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BRIDGEPORT GEOTHERMAL ENERGY PROJECT:

**A Heating District
and Small Scale Electric
Feasibility Investigation**

SEPTEMBER 1982

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BRIDGEPORT GEOTHERMAL ENERGY PROJECT:
A Heating District and Small-Scale-
Electric Feasibility Investigation

Contract 500-81-003

FINAL REPORT

July, 1982

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Prepared By:

LAHONTAN, INC.

ALTERNATIVE ENERGY SYSTEMS

Sacramento, California

For

CALIFORNIA ENERGY COMMISSION

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This document has been prepared by Lahontan, Inc., for the California Energy Commission under Contract 500-81-003.

The work was performed under the direction of the following California Energy Commission, Development Division, staff: Ronald W. Kukulka, Chief; Leon G. Vann, Jr., Deputy Chief; Ralph Chandler, Acting Manager of the Small Power Producers Office; Michael Smith, Geothermal Program Manager; and David Hill, Contract Manager. Other key geothermal staff that provided technical assistance were: Susan Brown, Andy Coughanour and Edward Ennis.

The Lahontan Project Manager was Mr. Alfred B. Longyear, President. Key Lahontan contributors were Mr. Peter Klaussen and Mr. Philip A. Edwardes. Administration and publication services were provided by Ms. Judie Houston.

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was the Project Manager for their very supportive efforts. Mr. Norman D. Knowles, Vice President, Francana Resources, Inc., contributed to a creative approach to a direct use geothermal sub-lease with Lahontan and released Francana and the Vulcan Group (investors) funded data to the Project for purposes of planning and siting the direct use supply well. The degree of constructive cooperative effort by all parties has contributed to defining at least one feasible approach to the Bridgeport Geothermal Project.

LEGAL NOTICE

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ABSTRACT

The Bridgeport Geothermal Project, a proposed community heating district, appears to be feasible. Analysis of the feasibility of the Bridgeport Geothermal Project required three critical assumptions: a successful supply well, a commercially viable wellhead generator, and successfully obtaining simultaneous financing from private investors, a commercial lender and a granting agency.

The geothermal supply well for the Bridgeport Project will be sited near Travertine Hot Springs about 1½ miles southeast of town. The well should yield 1,000 gallons per minute at 205°F to 240°F. The hot brine will be piped (1) to a primary heat exchanger for the heating district which will distribute heat to public and commercial buildings via a fresh water loop, and (2) to an organic Rankine boiler to drive a 500 KW (gross) generator.

The institutional structure for the project is well established. The capital cost of the installed project will be about \$4.1 million to be raised through equity, commercial debt and grant funding. The system revenues are projected to result in a positive cash flow in the eighth year of operation, and over a 20 year payout are projected to yield an internal rate of return (IRR) of 23⁺% to the private investors.

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SUMMARY

The economic feasibility of a geothermal heating district has been determined for Bridgeport, Mono County, California. Under Contract 500-81-003 with Lahontan, Inc., the California Energy Commission effort built upon previous private and state funded activities in the area. The Bridgeport site was selected based upon the extensive background work, community interest, conformance with the Commission's geothermal marketing criteria, U.S. Bureau of Land Management (BLM) leasing activities pertinent to the project, and more specifically, the opportunity to investigate factors pertinent to a very small-scale system. It is hoped that positive results from investigation of a small-scale system can be used in establishing a core system for many other communities of the same size and larger.

The investigation was directed at determining how to make the system economically feasible rather than determining whether or not one or more options were feasible. This effort was intentionally limited in scope so that the cost of the feasibility phase would be in balance with the anticipated cost of the overall Project. Further, the economic analysis has been structured so that, as the Project progresses and changes or new data are obtained, the analysis can easily be up dated and reassessed.

The institutional structure is composed of real entities that already have an interest and stated commitment to the Project. Agreements, in part, are already in place. The principal participants and their proposed roles include:

U.S. BLM - Releasing non-competitive leases in the Bridgeport - Bodie Hills area.

Francana Resources, Inc. - Principal leaseholder in the area including the optimum well site.

Lahontan, Inc. - Alternative energy systems developer; subleaseholder for geothermal direct use energy under 250°F; under agreement with the Bridgeport Public Utility District for the feasibility study and proposed developer of the financing and of the system for the PUD.

Bridgeport Public Utility District (PUD) - Owner/operator of water and sewer systems with expressed interest in owning and operating the heating district provided it is economic and self sustaining.

Mono County - Local government and lead agency for land use permitting. The County buildings comprise the major portion of the heating district load and, hence, will be the beneficiary of the lower cost energy from the system.

U. S. Geological Survey (USGS) - Permitting for exploration, development and operation of the geothermal direct use resource.

Southern California Edison - Distributor of electric power in the area; an expressed interest in purchasing power from the wellhead generator.

California Energy Commission - Competitive allocation of Bosco funds and planned support of wellhead generation demonstrations; technical assistance support for the PUD.

The siting of the well has resulted in an increased length and material cost for the supply line. In order to increase the revenue flow to compensate for this increase in capital, the optional wellhead generator has become mandatory. The wellhead generator, as defined herein, when integrated in a heating district not only supports itself but improves the overall economics of the integrated system. These added capital costs plus the ever increasing cost of money have required the use of grant money to purchase some of the foregoing "non-economic" elements of the system. When such occurs, the system cash flow runs in

the black in the eighth operating year (tenth project year) and over a 20 year period shows an Internal Rate of Return (IRR) 23.3%. This would improve if the investors sold their interests (to the PUD) say, in the sixth year. The economic model includes the proposed following funding:

Equity	\$1,244,910	
Debt	1,695,520	20 year, 14% lease/purchase
Grant	<u>1,209,270</u>	
TOTAL	\$4,149,700	

It may be noted that the prototype wellhead generator installed is conservatively estimated at \$1,207,923 which qualifies for R & D tax credits.

The major risk areas include:

1. The resource estimates are based upon surficial surveys. A well must be drilled that will deliver 205°F, preferably 240°F at 1000 gpm.
2. Although the wellhead generator will be using commercially proven components, it will still be a prototype energy system.
3. The need for a grant will require a unique timing of financing commitments. The granting entity, the commercial debt lender and the private investors must be ready to commit at the same time.

Recognizing these risk areas, the unique nature and close proximity of the resource, the positive attitude of the community and its real needs for the system, plus the existing agreements and structure of an implementing team combine to make the Bridgeport Geothermal Project an excellent opportunity for a geothermal development.

INTRODUCTION

In conformance with the California Energy Commission's (CEC), effort to accelerate the development of geothermal resources in the State, a project-specific feasibility investigation has been conducted.

The Project is one of five described and assessed in the CEC geothermal direct use marketing study, Contract 500-80-130⁸. The objective of this Project has been to determine the technical, economic and institutional feasibility of developing and operating a small-scale, geothermal direct use heating district in Bridgeport, Mono County, California. A small-scale, "wellhead" electric power plant and a low-head hydro generator have been considered as options.

Bridgeport (population 500), County seat of Mono County, was selected based upon background work conducted by the private sector, local community interest, a nearby resource, conformance with CEC marketing planning, and U.S. BLM leasing activities in the area. In addition, the site was specifically selected for this feasibility effort, under CEC contract, in order to investigate factors pertinent to a very small-scale system. It is hoped that such a small-scale system, if feasible, could then become a core system for many other communities of the same size and larger.

Background

In 1977 discussions were held between Cal Trans and Lahontan regarding the potential of developing a geothermal heating system for the new State road maintenance facility at Bridgeport, using non-competitive leases applied for by Cal Trans. Based upon findings of other heating district projects and based upon the location of the Cal Trans leases and their station, a larger load would be required to justify the development of the resource. Follow-up investigations by Lahontan were conducted in the '77 - '80 time period. These determined community interest, BLM leasing scope and schedule, and an evaluation of direct use

and sublease potential with the principal holders of non-competitive lease applications in the area. Through an assessment of the BLM leasing data, discussions were initiated with Francana Resources, Inc. and affiliated lease applicants, to establish a feasible approach to developing the geothermal direct use resource. Other background activities were as follows:

- ° Cascadia Exploration - Surficial exploration for Francana Resources, Inc.
- ° California Division of Mines and Geology - Surficial geoscience exploration.
- ° Cal Trans - Surficial geoscience exploration and design of the road maintenance facility for retrofit.
- ° Mono County - Development of a geothermal element for their General Plan through CEC-sponsored effort conducted by Inyo Mono Association of Governmental Entities (IMAGE).
- ° US BLM - Preparation of an Environmental Assessment for non-competitive leasing.
- ° Bridgeport Public Utility District (PUD) - Evaluation of their potential role in future development of low head hydro and geothermal energy systems.
- ° Lahontan, Inc. - Institutional assessment and planning, preliminary energy assessment of public buildings, aerial photos and surface siting investigations.

