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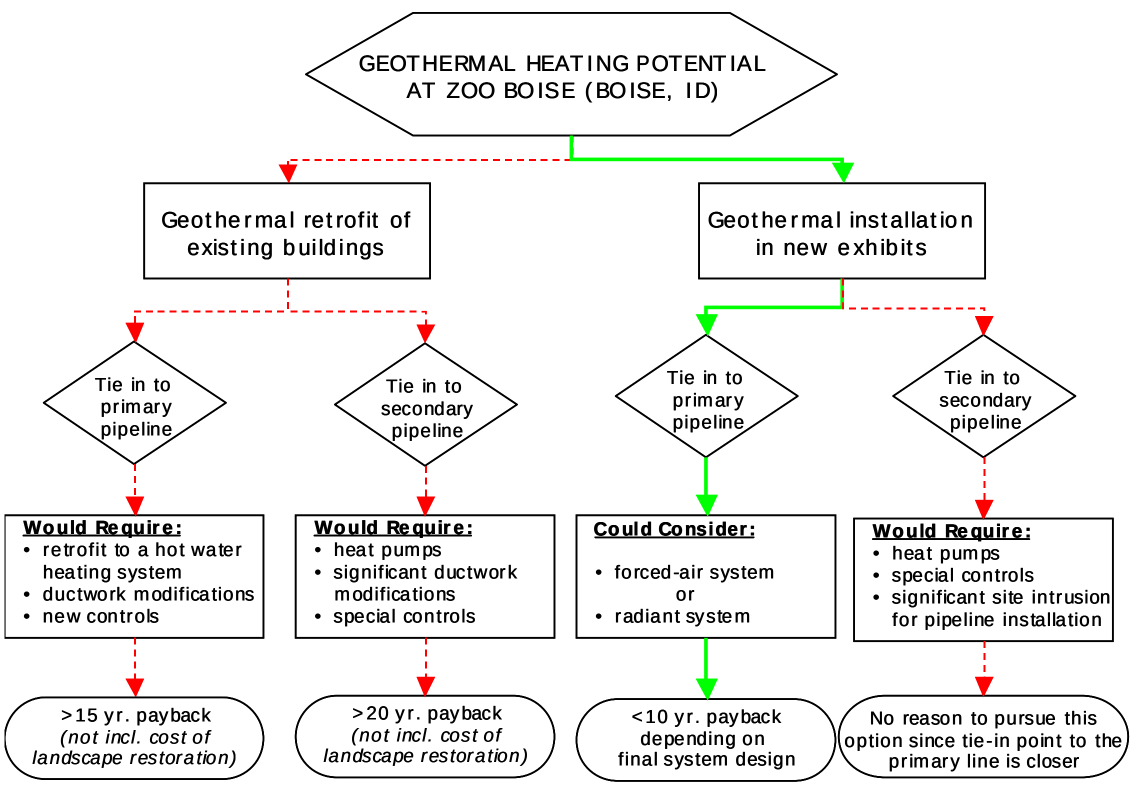
PRELIMINARY FEASIBILITY STUDY FOR POTENTIAL USE OF GEOTHERMAL HEATING AT ZOO BOISE

EXECUTIVE SUMMARY

The Geo-Heat Center conducted a preliminary assessment of the feasibility for Zoo Boise to connect to the City of Boise, ID geothermal district heating system. We subdivided the project into two categories: **(1)** retrofitting existing buildings and **(2)** outfitting new planned exhibits. Within these two categories, we considered the economics of supplying the geothermal water via two mechanisms: **(i)** the primary geothermal pipeline and/or **(ii)** the secondary (collection) pipeline (i.e. geothermal water that has been used by other customers but still has some useable heat content).

Results of the preliminary study are summarized in the following flow chart. Dashed red lines represent unfavorable options and solid green lines represent favorable options.



