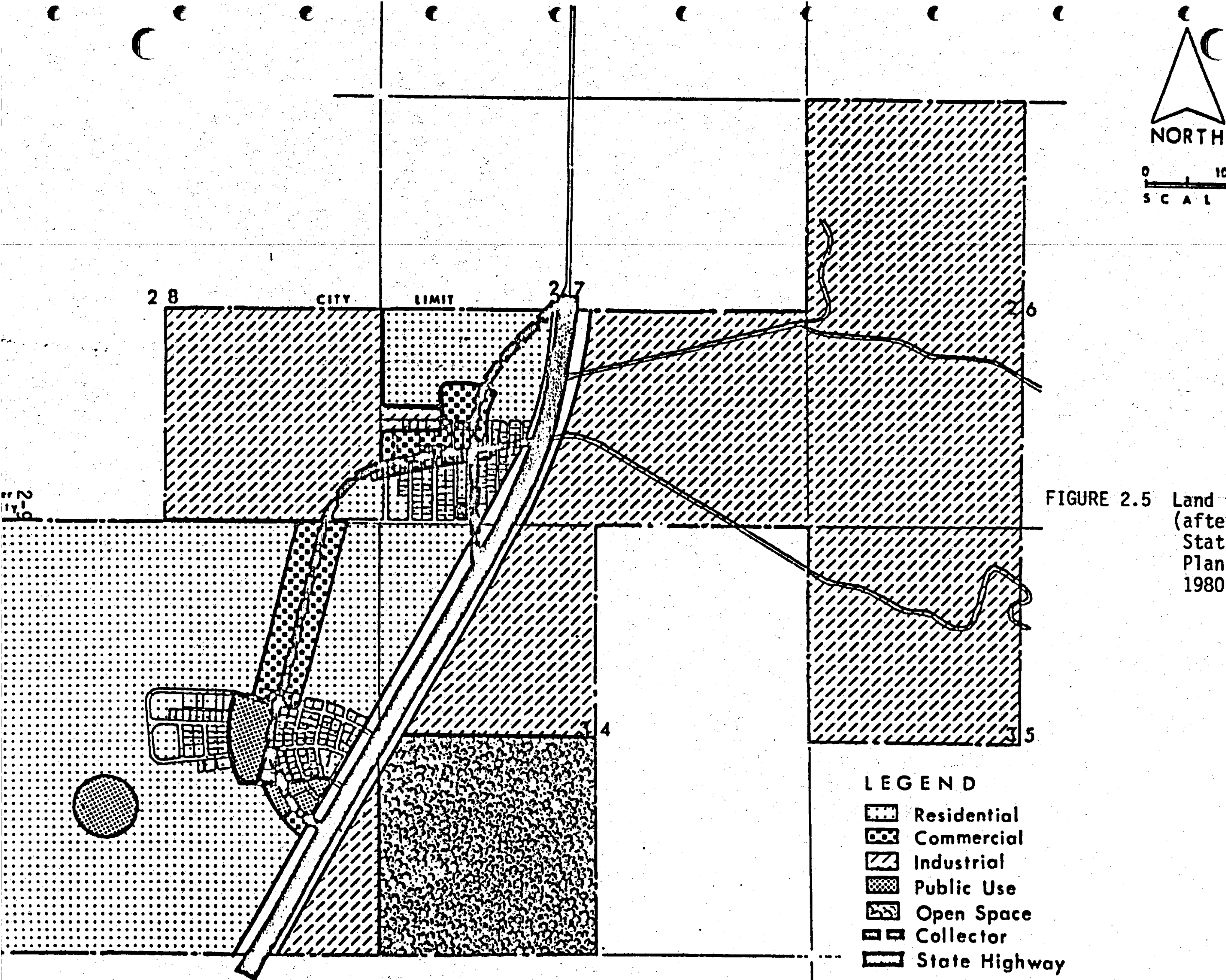

FIGURE 2.5 Land Use Plan (after Nevada State Land Use Planning Agency 1980).

TABLE 2.2 Land Use Survey (after Nevada State Land Use Planning Agency, 1980).

Type of Use	South Gabbs	North Gabbs	Total
Residential units	187	104	291
Churches	2	2	4
Grocery	-	1	1
Service Station	-	1	1
Motel	-	1	1
Cafe	-	1	1
Bar	-	1	1
Bottled water sales	-	1	1
Post Office	-	1	1
City Hall	-	1	1
County Offices	-	1	1
Playground	-	1	1
Elementary School	1	-	1
High School	1	-	1
Doctor's office	1	-	1
Fire Station	1	-	1
Library	1	-	1
VFW	1	-	1
Community building	1	-	1
Community park	1	-	1

NOTE: The preliminary results of the 1980 Census show 303 residential units (U.S. Bureau of the Census, 1980).

of the residential units are mobile homes (Nevada State Land Use Planning Agency, 1980).

South Gabbs is almost entirely owned by Basic, Inc., where it develops the land as needed for its employees (Nevada State Land Use Planning Agency, 1980). Residences in North Gabbs are mostly privately owned.

2.5 Economy

The economy of Gabbs is essentially one-industry based, as indicated by the employment in the City:

	Number of Workers	Percent
Basic, Inc.	300	83
Retail Sales and Service	20-25	6
Government Employment (city, county, Post Office, schools)	30	8
Other	5-10	2
	355	100

Source: Nevada State Land Use Planning Agency, (1980).

Basic, Inc. will soon be increasing employment by about 5 percent (Nevada State Land Use Planning Agency, 1980). As additional workers are employed at Basic and as the mining activity in surrounding areas increases, still more structures, especially residences, will be built. The town could increase in population by an additional 400 persons without undue strain on its land and infrastructure (Nevada State Land Use Planning Agency, 1980). The timing of population growth is not known, although it could occur in the next five years.

Incomes in the community are relatively high, with only two percent of the residents classified as below the poverty level (W. Cuchine, 1980).

The city has no bank, pharmacy, or hardware store, so residents must travel at least 60 miles to obtain these services. This is a loss of the tax base as well as an inconvenience to the community; however, the residents are generally satisfied with the present way of life in Gabbs and are seeking no major changes (Nevada State Land Use Planning Agency, 1980).

Several construction projects are planned. An addition of approximately 6,000 square feet is planned for the Fire House, and across the street, a Nye County complex of about 6,000 square feet. It will accommodate facilities such as the administrative offices of both the city and county, the Sheriff's office, the police station and jail (P. Butler, 1980).

3.0 RESOURCE EVALUATION

3.1 Introduction

The Gabbs geothermal area lies on the eastern edge of the Gabbs Valley hydrographic area. Water wells drilled over the past 40 years for the Gabbs municipal water supply have encountered thermal waters of up to 155°F in the immediate vicinity of the town site. Five miles due north of the Gabbs wells is another well producing 129°F water from alluvium at 243 feet.

3.2 General Geology

Gabbs lies on the eastern edge of Gabbs Valley where it abuts the Paradise Range, which is host to a complex assortment of mineral deposits, the most important being magnesite. Both North and South Gabbs, and the municipal wells, are situated within the low sage -covered Quaternary alluvium within one-half mile of the range front.

3.2.1 Stratigraphy

The core of the Paradise Range (Plate I) consists of Permian, Triassic, and Jurassic sedimentary and volcanic units, including carbonates, greenstone, quartzite, a wide range of silicious clastics, and andesitic flows and tuffs. To the south and east these rock units are covered with

Tertiary lava flows and pyroclastic rocks of dacitic to rhyolitic composition.

Intrusive igneous rocks which range from granites to gabbros, were emplaced largely in the older rocks, from Mesozoic to Tertiary time. The most youthful igneous rocks in the region are andesitic and intermediate composition flows and breccias which are dated as 34 to 7 million years in age (Stewart and Carlson, 1976). A probable caldera of similar age is located in Gabbs Valley with the center of the caldera approximately ten miles west of the town of Gabbs.

Beyond the older bedrock of the range to the east, Quaternary alluvium covers Gabbs Valley. The valley fill of Nevada's intermontane basins consists largely of poorly consolidated, finely -interbedded clays, silts, sands, and gravels of late Tertiary through Quaternary age. In some areas these continental sedimentary strata may include significant volcanic interbeds.

3.2.2 Structure

Although the configuration of Gabbs Valley is not linear in the north-south direction typical of the Nevada Basin and Range, its present form is certainly due to the faulting of this orogenic episode. Vitaliano and Callaghan (1963) mapped a major fault along the western margin of the Paradise Range, 1,000 feet east of the city limits. Additional parallel faults probably lie hidden beneath the alluvium of the valley floor in the town site area.

3.3 Hydrogeology

3.3.1 Ground-water Flow System

Delineation of the hydrologic system is essential in understanding the geothermal potential in the Gabbs area. The ground-water system can be separated into the near-surface alluvial aquifers and the deep underlying bedrock aquifer. The alluvial aquifer's permeability is primarily controlled by its sedimentary structure. Due to compaction, the permeability generally decreases with depth until fractures become chiefly responsible for the transmission of the water. Secondary fracture permeability is indicated in the consolidated bedrock.

The source of recharge for the ground-water system occurs in the mountains as meteroic water which, in part, collects in intermittent streams and infiltrates to the ground-water table through unconsolidated valley deposits and along range front faults. Part of the precipitation enters fractures in the mountains and is transmitted to the valley fill and the deep bedrock aquifer. Eakin (1962) estimated an average annual recharge to the Gabbs Valley of 5,200 acre feet.

Meteoric water deep in the bedrock fractures is heated by the abnormally high crustal heat flow common in the Basin and Range province. In response to the density gradient induced by the increased temperature, the water circulates upward along the range front faults into alluvial aquifers. Once in the alluvium, the thermal water flows outward from the faults into the unconsolidated sands and gravels, and mixes with cooler water. Wells in the Gabbs vicinity are located in the alluvial aquifer.

Natural ground-water discharge occurs where the water table intersects the land surface. In Gabbs Valley there are two such areas. The principal region is the topographically low area of Alkali Flats located in the western part of the valley. The second area, near Gabbs (Plate I, area of evapotranspiration from ground water), is where the water table ordinarily would be expected to be fairly deep. The shallow water table apparently results from the combination of a nearby source of recharge, the Paradise Range, and a dam effect caused by the reduction of transmissibility of the valley fill westward from the mountains. The reduction of transmissibility may be due either to a decrease in the permeability of the valley fill away from the mountain front or to a partial barrier resulting from a constriction or faulting and tilting of the Tertiary valley rocks (Eakin, 1962). The mechanism responsible for this unusual area of discharge has an effect on the geothermal regime since the main body of thermal wells is also located in this region (Plate I).

3.3.2 Ground-water Chemistry

The chemical quality of the thermal water wells reported is relatively uniform with total dissolved solids (TDS) around 700 to 850 ppm (Table 3.1). All of the wells produce water with a high fluoride concentration substantially above Nevada Division of Health standards. Only a trace of arsenic was found in Well No. 10. In the hot springs located 16 miles west of Gabbs, a boron content of 1.6 ppm was reported. Kellys Wells, south of Gabbs (Plate I), also reported a boron content of 0.8 ppm.