The CEC funding for this Project has been directed at accelerating the feasibility investigations with emphasis in the following areas:

- ° Documenting the Project description and site.
- ° Summarizing the geothermal resource and well siting work.
- ° Conceptual systems engineering.
- ° Conceptual economic assessment.
- ° Defining the Implementation Plan.

This CEC effort expedites the decision-making process so that the proposed private/public development can go forward. Technical Assistance by CEC can be appropriate to assist the PUD in its decision making process. Use of Bosco (AB 1905) or other grant funds will be required to finance a non-economic portion of the capital. This has resulted from an unexpected increase in distance from the well site and the need for the high risk wellhead generator to increase the thermal load.

Since issuance of leases by the BLM had been delayed,¹ the originally proposed Francana exploration well work has also been delayed. This precluded incorporating the results of such exploration in the Project. The feasibility model has been defined so that actual data can be incorporated as it becomes available in the future. Further, in that the recommended initial well site has been located at least a 1/2 mile further from the load than was originally planned, and in that the supply line has to be steel rather than asbestos/cement to handle the 400 foot drop between the supply well and the utility plant, as well as the wellhead generator, these potentially high risk elements have been isolated in the economic model. This will permit independent assessment of these elements as to their affect on overall project economics and to define the best means of financing such elements.

It must be noted that all principle entities have been under agreements for the performance of the feasibility effort.^{3,4,5} The principle private entities are under agreement for the development of the resource

provided the Project remains feasible.⁵ The formalization of agreement between the private and public entities are to occur prior to the start of development. The principles of these documents are part of the Implementation Plan.

This report documents the publicly funded effort and includes privately funded collected and analyzed data, released for use in this report. Supporting documentation is on file in the Small Power Producers Office of the CEC.

This report discusses the investigation and results under the following headings:

Summary, Project Description and Site, Geothermal Resource, Systems Engineering, Economic Assessment, Implementation Plan, and Conclusions and Recommendations. Reference documents have been listed and are indicated in the text by corresponding superscript numbers.

During the investigation an interesting piece of history was uncovered. It seems that the world's first electric power transmission was developed in the area in the late 1800's. A hydro electric generator was developed on Green Creek, to the southwest of Bridgeport and power was transmitted, through Bridgeport Valley, to a remote power station at the mining town of Bodie, to the southeast of Bridgeport. The engineers required the 13 miles of power lines to be run in a straight line since it was not known at the time that the electricity would stay on the line in a curve. The power station, including transformers, are preserved at the ghost town of Bodie, now a State Historical Park.

One can speculate, as history repeats itself, that a wellhead generator in Bridgeport Valley could have a marked impact on the local economy. A 1/2 MWe unit would take care of the electric power requirements of Bridgeport and other loads from just north of Lee Vining to north of Bridgeport (on the order of 50 miles) along US 395 on the east side of the Sierra Nevadas.

DISCUSSION

Project Description and Site

The overall project is the definition, development and operation of a geothermal direct energy utility system in the community of Bridgeport, California. The utility system will supply heating energy from a geothermal hydrothermal well or wells located in the vicinity of Travertine Hot Springs (T5N, R25E, Sec. 34) on a bench of land just east of and 400 feet above Bridgeport. The well site area is otherwise known as "Big Alkali Caldera".

Initially two other resource areas were considered as alternatives. "The Hot Springs" (T4N, R25E, Sec. 9 & 10) is located south of Travertine Hot Springs and Fales Hot Springs (T6N, R13E, Sec. 24) is located 14 miles north of Bridgeport on US 395. Both areas are located an uneconomic distance, due to high pipeline costs, from Bridgeport. Hence, the feasibility study has concentrated on the Travertine Hot Springs resource area. See Figure 1 for general layout of the Project Area.

The geothermal fluid supply system includes the supply well or wells and their pumps, a moderate-pressure (400 ft. head), high-temperature (200-250°F) supply pipeline from the well site to a utility plant to be located in the vicinity of the County Road Maintenance facilities. After passing through a primary heat exchanger and an organic fluid boiler (heat exchanger), the geothermal fluid will be injected through a nearby injection well. The heat for the heating district is transferred in the Primary Heat Exchanger, in the Utility Plant, to a fresh water loop filled with treated boiler quality water. Circulating pumps will distribute the heated water through the community. Fifteen public buildings were considered as the base load. Fourteen of these buildings are considered economic for retrofit. Of these, all but the school have hot water heating systems which permits a simple water-to-water retrofit.

The school has propane gas-fired air heaters and, hence, would require a completely redundant hot water heat system. Retrofits of public buildings and any year-around commercial buildings that wish to participate are proposed to be capitalized as part of the system with a payout of the retrofit costs over a near-term period. This will assure a base load for the system.

Initially, a low-head hydro turbogenerator and an organic Rankine cycle wellhead generator were considered as potential add-ons. The low-head hydro was considered in order to utilize the head rise associated with an estimated 200 feet net rise (400 feet at shut off) from the supply well to the Utility Plant. An engineering estimate indicated that such a system was not cost effective. However, detailed assessment of several supplier-proposed organic Rankine systems indicate that a wellhead generator can be cost effective. A 500 KW (gross) system has been incorporated into the Utility Plant. This unit is undergoing further assessment under a CEC Technical Assistance agreement for Bridgeport and other similar sites. This Technical Assistance agreement was requested by Lahontan since such effort is beyond the scope of this contract, and because preliminary analysis indicated that the wellhead generator was necessary to produce an adequate, revenue-producing thermal load for this Project. To establish realistic costs for a generator system, this additional assessment has been required.

The integrated heating subsystem and wellhead generator subsystem operate primarily as a series cascade -- supply well-to-generator and then generator-to-heating system. Provisions for parallel flow are also included to permit (1) priority of supply well flow to the heating system during peak demand and (2) bypass of generator during down time for generator servicing. If the operating temperature regimes for the generator overlap those of the heating system, the heating system priority would require reduction of total direct flow to the generator and bypass to the heating system.

DISCUSSION

Geothermal Resource *

The "Big Alkali" caldera geothermal resource area is located in the Bodie Hills at the eastern base of the Sierra Nevadas within the Basin and Range physiographic province. The Bridgeport geothermal area lies on a north to south trending belt of geothermal areas located along the western edge of the Basin and Range province. The significant western edge geothermal areas extend from Coso Hot Springs, Inyo County, to Newberry Crater, Oregon.

The geology of the Bridgeport geothermal locality is predominately andesite to dacite volcanic rocks at the surface. Age dates for the Willow Springs formation yield ages of approximately 7.8 - 8.0 million years for the andesite flows and 5.3 million years for the rhyolite flows.

The oldest rock unit exposed in the western Bodie Hills is a basement unit which consists of Paleozoic quartzite and hornfels. This basement unit is exposed approximately 7 miles southeast of Bridgeport along the road connecting Highway 395 and the ghost town of Bodie. The Aurora Canyon Andesite is younger than the basement rocks but older than the Willow Springs formation and crops out approximately 2 miles to the northeast of Bridgeport along Aurora Canyon. Here, the Willow Springs formation lies directly on the older unit which is 11 - 29 million years old. Younger sedimentary rocks are also exposed in the Bridgeport area.

Based upon Cascadia's field mapping and air photo analysis of the Bridgeport-Bodie Hills area, there appear to be two main directions of faulting. In the southern part of the area along the road to Bodie ghost town and extending northwest approximately half way to Bridgeport is a northwest trend marked by several faults, some of which are

*Excerpts from Reference 5, Cascadia Exploration well site recommendation report.

indicated on the map by Chesterman and Gray (1975). In the area between Bridgeport and the Bodie road, the northwest fault trend is cross cut by a northeast to north-northeast fault trend. Faults across the entire area appear to be mostly represented by vertical displacement. Also present within the Bodie Hills area is the Big Alkali caldera. This topographically obvious feature represents an ancient volcanic center out of which much of the Willow Springs formation apparently erupted.

