FORT BIDWELL INDIAN COMMUNITY COUNCIL
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Established January 28, 1936 under the I.R.A. of June 18, 1934

EXECUTIVE SUMMARY

Fort Bidwell Indian Reservation
Geothermal District Heating System Feasibility Study

Following is the final report of a study funded under grant contract No. DE-FG36-05GO15181 to the Fort Bidwell Indian Community (FBIC) from the United States Department of Energy (DOE) Tribal Energy Office, to determine the feasibility of establishing a Geothermal District Heating System on the reservation.

The Gidutikad Band of the Northern Paiute Tribe is federally recognized as the Fort Bidwell Indian Reservation (FBIR), located in the geothermal-rich Basin and Range Province of Northeastern California.

The reservation has three geothermal wells from 500-ft to 2900-ft in depth, ranging from 100°F to 200°F and a fourth well (FB-4), recently drilled to 4700-ft which is due to be tested for temperature and flow in Spring 2009. It is hoped that FB-4 flow/temperature will support power generation.

Through a district heating system, one geothermal well can heat all of the 46-homes, 5-apartments, and 7-community buildings with clean, renewable energy that can be cascaded for direct uses, e.g. green-housing, aquaculture, etc. before re-injection.

Piping was installed to several of the homes and community buildings in previous years, so part of the feasibility study was to GIS all of the existing structures. Biological and archeological studies were done on the proposed piping corridors, water chemistry tested and a permitting discussion included in the final report.

The proposed engineer-designed system would cost about $1,500,000 to install and the annual space and water heating electricity cost savings would be about $124,300, with an estimated payback of 12 years.

Surveys completed in 2000 and 2002 indicate the preference of tribal members to utilize their geothermal resources as part of their economic development plan. However, community support is essential to the next step in the district heating/power production process. Perhaps a capacity building grant would allow the Tribe to engage more of its members in the geothermal development process and build a consensus for economic energy expansion.

John R. Vass, Tribal Administrator

Ft. Bidwell Indian Reservation

GEOTHERMAL

Direct-Use

Feasibility Study

Merrick Consulting
Direct-Use Geothermal and GIS Services
P.O. Box 125 Canby, CA 96015 Phone: (530) 640-1477

April 20, 2007

Fort Bidwell Indian Community
PO Box 129
Fort Bidwell CA 96112

Project Title: Renewable Energy Development on Tribal Lands
Award Number: DE-FG36-05GO15181

Dear Friends,

It has been a privilege to serve the Gidutikad Band of the Northern Paiute Tribe (the Fort Bidwell Indian Community, FBIC) during this last year. The Reservation is host to a geothermal resource that has the capacity to serve the inhabitants for generations to come if the Tribe chooses to develop it.

During the feasibility study, I had a chance to talk with most of the residents on a one-to-one basis about the geothermal study and the implications of choosing to develop this resource. Whether the residents were for or against development, I was treated with respect and consider all of the Tribal members I had contact with as my friends.

Coming from a small rural community myself, I understand the challenges and choices that lay ahead of the Tribe. Large projects such as geothermal development are not entered into lightly. My hope is that this DOE funded study brings the Tribe the information and understanding needed to make the best choices for all residents.

Sincerely,

D. Merrick

Dale Merrick
Merrick Consulting

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Merrick Consulting
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FT. BIDWELL INDIAN RESERVATION GEOTHERMAL DISTRICT HEATING SYSTEM FEASIBILITY STUDY FINAL REPORT

April 2007

I. INTRODUCTION

This is the final report on the feasibility of a geothermal district heating system on the Fort Bidwell Indian Reservation. This study is funded under grant contract No. DE-FG36-05GO15181 to the Fort Bidwell Indian Community from the United States Department of Energy (DOE) Tribal Energy Office.

The Gidutikad Band of the Northern Paiute Tribe (the Fort Bidwell Indian Community, FBIC) has a great opportunity to develop its geothermal resources for the benefit of present and future generations. Geothermal development could ultimately lead to energy and economic self-sufficiency. The geothermal potential on the Ft. Bidwell Indian Reservation is extensive and could provide income, energy, jobs and opportunity for generations if the Tribe chooses to develop these resources.

Community participation studies in 2000 and 2002, resulted in a Community Action Plan and an Economic Development Plan both of which identified development of the geothermal resources as a high priority. In conversations undertaken as part of this study, Tribal members have revealed no shortage of dreams for future projects. Some members envision a convenience store/gas station; some spoke of greenhouses; others see a golf course on the Reservation and still others a casino.

Use of a geothermal heating system on the Fort Bidwell Indian Community would be not only feasible but highly desirable under certain conditions. All of the residences and community buildings, as well as these potential future projects could be heated by the Tribe's geothermal resources. Energy costs such as for propane and electricity will continue to escalate with time, making the Tribe's development of their geothermal resources a good investment today, for a secure energy future.

What is a Geothermal District Heating System?
A geothermal district heating system delivers hot water, usually from one well, to heat many buildings. Hot water from a geothermal well flows constantly through a heat exchanger and is

injected down another well back into the geothermal reservoir. The geothermal water is never exposed to the atmosphere nor used in the pipes that serve the buildings. Clean or treated water in a separate closed loop piping system passes through the other side of the heat exchanger and carries the heat from building to building, delivering it to individual heat exchanger units where the heat is transferred into the buildings' forced air ventilation systems, used in radiant floor heating, and/or providing heat to the hot water heater or all three. The water in this pipe loop is constantly circulating through the geothermal heat exchanger to be reheated, and continues back around to the buildings and back again through the heat exchanger.

The Geothermal Resource

The initial resource examined for its potential to provide energy to a Tribal geothermal district heating system was the FB-3 geothermal well. While FB-3 would be an outstanding energy provider for district heating, the water chemistry would preclude land or surface water discharge under today's Environmental Protection Agency (EPA) standards. Disposal down an injection well is the solution. Potential injection scenarios are discussed below.

What Would It Mean to the Residents?

Geothermal district heating systems are inherently reliable and clean, and entail significant energy cost savings over time. Residents of the I'SOT Community in Canby, California found that the buildings were more comfortable after installation of geothermal district heating. With electric or furnace heating, the temperature varies considerably, with heat going off and on. Geothermal heat is delivered more evenly and seems to distribute better within homes. Residents with wood stoves or fireplaces can continue to use them if they wish, using the geothermal heat to maintain minimum temperatures.

The systems do have ongoing maintenance and oversight needs. That oversight can be done by a designated person or contractor in a way that imposes no duties on residents, other than to report any problems should they arise. The Tribe's current heating systems rely on electricity, propane and wood. If any one of those heating systems were to break down, it likely would affect one residence or building. However, buildings on a geothermal district heating system are interconnected like those on a public water system, affecting everyone on the system. Thus, vigilance is required.

Considerations for Residents and Nonresident Members of FBIC

The estimated project cost for a district heating system would be approximately $1.5 million. To protect that investment and ensure the success of the project through the turnovers in tribal governance over time, it is recommended that it be undertaken by an Enterprise Corporation or similar entity, such as is being done for the FBIC timber program. Formation of a tribal utility might be considered.

The importance of community support also cannot be underestimated. Assuming no grants were used to finance the project, payback on the proposed geothermal district heating system is approximately 12 years. That assumes that all residents would connect to the new system. The economics would be less desirable if only half of the residents connected. Further, the success of any project is questionable at best if community support is divided.

II. BACKGROUND

The Gidutikad Band of the Northern Paiute Tribe (the Fort Bidwell Indian Community, FBIC) resides in the extreme northeast corner of California, west of the Town of Ft. Bidwell. The Fort Bidwell Indian Reservation (FBIR) has extensive low and suspected moderate temperature geothermal resources. There are currently three geothermal wells on the reservation and a fourth, deeper exploration well is planned to be drilled during the summer of 2007 to determine power producing potential.

For a time, the existing wells were used in a demonstration aquaculture project on the reservation and some buildings were heated with heat pump technology for some years, but that installation is now defunct.

The tribe, with the assistance of consultants, including Merrick Consulting, has undertaken this feasibility study for a geothermal district heating system to serve all buildings on the reservation. I'SOT, Inc. has recently installed a successful geothermal district heating system in a community of similar size in Canby, California, about 50 miles as the crow flies and about 75 miles driving distance from the reservation.

III. RECOMMENDATIONS/CRITERIA FOR DECISION MAKING

The following recommendations and criteria for consideration may serve to guide a future decision to proceed, or not proceed, with the development of a geothermal district heating system. See also the Steps for Implementing Geothermal District Heating, at the end.

Criterion #1: Potential for Integration of Power and Cascaded Geothermal System. While most geothermal district heating systems use a primary well, there are two potential sources of hot water to serve a district heating system on the reservation. FB-3 is the primary well identified for this use. The Tribe may also consider cascading the spent geothermal water from a possible power project. That is, using the heat from geothermal water first in power production then in successively lower temperature direct-use applications until re-injection. Such practices maximize the benefit obtained from the resource.

If the FB-4 well, planned for drilling in the summer of 2007, is hot enough and has sufficient flow to drive a power plant, the cooler, but still hot discharge water from the plant could be used to provide energy to a Tribal district heating system. Under that scenario, it may be feasible to convert FB-3 to an injection well. That would cost less than drilling a new injection well. If FB-3 *and* FB-4 wells were both used for power generation, a new injection well would be needed.

Unless grant funding were obtained, drilling a new injection well for a district heating project would make the project economically infeasible at current drilling rates. The option of surface discharge of the discharge water is not considered feasible, due to the levels of mercury, arsenic and boron in the water. Further, injection is routinely required by permitting agencies and provides additional benefits to a geothermal resource project by sustaining the reservoir. And re-injection is the approach that honors the tribal environmental values.

The FB-3 well alone could serve a well-designed district heating system *and* serve a commercial load of two 50,000 square ft. greenhouses or other equivalent energy heat loads. While previous discussion focused on the potential for expanding district heating to the Town of Ft. Bidwell as a possible revenue source, the greenhouse concept serves as a convenient "placeholder" providing a quantifiable energy load with which to begin the design process.

There is no reason to believe that the new FB-4 well should not far exceed the temperature and productivity of FB-3. However, if all that was found in the FB-4 drilling was the same resource as FB-3, there would still be enough energy to provide electricity and direct-use applications for FBIC, yet on a smaller scale than a much hotter FB-4 would provide.

Criterion #2, Finance
The cost of installation of a new geothermal district heating system to serve the reservation was estimated at $1,500,000, not including FBIC's administration costs. Current overall energy costs to heat all project buildings were estimated at $126,300 per year, with a simple savings payback of a district heating system of approximately 12 years. Should full or partial grant funding be available, the payback period would be shorter. Energy cost savings can be as much as 90%.

Criterion #3, Long-term, Consistent On-site Maintenance
Geothermal heating technology is water-based and can freeze even though most pipes are safely buried below the frost zone. In case of events such as loss of electrical power, hot water coils in vacant buildings and mechanical room plumbing, if left exposed, can cause expensive damage if maintenance personnel are not alerted to a potential problem or are non-responsive. While maintenance requirements, for the most part, are minimal and may only require a few hours per week, there are critical times when attendance is required. Automatic computerized monitoring of the system pressure and temperature can be integrated into the system. A monitor from outside the Tribe may be considered and contracted to oversee that maintenance is being performed.

Criterion #4, Majority Support of the FBIC
Community support is essential to the success of any project that is undertaken by that community – whether residents or nonresident members. Additionally, the project will be more economical (and a funding agency would be more inclined to fund it) if most of the residents were going to connect to the system. Sharing of information about geothermal district heating with tribal members through workshops and mailings, and polling to get feedback on support for the project, is recommended.

IV. APPROACH AND FINDINGS

Building Identification and Heating Load Assessment
Approach – The first task was to identify buildings within the project area that would receive heating from a possible geothermal district heating system and place them into a geographical information system (GIS) (Appendix A). Care was taken to be as unobtrusive as possible to Tribal residents. When on the reservation, a Tribal member was present as a guide as often as possible. Instead of inspecting each building and heating system, a more hands-off approach was used by using accounts of maintenance personnel and long time residents to get information on building and heating types. Sample buildings were physically measured and used as models for other similar buildings. The project engineer, Brian Brown, was provided with all pertinent information with which to complete a heating load assessment (See Appendix C).

A Tribal geographical information system (GIS) was created with the compiled information and installed on selected FBIC computers. A table in the GIS includes building number, address, resident's name, square footage, and a hot-linked picture of the building. All maps in this report were printed from this GIS file (Appendix A).

Findings -- The FBIC includes 58 existing heated buildings totaling about 96,546 square feet floor area. Existing buildings include 44 wood-frame residential buildings between 960-2,000 ft^2, 5 small apartments (935 ft^2 each) and 7 Tribal community buildings. The largest of these buildings are a 5,296 ft^2 Tribal Community Center, an 8,100 ft^2 gymnasium, a 4,960 ft^2 Indian Health Clinic and a 3,520 ft^2 Fire Hall. Currently, most of the buildings are heated with electric forced air furnaces. Other heating equipment includes wood stoves and electric baseboard heaters.

Geothermal Resource Evaluation
Approach – All existing reports on the Tribal geothermal wells, with emphasis on the FB-3 well, were gathered and evaluated by the project engineer. The Principal Investigator and geologist for the planned FB-4 well were interviewed.

Samples of water from FB-3, as well as all other Tribal geothermal wells and several wells in the Town of Ft. Bidwell were taken and analyzed to understand local water chemistry and make a determination if land or surface water discharge of spent geothermal fluids was an option for disposal. (Appendix B)

Findings -- In the 1980's, the California Energy Commission invested funding to drill three geothermal wells on the Ft. Bidwell Indian Reservation, all with successful outcomes. The following is a description of those wells and potential use.

- FB-1 was drilled in 1981 to a depth of about 507 feet. It is about 500 ft. east southeast of the Old Soldier's Well. The well has an artesian flow of 450 gpm at 116°F. It was used for several years with heat pump technology to supply space heating for the Tribal Community building, a six unit apartment complex, a private residence and a small gymnasium. Other than the heat pump application that it had been previously used for, the well could also be used for a future swimming pool / spa application.

- FB-2 was drilled in 1983 and used for several years to grow catfish on a Tribal aquaculture project for market. It was drilled about 1,600 ft. southwest of the FB-1 and has a depth of 1,260 feet. The water flows artesian at about 1,500 gpm at 96°F and is perfectly suited for aquaculture (fish farming) if the Tribe decides to again undertake aquaculture operations.

- FB-3 was drilled 1,750 ft. west of the FB-2 well in 1985 to a total depth of 2,920 feet. The well has an artesian flow of 350 gpm at 198°F and is located about 167 feet above the community. The maximum temperature encountered in this well was 209°F at 2,330 ft. Originally, this well was drilled to explore for power generation, but when the temperature was inadequate, it was targeted to provide heat for a geothermal district heating system.

  A feasibility study completed in 1987 recommended extracting the heat from this well for a district heating system with surface disposal to a nearby stream. Today's environmental laws would make that impossible because levels of mercury, arsenic and boron exceed Environmental Protection Agency (EPA) standards. The surface disposal option of geothermal water would also conflict with Tribal values of "only taking what is needed" from the Earth. Re-injection of geothermal fluids is the only disposal option that is realistic at this time.

FB-4, a planned geothermal well funded by the DOE and CEC, will be drilled in the summer of 2007 to a planned depth of 5,500 ft to discover a possible higher temperature resource for power production. Encouraging data points to a possible 300°F resource. If successful, this well would also need a re-injection well in order to dispose of the geothermal water that passes through a power plant. For planning purposes, a preliminary estimate for possible power production from this well was set at a conservative 1 MW. If FB-4 is able to meet this conservative expectation, at least 75% of the power could be sold after Tribal energy needs are met and a district heating system supported by these fluids could easily take care of Tribal heating needs and beyond.

This option also has the advantage of potentially expanding the capacity of the district heating system. In the years to come, the Town of Fort Bidwell will grow as will energy costs for heating that community. This puts the Tribe in the position of supplying power in the future if they choose to do so. At the very least, the Tribe would be able to realize energy self-sufficiency.

The existing FB-3 well could be considered for conversion to an injection well. Depending on the results of the FB-4 well, various options may be considered that would combine the two projects. Even if FB-4 produces water at the same temperature as FB-3, it would provide additional opportunities. Recently improved power generation technologies might allow generation of electricity in a power plant using the production from both FB-3 and FB-4.

Technology Analysis and Preliminary System Design
Approach – Each project building was assigned an appropriate hydronic technology that would be most easily retrofitted into the existing furnace or unique situation. A 1987 feasibility report was reviewed. Tribal elders and staff were interviewed.

Findings – The proposed district heating system design capacity for this feasibility study is $12x10^6$ Btu/hr, with a design circulation of 600 gpm and a 40°F temperature drop. The system would have the capacity to meet the design heating load of the existing community buildings of about 2.5 $x10^6$ Btu/hr, plus serve a commercial load of two 50,000 square ft. greenhouses or other potential energy intensive commercial heat load. That heating capacity is well within the known capability of geothermal well FB-3.