At this time, it does not appear economically justifiable for Zoo Boise to retrofit existing buildings to the Boise geothermal district heating system. For connection to the primary geothermal pipeline, significant modifications to existing systems and equipment would be required, resulting in a simple payback on investment exceeding 15 years, not including the cost of landscape restoration. For connection to the secondary geothermal pipeline, modifications to existing systems would also be required in addition to the installation of water-source heat pumps, resulting in a simple payback period exceeding 20 years, not including the cost of landscape restoration. However, other possible energy-savings measures were identified for existing buildings, such as ventilation air heat recovery and a water-source heat pump at the penguin pavilion.

It <u>does</u> look economically attractive for Zoo Boise to further explore options to outfit new exhibits to the primary geothermal pipeline. Short payback periods of less than 10 years are possible, depending on final heating system design combined with whether or not the City of Boise absorbs the cost of the geothermal pipeline up to the point of use. The City of Boise should bring the geothermal pipeline at least to the property boundary at no cost to the customer. If Zoo Boise chooses a radiant floor type system, the payback could be almost immediate with a geothermal system due to avoided boiler costs. There are also intangible benefits for connecting to the geothermal district heating system, such as improved public relations of using renewable energy to enhance new exhibits. There are also future options of adding snow melting systems as walkways and parking areas need replacing.

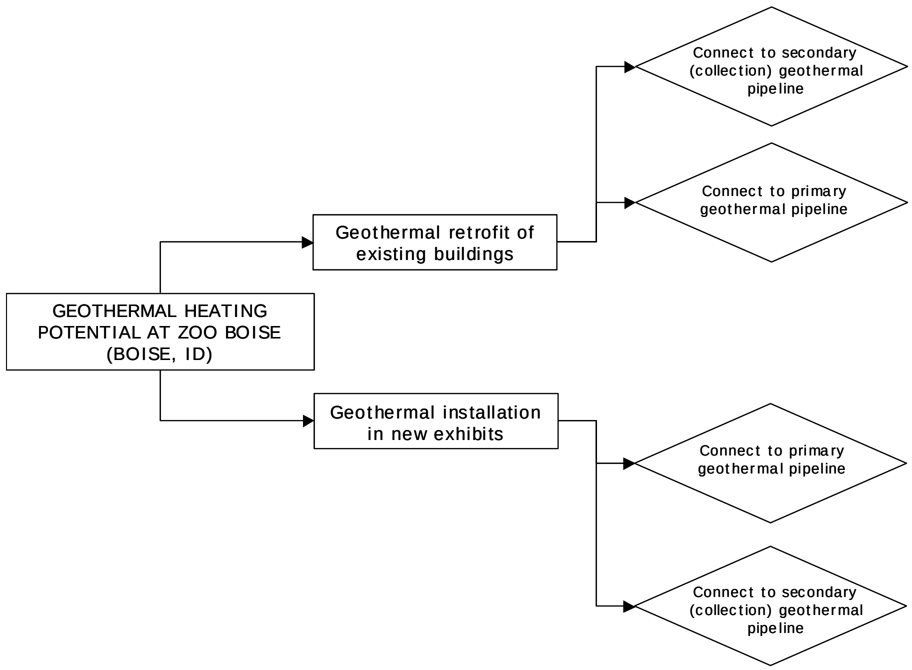
At this time, if Zoo Boise is interested in pursuing geothermal heating potential, it is recommended that zoo representatives meet with the City of Boise to discuss options for extending the primary geothermal pipeline to the new zoo exhibits. The contact person at the City of Boise is Kent Johnson, P.E. at the Public Works Department (Ph. 208-384-3926). The City will make the final decision as to whether pipeline construction is economical for them too. In the meantime, a more detailed engineering feasibility analysis should be done by the Zoo's mechanical engineering consultant to narrow down the preferred heating system.

Sincerely,

Andrew Chiasson, P.E.