The thermal waters are located at a relatively shallow depth and therefore are able to mix with

TABLE 3.1 Water Quality Data

Constituent (a)	Concentration, by Wells (b + d) 3	4	5	6	7	8 (c)	10	(e) 28B1 Holly Well		
TDS	746	702	835	755	770	-	849			
Hardness (f)	58	53	70	63	58	65	80			
Calcium	23	21	28	25	23	19	32			
Magnesium	0	0	0	0	0	4	0			
Sodium	212	199	233	208	213	417	225			
Potassium	6	5	6	6	6		6			
Sulfate	400	375	442	405	405	382	442			
Chloride	34	29	40	29	29	27	35			
Nitrate	0.2	0.0	0.7	0.5	0.0	0.03	0.0			
Alkalinity (f)	30	38	30	28	32		30			
Bicarbonate	12	22	17	15	24		27			
Carbonate	10	10	8	8	6		4			
Fluoride	9.65	9.65	9.25	10.0	10.2	7.45	9.45			
Arsenic	0	0	0	0	0	0	0.005			
Iron	0.05	0.02	0.04	0.01	0.04	0.44	0.07			
Manganese	0.01	0.01	0	0	0	0.0024	0.01			
Color, Units	7	3	3	3	3		3			
Turbidity, Units	0.1	0.1	0.1	0.1	0.1		0.1			
pH, Units	8.43	8.39	8.42	8.40	8.42	8.45	8.33			
Temperature, °F	118	135	145	155	140	70	154	129	COLD	
Well Depth (ft.)	169	341	250	295	575	285	198	296		

(a) all values mg/l unless otherwise noted
(b) based on samples collected 3-27-79
(c) based on samples collected 5-14-75
(d) water quality data obtained from Pillsbury (1979)
(e) water temperature data obtained from Eakin (1962)
(f) $CaCO_3$

cooler subsurface water. Using the molar Na, K, and Ca concentrations, an empirical method of estimating the last temperature of water-rock interactions can be employed (Table 3.2). The results show a relatively uniform source temperature of between 176°F and 185°F.

Chemical geothermometers were developed in rapid flow, high- to moderate-temperature systems (i.e., Yellowstone; Geysers, CA). The Gabbs system is a relatively slow circulating low-temperature system; therefore, caution is advised in placing too much emphasis on the calculated reservoir temperatures. The Na-K-Ca geothermometer is at best a gross indication of the source water temperature.

3.4 Geothermal System

The Gabbs thermal area, as presently delineated, consists of seven municipal water wells, Nos. 3, 4, 5, 6, 7, 8, and 10. They lie in a line from the south end of South Gabbs to a mile and one-quarter northeast of North Gabbs (Plate I). The overall areal dimensions of the zone are two and one-third mile long parallel to the Paradise Range, and up to 700 feet wide in the area of wells 3, 4, and 5. The size of the reservoir is probably many times what is presently known.

TABLE 3.2 Source Temperature of Thermal Waters Using the Empirical Na-K-Ca Geothermometer Method (After Fournier and Truesdell, 1972).

Well No.	Relation Ion Composition(a)			Measured Temp.	Na-K-Ca(c) Geothermometer
	Calcium(b)	Sodium(b)	Potassium(b)		
3	0.000575	0.0092	0.00015	118°F	185°F
4	0.000525	0.0086	0.00013	135°F	176°F
5	0.00070	0.0097	0.00015	145°F	176°F
6	0.000625	0.0090	0.00015	155°F	180°F
7	0.000575	0.0093	0.00015	140°F	178°F
10	0.00080	0.0097	0.00015	154°F	170°F

(a) data from Pillsbury (1979)
(b) all ionic composition expressed in Molal solutions
(c) temperatures can vary upward to ± 15°F

Five miles to the north and equally distant from the main Paradise Range fault, Well 28B1, drilled to 296 feet, has waters of 129°F and stands alone. Only geothermal exploratory temperature gradient holes have been drilled between the two hydrothermal areas. The data from these recently drilled holes is proprietary to Microgeophysics' client company as to whether the two areas are actually one.

The depth to and thickness of the Gabbs reservoir is known only from wells drilled for municipal water. The shallowest well is No. 3 (TD 169 feet) and the deepest is No. 7 (TD 575 feet). The minimum apparent reservoir thickness, based on these wells which are 0.8 miles apart, is 406 feet. Table 3.3 lists the specifications of all the thermal wells and the Holly Well.

The limited delineation of the reservoir by drilling allows only the most conservative characterization of the reservoir volume. The known dimensions are: length, 12,000 feet; width, 700 feet; and thickness, 400 feet. The calculated reservoir volume, energy content, and extractable energy would be grossly misleading at this stage of reservoir confirmation. There is little doubt that the resource can support existing and planned thermal energy demand for space heating and similar uses over a long term.

TABLE 3.3 Well Characteristics

WELL	3 (a)	4 (a)	5 (a)	6 (a)	7 (a)	8 (a)	10 (a)	28B1 (b)	Holly Well (b)
Characteristics									
Depth (ft.)	169	341	250	295	575	285	198	296	189
Casing Size (in.)	8	8	8	8	10	12	16	10.75	6
Ground Elevation (ft.)	4587	4628	4598	4592	4579	4620	4620		4660
Depth to Standing Water (ft.)	67	93	58	49	44	107	51	143	140
Yield, gpm/ft.	-	-	-	-	8.4	36	3.7	-	-
Present Pumping Rate gpm	140	150	130	225	250	-	300	-	-

(a) information obtained from Pillsbury (1979)
(b) information obtained from Eakin (1962)

The present Gabbs wells which produce thermal water were drilled for non-thermal uses. It is unlikely that each of the present wells was drilled in an optimal location within the shallow geothermal reservoir to produce the highest temperatures possible at a reasonable depth. The recommended resource assessment program is designed to locate the range front fault zone which acts as a conduit for the hottest rising waters, which eventually supply the shallow reservoir currently tapped by the Gabbs wells.

The ultimate objective of the program is to provide drilling locations for production wells of high performance - meaning, sustained high temperatures and high flow (pumping) rates. Ideally, the drill sites will permit the intersection of the reservoir at a shallow depth, where it is fed by normal faults.

Successful wells would, in turn, prove to be cost effective in the purchase and installation of the entire district heating system.

3.5 Recommended Geothermal Resource Assessment Program and Estimated Costs

The resource assessment program includes surveys designed to locate optimum drilling locations for a production test well (and subsequent production and injection wells); and the drilling, logging and testing of a single production test well.

analysis to determine optimum flow rate, reservoir temperature, and water chemistry for engineering design.

The total minimum cost for a resource assessment program to the point of development drilling is $50,000 to $75,000. Production test well results and the estimated thermal energy demand for the City of Gabbs will determine the number of production and injection wells necessary for proper development.

3.6 State and Federal Funding Programs

Both the Federal Government and the Nevada State Legislature are concerned with encouraging the development of geothermal resources. Relevant Federal and State funding mechanisms which are currently applicable, are outlined below. The availability of the following listed programs should be verified when the question of funding is addressed.

3.6.1 Geothermal Loan Guaranty Program (GLGP)

The GLGP was created by the Federal government to encourage geothermal energy production by minimizing a lender's financial risk. Guaranteed loans may be used during any project phase from resource assessment through construction and operation. Recent legislation has raised the guaranty from 75 to 90 percent of a project's costs. A loan of this type is limited to $100 million per project or $200 million per borrower.

3.6.2 Small Business Administration (SBA) Loans

SBA loans are available to start, continue or expand businesses in developing, manufacturing, selling, installing or servicing geothermal energy resources. Loans up to $350,000 are made directly; 90 percent of a loan obtained from a private lender, up to $500,000 is guaranteed by SBA. The direct loans generally carry interest rates lower than those in private financial markets but are available only to applicants who are unable to secure private financing or a SBA guaranteed loan.

3.6.3 Farmers Home Administration (FmHA) Loans

While the U.S. FmHA administers several energy research and development loan programs, the Community Facility Loan is of particular interest. This loan may be used to acquire or develop any essential community facility. A geothermal district heating system would be a novel application for this type of loan. Resource assessment, production drilling and facility construction may all be included. Interest rates are especially favorable at five percent.

4.0 GEOTHERMAL RESOURCE APPLICATIONS

This section presents existing applications of the geothermal resource at Gabbs, and proposes some possible future applications. The technical and economic feasibility of the prime future application, district heating, is discussed, and estimates of the delivered cost of energy are given.

4.1 Existing Applications

The geothermal resource at Gabbs is used primarily to supply municipal and industrial water needs rather than energy needs. The geothermal water is pumped from six wells owned by Basic, Inc., to supply industrial process requirements, and also to supply residential and commercial water requirements. Since the water is too hot to be used directly, it is first pumped through cooling towers before being distributed throughout the city. Thus, a considerable amount of thermal energy is wasted in the present mode of operation. Rather than using this energy for space heating in homes and businesses, propane and heating oil are the primary fuels used. Of course, when the City of Gabbs was founded, these fuels were cheap and in plentiful supply. Today however, this is not the case and consideration must be given to the use of locally available alternative energy resources - particularly geothermal.

There is an existing industrial application of geothermal energy at the Basic mill. Flotation cells used for concentration of ores have been found to work more efficiently at warm temperatures (125-130°F). Geothermal water is used in the flotation process to maintain these temperatures. All other process heat requirements at the Basic mill call for very high temperatures. After the flotation cells, the next lowest process temperature requirement is over 1,600°F.

Another application of the geothermal resource which was once tried but abandoned, is that of swimming pool heating. The municipal pool was once heated by means of a heat exchanger which had the hot city water on the primary side and the pool water on the secondary side. The State eliminated this application, however, by ruling that failure of the heat exchanger walls would allow pool water to flow into the city water lines, thereby contaminating the city water. The pool remains unheated to this day and is, therefore, used only in the summer.

4.2 Potential Applications

The potential application which offers the greatest benefit in terms of fossil fuel conservation and reduced energy costs is that of a district heating system for the City of Gabbs. There is no question that the geothermal resource could meet the space heating and domestic water heating loads of the etire city. These loads are summarized in Table 4.1. As shown in the table, the peak heating load for the entire community is approximatly 263.8 therms/hr, or 26.38 million Btuh. This quantity of heat could be supplied by a total flow of approximately 1,320 gpm, assuming an average temperature drop of 40°F throughout the district. The diversity of load patterns typically found in a group of several hundred customers would result in a much smaller peak flow requirement in actual operation.