Hydrothermal alteration formed as a result of the percolation of geothermal fluids through the rocks in many parts of the Bodie Hills area. Alteration is very prominent along the northwest trend extending southeasterly from Bridgeport. To the southeast of Bridgeport there are two groups of thermal springs. One group, approximately 1½ miles from Bridgeport, is Travertine Hot Springs. The other thermal springs, approximately 3 miles southeast of Bridgeport, are "The Hot Springs". Both of these spring areas lie within the northwest trending path of extensive hydrothermal alteration. The two groups of springs also lie in the area of intersection where the northwest fault trend is cross cut by the northeast trend.

Well Site Selection

Several factors are involved in the selection of a production well site for the Bridgeport area. The geologic factors must be balanced with the economic and feasibility factors in selecting the site. The first consideration is the necessary physical characteristics of the resource needed for success of the project. For this direct-use project, a temperature of at least 140 to 150°F is necessary. Higher temperatures are desirable. Another physical parameter to be considered is the volume of fluid necessary. As fluid production is extremely difficult to estimate, particularly in an area such as this where no subsurface information is available and fracture production is anticipated, an attempt to maximize potential production was given high

priority in the selection of the well site. Because at the present time there are numerous unknown factors concerning the physical nature of the geothermal resource, future plans for utilization of the resource may require revision to reflect the character and quantity of the available thermal fluids.

While the temperature chemistry and volume factors are controlled by geology, other factors must be considered which are unrelated to geology. These include the proximity of the well to the area of proposed utilization, the legal rights to the geothermal system, and the physical ability to set up and drill a well. The proximity of Travertine Hot Springs to Bridgeport coupled with the known temperature of the springs (up to 158°F) suggests this area as a likely site for the first exploration well. Further to the south are The Hot Springs which discharge at a lower temperature of 104°F. As indicated by the California Division of Mines and Geology report (Martin and others, 1980), the very similar nature of the water chemistry for these two thermal springs, in relation to cold springs and water wells of the area, suggests a common reservoir for these two groups of springs. The higher temperature of Travertine Hot Springs may be due to the fact that the reservoir supplying these springs has a more direct link to Travertine Hot Springs than The Hot Springs. Fortunate, also, is the shorter distance between Bridgeport and Travertine Hot Springs.

Ownership of the geothermal resource within the project area must be considered. Travertine Hot Springs lie in the south-central portion of Section 34, T5N and R25E, which section is directly north of Section 3, T4N and R25E (Figure 2). Francana Resources holds the federal geothermal lease applications (CA4262 and CA2141) which cover most of Sections 34 and 3. Upon issuance of these geothermal leases, Francana Resources will own the geothermal resources below Travertine Hot Springs and the resources below 250°F are committed to this project.

Analysis of Sections 34 and 3 to select a specific well site included detailed examination of aerial photographs, reviewing the California Division of Mines and Geology report (Martin and others, 1980), and

utilizing information acquired from Cascadia Exploration's geologic field work in the area. Faults were plotted onto a map of the area of interest (Figure 2). At least three north-northeast trending faults extend through the area of Travertine Hot Springs. The eastern most of these faults can be traced through the eastern most area of thermal water discharge at the springs. A north-northwest trending fault can be mapped through the area but it lies approximately 1/4 mile east of the Travertine Hot Springs. Several companion faults to the north-northwest trending fault set, however, do appear to intersect the thermal spring area. The overall fracture pattern in this area appears to be one of a fan-shaped structure with the apex pointing northward. The thermal springs discharge from within the fan near the apex.

Indications of fractures in the hot spring area are also given by the orientation of travertine ridges. Several travertine ridges trend northeastward and are fairly conformable to mapped faults along the eastern area of thermal water discharge. One very distinct travertine ridge does trend northwest near the southern most area of thermal water discharge. This may represent a northwest trending cross fault through the area. There is, however, no additional strong evidence for a northwest trend, only a north-northwest trend noted above.

The California Division of Mines and Geology conducted several detailed geophysical surveys across the area. The surveys completed include gravity, magnetic, resistivity and seismic refraction surveys. For the most part the surveys were not useful in selecting a specific well site, since the survey lines did not extend far enough to the east. The geophysical surveys are useful to define structure west of Section 34 beyond the area of lease applications. The geophysical surveys indicate a definite disruption of the gravity and magnetic contours in the area west of Travertine Hot Springs. The residual gravity map shows a definite gravity high west of Travertine Hot Springs. This anomaly may represent either dense silicified rock, a small relatively shallow intrusive body, a buried volcanic plug or dome, or shallow basement rock.

In selecting the precise well site an attempt was made to select a site where a well would drill into a fault zone. Since the potential geothermal reservoir is in all likelihood a fracture reservoir, because the hydrothermally altered rocks contain little nonfracture porosity or permeability, the maximum fluid volume should occur along a fault. The geology of this area shows that in the past hydrothermal alteration had occurred extensively within the tuff breccia unit. This unit has now been largely rendered impermeable due to hydrothermal alteration. Stratigraphically controlled permeability in this area is no longer likely to be present. Fracturing also appears to control the location of thermal waters as indicated by the fracture pattern near the Travertine Hot Springs, as well as the orientation of the travertine ridges. The well site is located to the southwest of Travertine Hot Springs (approximately SE $\frac{1}{4}$, SW $\frac{1}{4}$, Section 34) in an area that has several faults trending toward the hot springs (Figure 2). The north-northwest trending fault structure very likely dips westward with relative downward movement on the west side of the fault. It seems quite likely that thermal fluids are circulating along the fault zone and fractures associated with the fault. Drilling at the selected well site should intersect this fault zone and allow production from the fractures associated with it.

It is expected that the fault zone will be encountered at a depth of approximately 900 feet at the selected well site, although other faults at shallower depths are likely to be encountered. The actual dip along the fault zone is unknown and the fault plane surface could be highly irregular so that a precise intersection point of the well bore and the fault plane cannot be accurately predicted. A well depth of 2,000 feet is recommended and has been used for estimating project costs because of the high degree of uncertainty in projecting the fault to depth. A 2,000 foot well should penetrate a fault zone containing thermal fluid within the area selected for testing.

The volume of fluid which will be encountered is unknown as there are no available subsurface data known to the authors for this area. Generally there is a wide range of variability in volume of fluid flow for wells

drilled into a single fracture reservoir. Chance determines whether or not a given well will penetrate the plane of a fault in an "open interval" where high fluid flow will be encountered or in a "tight interval" where fluid flow will be restricted or even nonexistent. To adequately test the Travertine Hot Springs area could require the drilling of several wells.

The temperature of fluid at a depth of 2,000 feet or less should be slightly higher than that measured at Travertine Hot Springs where temperatures up to 158°F have been measured. Silica geothermometry suggests subsurface reservoir temperatures up to approximately 230°F (Brook and others, 1979). Although this geothermometric temperature may represent the reservoir temperature, the well will probably not encounter the hottest portion of the reservoir. Based upon surficial evidence, Cascadia Exploration has estimated that the fluid temperatures which might be expected could be in the range of 160-170°F. Fluid temperatures below the temperatures of Travertine Hot Springs are also possible if cold water mixing occurs. Geothermometry analysis by others¹⁰ have indicated possible temperatures over 290°F. Since such analysis are considered to be speculative, actual temperatures will be dependent upon the actual drilling and pump testing of a well.

The Willow Springs andesite will probably be present down to a depth of at least 300 feet. With the lack of any subsurface information in this area, it is not known exactly what lies below the Willow Springs formation. It is possible that either of the two older rock units in the area will be encountered. As previously described, these units include the andesitic volcanic formation to the north and the basement metasedimentary rocks which crop out to the south. The residual gravity anomaly in this area suggests that a different rock unit than the Willow Springs does underlie the area at a relatively shallow depth.

Cascadia Exploration completed a soil-mercury survey of the western Bodie Hills for Francana Resources in 1980. The content of mercury (analyzed in parts per billion) within soil samples was determined for 470 locations.

Elevated soil-mercury concentrations often yield spatial and intensity data on geothermal systems. Statistical analysis of the 470 samples indicated that values over 32 ppb are anomalous (as opposed to background). The recommended well site lies within an area of mercury concentration greater than 63 ppb that also forms the north-northeast trend. The mercury data strongly supports the recommended well site as a likely location for a successful well.