INTRODUCTION

The Geo-Heat Center was initially contacted by the Idaho Energy Division to conduct a preliminary assessment of the potential for Zoo Boise to connect to the City of Boise, ID geothermal district heating system. We subdivided the potential for geothermal heating at Zoo Boise into two categories: **(1)** retrofitting existing buildings and **(2)** outfitting new planned exhibits. Within these two categories, we considered the economics of supplying the geothermal water via two mechanisms: **(i)** the secondary (collection) pipeline (i.e. geothermal water that has been used by other customers but still has some useable heat content) and **(ii)** the primary geothermal pipeline. The geothermal potential for Zoo Boise is summarized in the following flow chart.



A location map of Zoo Boise showing the geothermal district heating systems in Boise, ID is shown in Figure 1. As seen in this figure, the re-injection well for the City of Boise geothermal district heating system is located near the northeast end of the zoo property, and this would be the closest connection point to the secondary geothermal pipeline if feasible. However, to serve the new planned exhibits, a pipeline would need to be brought to the other end of the zoo at a distance similar to a tie–in to the primary geothermal water line. Therefore, we evaluated this option of the zoo connecting to the primary geothermal water line, of which there are a couple of ways to accomplish. First, a branch from the primary geothermal pipeline could be extended from near the Boise Art Museum (the closest current customer). Alternatively, a branch could perhaps be bored under the river to/from planned pipelines serving Boise State University (BSU) (see Figure 1). The timing of construction of the BSU pipeline is not known at this time, but the City of Boise should be consulted on this matter.