An alternate scenario was considered with a design capacity of $4x10^6$ Btu/hr, with a design circulation of 200 gpm and a 40°F temperature drop. The alternate scenario would meet existing community heating loads, but with less capacity for future expansion. (Appendix C)

Approximately 6,400 ft (2,700 lineal ft) of 2" to 2-1/2" supply and return pipelines had been installed in 1987. A backhoe was used to uncover the lines and an hour-long pressure test verified that the pipes could hold a constant 30 psi. Further analysis by the Project Engineer verified that this piping had the capacity to service the south end of the district heating system. (Appendix F)

Environmental Evaluation
Approach – Biological (Appendix D) and archeological (Appendix D) surveys were obtained, focusing on proposed piping corridors. Well chemistries were analyzed. A discussion of permitting required for installation of a district heating system was developed (see Steps for Geothermal District Heating System, below).

Findings - Re-injection of geothermal fluids was chosen as the method of disposal so no environmental impacts from surface discharge were considered. Tribal members were part of an ongoing discussion and training regarding geothermal production and disposal issues. Biological and archeological studies revealed no significant barriers to development.

Economic / Benefits Analysis
Approach – The economic evaluation was done by calculating heating load by assuming the heating energy is all electric. The cost of a potential pipeline from FB-4 to FB-3 was not included in the economic evaluation. In order to calculate economic benefits, prices for equipment and supplies were obtained.

Findings – The designed geothermal system would be approximately $1,500,000. Estimated annual electric heating costs savings would be $124,300, assuming hot water were also provided by the geothermal district heating system. Assuming all residents connected to the geothermal system, overall investment could be paid back in 12 years.

Training and Professional Development

Approach – Tribal members were invited to participate in all phases of this work and encouraged to ask questions. Whenever an area of interest was identified, additional opportunities for training and exposure to other projects were offered. Tribal members attended the 2006 Annual Meeting of the Geothermal Resources Council in San Diego, the California Geothermal Collaborative Tribal Geothermal workshop in Susanville, California, field trips to visit a district heating system and aquaculture farm in Canby, California, and to the Steamboat binary power project in Reno. Presentations were made to Tribal members at Tribal Council and other meetings. Several capacity-building opportunities were posted, offering involvement in the technical and research aspects of the project. The Tribal Chairman and 6 other tribal members participated.

Findings - Participants raised pertinent questions. Both supporters and skeptical tribal members participated. Understanding of geothermal energy and potential impacts to the tribe was increased. Some members expressed very positive feedback and some remain skeptical.

Tribal Review Meetings, Quarterly and Final Report

Tribal members and consultant participated in annual DOE Tribal Energy Office Renewable project reviews in Denver, and gave a PowerPoint presentation on the project at that meeting. Required periodic reports were submitted timely.

V. STEPS FOR DISTRICT HEATING SYSTEM DEVELOPMENT

The following elements were identified as essential to a successful district heating system project over time:

Community Support

Although much support for geothermal developments have been expressed in formal reports or interviews with tribal members, such support must be confirmed prior to undertaking a geothermal district heating project.

Determine injection site and possible integration with power generation

After completion of the planned Well FB-4, determine if and how a power plant project and a district heating project might be integrated to lower the cost for both by sharing of an injection well.

Finance/grant funding

Review the finance and grant funding options to pursue. Obtain the services of the financial, geological and mechanical engineering consultant expertise necessary to help develop finance or grant proposals to drill an injection well or rework FB-3, develop a final updated budget for drilling and testing an injection well and designing and installing a geothermal district heating system

Geologist/Drilling Engineer
Obtain the services of a professional geologist and drilling engineer to oversee the drilling of the injection well or rework of FB-3

Mechanical Engineer/Construction
Hire a mechanical engineer familiar with geothermal systems to put out for bid the construction of the geothermal system and oversee construction.

Operation/Maintenance
Any supplemental economic analysis or project planning must take into account the need for ongoing monitoring and maintenance of the system. Although these systems, once up and running are not labor-intensive, routine and sustained monitoring and maintenance are required.

Permit Requirements
Indian tribes are sovereign nations. Although they are subject to imperatives of the U.S. Congress, in general, Indian lands are not subject to state or local regulation. Tribal relationships with agencies of the federal, state and local governments are conducted on a government-to-government basis. The FBIC would be the proponent and the primary authorizing agency for permitting a geothermal district heating project. However, unless a Tribe has adopted a regulatory scheme for a particular action, projects on Indian lands are subject to federal law where a federal regulatory framework exists for that action.

The particular permits and regulatory compliance requirements of a project on Indian lands will depend on how the project is funded, whether it is conducted wholly on Indian lands or has offsite impacts and what natural resources might be affected by it. For instance, a project that uses federal funds must comply with the National Environmental Policy Act (NEPA), projects with off-reservation impacts would be subject to state and local regulation, and a state grant funding contract might require compliance with certain state employment and environmental laws, such as the California Environmental Quality Act (CEQA). Installation of a geothermal district heating system would be wholly on the Fort Bidwell Indian Reservation, so local regulation would not be an issue.

Environmental review under NEPA and CEQA would be facilitated and accelerated by the work undertaken as part of this feasibility study. Biological and archeological surveys were performed on the areas potentially disturbed by a district heating project. The biological surveys addressed both federal and state lists and found no threatened or endangered species issues for the project.

The archeological study found an area around which caution must be exercised, but no barriers to the project. It recommends all trenching activities be monitored by a professional archeologist except for the pipeline that would begin at FB-4 to FB-3 and end at a proposed district heating mechanical building (see Appendix A). Although the FB-4 to FB-3 pipeline is not a part of the district heating cost estimate, it needs to be addressed after FB-4 is drilled and options for re-injection explored.

According to Rabe Consulting, there are no known biological issues that would be prohibitive to development.

California has obtained primacy to administer the federal Clean Air Act and Clean Water Act through its various regional Water Quality Control Boards and Air Pollution Control Districts. However, tribes are not subject to California regulation, so, on Indian Lands, these laws are administered by the U.S. Environmental Protection Agency (EPA).

If a district heating project were to include the drilling of an injection well, or reworking of an existing well for use as an injection well, an injection permit would be required from EPA under the Safe Drinking Water Act.

Any work on the 20 Housing and Urban Development (HUD) homes would need to be closely coordinated at the planning stage with the FBIC Tribal Housing Office.

VI. CONCLUSION

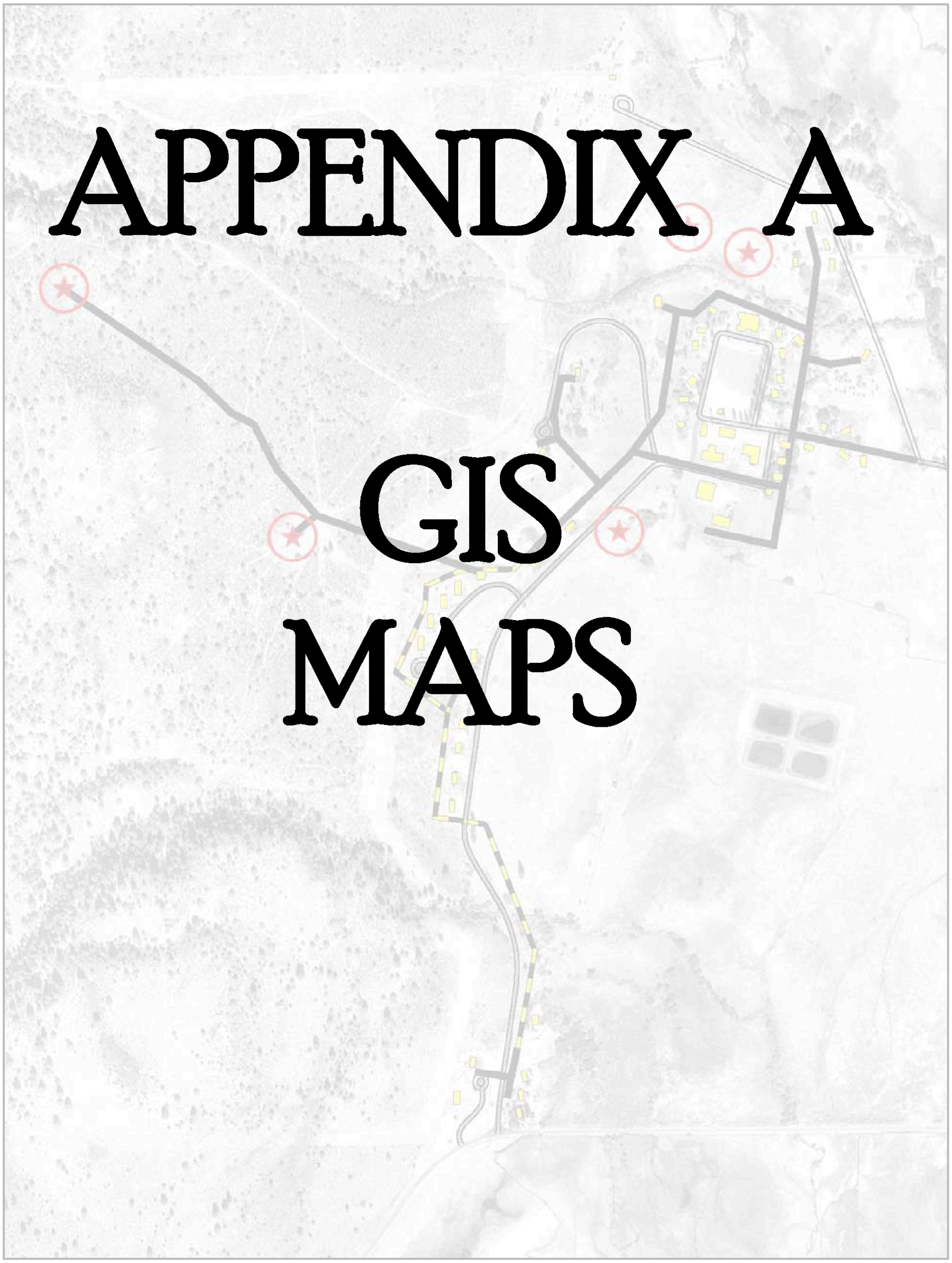
The Fort Bidwell Indian Reservation is rich in geothermal resources. A geothermal district heating system would provide economical, clean, low maintenance heat for the buildings on the reservation and could support any number of additional enterprises or income from sale of hot water off the reservation if the Tribe chooses to develop.

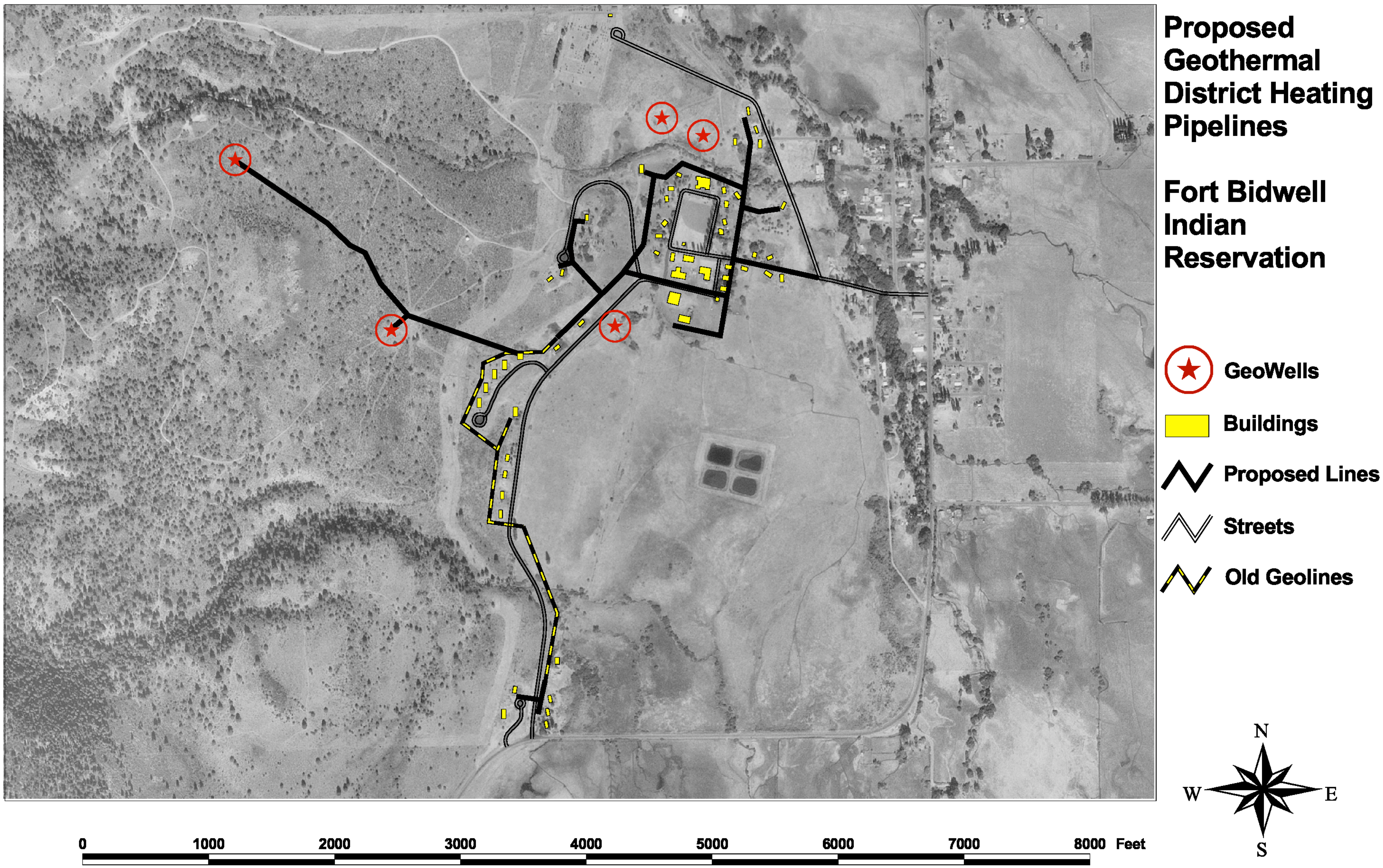
Wells FB-1 and FB-2 could be used for any number of Tribal projects including:

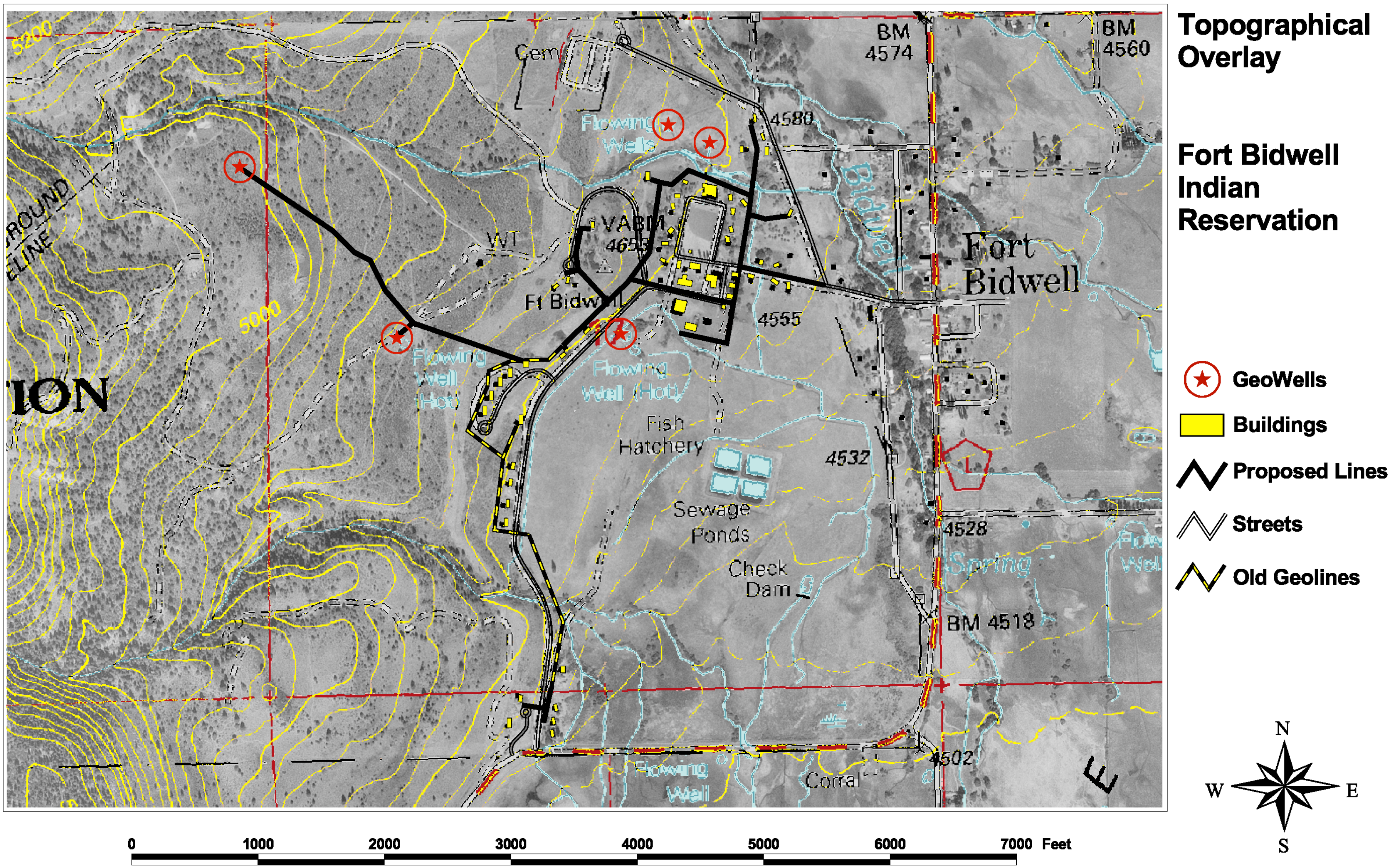
- Aquaculture (fish farming)
- Spas, medicinal soaking
- Resorts
- Tribal swimming pool