DISCUSSION

System Engineering

Prior to contract award, an initial energy usage survey of public building heating was conducted. The annual load for selected public buildings was then estimated at about 16,000 mm/Btu/yr.² As part of the CEC funded effort, Koepf and Lange, Consulting Engineers, were subcontracted to conduct the technical evaluation for the Project. Koepf and Lange were directed to consider commercial hardware and systems previously demonstrated in geothermal direct use applications. Koepf and Lange have used their experience in several direct use projects designed by them in the Susanville-Honey Lake Valley area. From an engineering standpoint, the climates, hydrothermal resource fluid characteristics and applications are similar to those of the Bridgeport Project.

The engineering was directed at the conceptual level primarily to identify key components, component sizing, materials, system size and configuration (to the level of a block diagram) for the preparation of an engineering budget. Thermodynamic and kinetic data, derived from load requirements and a projection of the resource capability, were used in this system engineering. The combination of a projected brine Total Dissolved Solids of >4000 ppm (Travertine H.S. chemistry) and the preponderance of water-to-water retrofits was used to define a primary heat exchanger with a fresh water energy distribution subsystem. Potential vendors for key components were selected from qualified bidders responding to the procurements in the Susanville/Honey Lake Valley projects. These are representative vendors only and are not recommended to the exclusion of others (see Table I).

The overall system layout including identification of the buildings and annexes that were initially considered are shown in Figure 3. A conceptual block diagram of the system including the supply-injection subsystem, small hydrogenerator (option), organic Rankine wellhead generator, primary heat exchanger (HTX 1), and the heating load distribution subsystem are shown in Figure 4.

TABLE I

POTENTIAL VENDORS FOR KEY COMPONENTS

<u>COMPONENT/SUBSYSTEM</u>	<u>TYPE</u>	<u>REPRESENTATIVE VENDORS*</u>
Supply Well Pump	Deep well turbine	Peerless, Aurora Peabody Floway
Utility Plant Piping, Pump Control Valves	Insulated steel, steel	Commercial Cla-Val
Supply-to-Injection Line	Insulated steel	Commercial
Distribution Piping	a) Asbestos/cement (A/C), factory insulated Uninsulated A/C	Manville Temptite Manville Transite
	b) Polybutylene (Shell Oil Co. material), factory insula- ted	Distributors/contractors
	c) Insulated steel	Commercial
Circulating Pumps	Horizontal centrifugal	Pacific Pumping, Bell & Gossett
Heat Exchangers - Primary	Stainless steel plate or shell and tube	Midland Ross, Alpha-Laval
Retrofits & Controls	Steel or copper	HVAC products
Cooling Tower	Wet tower	Baltimore Air Coil, Marley, J. F. Prichard
Electrical	Switchgear	Square D, GE, Westinghouse

*These vendors are representative but not recommended to the exclusion of others

Heating District Load

Following a field survey and preliminary analysis, sixteen of the eighteen public facility structures were selected and analyzed for peak and annual thermal loads. Two of the structures were screened out and subsequently an additional unit, Building 15, was eliminated from the economic assessment for lack of cost effectivity in the base load of the initial system. It is quite possible that after initial development and when additional load is defined in the outlying areas these less economic units could be included. The load analysis for each of thirteen buildings was based upon a building sketch, a review of building drawings in the Mono County offices, definition of areal layout, determination of heat transfer factors for each element of the structures based upon construction and insulation; and determination of working temperature drop and peak heat loss of major elements of the building; i.e., roof, floor/ceiling, walls, glass, doors. Infiltration and ventilation loads were calculated and added. An outside design temperature of -20°F and an inside temperature of 70°F were used with an annual heating rate of 8500 Degree-Days. Figure 3 lists the peak heating rate in m Btu H (thousand Btu/Hr.) and the annual rate in mmBtu/y (million Btu/yr.). Table 2 summarizes the loads for the system. Three of the facilities, Buildings 14, 15 and 16, marked (E), had to be estimated based upon external inspection. An unassigned annual load of 1500 mm Btu/y ($10^{+}\%$) was added. Hot water heating has not been included.

FIGURE 3 - Bridgeport Geothermal Energy System Layout.

KOEPP & LANGE CONSULTING ENGINEERS		FILE NO. 215
OWNER CITY OF BRIDGEPORT	CLIENT LAHONTAN, INC. - SACRAMENTO, CAL.	
PROJECT BRIDGEPORT GEOTHERMAL SYSTEM STUDY		
SUBJECT STUDY PLAN		
DATE 11/2/80		DRAWING NO. 215-1
SCALE 1" = 200'		Pg. 22

GEO THERMAL SYSTEM BRIDGEPORT, CALIF

FIGURE 4 - Bridgeport Geothermal System Schematic Diagram

(Koepe & Lange)

TABLE 2
APPLICATION PEAK & ANNUAL SPACE HEATING LOAD

Building Number	Description	THERMAL LOAD		Fluid Flow Rate, GPM
		Peak m Btu/Hr	Annual mm Btu/yr	
1	Elementary School	752	1,704	60
2	Courthouse	527	1,194	42
3	Sheriff	240	544	19
4	Sheriff Addition	306	695	25
5	Firehouse	569	1,289	45
6	Mono Co. Medical Center	994	2,252	80
7	Health Services	139	315	11
8	Mono Co. Memorial	384	871	31
9	Mono Co. Annex #2	510	1,157	41
10	Mono Co. Annex #1	440	997	35
11	Library	109	247	9
12	Mono Co. Shop #2	345	850	28
13	Mono Co. Shop #1	253	630	20
14	State Maintenance (E)	450	1,000	36
15	Forest Service (E)	200 ⁽¹⁾	500	16
16	Museum (E)	100	200	9
17	School District Office	-- (1)	--	--
18	Animal Shelter	-- (1)	--	--
Subtotal		6,318	14,445	507
Unassigned		700	1,500	56
Subtotal		7,018	15,945	563

NOTES:

(1) Facilities eliminated for poor pay back either in the preliminary review or prior to the economic assessment.

(E) Estimated based upon external evaluation.

Fluid Temperature Considerations

The system is based upon a temperature drop of 25°F which translates into about 8 gpm/100 m Btu/H. In general, this is independent of resource temperatures between 125°F and 205°F. The lower temperature limit affects heat exchanger size and cost and the upper temperature is limited by the safety of not exceeding about 195°F fluid temperature in a municipal heating district. Based upon the on-going assessment of organic Rankine wellhead generators, that are to be integrated into a cascaded heating district, the geothermal fluid boiler inlet temperatures can be used over a range of 180°F to 250°F or greater. Efficiency/economics limit the lower temperature. Fluid problems, resource lease limits and, most importantly, fit within the system cascade limit the upper temperature. The wellhead generator must have a brine flow rate compatible with the thermal load flow rate so that cascading and hence, sharing of supply system costs can be accomplished. If the generator can be supplied fluid at a temperature of say, 240°F, take an 80-°F (high) drop through the boiler, deliver 160°F to the primary Heat Exchanger which removes another 25°F for the heating district, injection will occur at about 130°F. Obviously, there is usable heat for another 10° - 40°F depending on the application. However, the IRS limits tax incentives to geothermal resource fluid temperatures of 50°C (122°F) or higher.

This temperature regime also permits considering resources for the wellhead with temperatures down to the 180°F range. The 240°F scenario addresses a pure cascade without temperature interference between power and heating demands. In a municipal system, the heating will have to have priority over power generation. If the fluid temperature of the generator boiler overlaps that of the heating district requirements at peak demand, generated power would be reduced.

Disposing of a significantly high fluid-flow rate leaving the generator will require a larger supply system and a larger injection system with higher pumping costs and most likely, an excess, wasted flow above that required for the heating district. Hence, it is desirable for wellhead generators:

- a) To be sized to match heating district flow rates on the order of 400 - 1200 gpm of geothermal fluid flow rate through the boiler.
- b) To have an overall plant efficiency, including condenser cooling and parasitic losses, of over 10%. This usually requires a multi-stage turbine with over 70% efficiency and a minimum parasitic and cooling load.
- c) To use commercially proven components compatible with the specific binary fluid at the operating temperatures or higher. This is of paramount importance in the case of the turbine shaft seals and bearings.
- d) To use R114 (Freon) or other equivalent, well known commercial binary working fluid -- preferably fire resistant.

Budget Estimate

The engineering budget estimate was prepared at the conceptual level. The approach has been to prepare the estimate in the form and content of a realistic contractor's firm bid for construction as of February 1982. The amount of detail between this estimate and a final engineering budget would change only in terms of time/inflation factors and the details of the final design.