It is obvious that district heating in Gabbs has tremendous potential. District heating is the only application of the Gabbs resource that offers potential benefit to the entire community. Other applications are of course possible, but none appear to be as good as district heating. For instance, another application of this low temperature resource is space heating for greenhouses. This does not appear to be a good application, however, due to the small local market and the distance involved in transporting the products to larger markets. This same limitation makes any agricultural application unfavorable, including aquaculture. Recreational uses are also very limited because of the small population and remote location. The local swimming pool is the only recreational use that can be recommended. Low temperature electric power generation would be possible, but presently only high

TABLE 4.1 City of Gabbs Space Heating and Domestic Water Heating Peak Loads

-Therms/Hour-

Description	South Gabbs		North Gabbs		Total	
	S.H.	D.W.H.	S.H.	D.W.H.	S.H.	D.W.H.
Houses	52.0	11.7	37.6	8.5	89.6	20.2
Mobil Homes & Trailers	43.5	9.5	25.9	5.6	69.4	15.1
Attached Houses	17.6	3.8	-	-	17.6	3.8
Churches	1.0	0.1	3.0	0.4	4.0	0.5
Schools	19.9	1.6	-	-	19.9	1.6
Library	1.0	0.1	-	-	1.0	0.1
Recreation Center	2.0	0.2	-	-	2.0	0.2
Fire Department	1.0	0.1	-	-	1.0	0.1
Doctor's Office	1.0	0.1	-	-	1.0	0.1
Restaurant	-	-	2.5	0.4	2.5	0.4
Motel (5 units)	-	-	3.3	0.6	3.3	0.6
Gas Station	-	-	1.0	0.1	1.0	0.1
Market	-	-	1.0	0.1	1.0	0.1
Bar	-	-	0.5	0.1	0.5	0.1
City Offices (includes Police)	-	-	1.0	0.1	1.0	0.1
Swimming Pool	-	-	5.5	0.4	5.5	0.4
TOTALS:	139.0	27.2	81.3	16.3	220.3	43.5
	166.2		97.6		263.8	

temperature resources are being considered for this application. Thus, power production is not likely to be a practical application of the Gabbs geothermal resource in the near future.

4.3 Engineering Design

The engineering design for a geothermal district heating system for Gabbs, Nevada, is necessarily based on several assumptions about the geothermal resource and its capacity. These include the following:

a) The quality of the geothermal water supply will be high enough that a heat exchanger at the supply wells will not be required.

b) Three new production wells capable of delivering 500 gallons per minute (gpm) each at approximately 150 F supply water temperature will be drilled in the vicinity of existing Well No. 6, west of Gabbs. These new wells will be about 500 feet deep with a pumping depth of approximately 200 feet.

c) Three injection wells will be drilled to a depth of 500 feet and a maximum of 500 gpm will be injected into each. One of these wells will be located near existing Well No. 6 and the remaining two will be located near existing Well No. 10 (south of South Gabbs).

In the engineering design, as shown on Figure 4.1, the heating supply system consists of a well pump at each of the three production wells with two circulation pumps connected in parallel, a pump at each of the three injection wells, and miscellaneous piping, valves and fittings. Hot water coils are specified for

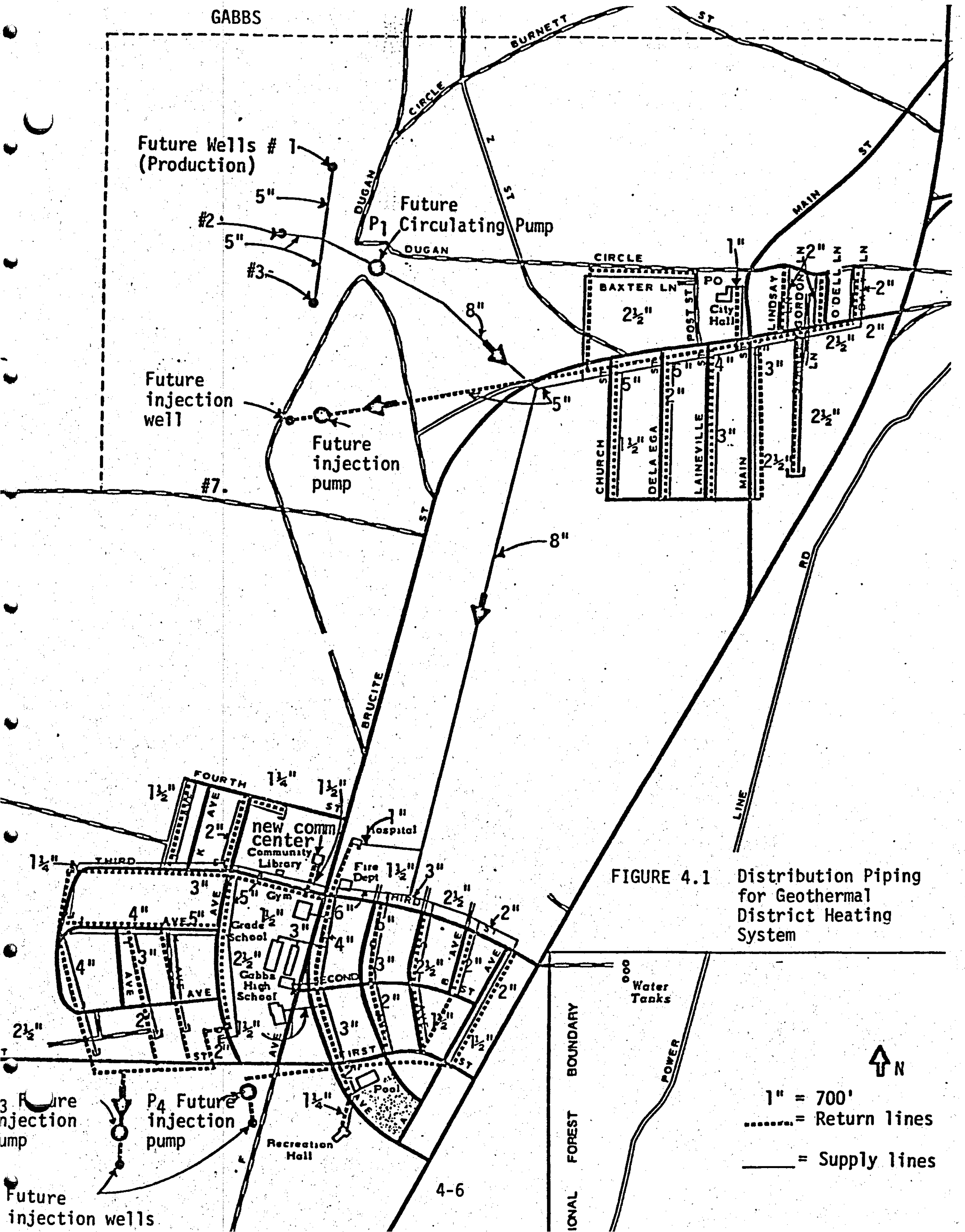

FIGURE 4.1 Distribution Piping for Geothermal District Heating System

retrofitting the forced air heating systems in residential and commercial buildings, and baseboard radiators are specified for retrofitting electrical heating systems in commercial buildings. Domestic hot water tanks with built-in heat exchangers and back-up electrical heating elements are used for retrofitting all domestic hot water systems.

The retrofit design for the forced air heating systems in both the residential and commercial buildings assumes space would be available for the retrofitting. The retrofitting of the forced air systems would be accomplished by modifying the supply ductwork near the furnace to accept a hot water coil(s). The geothermal fluid would flow continuously through the coil. The furnace fan would be shut off. When there was a requirement for space heating, the thermostat would cycle the furnace fan "on", blowing return air over the hot water coils. The air would be heated and circulated through the ductwork to the space. After the space was heated, the thermostat cycles the fan "off".

The retrofitting for electric heating systems requires the installation of a baseboard convection heating system. The hot geothermal water would flow through the baseboard convectors when a valve, controlled by the thermostat, would open to allow flow. The control valve would close when the heating requirements were satisfied. The electric heating system would be reserved for back-up heating.

A new domestic hot water heater with a built-in heat exchanger would replace the existing hot water heaters. The heat exchanger would accept the hot geothermal fluid and transfer heat to the water in the tank. The geothermal water would flow continuously through the heat exchanger in the tank.

When the heating load requirements for space heating are zero, the district heating system would be turned off. It would not be economically feasible to run the heating system pumps just to meet the domestic hot water requirements as they contain an electric heating element.

The retrofits, as designed for the space heating systems, would allow the existing equipment to be used for back-up purposes.

The district heating system was designed to supply the current peak heating load of 263.8 therms/hour (space heat and hot water) and the additional future loads generated by the new fire department building and the new county building. Each of these new buildings was estimated to be approximately 6,000 square feet in size with a peak heating load of 60 Btuh/square foot resulting in an additional peak heating load of 3.6 therms/hour per building. This results in a projected peak heating load of 271 therms/hour, which yields a requirement of 1,355 gpm for the total system. This is based on a temperature drop of 40°F across the hot water coils.

The well pump requirements were estimated to be 500 gpm and 212 feet of head each. This is approximately 47 horsepower per pump. The circulating pump requirements were estimated to be 750 gpm and 240 feet of head each. Two circulating pumps would be used in parallel, rather than using one pump, to provide some back-up in the event that one of the pumps should fail. The circulating pumps are approximately 75 horsepower each. The injection pump requirements were estimated to be 500 gpm each at 212 feet of head each, or 47 horsepower each.

The design criterion for residences for retrofitting was 1.0 therms/hour peak heating, including space heating and domestic hot water requirements. The design criterion for commercial buildings was the average (mean) peak heating load of 21 therms/hour required for both space heating and domestic hot water. The needs of individual commercial buildings would deviate from this value depending on size and individual requirements.

The design criterion for retrofitting electric heating systems for commercial buildings was 1.1 therms/hour peak heating load, based on the library's actual requirement.

To determine the fuel consumption per year (assuming 100 percent propane and no fuel oil), the modified degree day energy estimating calculation was used (ASHRAE 1980 Systems Handbook, Chapter 43). The basic equation is:

$$E = \frac{(H_L)(D.D.)(24)(C_D)}{(\Delta T)(n)(V_H)}$$

where:

E = fuel consumption per year (gallons/year propane)

H_L = design peak thermal load (Btuh). For Gabbs, $H_L = 27.1 \times 10^6$ Btuh (includes new fire department and new community center)

D.D. = number of base 65°F degree days per year. For Gabbs, 6,000 D.D./year

24 = unit is hour/day, converts out degree days

ΔT = design temperature differance = 70°F

n = heating system efficiency. For older propane equipment this approximates 0.70 at best

V_H = heating value of fuel. For propane this averages 91,500 Btu/gallon

C_D = correction factor for heating effect versus degree days. For 6,000 DD/year the mean C_D = 0.62

For Gabbs, calculation of E = 539,643 gallons/year propane. This formula is typically used as a simple means of estimating annual energy consumption when the design peak thermal load is known. It is most accurate for residential buildings with the margin of error increasing with the complexity of the building type. Since the nonresidential buildings in Gabbs are relatively simple municipal/commercial type buildings, this method was deemed to be acceptably accurate.

4.4 Economic Evaluations

4.4.1 Equipment Components and Cost Estimates

The capital improvement cost estimates associated with the engineering design described in Section 4.3 are presented here. Table 4.2 provides a summary of all of the major equipment and expense items for the design and construction of a geothermal district heating for Gabbs. The total capital cost is estimated at $4,149,324, which provides for the geothermal well engineering and construction, the central distribution piping system, and the retrofit of all residential, commercial and community buildings including the two 6,000 square foot buildings that are currently planned by the city and county. This cost also assumes that everything is constructed new and solely for the geothermal district heating system: new wells, new piping, and new retrofits including new domestic hot water heater tanks.