APPENDIX A

GIS
MAPS



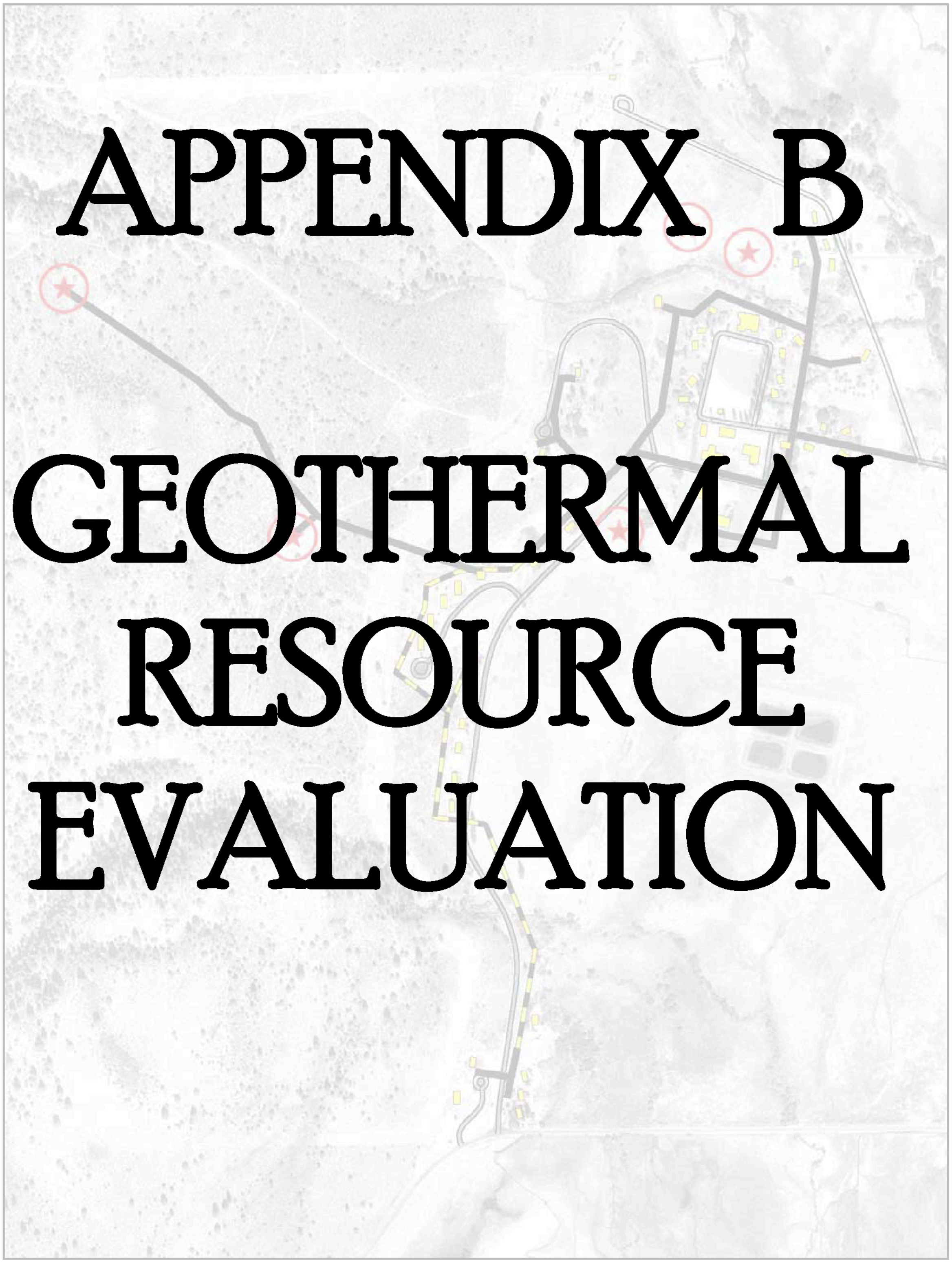

Proposed Geothermal District Heating Pipelines
Fort Bidwell Indian Reservation
GeoWells
Buildings
Proposed Lines
Streets
Old Geolines
N
S
W
E
0
1000
2000
3000
4000
5000
6000
7000
8000
Feet



Topographical Overlay
Fort Bidwell Indian Reservation
GeoWells
Buildings
Proposed Lines
Streets
Old Geolines
BM 4574
BM 4560
Cem
Flowing Wells
4580
Bidwell
Fort Bidwell
VABM 4655
WT
Ft Bidwell
4555
5000
5200
ION
Flowing Well (Hot)
Fish Hatchery
Sewage Ponds
4532
4528
Spring
Check Dam
BM 4518
4502
Corral
Flowing Well
N
W
E
S
0
1000
2000
3000
4000
5000
6000
7000 Feet

APPENDIX B

GEOTHERMAL RESOURCE EVALUATION




FB-1 GEOTHERMAL WELL
OLD SOLDIER'S WELL

FB-2 GEOTHERMAL WELL

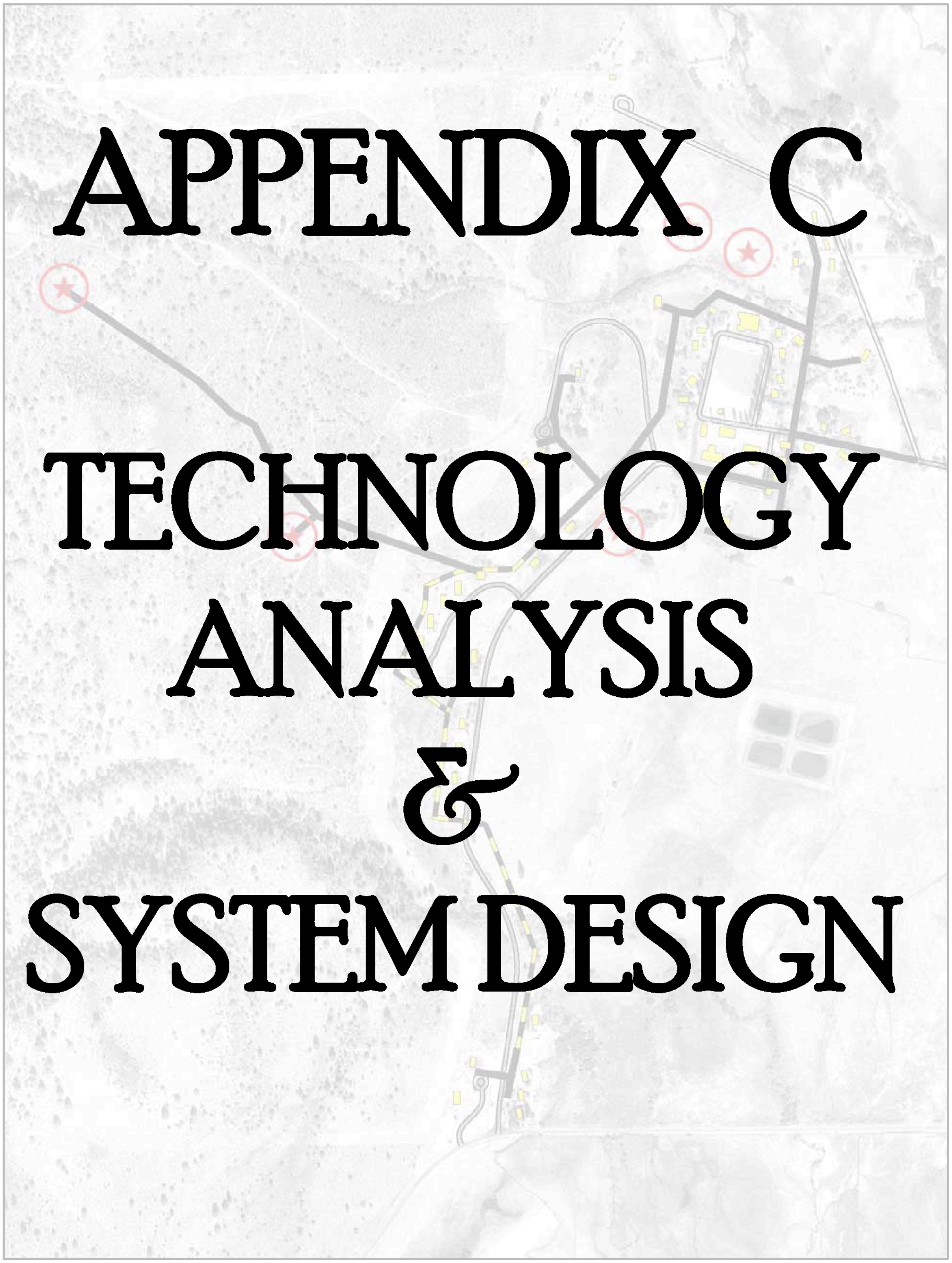

FB-3 GEOTHERMAL WELL


FB-3 GEOTHERMAL WELL

FB-4
FB-3
Soldier's Well
FB-1
FB-2
Image © 2006 DigitalGlobe
Image © 2006 TerraMetrics
ALL GEOTHERMAL WELLS
© 2005 Google
Pointer 41°51'35.29" N 120°09'44.09" W elev 4676 ft
Streaming 100%
Eye alt 6850 ft

APPENDIX C

TECHNOLOGY ANALYSIS & SYSTEM DESIGN



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FINAL ENGINEERING REPORT
GEOTHERMAL DIRECT USE FEASIBILITY STUDY ON THE FORT BIDWELL INDIAN RESERVATION

February 2007

Introduction

The Fort Bidwell Indian Reservation is located in Modoc County, in the extreme northeast corner of California. The reservation has abundant geothermal resources that provide the potential to provide a significant measure of energy independence and economic development potential. This project explores the feasibility serving the community with a geothermal district heating system. A parallel project is exploring drilling a new hotter well for potential power generation.

Heating Load

The Fort Bidwell Indian Community includes 51 existing heated buildings that could potentially be served by the district heating system. Information on building size and construction was collected and entered into an Excel spreadsheet for heating load analysis. See Appendix A. Many of the buildings are private residences that were not accessible for a detailed inspection; so much of the information is based on exterior observation and discussions with local contacts.

Buildings	Area, SF
44 wood-frame single-family homes	500-2400 1,460 avg
Apartment building 5 apartments Former community center	 940 ea 2,400
Maintenance building	1,800
Tribal housing office	3,360
Tribal Community Center	5,296
Health Clinic	4,960
Gym	8,100
Fire Hall	3,520
Total	98,350

Most of the buildings are heated with electric forced air furnaces or electric baseboard. Other heating equipment includes heat pumps, woodstoves and propane or oil furnaces.

The calculated total design heating load is about 2,400,000 Btu/hr, based on 68°F inside temperature and minus 4°F outside temperature. Annual heating energy is estimated to be 5.3×10^9 Btu, based on 6381 heating degree-days. Assuming the heating energy is all electric, the electrical consumption for heating would be 1.55×10^6 kWh/year. At $.07/kWh, the estimated heating cost is $108,500 per year. The use of cord-wood for supplemental heat would reduce the calculated heating cost. Propane and oil heat are currently more costly than electric heat.

Domestic hot water is provided by electric water heaters. The estimated energy use is 5,200 kWh per year per household, costing $362 per household or $17,800 for 49 households per year.

The entire community space and hot water heating could be provided by a district heating system supplied by existing or proposed geothermal wells. The potential energy cost savings is $126,300/year based on offsetting electric heat at current price.

Geothermal Resource

An existing well FB-3 was drilled in 1985 and tested to a shut-in pressure of 42 psi and an artesian flow of 387 gpm at 205°.1 The estimate at the time was that the well would produce 500 gpm of artesian flow at 205°F when properly completed. Informal testing of FB-3 in 2006 resulted in an artesian flow of 350 gpm at 198°F.

FB-3 would be an excellent heat source for a district heating system, but the water chemistry precludes surface disposal or injection into other existing geothermal wells. Use of FB-3 as a production well would require drilling a new injection well.

Plans are to drill a new well, FB-4, with a potential temperature of up to about 300°F. If that well is successful, the plan is to install a binary electric power plant. The effluent from the power plant will require an injection well, possibly FB-3.

This feasibility study assumes that flow from FB-4 will be cascaded from the proposed power plant to the district heating system, and then injected into FB-3.

District Heating System Design Capacity

The proposed district heating system design capacity for this feasibility study is $12x10^6$ Btu/hr, with a design circulation of 600 gpm and a 40°F temperature drop. The system would have the capacity to meet the design heating load of the existing community buildings of about $2.5\ x10^6$ Btu/hr, plus serve a commercial load of two 50,000 square ft. greenhouses or other potential energy intensive commercial heat load. That heating capacity is well within the known capability of geothermal well FB-3.

An alternate scenario was considered with a design capacity of $4x10^6$ Btu/hr, with a design circulation of 200 gpm and a 40°F temperature drop. The alternate scenario would meet existing community heating loads, but with less capacity for future expansion.

Cost Analysis

The preliminary cost estimate for the two capacity scenarios is shown in Appendix B. The cost estimate does not include any costs associated with the proposed new production well, power

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1 Culver, Gene, Feasibility Study for Aquaculture and Space Heating, Fort Bidwell, California, OIT Geo-Heat Center , October 1985, p7

plant or pipeline from the power plant to the FB-3 injection well. The pipeline from FB-3 to the heat exchanger building is included in the estimate.

The estimated electric heating cost savings of $126,300, less an estimated pumping cost of $2,000 per year results in a net electric cost savings of $124,300 per year. Comparing that to the estimated construction cost results in the following simple payback:

Alternative Capacity	Estimated Cost	Simple Payback years
12x10^6 Btu/hr	$1,500,000	12
4x10^6 Btu/hr	$1,200,000	9.7

A full evaluation of the economic feasibility of the project will include factors that are beyond the scope of this study. Some of those factors include:

- System load growth: Both alternatives provide capacity beyond the existing community heating load. Availability of geothermal heat could provide the catalyst for economic development, with significant financial benefit to the community.
- Cost of energy: The existing cost of energy is based on electric costs, which are currently very low by California standards. Increasing cost of electricity would increase the potential savings. Conversely, much of the existing heating may be provided by wood-burning stoves; reducing the calculated energy cost savings.
- Allocation of savings: Many of the potential buildings to be connected to the system are privately owned residences. Since some of the savings would be allocated to the homeowner, not all of the energy savings would be available to repay the system construction costs. Also, there may not be 100% participation in the system.
- Operations: There may be need for additional operations staff or outside contract operations, depending on the capabilities and interest of existing tribal employees.
- Maintenance: Any mechanical system requires maintenance; more as the system ages. A reasonable estimate is about 5% of capital cost per year maintenance reserve. To the extent that energy costs and energy sales are expected to rise with time, it may be reasonable to allocate growing future maintenance costs to the growing future revenue stream.
- Energy Independence and Environmental Benefit: This project fits right into the community's and the greater society's concern about the environment and sustainability. Perhaps some funding would be available for the carbon offsets.

DISTRICT HEATING SYSTEM DESIGN DETAILS

The district heating system will be designed as a primary-secondary system. See the proposed system schematic in Appendix C. The primary loop will consist of the geothermal water from the proposed power plant effluent to disposal. The secondary loop will consist of the pumping and distribution piping to circulate heating water to the various buildings for space heating and potable hot water. Heat is transferred from the primary loop to the secondary loop through one or more plate-and-frame heat exchangers.

Elevation and Pressures

The relative elevation of the wells and heat exchanger facility will affect the operating pressure and thus design of the district heating system. Approximate ground elevations are as follows:

- FB-4: 5025 ft.
- FB-3: 4746 ft.
- Heat Ex. building: 4625 ft.
- Highest house: 4670 ft.
- Lowest house: 4530 ft.