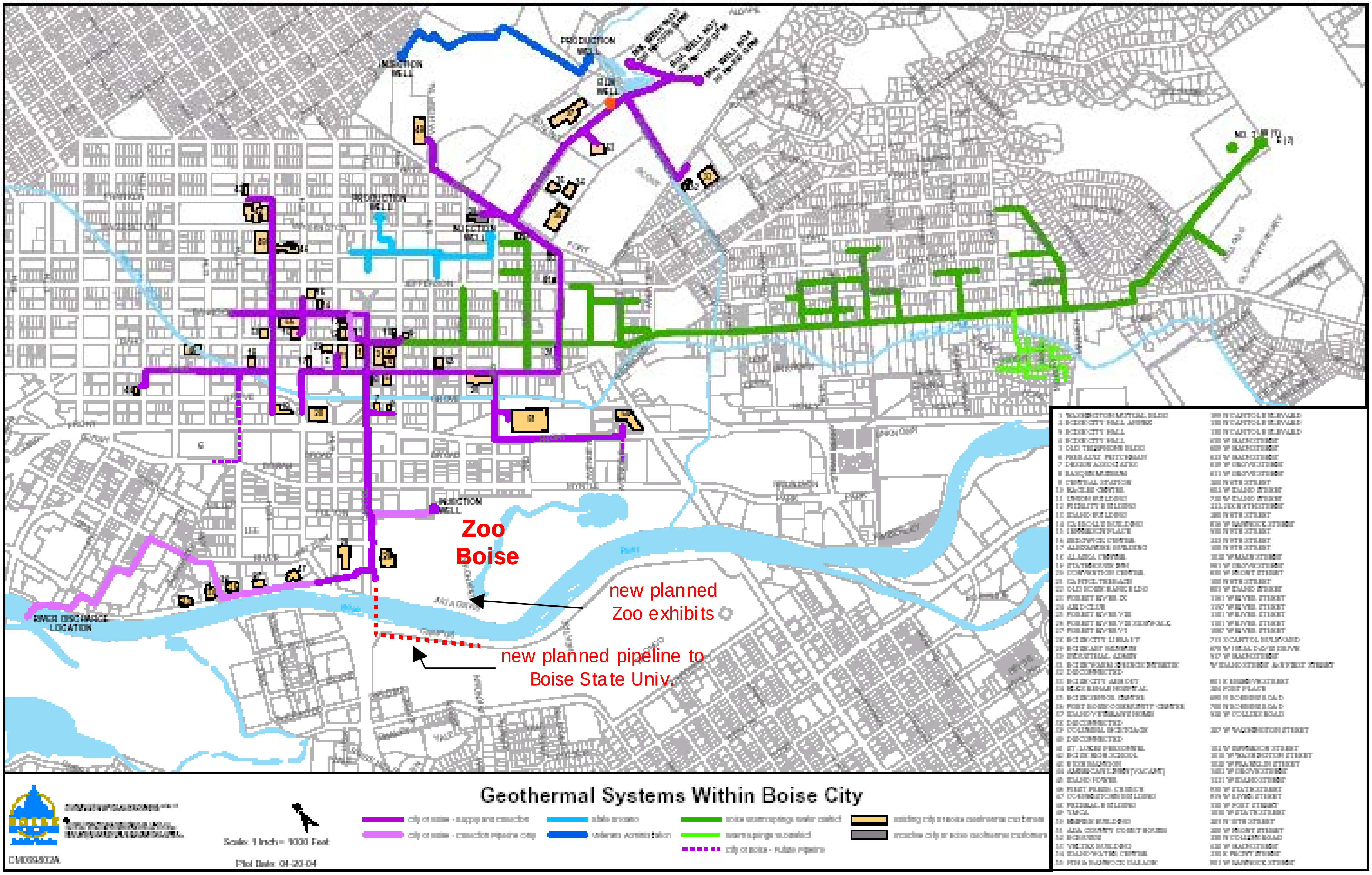


Figure 1. *Zoo Boise location map showing Boise geothermal district heating systems.*

The details of connection to the geothermal district heating system would have to be worked out with the City of Boise, since the City takes responsibility for bringing the pipeline to the customer. There would also need to be an agreement as to the actual point of delivery of the geothermal water, as the connection point could either be the zoo property line or it could be at the individual points of use themselves. Our analysis is based on the fact that the City agrees to bring the geothermal pipelines to the Zoo property boundary at a minimum. Economic scenarios are presented for the cases where the Zoo *would* and *would not* be responsible for routing the geothermal pipelines to the point of use.

METHOD OF STUDY

Geo-Heat Center staff walked through the zoo property in January 2005 with some members of the Idaho Geothermal Energy Working Group. We noted a mixture of unitary heating appliances in existing buildings, such as forced-air natural gas furnaces, electric radiant panels, and infrared natural gas radiant heating units.

As it is beyond the scope of our preliminary study to calculate the heat loss of each building, there are methods available to provide reasonable approximations of heat losses in buildings. For a typical building of "loose construction" and four exposed walls (or a building with high air infiltration rates), a heat loss of 50 Btu/hr/ft^2 is a good assumption for an outdoor air temperature of 0^{o}F and an indoor temperature of 65^{o}F. No heating is assumed to be required above outdoor air temperatures of 65^{o}F. Annual heating requirements are then found from hourly air temperatures taken from typical meteorological weather data for Boise, ID as shown in Figure 2.