TABLE 4.2 Cost Summary for Geothermal Central Distribution System and Building Retrofits

	Quantity	Cost Each	Total
Well Engineering & Construction			
Geologist (exploration)	6 wells	$ 552	$ 3,312
Geophysical	6 wells	2,217	13,302
Drilling	6 wells	12,500	75,000
Geologist (logging)	6 wells	3,370	20,220
Test pumping-production	3 wells	7,000	21,000
Test pumping-reinjection	3 wells	7,000	21,000
Water quality analysis	3 wells	350	1,050
Coordination, meetings, reports	6 wells	1,600	9,600
Well heat assembly	3 wells	10,000	30,000
			$ 194,484
Distribution Components			
Piping, supply and return	See itemization		$1,845,440
Valves and fittings	10% of piping costs		184,544
Circulating pump w/controls	2 each	$ 7,500	15,000
Well pumps	3 each	18,000	54,000
Reinjection pumps	3 each	6,000	18,000
Reinjection well pipe	600'	29	17,400
			$2,134,384
Retrofit Requirements			
Residence retrofit	287 residences	$ 3,375	$ 968,625
Commercial retrofit (from gas forced air)	20 buildings	6,175	123,500
Commercial retrofit (from electric heat)	1 building	8,201	8,201
			$1,100,326
Subtotal:			$3,429,194
Contingency (10%)			342,919
			$3,772,113
Engineering design and construction management (10%)			377,211
GRAND TOTAL:			$4,149,324

Table 4.3 provides an itemized listing of the distribution piping requirements and costs. Tables 4.4 to 4.6 show itemizations of the retrofit costs for three basic types of buildings in Gabbs: residential, commercial/community with forced air systems, and the electrically-heated library.

The engineering design has taken a very conservative approach, almost a "worst case", in order to avoid presenting a misleading or overly optimistic case. Several changes in the resource or design parameters could significantly reduce the project costs. Some of these possibilities include the following:

a) If the existing geothermal wells were used as either production or injection wells, there would be a savings on well costs.

b) If sufficient flow were generated by one or two new production wells, a third production well would not be required.

c) If return water were used for the proposed municipal water system, the quantity of water that would have to be injected would be minimized and fewer injection wells would be required. Also the water would be precooled for the municipal system.

d) If the requirement for injection were eliminated, there would be no need for the injection wells and pumps.

e) If injection is necessary, it may be possible to eliminate the need for pressurized injection, thus eliminating the need for injection pumps.

TABLE 4.3 Central Distribution System Piping Specifications and Costs

Piping Size	Lineal Footage Required			Unit Cost	Total Cost
	Supply Line	Return Line	Total		
8" Single	4725'	175'	4900'	$73	$ 357,700
6" Single	440'	440'	880'	59	51,920
5" Single	4100'	5500'	9600'	57	547,200
4" Double	2190'	2190'	2190'	83	181,770
3" Double	2515'	2515'	2515'	68	171,020
2½" Double	4410	4410'	4410'	56	246,960
2" Double	4290'	4290'	4290'	46	197,340
1½" Double	2015'	2015'	2015'	38	76,570
1¼" Double	440'	440'	440'	34	14,960
TOTAL:					$1,845,440

TABLE 4.4 Residential Retrofit Specifications and Costs per Residence (for all existing residences; 100,000 Btu/hr heat load)

Component	Specification	Quantity	Unit Cost	Total Cost
Pipe	1" double w/single conduit	50'	$30	$1,500
Valves & fittings				100
Hot water coil	800 CFM/sq.ft., 2 row, aluminum fin	6 sq.ft.		460
Ductwork modification	Labor			250
Hot water tank w/heat exchanger	82 gal., electric heating element			965
Tank installation	Labor			100
TOTAL:				$3,375

TABLE 4.5 Commercial Building Retrofit Specifications and Costs Per Building (for buildings with electric heat systems; 100,000 Btu/hr heat load)

Component	Specification	Quantity	Unit Cost	Total Cost
Baseboard radiator	900 Btu/hr/L.F.	123'	$32	$3,936
Pipe	1" double w/single conduit	100'	30	$3,000
Valves & fittings				200
Hot water tank w/heat exchanger	82 gal., electric heating element			965
Tank installation	Labor			100
TOTAL:				$8,201

TABLE 4.6 Commercial Building Retrofit Specifications and Costs per Building (for buildings with forced air systems; 210,000 Btu/hr heat load)

Component	Specification	Quantity	Unit Cost	Total Cost
Pipe	1¼" double w/single conduit	100'	$34	$3,400
Valves & fittings				300
Hot water coil	800 CFM/sq.ft.	13 sq.ft.	70	910
Ductwork modification	Labor			500
Hot water tank w/heat exchanger	82 gal., electric heating element			965
Tank installation	Labor			100
TOTAL:				$6,175

f) If the geothermal district heating system were installed at the same time a new municipal water system were installed, a cost savings could be realized by utilizing the same trenching for both systems.

g) If the existing domestic hot water heaters were used, in contrast to replacing them with domestic hot water heaters with built-in heat exchangers, significant savings in building retrofit costs would be realized.

4.4.2 Annual Operating and Maintenance Expenses

Annual operating and maintenance expenses have been estimated both for the prospective geothermal district heating system, exclusive of the in-building electrical costs for motors and fans, and for the total existing space and hot water heating fuel costs of all the residential, commercial and community buildings, based upon 1981 electricity and propane costs. Table 4.7 summarizes the various costs. The first year (1981) operating and maintenance costs for the geothermal system are figured at $151,072. The current total fuel and electrical heating costs for the community, all expressed in terms of propane at $8.10/MMBtu, are estimated at $399,956.

TABLE 4.7 Summary of Estimated Annual Operating and Maintenance Costs

Cost Element	Specifications	Total Cost
Geothermal District Heating System		
Electrical Costs:		
Well pumps	3 47HP = 105.0 KW	
Circulating pumps	2 75HP = 111.8 KW	
Reinjection pumps	3 40HP = 89.4 KW	
	306.2 KW*	
Demand charge	$3.00/KW/mo**	$ 919/mo
Energy charge	$0.04014/KWH***	8,972/mo
Deferred energy accounting adjustment	$0.0069863/KWH	1,562/mo
Subtotal:		$ 11,453/mo
Franchise fee (0.75%)		86/mo
Total Monthly:		$ 11,539/mo
Total Annual:*		$ 69,234

* assumes 6 months of continuous operation per year for a monthly electrical consumption of 223,526 KWH.

** assumes Gabbs already pays initial $3,500/month demand charge.

*** assumes Gabbs already pays cost of first 450,000 KWH used per month.

Cost Element	Specifications	Total Cost
Maintenance Costs:		
Wells	4% of $ 194,484	$ 7,779
Pipeline	1% of $1,862,840	18,628
Equipment	2% of $ 271,544	5,431
Subtotal:		$ 31,838
Administrative Costs:	Personnel, insurance and collections	$ 50,000
GRAND TOTAL:		$151,072

TABLE 4.7 Summary of Estimated Annual Operating and Maintenance Costs (Cont'd)

Cost Element	Specifications		Total Cost
	Current Fuel and Electrical Heating Systems		
Propane Equivalent:	539,643 gal/yr 91,500 Btu/gal		
Residential	80% of energy	$0.745/gal	$321,627
Commercial	20% of energy	$0.725/gal	78,248
Total:			$399,875****

**** fuel price equivalent is $8.10/MMBtu.

TABLE 4.8 Baseline Set of Assumed Economic and Financial Factors (applicable for the 30-year period of 1981 to 2010)

Economic/Financial Factor	Annual Escalation Rate
Labor and maintenance	8%
Natural gas, propane and fuel oil	14%
Electricity	10%
Long term commercial interest rates	12%
Municipal bond interest rates	10%
General inflation rate	8%

4.4.3 Economic and Financial Assumptions

Certain economic and financial assumptions have been made in the economic evaluations for Gabbs. Assumptions have to be made because the future cannot be projected with absolute accuracy. Specific values have to be assumed for the escalation rates of fuel electricity prices, escalation rates of labor and maintenance expenses costs of capital for construction, revenue bond interest rates, and the general inflation rates. The baseline set of economic and financial factors assumed this study, is listed in Table 4.8. Values other than those assumed for the baseline set of economic and financial factors are also equally valid, since it is difficult to project the future in today's energy and economic environment. Sensitivity studies can be performed by varying the assumed value of each parameter. This has not been done in this study.

Additional assumptions made for this evaluation include 100 percent financing of the district heating systems through the issuance of revenue bonds by Gabbs, a thirty-year amortization and operation period, and equal annual principal and interest payments on the municipal dept.

The 100 percent financing includes the costs of retrofit for each and every building in the city. It is assumed that the city would bear the initial costs of retrofit for the consumers, but the consumers would acquire ownership of their individual retrofit installations through their monthly utility service payments. If the city were to transfer legal ownership to the building owners at the time of retrofit, it is likely that the owners would be eligible for the various alternative energy device federal tax credits. The consequence of these tax credits would be immediate first year energy savings to the owner occupants.

4.4.4 Life Cycle Cost Analysis

The procedure chosen for the economic evaluation of the Gabbs geothermal district heating system was to calculate actual year to year costs of the geothermal energy and compare them to the costs of propane. Table 4.2 itemizes the component costs for the geothermal system. The year to year escalation factors are incorporated, with maintenance at 8 percent, electrical at 10 percent, and administrative at 8 percent; the first year costs are those identified in Table 4.9. The principal and interest payments on the

TABLE 4.9

ECONOMIC EVALUATION FOR GABBS DISTRICT HEATING SYSTEM
(ESCALATION RATES INDICATED IN PARENTHESES)