The original thought was to locate the heat exchanger building up on the bench near FB-3, at 4746 ft. elevation. However, that location would result in a maximum static pressure in the district heating at the lowest building of about 216 ft. or 94 psi. That pressure was considered higher than desired for the heating system materials. Locating the heat exchanger building 121 ft. lower, at 4625 ft., would reduce the minimum static to the difference between the highest and lowest building, which is 140 ft, or about 60 psi. That lower static pressure has less potential impact on heating equipment and piping selection.

The potential static head from the production well FB-4 to the heat exchanger building is about 400 ft, or about 174 psi. The pressure required to push the effluent back up the hill to the injection well FB-3, is about 121 ft. or about 52 psi static, plus any well backpressure and friction losses. The assumption is that the equipment will be designed for the maximum potential pressure, but back-pressure or pressure-reducing valves will be installed in the geothermal pipeline to limit the normal working pressure.

Operating Temperatures

The heat source for the district heating system is assumed to be geothermal water discharge from a geothermal power plant. The heating system design is complicated by the potential variation in temperature based on power plant operation.

- At design summer conditions, the discharge temperature from the power plant is expected to be about 190°F.
- At peak power production in cold weather, the discharge temperature could be as low as 160°F.
- When the power plant is off-line the district heating system could be supplied by bypassing flow from FB-4 around the power plant, which could result in supply temperatures as high as 300°F.
- The actual temperatures will need to be determined after completion of the well, and as a part of the power plant design.

Since the peak load on the district heating system would occur in cold weather, the district heating system would be designed to operate on the minimum winter geothermal temperature of about 160°F. The heat exchanger could remove 40° from the geothermal water, returning at 120° to the injection well. The secondary closed-loop side of the heat exchanger would be designed for a 150°F supply temperature and 110°F return.

The design supply temperature of 150°F is relatively low by district heating system standards. The benefits are the ability to operate at the minimum power plant discharge temperature and reserve capacity for peak heating loads. The district heating system heat output could be significantly increased by bypassing a portion of the flow around the power plant; reducing the power plant output, and increasing the temperature delivered to district heating system heat exchanger.

The district heating system is designed for year-around operation, providing both space heating and domestic hot water. When the power plant is off-line, it will be necessary to either operate on a backup heat source or to bypass the 300°F production well water directly to the district heating system. The preliminary design assumption is that the district heating system will be built to accept the hot bypass water. Alternative approaches would be to:

- Shut down the district heating system when the power plant is off-line, relying on back-up heating
- Flash the 300°F bypass water in a flash-tank, venting about 10% of the flow as steam and reducing the temperature to about 204°F.

A backup boiler is shown on the system schematic as optional, and is not included in the preliminary building layout or the cost estimate.

Equipment Pressure and Temperature Rating

The feasibility study assumed selection of geothermal piping, pumps, heat exchanger, and valves rated for 300°F and 200 psi. The geothermal piping will likely need to be welded steel to accommodate those conditions.

The equipment on the district heating side of the heat exchanger would be designed for a maximum of 180°F at 100 psi, the pressure rating of the PEX tubing proposed for a portion of the distribution piping.

Heat Exchanger Building Equipment and Controls

The heat exchanger building equipment would include geothermal injection/recirculation pumps, heat exchangers, heating water loop circulation pumps, expansion tanks and a central automatic control system.

Geothermal Injection/Recirculation Pumps: The primary need for the geothermal pumps is to recirculate geothermal effluent to temper the incoming geothermal water to less than 200°F. Recirculation would be necessarily primarily when the district heating system is operating on 300°F power-plant bypass geothermal water. A secondary use may be as a booster pump for geothermal injection.

The geothermal pumps would be an end-suction or in-line centrifugal pumps, with a pressure rating of about 225 psi. Variable speed drives would be used to control pump operation.

Primary Heat Exchanger: Geothermal water will flow through primary heat exchangers HE-1 and HE-2, to heat the closed-circuit district heating water. At design conditions, a geothermal flow of 600 gpm, would be cooled from 160° to 120°F in the heat exchanger, heating about 600 gpm of district heating water from 110° to 150°F, supplying a design design heating load of about 12,000,000 Btu/hr.

The reduced capacity alternative would reduce the design flow to 200 gpm and eliminate the second heat exchanger.

Heating Water Pumps: The heating water loop circulation pumps will be end-suction or in-line centrifugal pumps, each sized to meet about 2/3 of the design peak flow. Pumps will be operated by an adjustable frequency drive. Under average operating conditions, one pump is expected to operate at less than half speed and draw less than 20% of rated horsepower.

Backup/Peaking Boiler: A centrally located backup/peaking boiler could be installed to provide backup heat for the district heating system. Alternately, existing building heating systems could be utilized for backup. The feasibility study cost estimate assumes no boiler.

Instrumentation and Control: Distributed direct digital controls (DDC) should be used to monitor and control operation of the central plant equipment. Such a system would have the capability to trend operating data points, with a permanent record saved to a computer hard disk. Remote access through a modem or internet connection would provide ability for someone off-site to provide monitoring, alarms, and system maintenance.

Heating Distribution Piping

The heating water piping will be isolated by the heat exchanger from the high pressures and temperatures of the geothermal supply. New distribution piping could be pre-insulated fiberglass or ductile iron in larger sizes, and PEX plastic pipe in smaller sizes.

Preinsulated ductile iron pipe has been successfully used in the Klamath Falls district heating system. It has advantages of good durability and modest cost.

PEX pipe is available in 2-inch and smaller sizes, with a pressure rating of 100 psi at 180°F. PEX has the advantages of easy installation and corrosion resistance. The pipe can be field-insulated with flexible closed-cell insulation, and installed in a trencher trench.

Some galvanized steel piping was installed in the late 1980s that has never been used and is apparently in excellent condition. The existing galvanized pipe would be incorporated in the district heating system design.

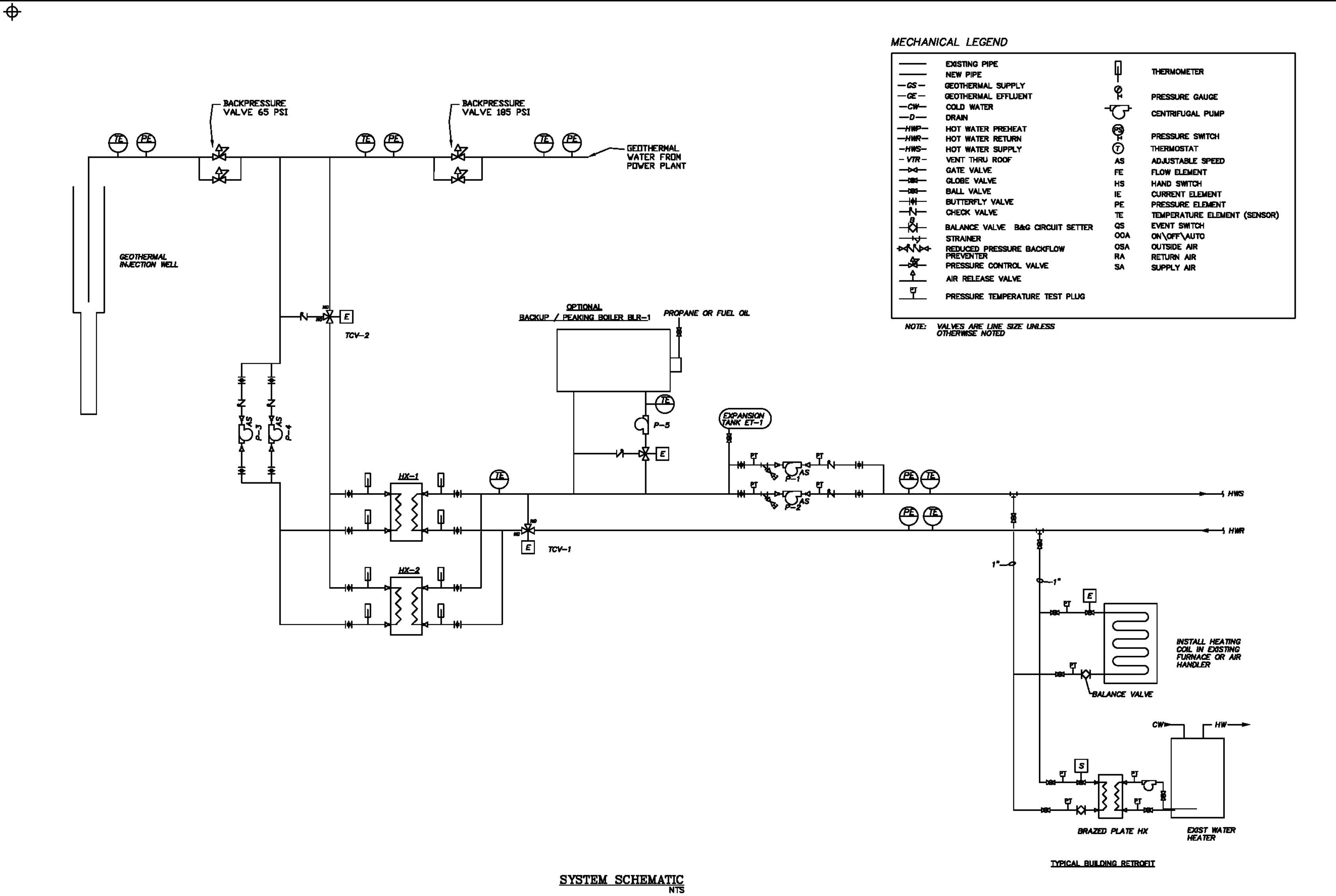
CUSTOMER CONNECTIONS

Space Heating: Design of an efficient geothermal district heating system starts at the point where the heat is used, in each individual air handler or water heater. It is only possible to maintain a high delta-T on the geothermal water if a high delta-T is maintained at the point of use. Heating coils must be selected for a low return water temperature, which must be maintained under part load by reducing or shutting off the flow when there is reduced or no heat demand.

For buildings with existing forced-air heating systems, hot-water heating coils can likely be added to the existing air handler in the air conditioner coil location. The coil would be selected to meet the design heating load operating on heating water with the supply temperature of 150° and a return water temperature of 110°F.

Building without existing forced air systems could be heated by installing a forced air system or hot water unit heater.

Potable Water Heating: The proposed concept for potable water heating is to use existing water heaters as storage tanks, and install a brazed heat exchanger, circulating pump, control valve, and controls at each water heater to allow heating off the district heating loop. The heat exchanger can be connected to the water heater through a concentric fitting installed in the drain fitting, thus minimizing disruption of the existing water heater piping.



SYSTEM SCHEMATIC
NTS

NO.	DATE	REVISION	BY

Project Title:
FORT BIDWELL GEOTHERMAL DISTRICT HEATING SYSTEM, FORT BIDWELL, CALIFORNIA

SYSTEM SCHEMATIC

Engineering by:
Brian Brown Engineering
PO Box 563
Fort Klamath, Oregon 541-783-3347

Expires: 12/31/07

DESIGN BKB
DRAWN BY
FILE NAME
APPROVED BY
SHEET 1
DATE
PROJECT NO.

Location:	FBIC, California		
Design Conditions		Winter	Summer
Dry bulb, F		4	87
Wet bulb, F			59
Heating degree days		6987	
Wind speed, mph		5	
Inside		68	78

Standard Pressure	14.70 psia
Elevation	4,200 ft MSL
Pressure	12.60 psia
SG	0.86

Windows

Type		SC	U	R value
0	None/ other side heated	0.00	0.00	1000
1	Dbl Glaze Vinyl Frame	0.35	0.37	2.7
2	Wood, single glaze	1.00	1.00	1.0
3	Aluminum, Single	1.00	1.30	0.8
4	Aluminum, Double w/ thermal break	0.88	0.67	1.5
5				

Doors

Type		U	R value
0	None/ other side heated	0.00	1000
1	Metal	0.30	3.3
2	Wood, hollow	0.47	2.1
3	Wood, hollow w/ storm	0.30	3.3
4	Wood, solid	0.40	2.5
5	Wood, solid w/storm	0.26	3.8
6	Metal Trailer Door w/ window	1	1.0
7			
8			

WALLS

Type				R(Insul)	R(Frame)	R(total)
0	None / Other side heated					2000
1	2x4 frame, insulated					10.8
	1/2" gwb	0.5	0.9 R/in	0.45	0.45	
	4" studs	3.5	16 "oc	0.00	3.50	
	R 11 Insulation			11.00		
	Lap siding, wood	0.8	1	0.75	0.75	
	Outside film			0.17	0.17	
				12.37	4.87	
2	2x4 frame, insulated					10.8
	1/2" gwb	0.5	0.9 R/in	0.45	0.45	
	4" studs	3.5	16 "oc	0.00	3.50	
	R 11 Insulation			11.00	0.00	
	T-111 siding	0.8	1	0.75	0.75	
	Outside film			0.17	0.17	
				12.37	4.87	
3	2x6 frame, insulated					18.1
	gwb	0.5	0.9 R/in	0.45	0.45	
	6" studs	5.5	24 "oc	0.00	5.50	
	Insulation	5.5		19.00	0.00	
	1/2 sheathing	0.5	1 R/in	0.50	0.50	
	T-111siding			0.20	0.20	
	Outside film			0.17	0.17	
				20.32	6.82	

6	2x2 frame, insulated					6.5
	Inside film			0.68	0.68	
	Plywood	0.5	1 R/in	0.50	0.50	
	studs	1.5	16 "oc	0.00	1.50	
	Insulation	1.5		5.00	0.00	
	1/2 sheathing	0.5	1 R/in	0.50	0.50	
	Vinyl siding			0.20	0.20	
	Outside film			0.17	0.17	
				7.05	3.55	
7	Steel Building/ insuluted					17.8
	Inside film			0.68	0.68	
	Plywood	0.5	1 R/in	0.50	0.50	
	studs	5.5	16 "oc	0.00	5.50	
	Insulation-R-19	5.5		19.00	0.00	
	1/2 sheathing	0.5	1 R/in	0.50	0.50	
	Steel Siding			0.00	0.00	
	Outside film			0.17	0.17	
				20.85	7.35	

ROOFS						
Type				R(Insul)	R(Frame)	R(total)
0	None / Heated above					2000
1	Attic w/ R19					18.6
	1/2" gwb	0.5	0.9 R/in	0.45	0.45	
	Insulation	5.5	3.5 R/in	19.25		
	2x6	5.5	16 "oc		5.5	
	Attic			1	1	
	plywood	0.625	1.2	0.75	0.75	
	Comp Roofing					
	tarpaper			0.17	0.17	
				21.6	7.9	
2	Flat, R11					10.9
	Inside film			0.68	0.68	
	gwb	0.5	0.9 R/in	0.45	0.45	
	Insulation	3.2	3.5 R/in	11.20		
	2x4	3.5	16 "oc		3.5	
	Insulation	0		0	0	
	Outside film			0.17	0.17	
				12.5	4.8	
3	2x8 frame, insulated					18.6
	Inside film			0.68	0.68	
	Steel Roofing	0.5	0.9 R/in	0.45	0.45	
	6" studs	5.5	24 "oc	0	5.5	
	Insulation	5.5		19	0	
	1/2 sheathing	0.5	1 R/in	0.50	0.5	
	Outside film			0.17	0.17	
				20.8	7.3	
4	2x8, No attic					12.7
				0.68	0.68	
	1/2" gwb ceiling	0.5	0.9 R/in	0.45	0.45	
	8" studs	7.5	16 "oc		7.5	
	Insulation, R 11	3.2	3.5 R/in	11.20		
	1/2 sheathing	0.5	1 R/in	0.50	0.5	
	tarpaper					
	Comp shingles			0.2	0.2	
	Outside film			0.17	0.17	
				13.2	9.5	

