Installation Guideline and Recommendation Report for the Tiffany Springs Animal Hospital

An Earnest Appraisal of Your Heating and Cooling Needs

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Submitted By:
Zachary Buckner
6985 Snow Way Drive,
Box 7254
St. Louis, MO, 63130

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I. Executive Summary

The owners of the Tiffany Springs Animal Hospital should consider installing ground source heat pump systems into their 6,500 square foot facility; a ground source heat pump system is a strong long-term solution for the building, especially in terms of annual utility bills due to its high seasonal energy efficiency rating (SEER). An air source heat pump would produce utility bills more than twice what a ground source heat pump would produce, as well as necessitate the installation of unsightly outdoor units directly in front of the building. The tax refunds and tax depreciation available for a ground source heat pump system make this system a viable short term solution as well.

Discussed within are the highest quality options for heating and cooling the Tiffany Springs Animal Hospital, both for an air source heat pump system and a ground source heat pump system. We at Buckner's Heating and Cooling choose Bryant for our heating and cooling needs, so we compared a system using the Bryant Evolution air source heat pump and a system using the Bryant GT-PX ground source heat pump. Using efficiency ratings from these two systems and the average utility costs in Kansas City from 2008, we calculated the average utility costs for the two systems.

The Tiffany Springs Animal Hospital will save $8,809 annually on utilities bills using a GSHP system as opposed to a traditional ASHP of the same size. They will also receive a tax credit of $7,000 and a tax depreciation of the cost of the GSHP over a period of five years. Finally, the use of sustainable business methods like GSHP might help increase public opinion of the Tiffany Springs Animal Hospital, leading to increased new and repeat business.

II. Why Choose Buckner's Heating and Cooling?

We at Buckner's Heating and Cooling are very excited that you have considered us for the installation and maintenance of your HVAC system. Before going into the specifics of your installation, we would like to tell you a little bit about ourselves and why we are the superior choice for HVAC installation in the Greater Kansas City area.

Our Customer Service

Buckner's Heating and Cooling stands out from others in the industry because of our commitment to customer satisfaction. Our founder, Roger Buckner, believes in paying attention to the small details and exceeding the customer's expectations. It's this approach to our business that motivates the team at Buckner's to provide superior service.

Our Team

Our expert NATE-certified technicians are professional, knowledgeable, and friendly. They take great pride in their work and don't cut corners. Each technician receives regular training, including bi-annual manufacturer instruction, to continually improve his proficiency. All of this expertise is available to Buckner's customers 24 hours a day.

Our Sales Process

The relationship between Buckner's and the customer begins when the phone is answered. Calls for replacement equipment are given directly to the consultant who will be making the initial visit.

We spend a lot of time listening to our customers, discussing their specific issues/concerns, and answering any preliminary questions. Measurements and digital photos of the existing equipment are taken. Once the information has been gathered, we sit down and discuss all the options. We

place a special emphasis on finding the right fit for the customer – there is no "cookie-cutter" approach for every circumstance.

At Buckner's, we are committed to satisfying the customer before, during, and after the installation. We look to build a relationship and refuse to apply pressure or suggest solutions that are not entirely in our customer's best interest.

Our Installations

Photo-worthy workmanship, high-quality materials, and no shortcuts; all are standard with a Buckner's installation. Every job, from the most basic to the most elaborate, receives a 100% satisfaction guarantee.

III. Air Source Versus Ground Source Heat Pumps

There are two choices before you as to what kind of heating and cooling system you will use in your building, an air source heat pump or a ground source heat pump. Each system has its own pros and cons, and so to help you better choose, this section of our installation guideline will contain basic information for both kinds of units.

III.a Air Source Heat Pumps

A typical air source heat pump (ASHP) consists of two major pieces of equipment: the outdoor unit and the indoor unit, as seen in Figure 1[1]. An ASHP works by thermodynamically manipulating a refrigerant fluid flowing through the copper tubing that connects the indoor and outdoor machinery. First, the compressor in the outdoor unit pushes the refrigerant through a vaporizer placed just before the A-coil in the indoor unit. The refrigerant is converted from a liquid to a gas by the vaporizer piece, drastically lowering its temperature. The cooled refrigerant circulates through the A-coil; as air from the blower fan passes through the A-coil, the low-temperature refrigerant absorbs the heat from the air. Now having absorbed heat from the