YEAR	PRINCIPAL AND INTEREST	MAIN-TENANCE (8%)	ELEC-TRICAL (10%)	ADMIN-ISTRATION (8%)	TOTAL GEOTHERMA, COST	GEOTHERMAL (0%) ($/MMBTU)	PROPANE (14%) ($/MMBTU)	TOTAL PROPANE COST	COST SAVINGS	CUMULATIVE SAVINGS*
1	440160.	31838.	69234.	50000.	591232.	11.97	8.10	399956.	-191276.	-177107.
2	440160.	34385.	76157.	54000.	604702.	12.25	9.23	455947.	-148755.	-127534.
3	440160.	37136.	83773.	58320.	619389.	12.54	10.53	519780.	-99609.	-79073.
4	440160.	40107.	92150.	62986.	635403.	12.87	12.00	592549.	-42854.	-31499.
5	440160.	43315.	101366.	68024.	652865.	13.22	13.68	675506.	22641.	15409.
6	440160.	46780.	111502.	73466.	671909.	13.61	15.60	770077.	98168.	61862.
7	440160.	50523.	122652.	79344.	692679.	14.03	17.78	877887.	185208.	108067.
8	440160.	54565.	134918.	85691.	715334.	14.49	20.27	1000792.	285458.	154224.
9	440160.	58930.	148409.	92547.	740046.	14.99	23.11	1140903.	400857.	200528.
10	440160.	63644.	163250.	99950.	767005.	15.53	26.34	1300629.	533624.	247171.
11	440160.	68736.	179575.	107946.	796417.	16.13	30.03	1482717.	686299.	294342.
12	440160.	74235.	197533.	116582.	828510.	16.78	34.23	1690297.	861788.	342228.
13	440160.	80174.	217286.	125909.	863528.	17.49	39.03	1926939.	1063411.	391014.
14	440160.	86587.	239015.	135981.	901743.	18.26	44.49	2196710.	1294967.	440886.
15	440160.	93514.	262916.	146860.	943450.	19.11	50.72	2504249.	1560799.	492029.
16	440160.	100996.	289208.	158609.	988972.	20.03	57.82	2854844.	1865872.	544630.
17	440160.	109075.	318128.	171297.	1038661.	21.04	65.91	3254522.	2215861.	598878.
18	440160.	117801.	349941.	185001.	1092904.	22.13	75.14	3710155.	2617252.	654964.
19	440160.	127225.	384935.	199801.	1152122.	23.33	85.66	4229577.	3077455.	713083.
20	440160.	137403.	423429.	215785.	1216778.	24.64	97.65	4821718.	3604941.	773433.
21	440160.	148396.	465772.	233048.	1287376.	26.07	111.32	5496759.	4209383.	836218.
22	440160.	160267.	512349.	251692.	1364468.	27.63	126.91	6266305.	4901836.	901646.
23	440160.	173089.	563584.	271827.	1448660.	29.34	144.67	7143587.	5694927.	969932.
24	440160.	186936.	619942.	293573.	1540612.	31.20	164.93	8143689.	6603077.	1041300.
25	440160.	201891.	681937.	317059.	1641047.	33.24	188.02	9283805.	7642758.	1115979.
26	440160.	218042.	750130.	342424.	1750757.	35.46	214.34	10583538.	8832782.	1194207.
27	440160.	235485.	825143.	369818.	1870607.	37.88	244.35	12065233.	10194626.	1276232.
28	440160.	254324.	907658.	399403.	2001546.	40.54	278.56	13754365.	11752820.	1362312.
29	440160.	274670.	998424.	431356.	2144610.	43.43	317.56	15679976.	13535366.	1452716.
30	440160.	296644.	1098266.	465864.	2300934.	46.60	362.01	17875174.	15574240.	1547725.
									108833928.	17315802.

* CUMULATIVE SAVINGS IS THE PRESENT VALUE OF THE ANNUAL COST SAVINGS, DISCOUNTED AT THE ANNUAL RATE OF 8%.

municipal debt for retirement of the revenue bonds are fixed at $440,160 per year. The cost of geothermal energy delivered to the consumer is simply the total of all yearly costs divided by the total annual consumption, which is 539,643 gallons of propane or 49,377 x 10^6 Btu.

The first year cost of geothermal energy is $11.97/MMBtu. It must be compared with only $8.10/MMBtu for propane. Therefore, in the first year, the geothermal system does not appear to be economically competitive.

It is necessary, however, to examine the relative costs of geothermal energy and propane over future years and out through the thirty-year prescribed life of the district heating system. Figure 4.2 shows the comparison very dramatically. Between the fourth and fifth years, the escalated price of propane ($13.68/MMBtu in year 5) overtakes the escalated costs of the geothermal system ($13.22/MMBtu in year 5) and considerable savings start to accrue to the consumers. Between years 7 and 8, the early-year excess expenditures for geothermal energy are fully recovered and significant annual savings accrue thereafter. By year 12, the cost of geothermal ($16.78/MMBtu) is about one-half of the projected price of propane ($34.23/MMBtu).

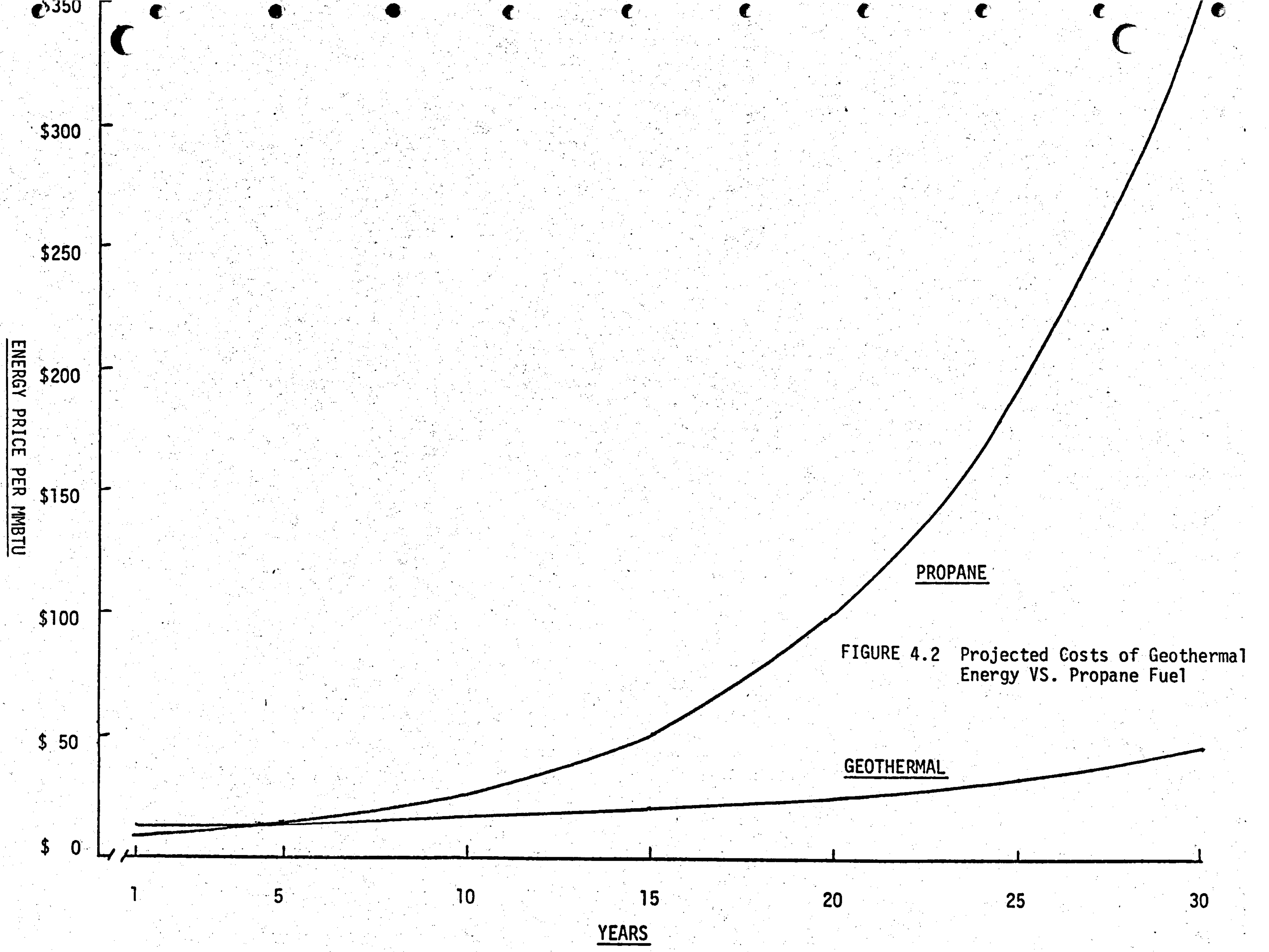

FIGURE 4.2 Projected Costs of Geothermal Energy VS. Propane Fuel

At year 30, the projected price of propane is $362.01/MMBtu compared to geothermal energy at $46.60/MMBtu.

Another significant perspective on the economic advantage of the geothermal district heating system is the comparison of the total dollar savings over 30 years to the consumers. If the cost differential per year is summed over the 30 years, a total dollar savings of $109,147,880 is realized. The present value (1981 value) of those savings is $17,325,760, which is roughly four times the required current capital investment to construct the geothermal system complete with building retrofits.

4.4.5 Taxpayer Tax Credits

Current federal law (Internal Revenue Code, Section 44C, as amended by the Windfall Profits Tax Act, Section 202) provides for a non-refundable tax credit for certain expenditures for equipment and structural components of a building that uses geothermal (renewable) energy. The credit is 40 percent of the renewable energy resource expenditure up to $10,000. To qualify, the equipment must (a) be new and meet performance standards, (b) be reasonably expected to remain in production for at least five years, and (c) be located in the taxpayer's principal residence. The credit may be carried over to future years for equipment purchase prior to December 31, 1985.

The value of this tax credit to each residential taxpayer can be calculated from the estimated retrofit cost per residence of $3,375. Forty percent of $3,375 is $1,350, which is an immediate first year tax savings to the individual taxpayer.

If the $1,350 were applied to the taxpayer's geothermal energy costs in the first year, the effective geothermal energy cost in that year would be substantially reduced and would be less than the cost of an equivalent amount of propane. The average residential building, in this study, is assumed to have a peak heat load of 1.0 therms/hr; this is equivalent to an average annual energy consumption of 182.2 MMBtu. At $11.97/MMBtu for geothermal energy and $8.10/MMBtu for propane, the annual energy costs are $2,181 and $1,476, respectively. Application of the $1,350 tax credit reduces the geothermal energy cost to $831, a savings of $645 over propane for the first year.

The real consequence of the tax credit is that the initial period of time over which the geothermal district heating system provides heating energy to the people of Gabbs at a higher price than propane is reduced from four years to less than two years. Further, in the third year the net additional cost to the taxpayer is only $271; and in the fourth year only $159. Thereafter, the taxpayer realizes direct savings of increasing amounts each year. In the tenth year, the annual savings are $1,970; and in the thirtieth year, the savings are $57,468 per taxpayer, an almost unbelievable number because of escalation factors!

5.0 INSTITUTIONAL REQUIREMENTS FOR GEOTHERMAL DEVELOPMENT

Equally important to the development of geothermal energy as the engineering and economic feasibility is "institutional" feasibility. The financial, environmental, legal and regulatory systems must allow the development. This section of the report describes the requirements for Gabbs for each of these institutional categories.

5.1 Financial Considerations

For many prospective geothermal developments, the need for substantial front-end capital has been a deterrent to development. Even where a very advantageous and clear-cut saving over other fuels can be incurred over the life of an energy system, a new system may not be possible because the funds for initial construction are simply unavailable; or they may be available at too high a penalty in the form of interest payments or in other priority investment opportunities that would be lost.

The types of financing options appropriate for geothermal development depend largely upon the total dollar amount of the project. If a geothermal well is already available and the heating system is one that is easily retrofitted at low cost (e.g. a forced air system), then the cost would not be high. If, at the other end of the spectrum, geothermal development requires an extensive exploration program, a test well, several production wells and injection wells, and buildings are expensive to retrofit (e.g. radiant electric systems), then the front-end costs will be much more. The appropriate financing must, therefore, be based upon the total capital required for development. The primary financing options available for geothermal development are described in this section.

For public agencies, the financing options for geothermal development generally take four forms. These include:

- Budget appropriation
- General obligation bonds
- Revenue bonds
- Assistance programs from another level of government.

5.1.1 Budget Appropriations

If a public agency has sufficient financial means relative to the cost of a geothermal development, a budget appropriation is the easiest and most expeditious means of providing the necessary funds. If a project cost is low or the budget surplus large, this funding form could fit the situation.