Ft. Bidwell Indian Reservation HVAC Data

	Building #	Description	ROOMS L ft	ROOMS W ft	ROOMS H ft	ROOMS Area sf	ROOMS Vol cf	ROOF Area sf	ROOF Type	WALL L ft	WALL H ft	WALL Area Gross	WALL Area net	WALL Type	Window sf E	Window sf S	Window sf W	Window sf N	Window sf Sum	Window Type	Doors area	Doors Type	ROOF UA	Wall UA	Wdo UA	Door UA	Total UA
1	L-21	**Maintenance**	60	30	12	1800	21600	1800	1	180	12	2160	1,848	7	0	0	0	0	0	2	312	7	96.9	103.9	0.0	312.0	512.8
2	10	**Tribal Housing Office**	84	40	8	3360	26880	3360	1	248	8	1984	1,729	3	48	72	32	40	192	1	63	1	180.9	95.6	71.0	18.9	366.4
3	13a	**Tribal Community Center a**	84	44	9	3696	33264	3696	1	256	8	2048	1,774	3	20	48	88	70	226	1	48	1	199.0	98.1	83.6	14.4	395.1
4	13b	**Tribal Community Center b**	40	40	11	1600	17600	1600	1	160	11	1760	1,535	3	60	40	62	0	162	1	63	1	86.1	84.9	59.9	18.9	249.9
5	14a	**Health Clinic a**	97	40	9	3880	34920	3880	1	274	9	2466	2,250	3	40	98	2	48	188	1	28	1	208.9	124.4	69.6	8.4	411.2
6	14b	**Health Clinic b**	36	30	9	1080	9720	1080	1	132	9	1188	1,040	3	24	0	24	72	120	1	28	1	58.1	57.5	44.4	8.4	168.4
7	872a	**Gym**	90	90	18	8100	145800	8100	3	360	18	6480	6,032	7	90	80	42	36	248	3	200	1	434.4	339.1	322.4	60.0	1156.0
8	872b	**Fire Hall**	80	44	16	3520	56320	3520	3	248	16	3968	3,338	3	48	48	64	50	210	1	420	7	188.8	184.6	77.7	420.0	871.1
9	32	**Residence**	47	29	8	1348.5	10788	1349	1	151	8	1208	954	2	92	60	48	12	212	1	42	1	72.6	88.3	78.4	12.6	251.9
10	34	**Residence**	47	29	8	1363	10904	1363	1	152	8	1216	998	2	48	32	80	16	176	1	42	1	73.4	92.3	65.1	12.6	243.4
11	44	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	982	2	72	32	12	12	128	1	42	1	62.0	90.8	47.4	12.6	212.8
12	56	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	930	2	62	16	70	32	180	1	42	1	62.0	86.0	66.6	12.6	227.2
13	64	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
14	68	**Residence**	48	20	8	960	7680	960	1	136	8	1088	894	2	48	32	56	16	152	1	42	1	51.7	82.7	56.2	12.6	203.2
15	72	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	928	2	62	32	56	32	182	1	42	1	62.0	85.9	67.3	12.6	227.8
16	78	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
17	89	**Residence**	47	29	8	1348.5	10788	1349	1	151	8	1208	1,029	2	57	16	48	16	137	1	42	1	72.6	95.2	50.7	12.6	231.1
18	90	**Residence**	48	50	8	2400	19200	2400	1	196	8	1568	1,360	2	64	16	54	32	166	1	42	1	129.2	125.8	61.4	12.6	329.0
19	98	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	918	2	64	32	64	32	192	1	42	1	62.0	84.9	71.0	12.6	230.6
20	102	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
21	110a	**Apt #1**	40	24	8	940	7520	940	1	127	8	1016	881	3	0	36	0	78	114	1	21	1	50.6	48.7	42.2	6.3	147.8
22	110b	**Apt #2**	40	24	8	940	7520	940	1	127	8	1016	881	3	0	36	0	78	114	1	21	1	50.6	48.7	42.2	6.3	147.8
23	110c	**Apt #3**	40	24	8	940	7520	940	1	127	8	1016	881	3	0	36	0	78	114	1	21	1	50.6	48.7	42.2	6.3	147.8
24	110d	**Apt #4**	40	24	8	940	7520	940	1	127	8	1016	881	3	0	78	0	36	114	1	21	1	50.6	48.7	42.2	6.3	147.8
25	110e	**Apt #5**	40	24	8	940	7520	940	1	127	8	1016	881	3	0	78	0	36	114	1	21	1	50.6	48.7	42.2	6.3	147.8
26	110f	**Old Community Center**	40	60	9	2400	21600	2400	1	200	9	1800	1,592	3	46	72	0	48	166	1	42	1	129.2	88.0	61.4	12.6	291.3
27	124	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	944	2	62	16	56	32	166	1	42	1	62.0	87.3	61.4	12.6	223.4
28	126	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
29	133	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
30	137	**Residence**	70	29	8	2030	16240	2030	1	198	8	1584	1,326	2	80	40	64	32	216	1	42	1	109.3	122.7	79.9	12.6	324.5
31	140	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
32	164	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
33	172	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
34	200	**Residence**				1584	11520	1008	1	132	12	1584	1,304	2	64	84	58	32	238	1	42	1	54.3	120.6	88.1	12.6	275.6
35	221	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
36	222	**Residence**	47	27	9	1269	11421	1269	1	148	9	1332	1,074	1	24	72	48	72	216	1	42	1	68.3	99.4	79.9	12.6	260.2
37	229	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5
38	237	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1	96.8	113.1	71.0	12.6	293.5

39	243	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1		96.8	113.1	71.0	12.6	293.5
40	244	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1		96.8	113.1	71.0	12.6	293.5
41	255	**Residence**	48	20	8	960	7680	960	1	136	8	1088	954	2	30	12	34	16	92	1	42	1		51.7	88.3	34.0	12.6	186.6
42	265	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,180	2	92	43	63	36	234	1	42	1		96.8	109.2	86.6	12.6	305.1
43	272	**Residence**	30	25	8	750	6000	750	1	110	8	880	748	2	24	30	24	12	90	4	42	1		40.4	69.2	60.3	12.6	182.5
44	279	**Residence**	48	20	8	960	7680	960	1	136	8	1088	910	2	16	48	16	56	136	1	42	1		51.7	84.2	50.3	12.6	198.8
45	281	**Residence**	57	29	8	1638.5	13108	1639	1	171	8	1368	1,157	2	57	32	64	16	169	1	42	1		88.2	107.0	62.5	12.6	270.4
46	301	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,222	2	92	43	21	36	192	1	42	1		96.8	113.1	71.0	12.6	293.5
47	303	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	954	2	32	60	16	48	156	1	42	1		62.0	88.3	57.7	12.6	220.6
48	316	**Residence**	62	29	8	1798	14384	1798	1	182	8	1456	1,210	2	57	48	63	36	204	1	42	1		96.8	111.9	75.5	12.6	296.8
49	345	**Residence**	47	29	8	1348.5	10788	1349	1	151	8	1208	1,018	2	60	32	24	32	148	1	42	1		72.6	94.2	54.8	12.6	234.1
50	379	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	910	2	57	48	63	32	200	1	42	1		62.0	84.2	74.0	12.6	232.8
51	403	**Residence**	47	29	8	1363	10904	1363	1	152	8	1216	1,005	2	16	57	32	64	169	1	42	1		73.4	93.0	62.5	12.6	241.5
52	413	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	910	2	57	48	63	32	200	1	42	1		62.0	84.2	74.0	12.6	232.8
53	447	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	910	2	57	48	63	32	200	1	42	1		62.0	84.2	74.0	12.6	232.8
54	507	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	910	2	57	48	63	32	200	1	42	1		62.0	84.2	74.0	12.6	232.8
55	635	**Residence**	48	24	8	1152	9216	1152	1	144	8	1152	910	2	57	48	63	32	200	1	42	1		62.0	84.2	74.0	12.6	232.8
56	673	**Residence**				1584	11520	1008	1	132	12	1584	1,304	2	84	58	32	64	238	1	42	1		54.3	120.6	88.1	12.6	275.6
57	916	**Residence**	25	20	8	500	4000	500	1	90	8	720	612	1	32	10	12	12	66	4	42	1		26.9	56.6	44.2	12.6	140.4
58	924	**Residence**	47	29	8	1363	10904	1363	1	152	8	1216	1,022	1	32	64	16	40	152	4	42	1		73.4	94.5	101.8	12.6	282.4
		Total				96,546																						

Temperature
72
-4

	#		Transmission Total UA	Transmission Load btu/hr	Ventilation Criteria	Ventilation Qty cfm	Ventilation Exh cfm	Ventilation btu/hr	Total btu/hr	Air flow Required 30 F dT cfm	Water flow Required @ 40 F dT gpm	Water flow Required @ 80 F dT gpm	Measured Air Flow cfm	Existing Heater Capacity Btu/h	Temperature rise required at Furnace 1 Capacity °F	Temperature rise required at calc Load °F
1	L-21	Tribal Housing Office	366	27,848	1 ach	448		36,772	64,620	928	3.23	1.62	813	56,000	69	79
2	10	Tribal Community Center a	395	30,026	1 ach	554		45,505	75,531	1,001	3.78	1.89	813	56,000	69	93
3	13a	Tribal Community Center a	395	30,026	1 ach	554		45,505	75,531	1,001	3.78	1.89	813	45,200	56	93
4	13b	Tribal Community Center b	250	18,989	1 ach	293		24,077	43,066	633	2.15	1.08	813	45,200	56	53
5	14a	Health Clinic a	411	31,255	1 ach	582		47,771	79,025	1,042	3.95	1.98	813	45,200	56	97
6	14b	Health Clinic b	168	12,802	1 ach	162		13,297	26,099	427	1.30	0.65	813	45,200	56	32
7	872a	Gym	1,156	87,853	1 ach	2430		199,454	287,307	2,928	14.37	7.18	813	45,200	56	353
8	872b	Fire Hall	871	66,203	1 ach	939		77,046	143,248	2,207	7.16	3.58	1,016	64,000	63	141
9	32	Residence	252	19,143	1 ach	180		14,758	33,901	638	1.70	0.85	1,016	64,000	63	33
10	34	Residence	243	18,500	1 ach	182		14,917	33,416	617	1.67	0.84	1,016	64,000	63	33
11	44	Residence	213	16,174	1 ach	154		12,607	28,782	539	1.44	0.72	1,016	64,000	63	28
12	56	Residence	227	17,271	1 ach	154		12,607	29,878	576	1.49	0.75	1,016	64,000	63	29
13	64	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	1,016	64,000	63	41
14	68	Residence	203	15,445	1 ach	128		10,506	25,951	515	1.30	0.65	1,016	64,000	63	26
15	72	Residence	228	17,313	1 ach	154		12,607	29,921	577	1.50	0.75	1,016	64,000	63	29
16	78	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	1,016	64,000	63	41
17	89	Residence	231	17,562	1 ach	180		14,758	32,320	585	1.62	0.81	1,016	64,000	63	32
18	90	Residence	329	25,006	1 ach	320		26,266	51,272	834	2.56	1.28	1,016	64,000	63	50
19	98	Residence	231	17,524	1 ach	154		12,607	30,131	584	1.51	0.75	1,016	64,000	63	30
20	102	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	1,016	64,000	63	41
21	110a	Apt #1	148	11,233	1 ach	125		10,287	21,520	374	1.08	0.54	880	56,000	64	24
22	110b	Apt #2	148	11,233	1 ach	125		10,287	21,520	374	1.08	0.54	880	50,000	57	24
23	110c	Apt #3	148	11,233	1 ach	125		10,287	21,520	374	1.08	0.54	1,583	80,000	51	14
24	110d	Apt #4	148	11,233	1 ach	125		10,287	21,520	374	1.08	0.54	1,299	68,260	53	17
25	110e	Apt #5	148	11,233	1 ach	125		10,287	21,520	374	1.08	0.54	813	56,000	69	26
26	110f	Old Community Center	291	22,135	1 ach	360		29,549	51,684	738	2.58	1.29	813	56,000	69	64
27	124	Residence	223	16,976	1 ach	154		12,607	29,583	566	1.48	0.74	1,200	63,800	53	25
28	126	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	1,099	99,655	91	38
29	133	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	1,099	99,655	91	38
30	137	Residence	324	24,659	1 ach	271		22,216	46,876	822	2.34	1.17	1,200	90,000	75	74
31	140	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	2,088	40,000	19	20
32	164	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	1,827	40,000	22	23
33	172	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	2,438	116,000	48	17
34	200	Residence	276	20,942	1 ach	192		15,759	36,702	698	1.84	0.92	891	52,000	58	41
35	221	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	891	52,000	58	47
36	222	Residence (old MD House 20HIP)	260	19,774	1 ach	190		15,624	35,398	659	1.77	0.88	950	56,000	59	37
37	229	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	950	46,000	48	44
38	237	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	948	80,000	84	44
39	243	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	900	65,530	73	47
40	244	Residence	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	950	56,000	59	44
41	255	Residence	187	14,180	1 ach	128		10,506	24,686	473	1.23	0.62	1,022	69,000	68	24
42	265	Residence	305	23,190	1 ach	240		19,677	42,867	773	2.14	1.07	880	56,000	64	49
43	272	Residence	182	13,868	1 ach	100		8,208	22,076	462	1.10	0.55	880	56,000	64	25

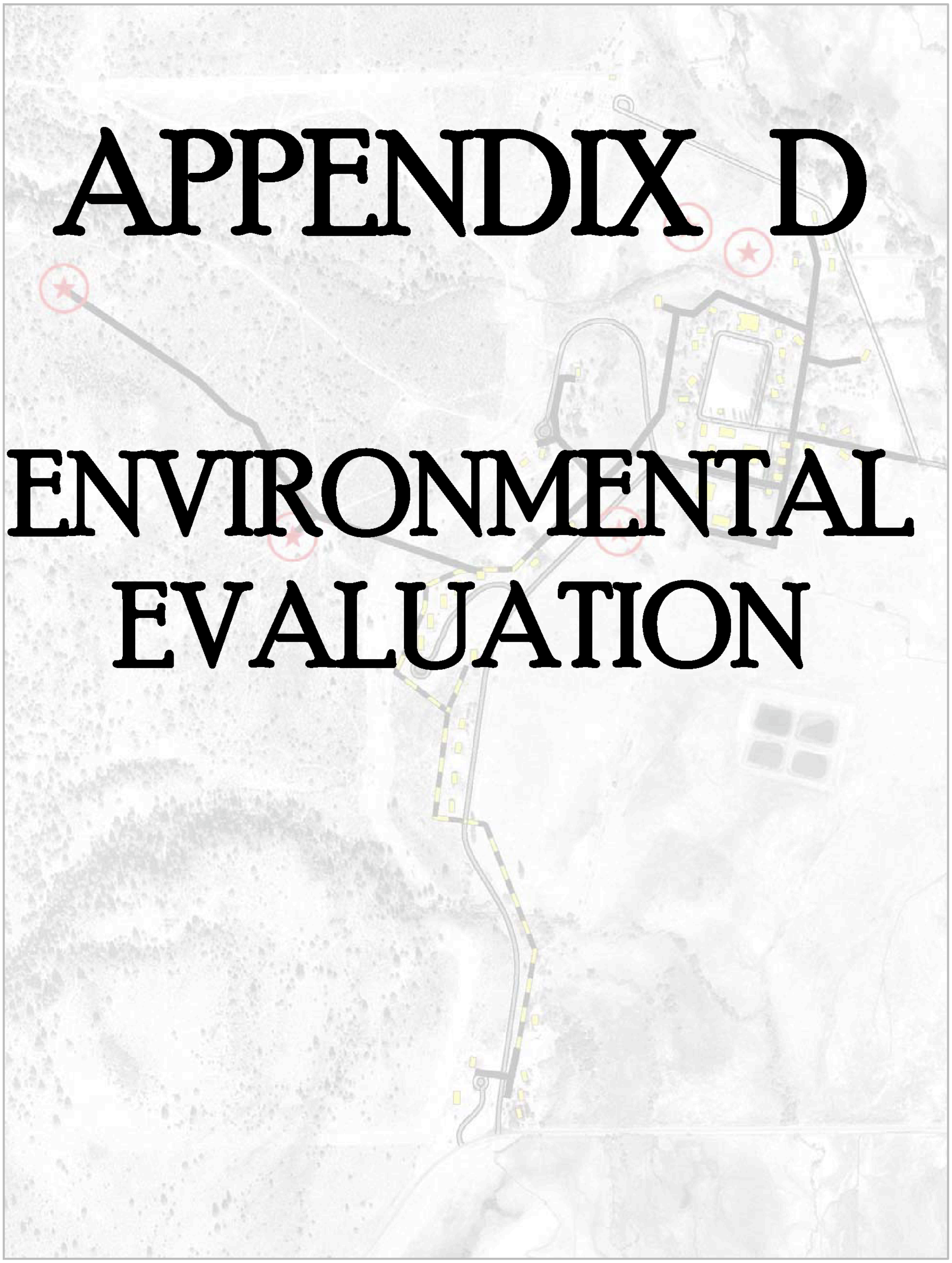
44	**279**	**Resdence**	199	15,107	1 ach	128		10,506	25,614	504	1.28	0.64	880	56,000	64	29
45	**281**	**Residence**	270	20,548	1 ach	218		17,932	38,480	685	1.92	0.96	880	56,000	64	44
46	**301**	**Residence**	293	22,304	1 ach	240		19,677	41,981	743	2.10	1.05	880	56,000	64	48
47	**303**	**Residence**	221	16,765	1 ach	154		12,607	29,372	559	1.47	0.73	880	56,000	64	33
48	**316**	**Residence**	297	22,557	1 ach	240		19,677	42,235	752	2.11	1.06	880	56,000	64	48
49	**345**	**Residence**	234	17,794	1 ach	180		14,758	32,552	593	1.63	0.81	880	56,000	64	37
50	**379**	**Residence**	233	17,693	1 ach	154		12,607	30,300	590	1.52	0.76	880	56,000	64	34
51	**403**	**Residence**	241	18,352	1 ach	182		14,917	33,269	612	1.66	0.83	880	56,000	64	38
52	**413**	**Residence**	233	17,693	1 ach	154		12,607	30,300	590	1.52	0.76	880	56,000	64	34
53	**447**	**Residence**	233	17,693	1 ach	154		12,607	30,300	590	1.52	0.76	880	56,000	64	34
54	**507**	**Residence**	233	17,693	1 ach	154		12,607	30,300	590	1.52	0.76	880	56,000	64	34
55	**635**	**Residence**	233	17,693	1 ach	154		12,607	30,300	590	1.52	0.76	880	56,000	64	34
56	**673**	**Residence**	276	20,942	1 ach	192		15,759	36,702	698	1.84	0.92	880	56,000	64	42
57	**916**	**Residence**	140	10,667	1 ach	67		5,472	16,139	356	0.81	0.40	880	56,000	64	18
58	**924**	**Residence**	282	21,459	1 ach	182		14,917	36,376	715	1.82	0.91	880	56,000	64	41
		Total		1,245,739					2,517,450	41,525	125.87	62.94				
		Pipe Heat Losses Supply				3000	100	16	48000							
		Return				3000	50	8	24000							
									72000							
									2,589,450							
									26.8208891	Btu/sf						