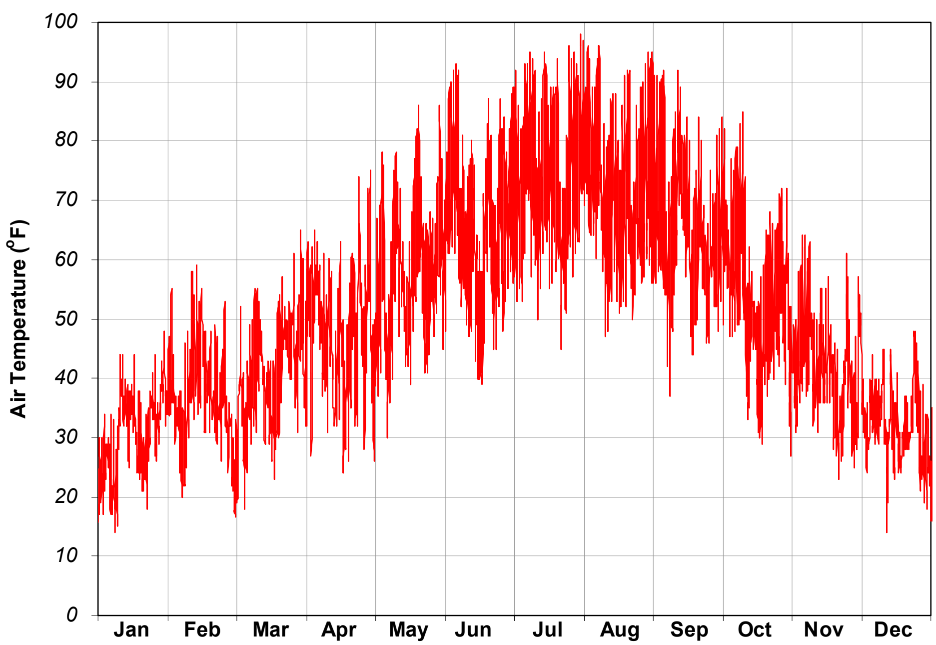


Figure 2. *Hourly air temperatures from typical meteorological year (TMY) weather data for Boise, ID.*

Geo-Heat Center staff also examined the injection well water temperatures provided by the City of Boise to determine suitability for heating with the secondary geothermal pipeline.

RESULTS OF STUDY

Figure 3 shows estimated annual savings with geothermal heating as a function of heated space (in sq. ft) at different natural gas rates (in therms). The City of Boise rate structure for the geothermal district heating system is such that the customer is billed at a rate that provides a 30% discount relative to natural gas, after adjusting for efficiency.

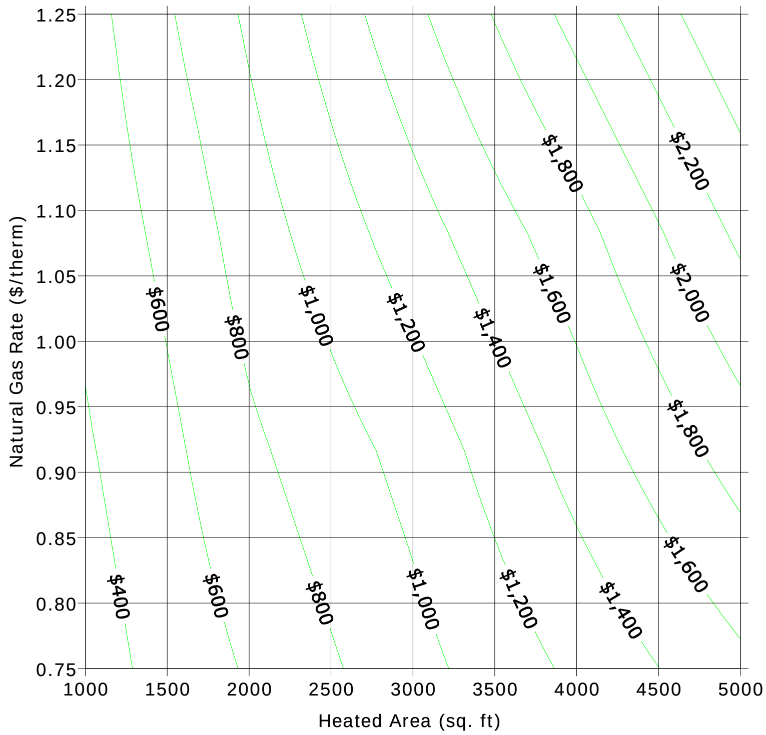


Figure 3. *Estimated annual savings map with geothermal heating. Note that 1 therm equals 100,000 Btu.*

Note that it is somewhat ironic in considering alternative heating systems. The more energy that is consumed, the more money is saved. This is advantageous to a relatively higher energy consumption application, such as zoo displays, where exhibits are partially indoors and outdoors, or where doors are frequently opening. On the down side, economies of scale of connecting multiple small buildings to a district heating system are not present that would otherwise be seen in one large building (i.e. in excess of 10,000 sq. ft). Therefore, interpretation of the savings map presented in Figure 3 is that it would be more cost effective to connect to the geothermal district heating system at relatively larger heating demands.