5.1.2 General Obligation Bonds

To fund a project that must be paid for over a period of time, general obligation bonds are often used by local governments. A disadvantage to their use in this case is that they encumber the general revenues of the local government.

5.1.3 Revenue Bonds

By issuing revenue bonds, front-end capital can be obtained. The bonds are then repaid from revenues received from the specific activity, without any encumbrance on the government's general revenues. In cases where geothermal development is relatively expensive in terms of front-end capital expenditures for the reasons mentioned previously, the issuance of revenue bonds might be the most desirable financing approach. If desired, the project cost could be amortized over a long enough period of time so that annual costs for the geothermal system would approximate or even be lower than the current operating costs for heat.

The 1981 Nevada Legislature impowered the State Department of Commerce to issue Industrial Development Revenue Bonds for the purpose of financing new construction, improvement, rehabilitation, or development of qualified industrial and commercial projects. Qualified projects include manufacturing, industrial, warehousing, commercial, research and development, health care facilities, and additions to hotels, casinos, motels, apartment buildings, and office buildings.

5.1.4 Assistance from Another Level of Government

Several Federal programs provide financial assistance for alternative energy development. Some of these might be appropriate for financing activities required for converting State-owned buildings to geothermal energy. Those that are most applicable are listed below:

- Program Research and Development Announcement (PRDA)

  This cost-sharing program is also made available by DOE from time to time to conduct economic and engineering feasibility studies. These awards are based on competitive proposals but generally are directed toward geothermal uses that have not previously been studied. Cost sharing by the proposer is required. Interested parties should contact the Department of Energy, Division of Geothermal Energy, for information about upcoming announcements.

- DOE Geothermal Loan Guaranty Program

  Still another DOE program is the Geothermal Loan Guaranty Program. The program will guarantee 100 percent of a loan for up to 75 percent of the project cost for a period of time up to 30 years. The borrower must contribute at least 25 percent of the project cost. A loan guarantee application is submitted to the DOE San Francisco Operations Office.

- HUD-Block Grant Program

  HUD allocates block grants to local governments to pay for community development activities such as district heating/cooling systems. Spending priorities are determined at the local level. Smaller cities, not automatically entitled to funds, may receive funds on a competitive basis.

- Farmers Home Administration Community Facility Loans

  The FmHA program is authorized to make loans to develop community facilities for public use in rural areas and towns not to exceed 10,000 people. Loans are available for public entities such as municipalities, counties, and special purpose districts. Funds may be used to construct, enlarge, extend or improve community facilities that provide essential service to rural residents, and to pay necessary costs connected with such facilities.

There are a number of debt and equity sources in the private sector which may also be considered (Anderson and Lund, 1979), including:

- Commercial banks
- Savings banks
- Savings and loan associations
- Insurance companies
- Trusts and pension funds
- Commercial finance companies
- Personal finance companies
- Mortgage bankers
- Investment banks
- Equity investors
- Small business investment companies
- Leasing companies

5.1.5 Recommended Financing Option for Gabbs

Of the possible funding sources, one seems most applicable to Gabbs. Revenue bonds could be used to finance the wells and the construction. The resource is reasonably well-defined so that drilling bears little risk. Because the community does not fit into the category of "depressed", which is used to select communities for many Federally-funded assistance programs, such programs are of limited value to Gabbs. Revenue bonds could be repaid with monies that otherwise would be used to pay propane bills.

5.2 Legal and Regulatory Requirements

Lands within and adjacent to the most prospective geothermal area are patented mining claims and mill sites, and parcels owned by Basic, Inc. and others. Considerable public acreage is administered by the Bureau of Land Management and the Forest Service.

5.2.1 Leasing Procedures

- Privately Owned Lands

Developers generally enter into contracts with the private owners to explore a property and develop the resources found there for an annual rent or royalty. There are no regulatory constraints as with Federal lands. Each lease must be negotiated separately with the landowner. Generally, these leases name the substances for which the lessee may explore and develop. Most are for a term of 10 years, which is normally time enough for the developer to explore, test, and begin production. The lessee is generally given the right to extend the lease beyond this period if the well remains productive. Royalty rates for geothermal wells average around 10 percent of the value of the energy produced.

- Publicly Owned Lands

Federal lands under the jurisdiction of the Bureau of Land Management are part of the prospective geothermal area. The Geothermal Steam Act of 1970 and the Regulations on Leasing Geothermal Leases allow private and public entities to acquire rights to develop geothermal resources on public lands. A prospective lessee may file a Geothermal Lease Application with BLM for up to 20,480 acres in the State. Presently an applicant must file on all the available Federal acreage in any one section with no more than 2,560 acres in any one lease. Leases run for a primary term of 10 years, with extensions which are dependent upon actively producing geothermal energy from the lease. A ten percent royalty on the value of the energy produced must be paid to the Federal government. For non -producing leases, there is an annual rental of $1.00 per acre per year through the fifth year.

From the sixth year through the tenth year, or until the lease becomes productive, the rental is increased $1.00 per acre per year. Costs of certain types of exploratory and development activity by the lessee are accepted in lieu of the escalating portion of the rentals.

Table 5.1 summarizes the leasing procedures for private lands. The Federal regulatory processes (pre-lease activities) for competitive (not applicable in this area) and non-competitive leasing is illustrated in Figure 5.1. A flow diagram showing required applications and regulatory processes for development on Federal geothermal leases is shown in Figure 5.2.

5.2.2 State Procedures and Regulations for Acquisition of Water Rights

- Application to Appropriate Water.

An application must be filed with the State Engineer, Division of Water Resources. The

TABLE 5.1 Procedures for leasing of private and Nevada State lands

	Actions Required	Time Frame
PRIVATE LANDS	Negotiated between private individuals	Depends on how fast individuals can reach agreement
STATE LANDS	Under aegis of State Land Registrar	
	• Contract between private party and state officials negotiated via Attorney General's Office - all is negotiable	
	• Public notice of contract	Simple press release for five (5) weeks, Notice of Intent
	If challenged could lead to public hearing	Indeterminate time
	If no challenge	Permit can be issued in 1-2 weeks
		A total of nine (9) weeks to several years for State leasing

FIGURE 5.1 GEOTHERMAL REGULATORY PROCESS

(COMPILED FROM GEOTHERMAL STEAM ACT OF 1970, FEDERAL RULES AND REGULATIONS 43 CFR PART 3000 AND 30 CFR PARTS 270 & 271, AND MEMORANDUM OF UNDERSTANDING FOR THE GEOTHERMAL PROGRAM - USGS, BLM, FWS)

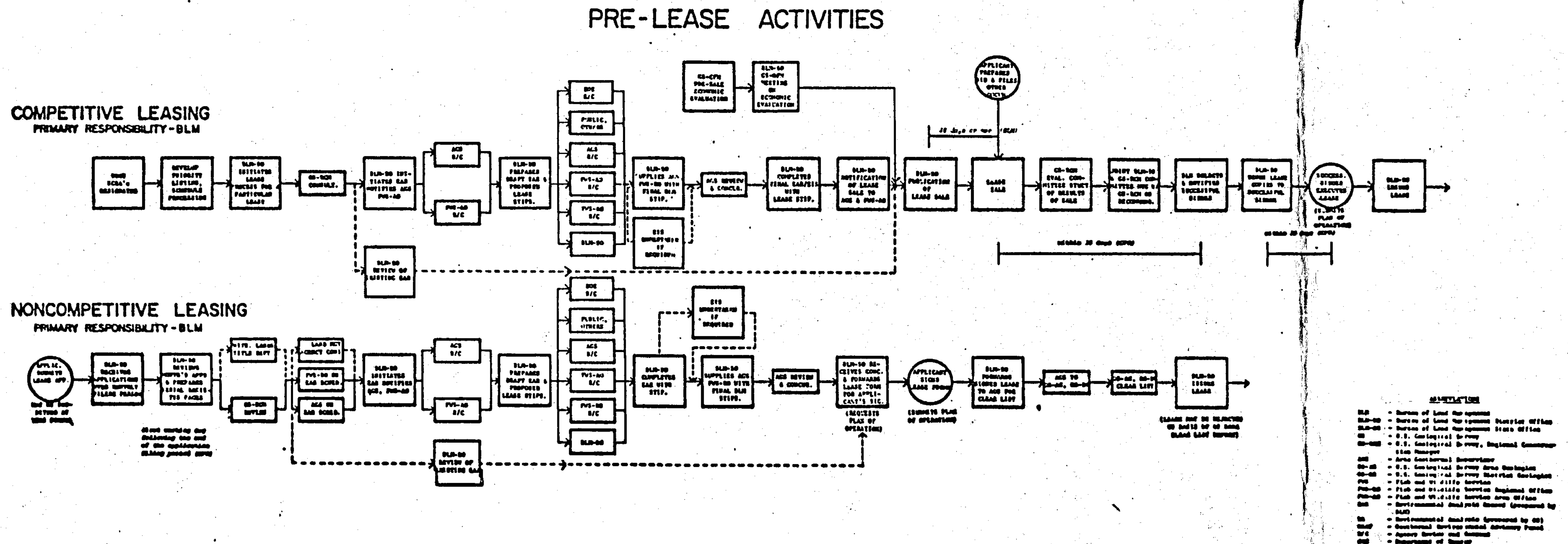

FIGURE 5.2 FLOW DIAGRAM SHOWING REQUIRED APPLICATIONS AND REGULATORY PROCESS FOR DEVELOPMENT ON FEDERAL GEOTHERMAL LEASES

KEY

- Solid box: Applications requiring submittal
- Dashed box: Government regulatory activities
- Oval: Lessee/operator activities

ABBREVIATIONS

AGS - Area Geothermal Supervisor
BLM - Bureau of Land Management
CM-USGS - Conservation Manager-U.S. Geological Survey
DEE - Diligent Exploration Expenditures
EA - Environmental Assessment
GEAP - Geothermal Environmental Advisory Panel
SMA - Surface Managing Agency

NOTES

1. Processing times shown are representative and are based on submittal of a complete application and where no unusual problems develop.
2. GEAP reviews an EA for first operations in an area, or if an unusual environmental problem may result from an operation.

application form should be accompanied by a $100.00 filing fee and a supporting map prepared by a licenced State Water Rights Surveyor.

Notice of an application is published once a week for four weeks in a newspaper with general circulation in the county where the applicant proposes to appropriate water. Formal protests against granting a permit may be filed during this period and up to thirty days after the last date of publication. If no protests have been filed, and if approval will neither impair or injure any prior appropriator, nor be detrimental to the public welfare, the permit will be granted.

If a protest is filed, the State Engineer conducts a field investigation, and if justified, will hold a hearing at which time a determination is made on the application.

Specific dates for the commencement and completion of drilling are established, and proof of beneficial use of water must be filed on a date specified by the State Engineer. There are also additional documents, such as Proof of Completion ($10.00) and Proof of Beneficial Use ($10.00) which are required.

When a water right certificate is granted, perpetual right to the use of a specific amount of water, for a specific purpose, and at a defined site, is guaranteed.

In undesignated basins, such as Gabbs Valley, property owners may drill prior to receiving a permit to appropriate water, but do so at the risk that such a permit may not be obtained.