In general, the estimate is based upon a 200+ item, detailed breakdown of components, material and labor prepared by Koepf & Lange. Unit prices are based upon standard estimating data tempered by engineering judgement for the geographic location of the project and the experienced gained in the actual construction on-going in the Susanville/Honey Lake projects.

The engineering budget is summarized in Table 3.

TABLE 3

Engineering Budget Estimate - Heating District

<u>Division</u>	<u>Materials</u>	<u>Labor</u>	<u>Sub-Total</u>
Div. 1 - General Requirements	77,000	72,000	\$149,000
Div. 2 - Site Work	50,500	127,690	178,190
Div. 3 - Concrete	11,550	17,000	28,550
Div 6, 7, 8, 9 - Buildings	9,000	--	9,000
Div. 9 - Finishes	9,000		9,000
Div. 15 - Mechanical	1,406,880	380,160	1,787,040
Retrofit 16 Bldgs.	---	396,640	396,640
Div. 16 - Electrical	72,250	27,400	99,650
Electrical Retrofit	---	--	36,800
			<hr/>
			\$2,693,870
Remove Bldg. 15			[109,469]
			<hr/>
		Estimate for Construction	\$2,584,401

System Energy Requirements

The subsystem energy requirements are summarized as follows:

° Pumping Power at well: (507 gpm, 230' head) = 49 HP

° Head Required at Utility Plant

Reinjection and friction	30'
Return Pipeline	70'
Utility Plant Equipment	30'
Supply Pipeline	70'
Supply Pump	20'

220'; (95 psi)

° Head Available for Hydro Turbine Generator (option)

H = 400' (Caldera to Valley) - 220' (Utility Plant) - 53' line friction = 127'

Turbine inlet power: (507 gpm, 127' head) = 27 HP

Net HP = 22

(This option is not cost effective at this time.)

° Wellhead Generator

Peak Rate Based on 500 gpm, 80°F temperature drop, 10% plant efficiency

Energy input = 500 gpm x 8.3 lb/gal x 60 min/hr x 80°F = 19,920,000 Btu/H

Energy output (10%) = 1,992,000 Btu/H = 583 KWH

° For the economic model, the use of geothermal fluid, at a conservative 500 gpm, between the heating demand and the power generation will permit 10 months (310 days) of power generation, 24 hrs/day. Using 500 KW Gross - 100 KW for internal parasitic losses and cooling tower - 75 KW for geothermal pump energy - 25 KW for distribution pumping, a net power of 0.3 MWe, or 2232 MWH/yr will be sold. The District Heating annual load is 15,945 mm Btu/yr per Table 2.

Economic Assessment

After discussion with local government officials, it was determined that the Bridgeport Public Utility District would be the most logical entity to act as the utility for the distribution and sale of energy. An alternative considered, and still a possible alternate, in the event the PUD desires not to participate, is the formation of a new energy company. However, the PUD expressed interest in being the utility entity, provided the system is and remains economically viable and self-sufficient. The economic scenario has been structured based upon recent experience in the City of Susanville Geothermal Project and the city/state/private project for the Susanville Correctional Center. Further precedence for this type of scenario is being set by the State's Cogeneration Projects wherein the State is prepared to enter into 3-party agreements for the development of these new energy systems. These agreements permit the State to acquire new energy supplies using private and commercial capital rather than attempting to raise the capital and operating funds when the State does not choose to finance such ventures through public funds.

Project Scenario

While there are many scenarios and variations that have and can be further considered, within the scope of this investigation, the following scenario outline has been followed for the economic assessment. This scenario is valid only as long as the project remains financable and economically viable for all parties concerned.

A. Resource

1. US BLM releases federal leases to Francana Resources, Inc.
2. The Francana-Lahontan sublease is brought up to date for the sublease of hydrothermal resources below 250°F. If, subsequently, a resource temperature above 250°F is discovered by Lahontan, and

the Bridgeport Project goes forward with the wellhead generator for electric power, it would be appropriate to revise the Francana-Lahontan sublease to at least allocate flow for the wellhead generator and heating district. Further, the sublease must include provisions for assured access to the resource by the PUD in the event either Lahontan or Francana do not retain their interest in the resource. In light of the potential for a "direct use" small-scale, wellhead generator and the mix of private and public participation, the issue of profit share/royalties will have to be addressed within the economic limits of the Project.

3. Lahontan and the PUD enter into Development and Operating Agreements in order to obtain commitments for financing.
4. Lahontan obtains financing through private risk capital, commercial debt financing and assists in the grant financing for the non-economic portion of the project. Grant financing would be direct to the PUD.
5. Under agreement with the PUD and under the terms of the Francana sublease, Lahontan explores, develops, operates and maintains the supply and injection well field. Under said agreement, Lahontan delivers all energy to the PUD for their distribution and assures the PUD of a continuous flow of geothermal heat. Venture capital (equity) financing is one of the primary sources of funds for this risk area.
6. The supply and distribution system are designed and constructed by Lahontan. As appropriate for tax purposes, a combination of equity and debt financing can be used here.
7. The wellhead generator is a prototype composed of proven technology and commercial hardware. The turbine assembly would be custom designed for the specific geothermal resource. This wellhead generator is also a risk area and would qualify for R & D tax

credits as well as grant funding. It is recommended that this unit be obtained from a reputable firm that would participate in this prototype installation. A strong warranty agreement will be required for this subsystem.

8. The principle retrofits would be arranged for under agreements between the consumer entities and the PUD. These will be designed and constructed by Lahontan as part of the original system installation. By simultaneously constructing the utility and principle consumer retrofits, a base or initial revenue flow can be assured.

NOTE: The economic model in this report, for simplicity, assumes the retrofits are capitalized as part of the system. In practice, these should be managed by the PUD as part of their distribution. In fact, the retrofits still can be capitalized and constructed as part of the system; however, pricing will have to be adjusted to amortize the retrofits, over and above energy costs, preferably over a 5-year period or less.

9. Under the proposed Lahontan-PUD agreements, the equity return and debt will be serviced strictly from system revenues. The PUD will have to have an assured method of rights to a continuity of geothermal fluid flow. Buy out arrangements between the PUD and private equity holders will include coverage of investor equity and a pre-negotiated rate of return on equity and an assured retirement of all debt. Operating agreements will define the share and use of future surplus revenues. Capital reserves for hardware and system growth financing must be addressed in the agreements.
10. The increases in capital costs, inflation and the need for the wellhead generator load requires use of grant funds for a portion of the capital in this scenario. It has been assumed that such would be obtained from Bosco (AB 1905) funds, either Mono County-of-origin allocation or CEC allocation. Other R & D or foundation

grant funds should be explored. (Whenever "Bosco" is used in this report, it is intended to mean grant funds from Bosco or other sources.) The tax incentives have been reduced as if the grant portion were "non-taxable" financing, such as an industrial revenue bond.

11. A ceiling for escalation of heating energy sales can be set. The fixed annual rate for debt service, amounting to about half of the annual costs, permits setting this ceiling in the range of 5 - 8% in the early years; in this scenario 5% has been assumed. This is the incentive for hooking up to the system. It also permits early amortization of retrofits. The final pricing policy must set initial pricing and an escalation formula for the PUD operations.
12. The size of the grant was selected so that the project cash flow turned into the black in the eighth year of operation. This amounted to \$1.21 million which, coincidentally, is the same order of magnitude as the estimated total installed cost of the prototype wellhead generator. However, tax considerations may recommend use of the grant money for public retrofits and distribution system.
13. The Project schedule used in this scenario includes the following:

Financing, Design and Construction 1982 - 1983

First full year of Operation, Calendar 1984

Project Economics

Coopers and Lybrand were subcontracted to conduct the economic assessment. This was conducted without audit, using cost data and factors supplied by Lahontan, and as generally used elsewhere in the industry. In summary, economic feasibility is shown when the capital is raised through a combination of private, commercial and grant moneys.

The capital costs, distribution of funds and sources of funds is shown in Table 4.