		CALCULATED LOADS				DESIGN		HEATING COIL SIZE							AIR SIDE			WATER SIDE			
		Building	Load	Furnace	est				Fins		Overall				RA		SA	HS	150	°F	
		SF	btuh	btuh	cfm	bhuh	cfm	tubes	H	L	H	L	vel	sfpm	72	Rise		HR	100	°F	duct size
				1											°F	°F	°F	gpm	feeds	gpm/f	
10	Tribal Housing Office	3360	75531	56000	813	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	19.5x19.5
10	Tribal Housing Office	3360	75531	56000	813	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	19.5x19.5
20	Tribal Housing Office	3360	75531	56000	813	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	19.5x19.5
30	Tribal Housing Office	3360	75531	56000	813	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	19.5x19.5
40	Residence	1363	33416	64000	1016	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	19.5x19.5
50	Residence	1152	28782	64000	1016	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	19.5x19.5
60	Residence																				19.5x19.5
70	Residence	960	25951	64000	1016	50000	1200	18	22.5	20	24.5	26	384	329	72	45	117	2.0	2	1.00	19.5x19.5
80	Residence	1798	41981	64000	1016	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	20x20
90	Residence																				
100	Residence	1152	30131	64000	1016	40000	880	14	17.5	16	19.5	22	453	388	72	49	121	1.6	2	0.80	19.5x19.5
110	Residence	1798	41981	64000	1016	40000	880	14	17.5	16	19.5	22	453	388	72	49	121	1.6	2	0.80	19.5x19.5
120	Residence	1798	41981	64000	1016	30000	800	14	17.5	16	19.5	22	411	353	72	41	113	1.2	1	1.20	20x20
130	Residence	1798	41981	99655	1099	50000	1200	18	22.5	20	24.5	26	384	329	72	45	117	2.0	2	1.00	19.5x19.5
140	Residence	1798	41981	40000	2088	34000	800	14	17.5	16	19.5	22	411	353	72	46	118	1.4	1	1.36	
150	Residence	1798	41981																		
151	Residence	1798	41981			38000	1200	14	20.0	20	22.0	26	432	370	72	34	106	1.5	2	0.76	
152	Residence	1798	41981	40000	2088	38000	1200	14	20.0	20	22.0	26	432	370	72	34	106	1.5	2	0.76	
160	Residence	1798	41981	40000	2088	46000	1500	18	22.5	22	24.5	28	436	374	72	33	105	1.8	2	0.92	16" dia
170	Residence	1798	41981	40000	1827	30000	800	14	17.5	16	19.5	22	411	353	72	41	113	1.2	1	1.20	21x21
180	Residence	1798	41981	116000	2438	40000	880	14	17.5	16	19.5	22	453	388	72	49	121	1.6	2	0.80	19.5x19.5
190	Residence	1798	41981	116000	2438	40000	880	14	17.5	16	19.5	22	453	388	72	49	121	1.6	2	0.80	19.5x19.5
200	Residence	1584	36702	52000	891	35000	800	14	17.5	16	19.5	22	411	353	72	47	119	1.4	1	1.40	11x4
220	Residence	1584	36702	52000	891	35000	800	14	17.5	16	19.5	22	411	353	72	47	119	1.4			15x20
230	Residence	1798	41981	46000	950	35000	800	14	17.5	16	19.5	22	411	353	72	47	119	1.4			
102	Residence																				
124	Residence	1152	29583	63800	1200																
126	Residence	1798	41981	99655	1099	56000	1100	16	20.0	18	22.0	24	440	377	62	55	117	2.2	2	1.12	
133	Residence	1798	41981																		
137	Residence	2030	46876	90000	1200	60000	1200	16	20.0	18	22.0	24	480	411	62	54	116	2.4	2	1.20	
140	Residence	1798	41981	40000	2088	30000	1200	14	17.5	20	19.5	26	494	423	72	27	99	1.2	1	1.20	
164	Residence	1798	41981	40000	1827	30000	1200	14	17.5	20	19.5	26	494	423	72	27	99	1.2	1	1.20	
172	Residence	1798	41981	116000	2438	20000	1200	14	12.5	27	14.5	33	512	439	72	18	90	0.8	1	0.80	
200	Residence	1584	36702	52000	891	26000	880	14	15.0	20	17.0	26	422	362	72	32	104	1.0	1	1.04	
221	Residence																				
222	Residence	1269	35398	56000	950	40000	950	14	17.5	16	19.5	22	489	419	72	45	117	1.6	2	0.80	
229	Residence	1798	41981	46000	950	40000	950	14	17.5	16	19.5	22	489	419	72	45	117	1.6	2	0.80	
237	Residence	1798	41981	80000	948	35000	800	14	17.5	16	19.5	22	411	353	72	47	119	1.4	1	1.40	
243	Residence	1798	41981	65530	900	40000	950	14	17.5	16	19.5	22	489	419	72	45	117	1.6	2	0.80	
244	Residence	1798	41981	56000	950	40000	950	14	17.5	16	19.5	22	489	419	72	45	117	1.6	2	0.80	
255	Residence	960	24686	69000	1022	40000	950	14	17.5	16	19.5	22	489	419	72	45	117	1.6	2	0.80	
265	Residence	1798	42867	56000	880	35000	800	14	17.5	16	19.5	22	411	353	72	47	119	1.4	1	1.40	
		66224																			

		CALCULATED LOADS Building SF	Load btuh	Furnace btuh 1	est cfm	DESIGN bhuh	WATER SIDE HS HR gpm	150 100	COIL GPM	DESIGN PRESS DROP PSI	CALC. Cv	ACTUAL VALVE Cv	ACTUAL PRESS. DROP PSI
10	Tribal Housing Office	3360	75531	56000	813	34000	1.4		1.4	2	0.96	1.2	1.28
20	Tribal Housing Office	3360	75531	56000	813	34000	1.4		1.4	2	0.96	1.2	1.28
30	Tribal Housing Office	3360	75531	56000	813	34000	1.4		1.4	2	0.96	1.2	1.28
40	Residence	1363	33416	64000	1016	34000	1.4		1.4	2	0.96	1.2	1.28
50	Residence	1152	28782	64000	1016	34000	1.4		1.4	2	0.96	1.2	1.28
60	Residence												
70	Residence	960	25951	64000	1016	50000	2.0		2.0	2	1.41	1.9	1.11
80	Residence	1798	41981	64000	1016	34000	1.4		1.4	2	0.96	1.2	1.28
90	Residence												
100	Residence	1152	30131	64000	1016	40000	1.6		1.6	2	1.13	1.9	0.71
110	Residence	1798	41981	64000	1016	40000	1.6		1.6	2	1.13	1.2	1.78
120	Residence	1798	41981	64000	1016	30000	1.2		1.2	2	0.85	1.2	1.00
130	Residence	1798	41981	99655	1099	50000	2.0		2.0	2	1.41	1.9	1.11
140	Residence	1798	41981	40000	2088	34000	1.4		1.4	2	0.96	1.2	1.28
150	Residence	1798	41981										
151	Residence	1798	41981			38000	1.5		1.5	2	1.07	1.2	1.60
152	Residence	1798	41981	40000	2088	38000	1.5		1.5	2	1.07	1.2	1.60
160	Residence	1798	41981	40000	2088	46000	1.8		1.8	2	1.30	1.9	0.94
170	Residence	1798	41981	40000	1827	30000	1.2		1.2	2	0.85	1.2	1.00
180	Residence	1798	41981	116000	2438	40000	1.6		1.6	2	1.13	1.2	1.78
190	Residence	1798	41981	116000	2438	40000	1.6		1.6	2	1.13	1.2	1.78
200	Residence	1584	36702	52000	891	35000	1.4		1.4	2	0.99	1.2	1.36
210													
220	Residence	1584	36702	52000	891	35000	1.4		1.4	2	0.99	1.2	1.36
230	Residence	1798	41981	46000	950	35000	1.4		1.4	2	0.99	1.2	1.36
102	Residence												
124	Residence	1152	29583	63800	1200	29583	1.2		1.2	2	0.84	3	0.16
126	Residence	1798	41981	99655	1099	56000	2.2		2.2	2	1.58	1.9	1.39
133	Residence	1798	41981										
137	Residence	2030	46876	90000	1200	60000	2.4		2.4	2	1.70	1.9	1.60
140	Residence	1798	41981	40000	2088	30000	1.2		1.2	2	0.85	1.2	1.00
164	Residence	1798	41981	40000	1827	30000	1.2		1.2	2	0.85	1.2	1.00
172	Residence	1798	41981	116000	2438	20000	0.8		0.8	2	0.57	0.8	1.00
200	Residence	1584	36702	52000	891	26000	1.0		1.0	2	0.74	0.8	1.69
221	Residence												
222	Residence	1269	35398	56000	950	40000	1.6		1.6	2	1.13	1.2	1.78
229	Residence	1798	41981	46000	950	40000	1.6		1.6	2	1.13	1.2	1.78
237	Residence	1798	41981	80000	948	35000	1.4		1.4	2	0.99	1.2	1.36
243	Residence	1798	41981	65530	900	40000	1.6		1.6	2	1.13	1.2	1.78
244	Residence	1798	41981	56000	950	40000	1.6		1.6	2	1.13	1.2	1.78
255	Residence	960	24686	69000	1022	40000	1.6		1.6	2	1.13	1.2	1.78
265	Residence	1798	42867	56000	880	35000	1.4		1.4	2	0.99	1.2	1.36
									35.0				

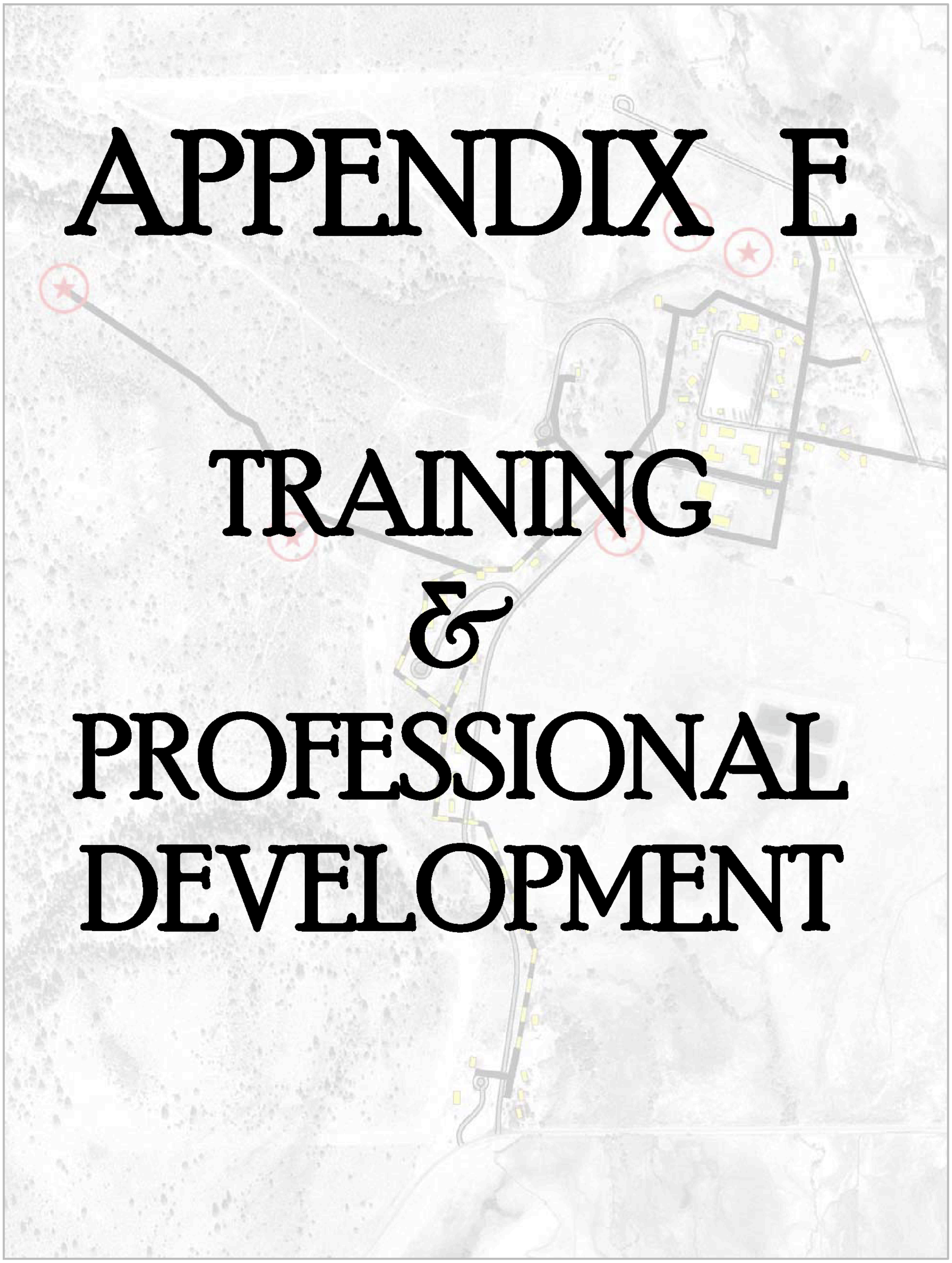
APPENDIX D

ENVIRONMENTAL EVALUATION



Environmental Review pages have been intentionally deleted. Contact the Fort Bidwell Indian Community for more information.

Administration Office 530-279-6310



APPENDIX E

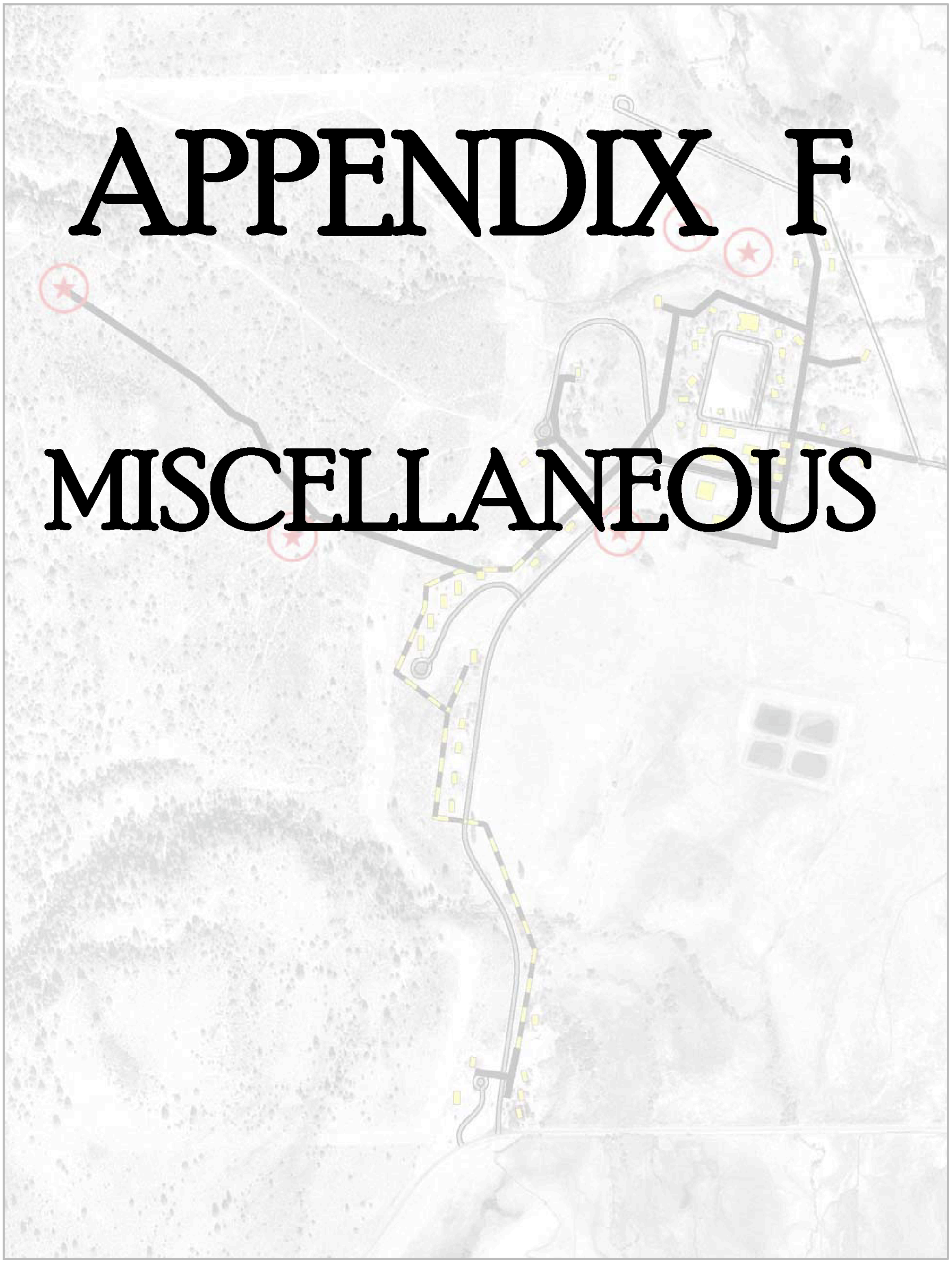
TRAINING & PROFESSIONAL DEVELOPMENT


ORMAT
Power Plant Tour
Reno 2006

ORMAT
Power Plant Tour
Reno 2006

APPENDIX F

MISCELLANEOUS



Direct-Use Geothermal in Indian Country
The Ft. Bidwell Indian Community Geothermal District Heating Project

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Key Words: Geothermal, district heating, feasibility, cascaded system, disposal, exploration well, chemistry, arsenic, boron, mercury, helium.