5.2.3 State Well Drilling and Completion Regulations

- Notice of Intention to Drill

  This document is required by the State Engineer's Office prior to drilling, deepening, or repairing a well.

- Waiver of Well Drilling Regulations

  A request to waive any well drilling regulations may be made in writing to the State Engineer's Office and will be considered if good cause is shown. Approval or denial of the request is made in writing to the well owner.

- General Construction Regulations

  Regulations have been determined by the State Engineer for casing, sealing, and other materials to be used in drilling a well. All wells must be cased and constructed so that no contamination can occur because of surface conditions. In addition, permits issued to appropriate ground water for irrigation, municipal and industrial purposes, require the driller to provide an opening near the top of the casing at least two inches in diameter so a measuring device can be inserted to measure the distance to the water surface.

- Well Log

When drilling a water well, a log is required for the State Engineer's Office. The log includes:

1. Well location and ownership
2. Driller and drill rig type
3. Rock strata penetrated; thickness and depth
4. Water-bearing zones
5. Test results
6. Water level and temperature
7. Well design and completion description

5.2.4 Other State Permits and Certificates

A water Pollution Control Permit will be necessary for disposal of the geothermal water by:

- Well injection,
- Infiltration trenches
- Evaporation ponds, or
- Surface discharge

The Water Pollution Control Section of the Nevada Division of Environmental Protection issues these permits. The basic information requested by the agency pertains to the: supply rates, water quality, use of the water, and mode of disposal. Ninety to 120 days is the normal time for processing applications. The cost is $100.00 for a single discharge (injection well) location. If more than one well is used in the immediate area, $25.00 is charged for each additional discharge point.

Injection of the geothermal water must be made into geologic formations which have water of similar quality to the injected water.

The district heating alternatives described in this study are all closed-loop systems, which do not deal with extraordinary or potentially deleterious fluids, gases, or temperatures. It will not be necessary to obtain permits which regulate or control air quality, noise, or land disturbance.

5.2.5 City Permits

A building permit is required for any structures constructed and for mobile home installation. Buildings must conform to uniform construction, wiring, and plumbing codes. Applications for a building permit may be obtained from the Gabbs City Clerk. The permits are normally issued within one or two days.

5.2.6 Public Utility Regulation

Under the jurisdiction of the Public Service Commission, geothermal resource developers will be regulated as public utilities only if they sell heat, water or power. There are two exceptions:

1. Municipalities which construct, lease, operate, or maintain energy facilities do not need the commission's approval, but are under their general jurisdiction.

2. Geothermal General Improvement Districts were established by the 1979 Nevada State Legislature. GID's may develop geothermal resources and provide heat without utility regulation.

   A General Improvement District (as outlined in NRS 318) can be established to develop natural resources to furnish space heating.

   The forming of a GID is initiated by either a resolution by the County Commissioners or a petition by any property owner in the proposed GID.

A statement requesting the ordinance creating a GID will show that the district is:

a. A Public convenience and necessity,

b. Economically sound and feasible,

and include a Service Plan showing - a financial survey; preliminary engineering or architectural survey for services to be provided and financed; map of proposed GID showing boundaries, population and assessed value; describe facilities to be provided and an estimate of costs. The Service Plan processing fee is $200. The fee is waived if the request for the GID is made by the County Commissioners.

A hearing will be scheduled on the creation of the GID. The County Clerk will mail written notice to all property owners within the GID. Any property owner within the district may protest against the establishment of the GID. If a majority of property owners file a signed written protest, the district is automatically not established. If a majority of property owners do not file a protest, the County Commissioners will decide at the hearing if a GID will be established. Appeals may be made within 30 days of the County Commissioners decision.

After establishing a GID the County Commissioners act as a temporary Board of Trustees setting up:

a. Accounting practices and procedures.

b. Auditing practices and procedures.

c. Budget.

d. Management standards.

The County Commissioners shall appoint five members to the Board of Trustees to oversee the GID.

The GID can be paid for by a general tax on property in the district, bonds, borrowing from the State of Federal Government, or special assessments.

5.3 Environmental Considerations

Geothermal resources are a relatively benign source of energy. Available information was reviewed to identify any significant environmental problems that would be likely to occur at Gabbs as a result of geothermal development.

5.3.1 Water

Water quality is the primary environmental consideration in hydrothermal energy development. The mineral content tends to be higher than ordinary ground water, and certain elements may be present that are harmful to humans, animals, and/or plant life. Prevention of pollution by chemicals in the geothermal fluid in a district heating system can be accomplished by several means:

1. Chemical treatment of the fluid to change the chemical composition.
2. Removal of selected elements.
3. Confinement of the geothermal fluid in a closed system.

After the heat has been extracted from the geothermal fluid, it may either be injected into the geothermal reservoir by means of disposal wells, or water quality permitting, it may be disposed of at the surface. The manner of disposal must be approved by the Nevada Division of Environmental Control.

5.3.2 Air

A closed-loop district heating system such as the one proposed for Gabbs would not allow any noxious gases, which might be present in the geothermal fluid, to be emitted. Hydrogen sulphide is the most noticeable gas generally associated with geothermal waters, but is normally in higher temperature systems.

Dust from vehicular traffic and construction activity may also pollute the air temporarily. Preventing this requires little more than sprinkling water during such activities. The State Air Quality Control Division is charged with assuring that air quality standards are met, and with issuing permits for discharging pollutants into the air.

5.3.3 Land

Land subsidence may occur with the long-term removal of geothermal fluids from the geologic formations (the reservoir) at depth. This phenomena is dependent upon the character of the formations, and the quantity, and rate of fluid removal. The likelihood of subsidence can be anticipated to a large extent, from previous experience in the area, where water wells have been producing. A usual preventive measure is to inject the fluid back into the same reservoir.

It is possible that injection of geothermal fluids could stimulate seismic (earthquake) activity. Considering the shallow depth of injection, this does not seem likely to happen.

Soil erosion from construction and vehicular traffic would be no more detrimental to the environment than a well and distribution system for cold water.

5.3.4 Noise

Although noise has been a problem at The Geysers power generation site in California, because of steam being vented to the atmosphere periodically, hot water in a closed-loop system at Gabbs would be essentially noise-free. The most significant noise problem would be the short-lived drilling of the production and injection wells.

5.3.5 Ecological Relationships

The area likely to be affected by the well sites and the distribution system, outside of the immediate townsite, has little cultivated vegetation. The natural vegetation which would be disturbed in limited areas is largely low-growing sage and grasses.

The long-term impact on the indigenous wildlife present on the periphery of the community would be essentially nil, since most of the system would be buried.

5.3.6 Water Availability

The availability of water is a key concern surrounding geothermal resource development in all Nevada basins. Removal of thermal waters would not be allowed if it constitutes a threat to prior water appropriations. In the case of Gabbs, injection of fluids would constitute non-consumptive use.

5.3.7 Socio-Economic Impacts

Because of Gabbs' limited work force, construction crews would probably be brought in for most of the well drilling, pipeline construction, and facilities retrofit. Since the town is somewhat remote, the workers might prefer to live near the construction site, rather than commuting. If so, a number of temporary housing units (mobile homes and recreation vehicles) could be located in the area.

6.0 DEVELOPMENT PLAN

To develop geothermal energy requires a number of different types of activities. One necessary activity is to arrange funding for the capital costs of development. This may be in the form of a direct front-end allocation from existing savings or budget surplus, or it may be in the form of a grant or a loan to be repaid over time.

Another necessary activity is the drilling of the geothermal wells. If insufficient resource and reservoir information is available, then an exploration program must be conducted prior to well development. An exploration program can include geologic, geophysical, and temperature gradient hole surveys, leading to a production test well.

Once the resource is proven, techniques for using it must be chosen. Final engineering designs will take into account the amount of fluid available, its quality and temperature. The number of wells required to fit the energy demand will depend upon these resource parameters. Pumps will be required unless the resource is artesian - that is, flowing under its own pressure. The materials for the system will be selected to be compatible with the particular minerals in the fluid.

After the engineering design is completed and cost estimates are made, then bid documents can be prepared, bids solicited and a contractor selected. Then, the buildings can be retrofitted, pumps, heat exchangers or other such equipment installed and pipelines constructed.

Prior to each step in the resource development and engineering process, the necessary legal steps must be taken. For geothermal development, either outright ownership or geothermal leases are needed, both for the surface to be used, and for the mineral and/or water rights, as dictated by the site ownership characteristics. Certain permits and licenses are required, also as dictated by the site characteristics. In order to determine these permit requirements and the general acceptability of a project, an appraisal of the environmental conditions at a particular site is required. The following pages describe each of the primary development activities specific to Gabbs. A timeline chart shows all of the various activities required, the approximate time required for each, and the relationship of these activities to each other.

6.1 Financing

Formation of a geothermal General Improvement District, described above in 5.2.6 Public Utility Regulation, appears to provide a good avenue for the city to develop the resource to furnish energy for space heating, without utility regulation.

Before any project such as a geothermal district heating system project at Gabbs can begin, developers need to be assured that they can pay for it. After the first well is drilled and the engineering design and cost estimates are completed, revenue bonds could be issued to complete the project. Although the bond issuance program can vary enormously, for the purposes of this study, it is assumed to require six weeks.

6.2 Resource Exploration and Production

Before drilling geothermal production wells at Gabbs, appropriate sites must be selected. A geological investigation and geophysical surveys constitute an exploration program that will add to the available information to allow the site to be selected. Such an exploration program would require about three months to complete.

Once the well sites have been selected, bid documents can be issued, bids accepted and a contractor selected. Then the drilling can begin. Although difficulties in the contracting process (such as a shortage of available drilling rigs) or in the drilling itself, could cause the drilling to take much longer, a six month period is estimated for the time required for issuing requests for bids, contracting, and drilling the wells.

Prior to drilling for geothermal energy where either the surface or mineral rights or both are federal, geothermal leases would be needed. Within the city limits there are Federal lands administered by the U.S. Forest Service, patented mining claims, and other fee land. Depending upon the specific drilling site, either Federal leases or negotiation with the owners of the mining claims (e.g. Basic, Inc.) for geothermal rights might be necessary.

Several permits are also needed prior to drilling. A water appropriation application should be filed with the Nevada State Engineer, along with a Notice of Intent to Drill. The existing wells and accompanying water rights in Gabbs are owned by Basic, Inc. Any subsequent wells would not be allowed to affect the prior rights of Basic. However, if there is sufficient water available to be tapped, water rights could be appropriated. A fluid discharge permit will also be required from the Nevada Division of Environmental Protection in order to inject the spent geothermal fluids into injection wells.

Following the well drilling, after proper publication of the application to appropriate water and the protest filing period has passed, the water rights certificate can be granted.

6.3 Engineering Design

Final engineering design would be needed to include the actual geothermal resource characteristics discovered in the well drilling process and to develop component specifications. A similar process to that for selection of a drilling contractor would be required in order to select an engineering firm to do this work. Then, the engineering design would be prepared, along with cost estimates. To select the design contractor, complete the final design and prepare bid documents is estimated to take nine months.

A contractor would then be selected. Before the construction work can begin, a building permit is necessary for retrofitting the building heating systems.