TABLE 4
Capital, Distribution & Sources of Funds

Item	Geothermal		Wellhead	Supply	Heating	Total
	Tangible	Intangible	Generator	Pipeline	System	
GEN REQUIREMENTS	0	0	0	0	0	149,000
SITWORK	0	4,840	0	34,160	139,190	178,190
CONCRETE	1,200	0	0	0	27,350	28,550
BUILDINGS	4,500	0	0	0	4,500	9,000
FINISHES	0	0	0	0	9,000	9,000
MECHANICAL	220,840	236,440	0	291,200	1,435,200	2,183,680
ELECTRICAL	74,550	0	0	0	25,100	99,650
ELECTRICAL RETRO.	0	0	0	0	36,800	36,800
DROP BLDG NO. 15	0	0	0	0	-109,469	-109,469
ADD WELL-HEAD GEN.	0	0	1,000,000	0	0	1,000,000
TOTALS	301,090	241,280	1,000,000	325,360	1,567,671	3,435,401
6% ENGINEERING	18,065	14,477	60,000	19,522	94,060	206,124
7% PROJECT MGMT	22,341	17,903	74,200	24,142	116,321	254,907
6.5% FINANCING CHG	22,197	17,788	73,723	23,987	115,573	253,268
TOTALS	363,694	291,448	1,207,923	393,010	1,893,626	4,149,700
INVESTMENT TAX CR.	36,369	0	120,792	39,301	189,363	385,825
BUSINESS ENERGY CR.	54,554	0	181,188	58,951	284,044	578,738
5-YR DEPRECIABLE	363,694	0	1,207,923	393,010	1,754,436	3,719,062
10-YR DEPRECIABLE	0	0	0	0	139,190	139,190
CAPITAL SOURCES						
BOSCO	0	0	0	393,010	816,260	1,209,270
EQUITY	363,694	291,448	589,769	0	0	1,244,910
DEBT	0	0	618,154	0	1,077,366	1,695,520
TOTALS	363,694	291,448	1,207,923	393,010	1,893,626	4,149,700

The economic assessment for the two years of development, first ten years of operation and the twentieth year is shown in Table 5.

TABLE 5
BRIDGEPORT GEOTHERMAL PROJECT ECONOMIC ASSESSMENT

FORECAST ITEM

KEY ASSUMPTIONS	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	2001
mm Btu SOLD	0	0	15,945	15,945	15,945	15,945	15,945	15,945	15,945	15,945	15,945	15,945	15,945
\$/mm Btu	11.00	11.55	12.13	12.73	13.37	14.04	14.74	15.48	16.25	17.06	17.92	18.81	27.80
MWH SOLD	0	0	2,232	2,232	2,232	2,232	2,232	2,232	2,232	2,232	2,232	2,232	2,232
\$/MWH	88.90	97.79	107.57	118.33	130.16	143.17	154.63	167.00	180.36	194.79	210.37	227.20	394.02
OPERATING REVENUES													
HEATING DIST SALES	0	0	193,373	203,042	213,194	223,853	235,046	246,798	259,138	272,095	285,700	299,985	443,214
ELECTRICITY SALES	0	0	240,094	264,103	290,514	319,565	345,130	372,741	402,560	434,765	469,546	507,110	879,452
NET REVENUES	0	0	433,467	467,145	503,707	543,419	580,176	619,539	661,698	706,860	755,246	807,095	1,322,666
OPERATING COSTS													
O&M LABOR	0	0	29,702	32,376	35,290	38,466	41,928	45,701	49,814	54,297	59,184	64,511	128,542
UTILITY COSTS	0	0	14,199	15,619	17,181	18,899	20,411	22,044	23,807	25,712	27,769	29,990	52,011
OTHER O&M EXPENSES	0	0	120,212	129,828	140,215	151,432	163,546	176,630	190,761	206,021	222,503	240,303	444,785
ADMINISTRATION	0	0	29,160	31,493	34,012	36,733	39,672	42,846	46,273	49,975	53,973	58,291	107,893
INSURANCE	0	0	71,265	76,253	81,591	87,303	93,414	99,953	106,949	114,436	122,446	131,018	225,113
TOTAL OF COSTS	0	0	264,538	285,569	308,289	332,832	358,970	387,173	417,605	450,442	485,876	524,113	958,342
NET FROM OPS	0	0	168,929	181,576	195,419	210,586	221,206	232,366	244,094	256,418	269,370	282,982	364,324
DEBT SERVICE	0	118,686	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000
PROJECT CASH FLOW	0	-118,686	-87,071	-74,424	-60,581	-45,414	-34,794	-23,634	-11,906	419	13,371	26,982	108,324
DEPRECIATION	0	0	483,171	710,228	676,996	675,605	675,605	6,960	6,264	6,264	6,264	6,264	0
INTANGIBLE DRILLING	120,640	120,640	0	0	0	0	0	0	0	0	0	0	0
DEPLETION	0	0	26,008	28,029	30,222	32,605	34,811	37,172	39,702	42,412	45,315	48,426	79,360
ADD BACK PRINCIPAL	0	0	18,627	21,235	24,208	27,597	31,460	35,865	40,886	46,610	53,135	60,574	172,793
OPERATIONS INCOME	-120,640	-239,326	-577,623	-791,446	-743,592	-726,026	-713,748	-31,901	-16,986	-1,647	14,927	32,867	201,757
EQUITY ITEMS													
CAPITAL REQUIREMT	1,244,910	0	0	0	0	0	0	0	0	0	0	0	0
TAX CREDITS	0	662,246	0	0	0	0	0	0	0	0	0	0	0
VALUE OF OPS INC.	60,320	119,663	288,811	395,723	371,796	363,013	356,874	15,951	8,493	823	-7,464	-16,433	-100,879
PROJECT CASH FLOW	0	-118,686	-87,071	-74,424	-60,581	-45,414	-34,794	-23,634	-11,906	419	13,371	26,982	108,324
EQUITY FLOW	-1,184,590	663,222	201,741	321,299	311,215	317,600	322,080	-7,683	-3,413	1,242	5,907	10,549	7,446
CUM. EQUITY FLOW	-1,184,590	-521,368	-319,627	1,672	312,887	630,487	952,567	944,883	941,470	942,712	948,619	959,168	1,062,418
EQUITY NPV @ 20% IRR % =	86,254 23.3												

The notes associated with Table 5 are as follows:

1. The heating district load is assumed constant without growth at 15,945 mm Btu/yr.
2. The sale of heat is based upon current propane energy costs escalated to \$11.00/mm Btu (delivered/consumed) in 1982 and then escalated at no more than 5%/yr.
3. The electric power sold is assumed constant (without growth through system expansion) at 2232 MWH/yr. The price is current pricing escalated at 10%/yr for '81-'87, 8%/yr for '88-'94 and 7%/yr for '95-'01.
4. O&M labor is one full time equivalent, \$25,000/yr, escalated at 9%/yr.
5. Other O&M is estimated at 3% of capital hardware escalated at 8%/yr.
6. Administration is estimated at \$25,000/yr escalated at 8%/yr.
7. Insurance for equipment only is estimated at 1.5% of installed capital, escalated at 7%/yr.
8. The debt (Table 4) of \$1,695,520 is a 20 year taxable debt at 14% or equivalent. At 14%, this is most likely equity plus a lease arrangement under present financial conditions. The \$118,686 in 1983 is 14% interest only on the debt, for one-half year, for construction financing.
9. Depreciation is composed of 5 year and 10 year, straight line, (see Table 4).
10. Intangible drilling costs are expensed in the first two year development effort.

11. Depletion allowance is 15% of up to 40% of net revenue or half of 40% of net revenue less portions of costs including depreciation, whichever is less.
12. Operations Income is composed of Revenues - Operations Costs - Interest (but not principal) - Depreciation (including Intangible Drilling Costs and Depletion).
13. There are no specific profits or royalties shown on this spread sheet. These will have to come from the revenues and downstream surpluses. Such will be defined in the final agreements.
14. Resource, or more specifically, revenue insurance of about 2-3% of revenue should be considered for the early years before a capital reserve is accumulated.

IMPLEMENTATION PLAN

Introduction

The Implementation Plan outlines the steps and procedures and identifies the principal entities required to develop, start up and initiate operation of the Bridgeport Geothermal Energy System. The Plan has the following principal elements:

- ° Institutional - Identification of principal participants; their roles and interfaces; and major agreements and permitting processes.
- ° Financing - Assessment of principal avenues for financing the Project as of this time. This is a rapidly changing, time dependent situation.
- ° Resource Development - Completion of exploration and development of the supply and injection wells.
- ° Systems Development - Engineering design, procurement, construction and the test/run-in of the integrated energy system.
- ° Retrofitting - Approach to retrofitting of the public buildings, the near-term commercial/private buildings and the longer range additional hookups.
- ° Systems Maintenance - Approach to maintenance of the components and subsystems.
- ° Pricing - Approach to the development of a pricing policy for the sale of thermal energy and electric power.
- ° Work Scope and Schedule.