Abstract

The Gidutikad Band of the Northern Paiute Tribe (the Fort Bidwell Indian Community, FBIC) resides in the extreme northeast corner of California, west of the Town of Ft. Bidwell. The Fort Bidwell Indian Reservation (FBIR) has extensive low and suspected moderate temperature geothermal resources. There are currently three geothermal wells that are on the reservation and a fourth exploration well is planned to determine power producing potential. A feasibility study funded by the DOE Tribal Energy Program is underway to provide a basis for an FBIC determination of whether to proceed with, and the most efficient way to use the Tribe's geothermal resources in a district heating application. The potential for combining power generation with district heating as an effective and more economical way to obtain the goals of each is also being addressed.

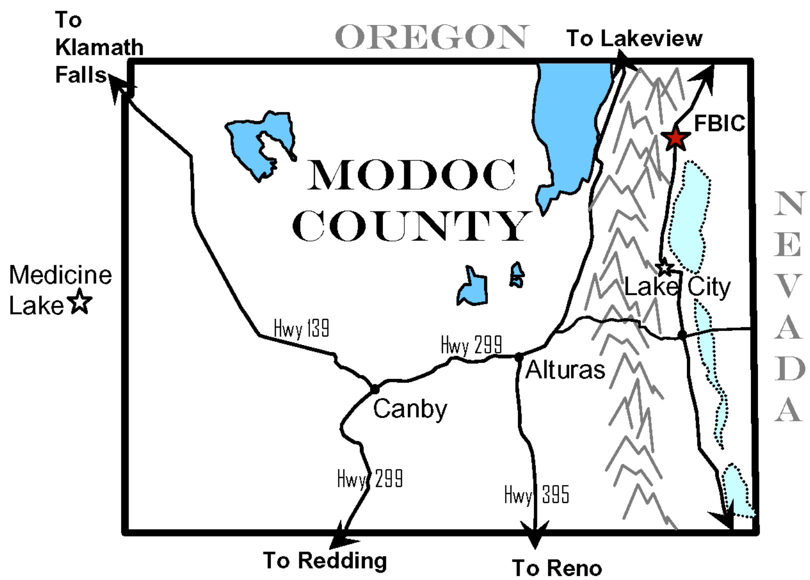

Figure 1 – FBIC shown with star in upper right.

Introduction

The FBIR has documented geothermal, biomass and hydropower energy. Regional resource maps also indicate the potential for both solar and wind resource use. Although a comparatively small reservation, it is rich in renewable energy resources. It is the geothermal resources, however, that have the potential to dramatically impact the Tribe's energy needs and financial future. Currently, the private residences are heated with electrical central heating, electrical resistance baseboard and woodstoves using juniper wood from reservation lands. The community buildings are heated with propane. Electricity is purchased from the local rural electric co-op.

Background

As Camp Bidwell in the late 1800's, the US Army drilled a well they used for bathing purposes. They even piped hot water into the buildings. This "Old Soldier's Well"is the oldest hot spring with artesian flow on the reservation. The military fort evolved into the Ft. Bidwell Indian Reservation and over the past 100 years, this spring has been used by the Tribe for bathing, soaking and medicinal purposes. It now flows approximately 15 gpm at108˚F. Three other geothermal wells were drilled with funding from the California Energy Commission (CEC) in the 1980's, all for direct-use purposes including growing fish, greenhouse and district heating applications.

Figure 2 – Old Soldier's Well and pump house of FB-1 at top.

In 2004, a Department of Energy (DOE) GRED III cost-share grant was awarded to the FBIC to drill a slim-hole geothermal well to explore for a commercial temperature resource capable of power generation. The Principal Investigator for that exploration drilling project is Joe LaFleur. Drill costs escalated steeply since 2004 and, in 2006, CEC GRDA funding was obtained to help finance the completion of the exploration well and to deepen it.

In 2005, the FBIC also answered a solicitation from the DOE Office of Energy Efficiency and Renewable Energy's Tribal Energy Program. That program;

> "promotes tribal energy self-sufficiency and fosters employment and economic development on America's tribal lands through financial and technical assistance to tribes. The program offers assistance for renewable energy feasibility studies and shares the cost of renewable energy projects on tribal lands. The program also offers assistance to tribes for the initial steps toward developing renewable energy and energy efficiency projects, including strategic planning, energy options analysis, human capacity building, and organizational development planning." (Tribal Energy Program Website, US Department of Energy)

Resource

The FB-1 well was drilled in 1981 about 500 ft. east southeast of the Old Soldier's Well to a depth of about 507 feet. The well has an artesian flow of 450 gpm at 116˚F. It was used for several years with heat pump technology to supply space heating for the Tribal Community building, a six unit apartment complex, a private residence and a small gymnasium.

The FB-2 well was drilled in 1983 and used for several years to grow catfish on a Tribal aquaculture project for market. It was drilled about 1,600 ft. southwest of the FB-1 and has a depth of 1260 feet. The water flows artesian at about 1500 gpm at 96˚F and is perfectly suited for an aquaculture application.

The FB-3 well was drilled 1750 ft. west of the FB-2 well in 1985 to a total depth of 2920 feet. The well has an artesian flow of 350 gpm at 198˚F and is located about 167 feet above the community to be served. The maximum temperature encountered in this well was 209˚F at 2,330 ft.

The FB-4 well is scheduled to begin drilling in 2006 to a target depth of 5,500 ft. It is located approximately 2000 ft. northwest of the FB-3 well. Significant work was completed during the Phase I portion of a GRED III grant to understand the Reservation's hydrothermal system and to site and drill the new well for power production purposes.

Samples from the Fort Bidwell geothermal wells show unusually high levels of the helium 3 isotope. In fact, the FB-3 well gives a $^{3}He/^{4}He$ ratio relative to atmospheric of 2.58 Ra, the highest recorded in the entire Basin and Range Geologic Province. Geothermometry of the FB-3 well suggests that reservoir temperatures at depth may be in the range of 300 °F. (Resource information from LaFleur, J., 2005, *Geothermal Resource Exploration and Definition of the Fort Bidwell Indian Reservation Hydrothermal System*).

The Direct Use Feasibility Study

The purpose of the district heating feasibility study is to provide information that will form a basis for a decision by the Tribe whether or not to pursue a geothermal district heating system. A form of energy audit will be undertaken on all tribal buildings, recommended materials and equipment will be identified, environmental baseline data will be collected and regulatory requirements identified.

What was not known at the time of the proposal to the Tribal Energy Program (TEP) was the extent and quality of previous work on district heating, including the installation of a service loop to some of the Tribal residences. Word of mouth was that there were some lines installed in 1987, two years after FB-3 was drilled, but they were never hooked up to the residences (Fort Bidwell Indian Community, 2006, Personal Communication).

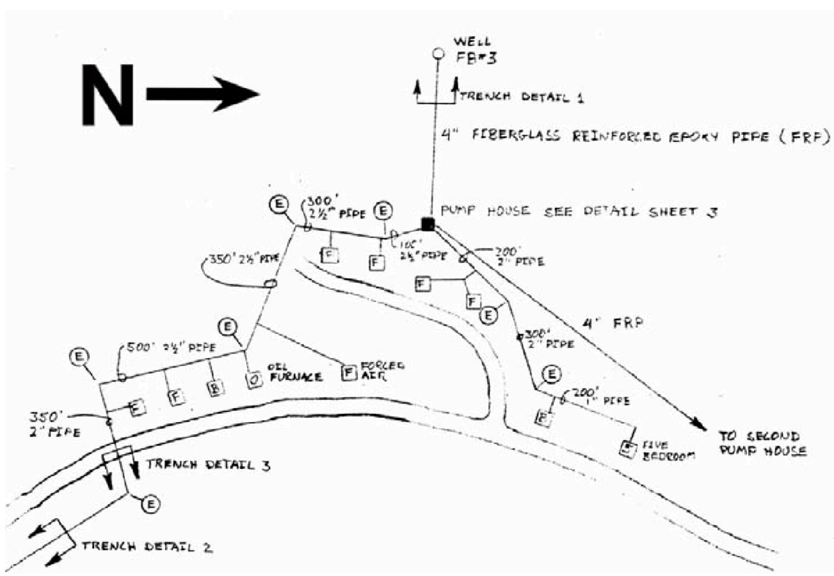

Figure 3 – Partial Chitwood Pipe Distribution Layout

This author assumed that there was no engineering involved and that any work that had been done would not have been adequate to incorporate into a new project.

While searching through old records, a feasibility study by Chitwood Energy Management of Mt. Shasta, CA was found that detailed an engineered geothermal district heating system. The report, dated September 1987, targeted the FB-3 well as the resource and showed a closed loop system isolating the geothermal water from the residences. The way the engineer chose to mitigate impact to the environment in 1987 was to make an efficient system that would discharge at low flow rates, which were not specified. Also, the exact method of disposal of geothermal fluids was not specified in the engineering report, leaving the only options to discharge to land or into one of two creeks in the area.

The report also showed the routing of the distribution system that verified word of mouth accounts about previous installations. Because there was variable recollection of specific details from Tribal Elders regarding the actual installation, the decision to hire a backhoe operator was made to uncover some of the pipeline.

Figure 4 – Supply/Return Lines

In April 2006, supply and return lines were uncovered in two places that were described in the engineers report. Two-inch galvanized steel pipelines were found. They had been field-insulated with formed rigid Styrofoam insulation and appeared to be in perfect condition. It seems that over 6400 ft of 2 to 2 ½ in. supply and return pipelines had been installed, pressure tested and never used. These lines serve the south end of the Reservation and constitute about half of the service loop needed for the district heating system. According to ones that worked on the project, tees had been installed at every residence at the south end for hook-up; this was verified at one of the sites we chose to excavate. A pressure test of the pipeline held a constant pressure of 30 psi for one hour. Further location of the lines will be attained by a metal detector and accurately documented in the Tribal GIS.

Disposal Decisions
Much has changed in the last twenty years with respect to disposal of geothermal fluids. As time moves on, it is becoming more difficult to facilitate disposal to land or surface waters. The method of disposal can make or break an otherwise viable project. The feasibility study will address all disposal options.

In the long term, the most responsible way of disposal would be re-injection. While a small annual discharge of about 15-20 gpm would take care of the Tribe's space heating needs today, the future discharge could be substantially increased if the adjacent Town of Ft. Bidwell were to be added on to the Tribe's district heating system. Without reinjection, it is reasonable to assume that the capacity of the FB-3 well may diminish over time if surface discharge increased with the area's energy demands.

The FB-4 geothermal exploration well may be completed this year if all goes as planned. If a resource capable of power generation is encountered, an injection well will likely have to be drilled Depending on the results of the FB-4 well, various options may be considered that would combine the two projects. If power generation is successful, resource from the power plant could be cascaded to supply the direct heating system; in which case the FB-3 well might be considered for injection. If FB-3 is used to supply the district heating, the required injection well may be capable of disposal for both projects.

This option also has the advantage of potentially expanding the capacity of the district heating system. In the years to come, the Town of Fort Bidwell will grow as will energy costs for heating that community. This puts the Tribe in the position of supplying power and heat for generations to come if they choose to do so. At the very least, the Tribe would be able to realize energy self-sufficiency.

Conclusions
There is more than enough energy available from the FB-3 geothermal well to support a district heating system, not only for the Reservation but for the entire Town of Fort Bidwell and beyond. A district heating system in Canby averages an annual flow of 13.3 gpm to heat a similar number of buildings. However, in order for this district heating system to be economically viable, the method of disposal may be a deciding factor.

Reasonably, the two projects can be combined to reduce costs. The use of the existing FB-3 as an injection well, even if it requires deepening, would save the cost of drilling a new injection well. Final alternative recommendations will depend on the temperatures and flow rates encountered in the proposed FB-4 well.

We do know that as energy costs increase, however, the likelihood of Indian Country becoming involved in selling renewable energy to their neighbors will increase. Tribes today are ever more developing and marketing energy from wind, solar, hydro and bio-mass resources on Tribal lands. The Tribe in Fort Bidwell may have one of the most promising geothermal resources in Indian Country. The time is coming when Tribal renewable energy reserves could profit the Tribe directly by incorporating them into the energy mix to their fellow Americans.

This project is not just an ordinary opportunity to prepare the Tribe for a decision on installing a district heating system; it is an extraordinary chance for the Tribe to develop what may be an energy self-sufficient future.

This direct-use feasibility study will conclude by the end of 2006 and a further paper will be written to conclude this study. This paper was supported by the Tribal Energy program of the DOE.

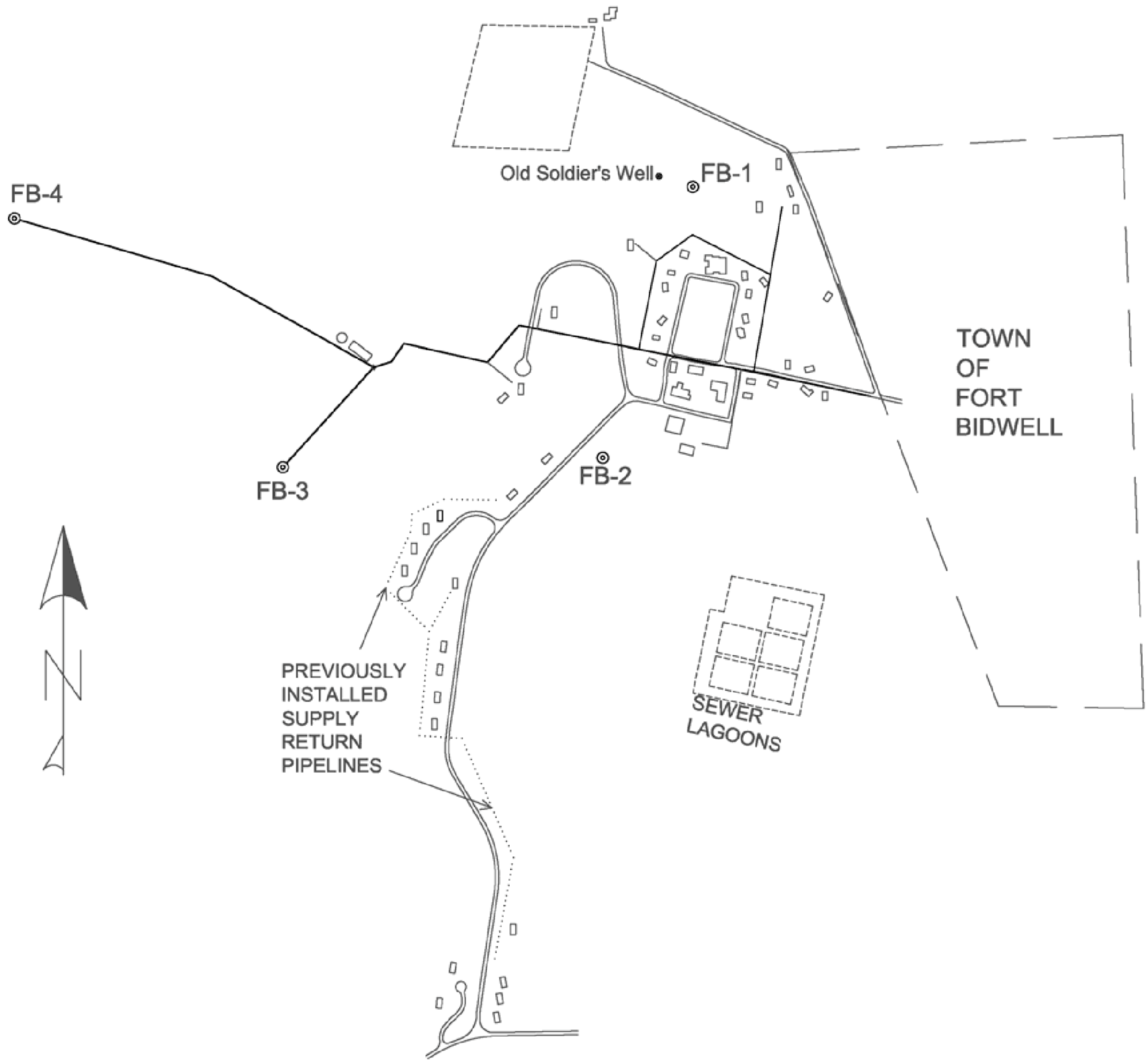

Figure 5 – FBIC Overview

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Tribal Energy Program Website, US Department of Energy

LaFleur, J., 2005, *Geothermal Resource Exploration and Definition of the Fort Bidwell Indian Reservation Hydrothermal System*, United States Department of Energy, Phase I Technical GRED III Report DE-FG36-04GO14343.