Retrofitting Existing Buildings

Connecting to the Secondary Geothermal Pipeline. This scenario considers use of the secondary geothermal water that has been used by other customers. The closest connection point would be at the northeast end of the zoo property (see Figure 1).

Geo-Heat Center staff reviewed injection well water temperature data supplied by the City of Boise and concluded that the secondary geothermal water would not be useful for heating without heat pumps, as the water temperature was routinely observed to be 100°F or less during the winter months. The most practical retrofit, therefore, would be a water-to-air heat pump, but would require special water flow controls and significant ductwork fabrication and/or modification. Discharge air temperatures from heat pumps are lower than furnaces, and more airflow would be required to meet the heating demands. For best comfort from a heat pump system, evenly distributed airflow is necessary. It would also be difficult to retrofit various unitary electric resistance heating units under this scenario.

For retrofit of small buildings under this scenario, assuming a natural gas rate of $0.85/therm, we estimate a payback period exceeding 20 years. As this estimate does not include landscape restoration or pipeline installation, this scenario was not considered any further.

Connecting to the Primary Geothermal Pipeline. This scenario considers use of the primary geothermal water, which is at a temperature of approximately 150°F, and therefore it can be used directly for heating purposes. The closest connection point would be at the northwest end of the zoo property (see Figure 1).

While being able to better meet heating demands than with heat pumps, a different set of retrofit equipment would be required under this scenario. The current heating systems are all-air systems, and these would have to be retrofitted to hot water systems. Therefore, at a minimum, retrofitting would require installation of hot water coils at all terminal units, hot water supply and return piping, ductwork modifications to accommodate the new water coils, and new controls.

For retrofit of the small zoo buildings under this scenario, economies of scale are not present, and the payback period would be at least 15 years, assuming a natural gas rate of $0.85/therm. For this scenario to be cost effective, a building size would need to be at least 10,000 sq. ft, decreasing the payback period to below 10 years.

Other Possible Energy Savings Opportunities. One possibility for reducing energy consumption in the existing zoo buildings is with air-to-air heat recovery ventilation (HRV) units. These units help to manage ventilation of small buildings by pre-heating cold outdoor air; fresh outdoor air warms in a heat exchanger as it passes by exhaust air, thereby reducing the heating load caused by the incoming cold outdoor air.

Another energy savings opportunity identified during our walkthrough was installation of a water source heat pump that would utilize water from the penguin pond to heat and cool the penguin pavilion building. This could be done assuming there is sufficient flow-through of the pond water so as not to disrupt the penguin habitat.

New Construction

Connecting to the Primary Geothermal Pipeline. This scenario considers use of the primary geothermal water in the new planned exhibits at the northwest end of the zoo. The location of the new exhibits is convenient for connection to the primary geothermal pipeline, and would result in little intrusion to the zoo property.

New construction obviously allows more freedoms in selecting a heating system, and there are many options. Important considerations in selecting a heating system include, capital cost, required maintenance, energy consumption, comfort for both animals and humans, and simplicity of the system for maintenance staff. Table 1 provides a comparison of the different heating systems that might be considered for the new exhibits. All electric heating systems are not considered due to their high energy consumption.

TABLE 1.
COMPARISON OF POSSIBLE HEATING SYSTEMS FOR NEW ZOO EXHIBITS

Conventional	Geothermal
Forced-Air Systems	
Natural gas furnace (ducted)	*Air handling unit with hydronic (hot water) coil in duct*
Natural gas unit heater(s)	*Hydronic unit heater(s)*
Radiant Systems	
Infrared natural gas heaters (tubes and/or panels)	*Hydronic radiant panels and/or perimeter baseboard finned tube radiators*
Radiant floor/turf with hot water supplied by natural gas boiler	*Radiant floor/turf with hot water supplied by geothermal system*

To make a comprehensive cost comparison at this time is beyond the scope of this study, and would be difficult without further details of the zoo plans. The most probable lowest cost heating option for new exhibits would be a system with forced-air natural gas unit heaters or infrared radiant heaters. If Zoo Boise were considering a higher comfort system such as a radiant floor heating system with a hot water boiler, a geothermal system would be about the same cost or less. This is because avoided boiler costs would offset additional equipment such as heat exchangers that would be needed for a geothermal system.