The background for this plan was the "Bridgeport Geothermal Project Plan - Draft," February 1982. This document was reviewed with the principal participants in the Project with the results incorporated herein. The Implementation Plan is prepared in narrative, outline form to be used as a guide for the implementation process.

Institutional

The principal participants and their roles are as follows:

USBLM - Issuer of non-competitive Teases to Francana in July 1982.

The USBLM Final Environment Assessment ¹ has been reviewed by Lahontan and Cascadia Exploration. There are no major impediments identified that can preclude going forward with the development of the Bridgeport Geothermal Project as presently structured. As indicated in the BLM letter dated April 22, 1982, (Exhibit 1) no significant effect upon the quality of the human environment has been identified and hence no Environmental Statement will be prepared for the proposed leasing.

Francana Resources, Inc. - Principal geothermal leaseholder in the Big Alkali Caldera, Travertine Hot Springs area.

Lahontan, Inc. - Alternative energy systems developer with geothermal direct use sublease from Francana for fluids at less than 250°F; under agreement with the Bridgeport PUD and the California Energy Commission to conduct the feasibility investigation; and proposed developer of the direct use resource and energy distribution system for use by the PUD as a geothermal heating district. Lahontan to wholesale all energy solely to the PUD under a long-term agreement that assures a flow of energy to the PUD. It is proposed that the equity capital will be raised by Lahontan.

US Geological Survey - Permitting for exploration, development and well abandonment for geothermal resources on Federal lands. Lahontan to obtain permits from USGS.

Mono County - Land use permits control all development in the County. The Geothermal Element in their General Plan regulates exploration and development on non-Federal lands. Lahontan will apply for permits to develop that portion of the energy system which lies on other than Federal lands. The County also owns public buildings that are proposed to be the major load for the heating district. It is proposed that the County and the PUD will enter into a long-term agreement for the use of low cost geothermal heat in the public buildings.

Bridgeport Public Utility District - The PUD will distribute all heat and electric energy in the community of Bridgeport. Most likely the electricity will be sold under a negotiated PURPA formula with Southern California Edison (SCE) Bridgeport Station. An alternative is to sell the electricity to others and wheel through SCE. The PUD will maintain and operate the system under agreements with Lahontan. The PUD will acquire the distribution system when all debt and equity is retired. The PUD will have a buy out formula to acquire the system at any time.

Financing Entity - A financing entity will furnish the debt principal. It is proposed that the debt and interest will be retired by the revenues from the sale of the energy.

State of California -

California Energy Commission - Source of Technical Assistance and, potentially, a portion of the Bosco funds and other grant funds for funding the non-economic or high risk portions of the system.

Cal Trans - An energy consumer for their road maintenance station.

Southern California Edison (SCE) - The electric power utility that can purchase surplus electric power from the wellhead generator. Such purchase would be made under agreement between the PUD and SCE.

The agreement between the PUD and Lahontan for the development and for the operation of the system is the controlling document for implementation. When formalized, this can be either a two step or phased single agreement (preferred) or two successive agreements. This agreement would include the supply of geothermal energy from Lahontan to the PUD. The sale by the PUD of heat energy and electric power and the installation of retrofits for consumers of the energy will be under agreements between the PUD and the local consumers and the electric power utility, SCE.

Financing

All of the project financing must be committed to the Project before risk money is spent for the exploration, supply and injection wells.

The project financing will be based primarily upon revenue financing. Revenue from the energy sales will be used to retire the debt, pay the interest, return the equity and furnish an adequate return on equity as well as finance the cost of operations.

The extra long, moderate pressure (400 ft. head) supply line plus the projected relatively expensive drilling of the exploration/supply well and the prototype wellhead generator have raised the capital requirements to a point where revenue flow from heating the public buildings will not support the financing at today's cost of money. (The wellhead generator is needed to increase the thermal loading and revenue flow of the system, and it pays for itself under the assumptions and conditions used in this investigation.) This "extra" capital, under this scenario, has to be supplied by a grant. Potential sources of grant funds include Bosco

funds from Mono County - County of origin allocation; Bosco funds from CEC allocation for geothermal counties and local governmental entities (B-PUD); CEC R&D grants for innovative projects; foundations and other unidentified sources. Equity financing will be approached by exploiting the tax incentives for alternative energy projects. This includes the normal 10% investment tax credit (ITC) plus an additional 15% business energy credit (BEC). The latter is reduced in half if the debt financing is of a non-taxable type, (industrial revenue bonds, etc.). In addition, a straight line accelerated depreciation over 5 years is permitted for geothermal hardware. The geothermal wells qualify for intangible drilling cost write off and depletion allowances.

The economic scenario for this investigation originally considered 30% equity and 70% debt financing. When the grant was determined necessary, it was sized and the debt reduced accordingly, so that the project cash flow turned into the black in the eighth year of operation, (tenth Project year).

Debt financing, as of this time, most likely will be either a lease purchase or an industrial revenue bond. A combination of short and long term bonds can also be packaged along with the equity by commercial financing institutions.

Resource Development

Based upon the work accomplished by Cascadia Exploration for Francana and for this Project, the first logical step would be an exploration hole to be drilled in the SE 1/4, SW 1/4, Section 34, T5N, R25E, just southeast of Travertine Hot Springs. This hole would be sized for a supply well capable of producing up to 1000 gpm of flow (about 10" dia. well bore), and would be drilled to a depth of up to 2000 feet. The geology indicates that the resource is in a faulted system and hence the hole must intercept the plane of one of the appropriate faults in an "open interval" to achieve adequate flow rates of geothermal hot water. A suite of logs would then be run to determine the zone(s) of production and other down hole conditions. Depending upon condition of the hole, an air lift test of

flow may be run with the drill rig in place. Artesian flow is possible but flashing and high flow rates of steam are not expected. The well completion design will be finalized and the casing with slotted liner/screens/gravel pack/etc. will be installed in accordance with the geologists' and reservoir engineer's recommendations. A short (24-72 hr.) pump test will be run, using the driller's pump to measure well draw down (short term). Based upon this test, the supply pump procurement specifications will be prepared and the pump ordered. This total effort from drill spud-in to pump order and delivery is the critical path for revenue flow and also is the highest risk area.

If the first well does not hit hot water of adequate flow rate or temperature, the test results will be assessed and the hole will be deepened, slant drilled and/or another hole drilled. These activities will continue until adequate energy flow is developed or until the economic limit to the Project is reached.

An alternate, "slim hole" approach to exploration can be taken at a lower initial cost for the first hole(s). However, it is possible that total drilling costs will increase by the cost of the slim holes.

Depending on the final business plan, the injection well could be installed as part of system construction and thereby not require risk capital for this item. The full scale, 30 day pump test of the supply well will most likely require the use of the injection well.

Systems Development

A Basis of Design will be required to obtain the financing commitments. This will most likely be funded by the initial investors and capitalized or expensed as their business plan dictates.

When construction funds are committed, the engineering, drawing specifications and long lead procurement will be the first efforts in the construction.

After completion of the supply well, the pump and its variable speed drive will be installed. A weather protection structure for winter time maintenance will be constructed at the wellhead. This facility must be maintainable by personnel on foot or snowmobile during winter. This includes a built-in capability to pull and replace the pump and all wellhead equipment. Most likely, all central signals including pump speed will be generated and controlled at the Utility Plant facility near the County Road Maintenance facility.

The single, steel, insulated supply line will transmit geothermal fluids from the well(s) to the Utility Plant. All control functions, heat exchange and power generation will occur at the Utility Plant. Spent geothermal fluids will be injected under pressure through the injection well to be located as close as practical to the Utility Plant. The fluids will be maintained at pressure without exposure to the atmosphere and without admittance of oxygen into the fluid. The integrity and accountability for extraction, transport and injection of geothermal fluids is the legal responsibility of the developer of the geothermal well system. Except for programmed or emergency shutdowns, there will always be a continuous, minimum flow of geothermal fluids through the supply and injection system.