Chitwood Energy Management, September 25, 1987, *Fort Bidwell Indian Reservation Geothermal District Heating Project*

Fort Bidwell Indian Community, 2006, Personal Communication

LESSONS LEARNED

Note: This report was written expressly for the DOE/CEC grant-funded Geothermal Well Drilling Project on the Reservation, however, many of the lessons learned apply.

ISSUES ADDRESSED DURING GRANT TERM

In undertaking the first deep geothermal drilling project on tribal lands in over two decades managed solely by a tribe with the assistance of a Consultant Team rather than a Lessee or Private Partner, we knew we would be breaking new ground. Herein, we attempt to identify the challenges we faced and recommend actions to those (tribes, agencies, and consultants) who might pursue similar projects.

Project Background

The project was presented to the tribe by the Consultant Team to be funded by grants to explore the possibility of identifying a geothermal resource capable of power production and ultimately provide income to the tribe.

The Tribal Council chose to work with a Consultant Team rather than a Lessee or Private Partner in the hope of substantial potential income for the community versus a small royalty from leasing, as is the case for most tribal power developments.

Rising drilling costs over the project term required additional funding so both federal and state grants were secured, complicating agency compliance and adding levels of jurisdictional complexity.

1. The Challenges of Tribal Interaction and Grant Administration

The Fort Bidwell Indian Community (FBIC) was the grant recipient and as such had the primary responsibility to manage the grant through its administrative staff. However, under grant terms, the Consultant Team assisted in managing budgets and reporting, in addition to the Technical tasks.

Turnover: The first challenge we faced was providing information to and interfacing with Tribal Council, staff and the tribal community. The Consultant Team reported primarily to the Tribal Administrator, but staff and Council turnovers interrupted a regular flow of information to Tribal decision-makers. During the four plus years of the project, the council was re-elected twice and the chairmanship changed five times; there were three tribal administrators, five interim administrators, and two finance officers. There was general tribal support for the project, and different individuals took an active interest from time to time, but there was no single tribal representative to act as liaison for the tribe throughout the entire term of the project. Despite the problems, however, the project remained viable and in compliance, due to the tribe's basic stability and the fact that the Consultant Team remained intact.

Increased Administrative Costs: Council/staff turnovers, rig availability, grant negotiations, and contract execution led to the second challenge of unanticipated increases in administrative costs. Peculiar to this project were the following issues:

- Sovereign Immunity and State Contracting: The Tribal Council initiated a review of the California Energy Commission (CEC) agreement by California Indian Legal Services (CILS), who in turn raised concerns about waiving sovereign immunity. They cited a court case that was later found to be inapplicable to the project and in fact, withdrew their opinion. However, this consumed much consultant time and effort to address these concerns to the satisfaction of the Council. See also Prevailing Wages, below.

- Contracts: Differences of opinion arose among Council members and staff as to whether or not the consultants would be required to sign contracts with the tribe to carry out their grant tasks. The consultants generally felt they were partners with the tribe as participants in the grants. In the end a contract was developed only with ThermaSource, the drilling contractor, to ensure compliance with DOE and CEC grant provisions.

- Insurance and Hold Harmless Clauses: The Council raised concerns about tribal liability in case of an injury or death during drilling, to which the Consultant Team responded with research covering injury/mortality statistics on drilling and other like-industry projects. To ensure coverage, the contract required the tribe to be named as additional insured on the driller's substantial insurance coverage, and certificates of insurance were required of all consultants and subcontractors, as is routine on construction projects.

Recommendations:

Agencies: Allow redundancy in grant budgets for tribal staff and consultant staff administration functions; budget for tribal legal counsel on project issues, especially on groundbreaking projects.

Consultants: Include contingency costs in proposal budgets for administrative tasks to compensate for staff turnover, for research to respond to unanticipated legal issues, to develop contracts, and for the time and travel to re-educate new Councils (see also, Outreach, below).

Tribes: Contract a tribal representative with the time, interest, an expense account and the support of Council to participate in every aspect for the entire term of the grant/project. This person would act as liaison between the Council, the tribal community, Consultant Team, and agencies. Hold legal counsels accountable for their opinions, ie. that they relate them to the specific project in question.

2. The Challenge of Prevailing Wage, a Jurisdictional Issue

Another challenge was the requirement to pay Prevailing Wage by the state CEC grant but not by the federal Department of Energy (DOE) grant. Again, the issue of sovereignty and the inapplicability of state and local laws to tribal lands was raised. The Consultant Team, in concert with the Tribal Chairperson, attempted to address and resolve the issue as follows:

As required by the CEC contracting process, we requested a formal determination from the CA Department of Industrial Relations (DIR) regarding whether: a) an exploration well qualifies as a public works or construction project, and/or b) state prevailing wage regulation applies to projects on tribal lands. After several letter exchanges with DIR and contract delays, it was decided to temporarily and narrowly waive sovereign immunity for this one specific project. Consequently, no final ruling as to the applicability of California Prevailing Wage requirements on tribal lands was made by DIR or CEC. Prior to reaching that decision, however, the following inquiries were undertaken in researching the subject.

We consulted the DOE regarding their experience with and applicability of the federal Davis-Bacon Act (federal law upon which CA law was originally based). DOE advised that they do not apply Davis-Bacon to exploration wells because they are not considered construction projects.

We spoke to the Bureau of Indian Affairs (BIA) staff, with oversight responsibilities for oil and gas drilling on Indian lands, about the applicability of Davis-Bacon and state prevailing wage provisions to similar projects. They were unaware of the issue in their experience of drilling oil and gas wells on tribal lands or elsewhere.

We contacted the DOE Tribal Energy Office, who passed on the following opinion from their staff:

> " . . . the Davis-Bacon Act does not generally apply to financial assistance awards. However, it is not always straightforward unless the Federal grant program legislation does not require compliance with the Act. However, if covered by legislation, it may not apply to the financial assistance agreement between DOE and the recipient, but would apply for "construction" activities subcontracted for under the agreement. <u>Hence, applicability would need to be made on a case-by-case basis.</u> Please also be aware that states and other non-Federal organization may apply Davis Bacon as a term of their funding." (Emphasis added)

We know that casinos are developed on tribal lands under negotiated "compacts" between Tribes and the State of California; however, we found no helpful guidance in the compact language.

We discovered that CalTrans, the state transportation agency, had significant experience contracting with Indian Tribes and talked with their legal counsel about how the subject of sovereignty was handled in their contracts. They expressed a willingness to talk to the CEC legal staff and we passed this information along to the CEC.

In the end, and in regard to all of the issues that pitted sovereign immunity against state laws, the CEC legal staff acknowledged they had neither the expertise nor the research budget to make a determination on tribal law, and concluded that it was impossible to alter a contract resulting from a competitive solicitation.

One final note is the imposition of prevailing wage as a barrier to the employment of tribal members during drilling. The resulting disparity in pay rates for non-technical jobs on the reservation often results in conflict and discontent.

Recommendations:

Agencies: Energy agencies should resolve whether exploration drilling is a "construction" project under federal and state laws. Further, California should resolve whether its prevailing wage laws are applicable on tribal lands.

Consultants: Be aware that prevailing wage is a budget matter and that the resolution of all sovereignty conflicts can be very costly and time-consuming.

Tribes: Consult with other tribes and tribal organizations for guidance on this issue.

3. The Challenge of Tribal Sales Tax Exemption

At 7.75%, CA sales tax exemption on materials and supplies represented a significant savings to the project. However, meeting the terms of the exemption, especially with suppliers and contractors unfamiliar with the law was a tedious process.

Recommendations:

Consultants: Address the issue and process of sales tax exemption during the drafting of contracts and before signing between the tribe and prime contractors.

Tribes: Make a determination of the proper documentation, and provide it to contractors soon after signing the grant agreement to allow purchase of supplies at the best prices.

4. The Challenge of Tribal Member Participation and Employment

Throughout the project, the Consultant Team offered information about geothermal energy and the exploration-drilling project to all tribal members through a variety of activities.

a. At the beginning of the project, copies of a video about geothermal energy, and a supply of brochures and other handouts were offered at the FBIC Community Center.
b. The Consulting Team made numerous presentations to the Tribal Council and community members, including a PowerPoint prepared to address all concerns raised about the project.
c. At least three articles and updates were included in tribal newsletters, distributed to members, both on and off the reservation.

d. The Consultant Team conducted field trips (under separate funding) to a geothermal fish farm, geothermal district heating facility, and a binary power plant.
e. Tribal Council and other tribal members attended conferences and workshops about geothermal energy.
f. A PowerPoint presentation about Permitting of Exploration Drilling on Tribal lands Without a Lease was presented at the Geothermal Resources Council Annual meeting workshop on Land, Lease and Unit Legal Issues.

FBIC policy encourages the hiring of tribal members on reservation projects. However, few jobs are generated by technical projects performed primarily by outside contractors. Consultants are often not set-up to hire employees and drilling contractors have their own crews. When jobs do arise during the project, tribes should have an eligible list of temporary employees that consultants/contractors can draw upon.

FBIC used separate grant funding that provided for capacity building tasks, to hire three tribal members as fire-watch-security crew. Their duties included monitoring the water supply system, watching for fire hazards due to high fire danger in the surrounding forest, and general security of the access road and site. This afforded them an opportunity to see first-hand the operation of the rig, follow the drilling data gathering in real-time in the geologist (Principle Investigator) trailer, and ask questions to share information with other tribal members.

Recommendations:

Agencies: Allow capacity building line items in budgets for geothermal grants to tribes. As newcomers to geothermal, tribes need training, education, exposure, and participation in geothermal operations to become real partners in solving America's energy crisis.

Consultants: Consider how to integrate and budget tribal employment into project tasks.

Tribes: Identify potential jobs and screen members for eligibility under tribal hiring rules early in the grant process. Plan with staff to hire temporary tribal employees from the eligible list as job opportunities arise during the project.

5. The Challenge of the Tribe as a Permitting Agency

As this was the first deep exploration well drilled on tribal lands for over two decades, there were no helpful experts or publications to give regulatory direction, and determining the legally required permitting and regulatory framework for this project was an exercise in frustration.

In early conversations with the FBIC, consultants were advised that no permits were required, the tribe is not subject to state permitting, and don't talk to the Bureau of Indian Affairs or state agencies. Online searches for relevant regulatory guidance was difficult, in that BIA, because of ongoing litigation, had no website nor did their staff have email. Initial inquiries to the BLM yielded inaccurate information and subsequent inquiries to BIA staff resulted in contradictions.

BIA was certain about their authority. FBIC was certain of their sovereignty. It was not pleasant being first, and even now some uncertainty remains.

This project had a unique permitting/regulatory framework, and has been described in more detail in an Appendix to the Phase I Report, but will be briefly updated here.

Tribes are sovereign nations. They cannot lease their lands under the Geothermal Steam Act, yet can do so under the Indian Minerals Development Act (IMDA). Operations on leased tribal land are subject to the regulation of the BIA and BLM under the IMDA. However, if they pursue exploration of their lands as a tribe or tribal entity and retain all rights to the land and resource, they may not be subject to IMDA oversight. While this project was pending, the Energy Policy Act of 2005 was passed. It provides that tribes wishing to regulate energy development on their lands can do so under an energy management plan that is approved and monitored by the BIA. However, they forfeit the right to sue BIA over management of their lands.

<u>NEPA/CEQA</u>: For this project the initial grant was with the DOE for an exploratory slim hole. As the lead federal funding agency DOE considered the slim hole eligible for categorical exclusion under NEPA. Tribes are subject to the Endangered Species Act and most of the various Cultural Resources regulations. Biological and Cultural resource surveys were undertaken as grant tasks and DOE approved the project under NEPA.

Although the tribe initially took the position that no BIA involvement was required, contact was eventually made with the Redding and Sacramento offices by the Tribal Administrator. BIA agreed no permits were required under these circumstances, so after the well pad and sump were constructed, application was made to CEC for supplemental funding and widen the bottom part of the well.

The CEC grant triggered CEQA (California Environmental Quality Act) and an investigation into whether a change to a larger well under state funding might prompt BIA and BLM oversight. BLM staff stated they had no experience working on tribal lands, but, would have to take a second look at NEPA as an agency separate from BIA, potentially requiring an expensive (unfunded) EA and delay of at least 6 months. Note that DOE, BLM and BIA don't have the same categorical exclusion guidance, although they sometimes accept the determination of the other lead agency. So, as a regulatory matter, the project skated along on untested ice, but was eventually carried by strict compliance with applicable regulations, and the power of tribal sovereignty.

Because the well was an exploration well with no additional surface disturbance or significant increase in emissions from drilling or potential well testing, CEC approved the widening and deepening project under CEQA. Actual approval to proceed with the wider bottom hole, however, was withheld until DOE funding was exhausted.

<u>EPA</u>: Tribes are subject to other federal laws, including the Clean Air Act, Clean Water Act, and Safe Drinking Water Act, under which permits on other federal lands are issued by state agencies for air emissions and discharges to the land surface. On tribal lands, they are under the

jurisdiction of the EPA, so contact was made with this agency. There is a remaining issue as to whether or not an Injection Permit might be required under the Safe Drinking Water Act if, during or after drilling, there is injection test of produced fluids. EPA staff suggested that FBIC submit a plan of operation and request a "determination of applicability," but the well has not yet been tested and that issue was set aside until final plans for well testing are made.

BLM and CADOGGR. Because the project had no apparent applicable regulatory oversight, the Consultant Team recommended to FBIC, early on, that they voluntarily subject the project to the technical review of the Bureau of Land Management (BLM) or the California Division of Oil, Gas and Geothermal (CADOGGR). The Tribal Administrator, at the time, declined to do so, fearing "unintended consequences."

Standards: Applicable technical, and regulatory standards and procedures had to be identified and voluntarily complied with by the Consultant Team. We lined the sump, complied with standard well casing and cementing design and testing procedures, used an appropriate blow out preventer (BOP) and tested the BOP in accordance with accepted standards. We also wrote a list of project requirements for personnel working on the Reservation, developed a drilling Emergency Response Plan and Emergency Phone List, obtained chemical analyses of the sump, and generally policed ourselves as to standards familiar to us from decades of experience.

Recommendations:

Agencies: 1) Resolve the applicability of BIA regulations under the Indian Minerals Development Act (and self-determination statutes), as well as the Energy Policy Act of 2005 when a tribe explores or develops their own resources without a lease or "minerals agreement." Specifically, what is it that triggers IMDA oversight where there is no encumbrance of the land or resource?

2) Provide a generic geothermal energy management plan suitable for adoption by tribes and approval by the BIA, along with an analysis of the process for, and impacts of adopting, such a plan under EPAct 2005.

3) In California, the Division of Oil, Gas and Geothermal Resources (DOGGR) has responsibility under an MOU with EPA to regulate injection under the Clean Drinking Water Act. On tribal lands, this responsibility falls under the jurisdiction of the EPA. Determine the jurisdictional, regulatory and permitting requirements for exploration well testing (which might include an injection test) on tribal lands to assist EPA in their oversight role.
Tribes and Consultants/Developers: Be aware of EPA's role and engage them early in the permitting process.

Respectfully submitted,
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