We can get a rough estimate of expected payback periods based on R.S. Means mechanical cost data and the estimated geothermal savings map shown in Figure 3 if we just consider the lowest probable cost scenario for a conventional system and a geothermal system. These would be the unit heater systems described above. Using R.S. Means mechanical cost data, an estimated payback map on geothermal heating systems was developed and is shown in Figure 4.

The above analysis assumed that the City would bring the geothermal pipeline up to the point of use. If this is not the case, Zoo Boise would incur the cost of routing the pipeline through the property. Cost considerations in pipeline installation include: cutting, removing, and hauling surface materials; trenching; bedding material and installation; pre-insulated pipe and installation (supply with un-insulated return); fittings and valves; re-landscaping; and engineering fees. However, to make a fair comparison to natural gas systems, some of the geothermal pipeline installation costs would be offset by natural gas piping installation costs. Estimating the incremental costs of a geothermal pipeline installation at \$25/ft, another payback map can be developed using the geothermal savings map from Figure 3. Figure 5 shows this payback map on the incremental costs of geothermal pipeline installation.

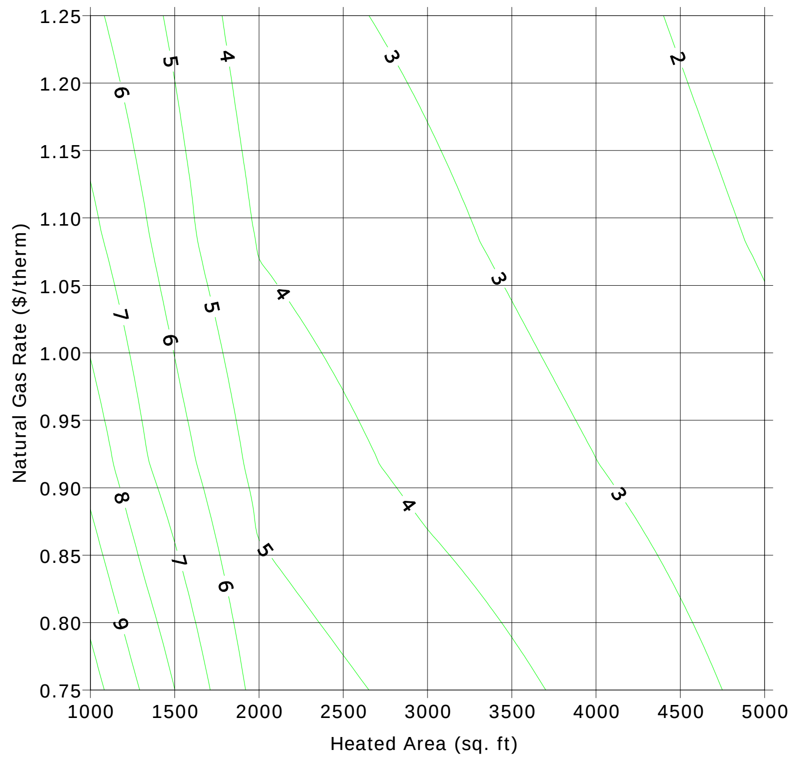


Figure 4. *Estimated payback period in years on a geothermal heating system with forced-air unit heaters relative to a conventional system with forced-air natural gas unit or radiant heaters.*