The Utility Plant, Wellhead Generation System and Distribution System will be constructed using commercial hardware and equipment. Tap off valve boxes will be located along the Distribution System near major building complexes and periodically elsewhere for commercial and private hook ups. The Distribution System will be filled (in a closed circuit) with treated water so as to be compatible with the hot water boiler systems. These boiler systems will be left on line for stand by and peaking when and if the load on this system ever reaches full demand. The treated water in the Distribution System will not be consumed. Make up for leakage only will be provided. Consumptive hot water will be furnished through heat exchangers at each retrofit. Continuous flow through the Distribution System will be required to assure adequate heat

for consumptive hot water and to prevent freezing of lines. All pipelines will be buried and the river crossing will be suspended from an existing bridge.

System controls will operate the startup and demand speed of the supply pump, transmission line controls, and distribution pressure and flow rate. Energy demand controls will operate the Distribution System pumps and valves. Each consumer facility or complex will have individual energy metering and flow to each consumer will be on a demand basis. The consumer will pay for the actual energy consumed. System controls will be located in the Utility Plant. Retrofit/consumer hook up controls and energy meters will be located at the site of each consumer facility or complex.

Retrofits to hook up consumers to the Distribution System will be managed by the PUD. For those consumers who sign up prior to system construction, their retrofits can be included in the overall system development and construction package. The PUD must at all times have control of the heating fluid in the Distribution System. The PUD will have the right to inspect retrofit installations and will specify the use of only approved materials that will be in contact with the fluid. Maintenance and repair of retrofits can be accomplished by commercial firms; however, such activity must be in accordance with PUD guidelines and subject to PUD inspection.

System Maintenance

The supply system maintenance will be the responsibility of Lahontan. From a practical standpoint and in preparation for the eventual take over by the PUD, most likely Lahontan will contract with the PUD for supply system maintenance and operation. The Distribution System will be maintained by the PUD under contract with the lender/owners of the system. When the PUD owns the system, all operations and maintenance will be their responsibility. The semi-automatic wellhead generator

will be designed for normal technician operation and maintenance. Technical support for maintenance and operation will be furnished through Lahontan and the principal suppliers. Only commercially proven hardware and equipment will be used. Even the components of the Wellhead Generator will have a commercial background behind them. All components and subsystems will have a normal commercial one-year warranty and an extended warranty service agreement can be obtained.

Pricing

Before agreements for consumer hook up can be reached, a pricing policy will have to be developed and adopted by the PUD. This policy must address issues such as:

- ° Incentives for hook ups - Low cost energy rates vs limited escalation rates. The issue of downstream disparity of geothermal energy rates vs conventional energy rates for those located on the pipeline vs those located remote from the pipeline.
- ° Disposition of Surpluses - Leveraged financing for system expansion, establishment of capital reserves and self-insurance funds vs rebates to consumers. Should surpluses be used to subsidize economic development activities of the community - attract industry and jobs (and improve the economics of the energy system).

There are some recent precedences that warrant further study. The City of Susanville's experience is one and the pricing modeling being done by C. Higbee of the Oregon Institute of Technology, Klamath Falls, Oregon, is another.

Pricing of the electric power for sale to SCE will require negotiation with the utility. Such negotiations will indicate whether the electric power can and should be sold locally, sold solely to SCE or sold to another consumer and wheeled through SCE. The objective should be to reduce the total cost of all energy to the community.

Work Scope and Schedule

The work effort will include the following general tasks:

- ° Development of Project Financing
- ° Institutional - permits and agreements
- ° Engineering - Basis of Design, 35% Engineering and Construction Design package
- ° Procurement
- ° Construction
- ° Checkout/Test
- ° Operations

The Project Schedule is shown in Figure 5. This schedule presumes that grant funding is available at the time private and debt funds are committed. In that some grant application/award processes have been known to take 6 - 18 months or more, the grant application process must be initiated before month No. 1 on the Schedule.

FIGURE 5
BRIDGEPORT GEOTHERMAL PROJECT

CONCLUSIONS AND RECOMMENDATIONS

1. Under the conditions defined herein an economically feasible scenario has been outlined for the Bridgeport Geothermal Project.
2. There are two high risk areas:
 - (1) Though there has been extensive surficial exploration, no geothermal wells have been drilled in the immediate vicinity of the proposed well site. A successful well yielding over 180°F - preferably over 240°F and over 1000 gpm of flow, has to be drilled before feasibility is truly in hand.
 - (2) Significant increases in capital costs have been identified that are beyond the revenue producing capability of the small Bridgeport heating load. A grant on the order of \$1.2 million will be required to offset these capital cost increases.
3. Provided temperatures in the range of 180°F - 240°F and flows in the order of 1000 gpm can be achieved, this Project is an ideal application for a wellhead generator. The state-of-the-art and the industry have matured to the point where fractional MWe units are practical when combined with a heating district. The systems integrator/supplier must be carefully selected. The procurement must be conducted under a sound agreement that commits the supplier to total system performance, reliability and maintenance such that the wellhead generator system can be considered as a commercial enterprise.
4. Initiation of the Project will require:
 - a) Commitment of all principal parties to proceed.
 - b) Commitment of risk money to locate a viable source of geothermal fluid.

- c) Commitment of a source of grant funds adequate to assure the economics of the system. This must be timely and coincident with the commitment of debt and private funds.

GLOSSARY

BTU - British Thermal Unit -- The heat required to raise the temperature of 1 lb. of water 1°F. "m Btu" represents 1000 Btu and "mm Btu" represents 1,000,000 Btu.

MWe - Mega Watt electric or 1,000,000 watts.

Organic Rankine -- Rankine cycle is a closed cycle energy conversion process. Organic refers to the nature of the fluid in the closed loop. Conventional automotive air conditioners using Freon are organic Rankine cycle systems.

Therm - 100,000 Btu

Total Dissolved Solids - "TDS" expressed in parts per million or "ppm" -- refers to salts dissolved in geothermal "brines" or fluids.

REFERENCES

1. "Final Environmental Assessment -- Geothermal Leasing -- Bridgeport - Bodie Hills Area", U. S. Department of the Interior, Bureau of Land Management, April 1982.
2. "A Proposal for a Feasibility Investigation of the Bridgeport Geothermal Energy System", Lahontan, Inc., proposal LG041781 to the CEC, dated April 11, 1981.*
3. "Contract #500-81-003", California Energy Commission, dated April 28, 1981, with Lahontan, Inc., to conduct the Bridgeport feasibility study.
4. "Agreement", dated September 14, 1981, between the Bridgeport Public Utility District and Lahontan, Inc., for the feasibility phase of the Project.
5. "Agreement", dated July 10, 1981, between Francana Resources, Inc., and Lahontan, Inc., for sublease of the direct use energy in the Travertine Hot Springs/Big Alkali area.*
6. E. V. Ciancanelli and K. E. Johnson, "Well Site Recommendation Bridgeport - Bodie Hills Geothermal Resource, Mono County, CA", November 11, 1981.*
7. "Bridgeport Geothermal Project Plan", February 1982, (Draft), Lahontan, Inc.
8. "Geothermal Energy, Opportunities for California Commerce", June 1982, Lahontan, Inc., under Contract #500-80-130 with California Energy Commission. CEC Report #500-82-008.

NOTE: All references are on file at the CEC Small Power Producers Office. Those marked (*) contain data developed outside of CEC Contract #500-81-003 and/or are considered proprietary to the entity that developed said data.

9. "Geothermal Energy Element of the Mono County General Plan", April 1981, IMAGE.
10. "A Geologic Reconnaissance of The Geothermal Area Near Bridgeport, Mono County, California", Road 09-MNO-395, CA Department of Transportation, Transportation Laboratory, August 1978.

EXHIBIT I

United States Department of the Interior

IN REPLY REFER TO

1791 (C-017.1)

BUREAU OF LAND MANAGEMENT
800 Truxtun Avenue, Room 302
Bakersfield, California 93301
Phone: (805) 861-4191
Office Hrs: 7:30 a.m. to 4:00 p.m. weekdays

APR 22 1982

Interested Parties:

Enclosed is a copy of the final Environmental Assessment (EA) for proposed leasing of geothermal resources in the Bridgeport-Bodie Hills area of Mono County, California.

This EA analyzes the general impacts which would result from geothermal development in the study area. It has been determined that the proposed leasing action does not represent a major Federal action significantly affecting the quality of the human environment in the sense of Section 102(c) of NEPA. Therefore, no Environmental Statement (ES) will be prepared on this proposed action.

If you have any questions concerning this document, please call Rand L. Lewman at (714) 872-4881.

Sincerely yours,

Garold W. Lamb
Acting District Manager

Enclosure