6.4 Construction

A system would be constructed according to the final design. Basically, this system would have pumps installed at each of the three production wells and at each of the three injection wells at the locations shown on the map, Figure 4.1. A distribution pipeline would be installed along existing streets.

Hot water coils would be installed in the existing forced air furnaces in residences and commercial buildings. Baseboard systems would be installed in the remaining structures. New hot water tanks with heat exchangers would be installed. Construction, including the bid process is estimated to require seven months. At the end of this phase, the system would be tested and put into operation.

The development plan, outlined in Table 6.1, shows that the entire geothermal development at Gabbs could be accomplished in two and one-half years, assuming that each of the tasks can be completed in a timely manner.

TABLE 6.1 Geothermal Development Plan for Gabbs

TASK	Duration of Task (months)	Project Milestone (month)
1. Secure funding for development of resource (assume private funds)	3	1st - 3rd
2. Apply for and secure geothermal resource rights; lease: private	1	1st
federal	12	1st - 12th
3. Exploration of the geothermal resource		
(a) Select contractor(s)	1.5	2nd - 3rd
(b) Conduct exploration surveys: geological, geophysical, temperature gradient holes	3	4th - 6th
(c) Evaluate survey results: select production and injection well sites; well specifications	1	7th
4. Drilling permits (temporary waiver)	0.5	8th
5. Obtain water appropriation	2 - 4	8th - 10th (or 12th)
6. Development of the geothermal resource: drill production well(s) and injection well(s)		
(a) Select drilling contractor	1.5	8th - 9th
(b) Drill, survey, pump test, and evaluate wells; complete wells	1 - 3	10th - 13th
7. District heating engineering design		
(a) Select design contractor(s)	1	14th
(b) Final design and cost estimates	6	15th - 20th
(c) Bid document preparation	2	20th - 21st

8.	Permits		
	•Air quality permit	1	22nd
	•Land disturbance permit	0.5	22nd
	•Registration certificate and Operating permit	1 - 3	22nd - 24th?
	•Fluid discharge permit	3 - 4	22nd - 24th (or 25th)
9.	Issue revenue bonds	1	22nd
10.	District heating system construction		
	(a) Select contractors	1	23rd
	(b) Construct wellhead and distribution system	6	24th - 29th
	(c) Retrofit buildings	6	24th - 29th
11.	Test the district heating system	1	30th

7.0 SUMMARY

Gabbs is a mining community of approximately 800 people, located in the northwestern corner of Nye County, Nevada. Basic, Inc., a magnesite and brucite mining and processing company, accounts for 83 percent of the town's employment.

A subsidiary of Basic supplies water to the city as well as to the parent company, which is the primary user of the system. There are seven municipal water wells of up to 575 feet in depth which partially delineate the geothermal reservior over a distance of 12,000 feet in length and a width of up to 700 feet. Recorded well temperatures are 70° to 155°F in the near-surface environment where mixing with cooler meteoric water occurs. The source temperature of these thermal waters is calculated to be 170° to 185°F using the empirical Na-K-Ca geothermometer method. A definitive geothermal resource assessment program is recommended to delineate optimum locations for production and injection wells for a district space heating system.

The geothermal resource is currently used to supply municipal and industrial water needs rather than energy needs. The water is first passed through cooling towers prior to distribution to the users. The only existing thermal application of the water (125 -130°F) is in the flotation cells for concentration of the magnesite ores.

The potential application which offers the greatest benefit in fossil fuel conservation and reduced energy costs is that of a district heating system for the city. The resource would easily meet space heating and domestic water heating loads of the town which are approximately 263.8 therms/hour or 26.38 million Btuh peak. This demand could be met by a total flow of approximately 1,320 gpm, assuming an average temperature drop of 40°F throughout the district.

Engineering design for the geothermal district heating system as outlined assumes that the water chemistry will not necessitate heat exchangers; and that there will be three production wells each delivering 500 gpm of 150°F supply water and three injection wells.

Retrofit of forced air and electric heating systems and domestic hot water heaters is designed to supply the current peak heating load of 263.8 therms/hour, as well as the future loads of the fire department and county buildings. The capital improvement cost estimates associated with engineering design is estimated at $4,149,320 for well engineering and construction, the central distribution piping system, and retrofit of all residential, commercial and community buildings including two 6,000 square foot buildings currently planned by the city and county.

Annual operating and maintenance costs for the geothermal district heating system are estimated to be $152,246 during the first year (1981), versus $399,956 for fuel and electrical heating costs for the current system. Economic and financial assumptions for the life cycle analysis of the district system provide for annual escalation rates for labor and maintenance at 8 percent; natural gas, propane, and fuel oil, 14 percent; electricity, 10 percent; long term commercial interest rates, 12 percent; municipal bond interest rates, 10 percent; and general inflation rate, 8 percent. Financing would be 100 percent through issuance of revenue bonds by Gabbs, with a 30 year amortization and operation period. Payments for retirement of the revenue bonds are fixed at $440,160 per year. The cost of geothermal energy delivered to the consumer is simply the total of all yearly costs divided by the total annual consumption, which is 539,643 gallons of propane or 49,377 x 10^6 Btu.

Between the fourth and fifth years, the escalated price of propane ($13.68/MMBtu in year five) overtakes the escalated costs of the geothermal system ($13.26/MMBtu in year five) and considerable savings start to accrue to the consumers. By year 12, the cost of geothermal is fully one-half of the projected price of propane. If the cost differential per year is summed over the 30 years, a total dollar savings of $108,218,102 is realized. The present value (1981 value) of those savings is $17,275,410, which is four times the required capital investment to construct the geothermal system complete with building retrofits.

Tax credits of 40 percent of the renewable energy resource expenditure up to $10,000 will provide an estimated tax savings of $1,350 during the first year to the individual homeowner. The real consequence of the tax credit is that the initial period of time over which the geothermal district heating system provides heating energy at a higher price than propane is reduced from four years to one and one-half years.

The financial, environmental, legal and regulatory systems will allow for this development to proceed with no difficult impediments. Revenue bonds appear to be the most desirable method of financing because of high front-end costs. Several Federal and State assistance programs are available for support of such a project.

The primary development activities specific to Gabbs are financing, resource exploration and production, engineering design, and construction. Considering the necessary legal steps and environmental conditions which must be addressed throughout the project, the estimated overall time for completion would be somewhat over two years.

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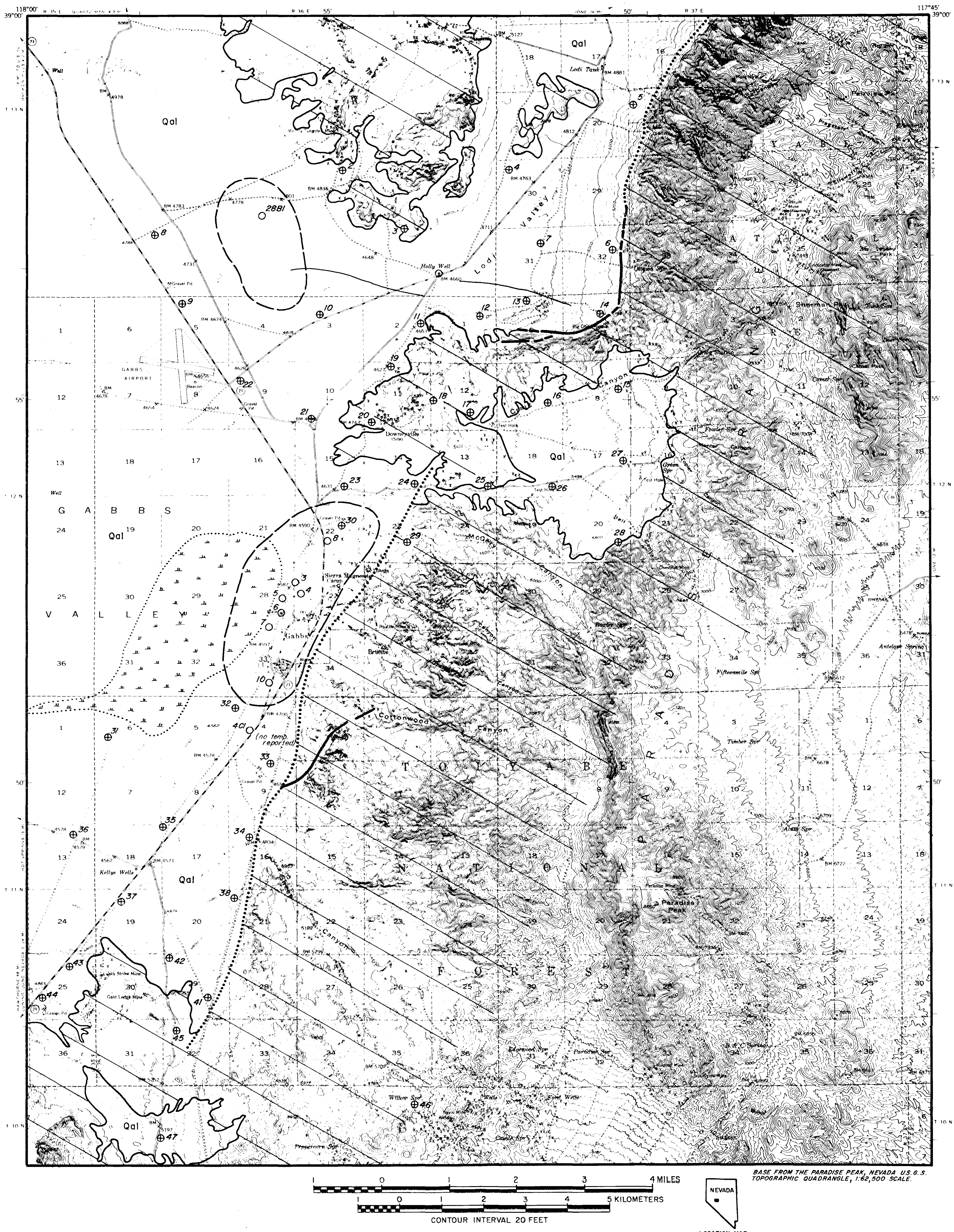

EXPLANATION

- Qal — VALLEY FILL OR ALLUVIUM
- AREA OF BEDROCK
- FAULT, DASHED WHERE APPROXIMATE, DOTTED WHERE CONCEALED
- CONTACT
- LINEATIONS OBSERVED FROM AERIAL PHOTOGRAPHS
- KNOWN THERMAL ZONES AT A DEPTH <600 FEET
- AREA OF EVAPOTRANSPIRATION FROM GROUNDWATER
- ○8 THERMAL WATER WELLS, >70°F
- ⊙8 COOL WATER WELLS, <70°F
- ⊕8 SHALLOW TEMPERATURE GRADIENT HOLE, DRILLED BY: *MICROGEOGRAPHICS* (Information not availabe)

N

PLATE 1

GEOTHERMAL DEVELOPMENT ASSOCIATES
235 RALSTON STREET RENO, NEVADA 89503 (702) 322-0938

GEOTHERMAL RESOURCE MAP OF GABBS AND VICINITY, NYE COUNTY, NEVADA

PREPARED FOR: NEVADA DEPARTMENT OF ENERGY
DATE: JANUARY, 1981 | SCALE: 1:62,500 | DRAFTED BY: NORRIS & WEBER