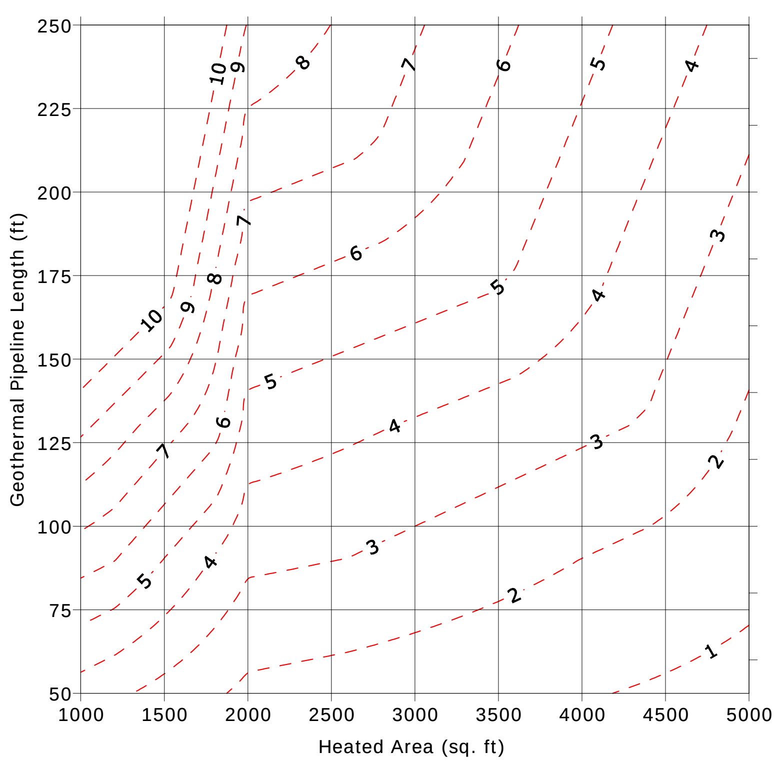


Figure 5. *Estimated payback period in years on incremental geothermal pipeline installation costs over natural gas piping installation costs (assuming an equal length of piping for each case).*

As seen in Figures 4 and 5, the payback period depends on the heated area, since more money is saved with larger heating demands. Assuming an acceptable payback period of 10 years, it appears to be feasible for Zoo Boise to further explore geothermal heating options at heated areas above 1000 sq. ft. However, if Zoo Boise must absorb the geothermal pipeline costs and still keep a 10-year payback period, geothermal heating is still possible depending on the heated floor space and necessary pipeline length. For example, supposing a heated area of 2,000 sq. ft was planned. Assuming a natural gas rate of $0.85/therm, Figure 4 estimates a payback period of about 5 years on the “in the building” portion of the system. From Figure 5, Zoo Boise could absorb the cost a 140 ft-long geothermal pipeline installation and still keep the payback period under 10 years.

CONCLUSIONS AND RECOMMENDATIONS

The Geo-Heat Center evaluated the potential for Zoo Boise to connect to the City of Boise geothermal district heating system. Scenarios of connecting to the primary and secondary geothermal pipelines were examined for both existing and future buildings.

In short, it does not appear economically justifiable for Zoo Boise to retrofit existing buildings to the Boise geothermal district heating system. Other possible energy-savings measures were identified such as ventilation air heat recovery and a water-source heat pump at the penguin pavilion.

On the contrary, it does look economically attractive for Zoo Boise to further explore options to outfit new exhibits to the primary geothermal pipeline. Short payback periods (<10 years) are conceivable, depending on final heating system design combined with whether or not the City of Boise pays for the geothermal pipeline up to the point of use. If Zoo Boise chooses a radiant floor type system, payback could be almost immediate with a geothermal system due to avoided boiler costs. There are also intangible benefits for connecting to the geothermal district heating system, such as improved public relations of using renewable energy to enhance new exhibits. Also, future options exist to add snow melting systems for walkways and parking areas as they need replacing.

At this time, if Zoo Boise is interested in pursuing geothermal heating potential, zoo representatives should meet with the City of Boise to discuss options for extending the primary geothermal pipeline to the zoo property. The contact person at the City of Boise is Kent Johnson, P.E. at the Public Works Department (Ph. 208-384-3926). The City will need to know projected heating loads, as this will help to make a final determination as to whether pipeline construction is economical for them too. In the meantime, a more detailed engineering feasibility analysis should be done by the Zoo’s mechanical engineering consultant to narrow down the preferred heating system.