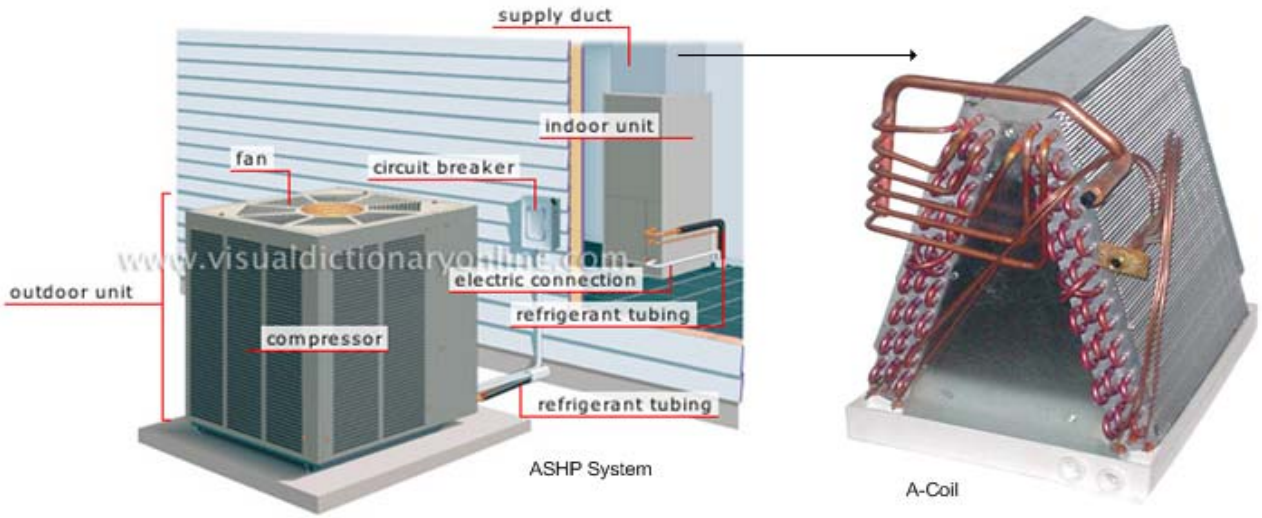

Figure 1: ASHP General View

air inside the house, the refrigerant continues through the copper piping to the coils along the edges of the outdoor unit. The fan in the outdoor unit then draws the heat from the refrigerant and diffuses it into the air. The refrigerant then passes through the compressor, which transforms it back to a liquid in order to go back to the A-coil and start the process over again. In order to heat your building, the ASHP will completely reverse its process to heat the air in your building and disperse cold air outside.

III.b Ground Source Heat Pumps

Figure 2: GSHP General View

A ground source heat pump (GSHP) consists of two major parts, the indoor unit, as shown in Figure 2[2], and the polyurethane or copper piping system buried outside of the building. A GSHP unit improves upon the technology of the ASHP by utilizing geothermal energy to heat and cool either the glycol-water mixture or refrigerant fluid that flows through the piping; the temperature of the earth stays about 50°F year round. In order to cool the building for a system using the glycol-water mixture, called a closed loop system, chilled liquid from the underground piping flows into the heat exchanger within the indoor unit, driven by a pumping motor. The heat exchanger is comprised

of two separate loops placed in contact with one another; one of which contains the chilled glycol-water mixture and the other contains the same refrigerant fluid found in an ASHP. Similarly, the mechanism that cools the air in the building works much in the same way as in an ASHP; however, the refrigerant fluid can now disperse its heat into the glycol-water mixture within the indoor unit, eliminating the need of an outdoor unit. The heated glycol-water mixture then flows from the indoor unit back into the underground piping where it disperses its heat and the cycle begins again. For a system running refrigerant through the ground loop, the process is simplified; the copper piping system that would once run into an outside unit is now buried, exchanging heat with the earth. A simplified, cartoon version of this process can be seen in Figure 3[3]. In order to heat the building, the process is reversed, absorbing heat within the underground piping and transferring it to the refrigerant fluid within the inside unit.

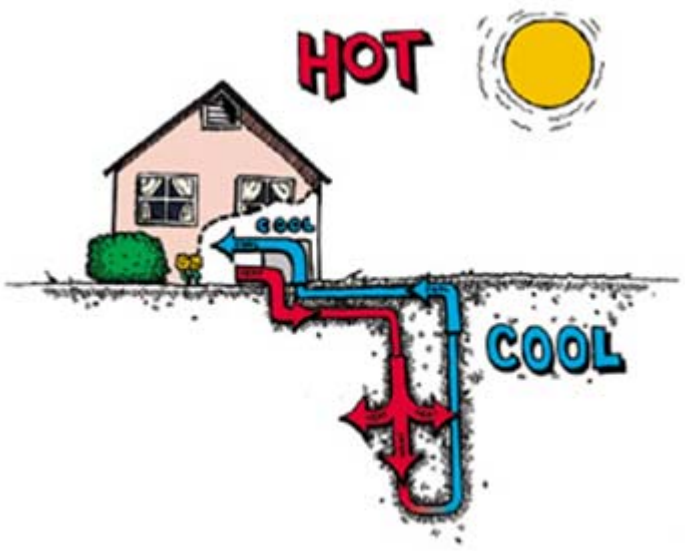

Figure 3: Cartoon Version of GSHP Process

III.c Comparison

Table 1 contains a side by side comparison of the two units over a number of different qualities of the systems. The main difference between the ASHP and GSHP is the way in which the unit disperses heat; an ASHP uses outdoor air to cool or heat the refrigerant fluid, while the GSHP uses geothermal energy. Herein lies the major drawback of the ASHP; because it uses outdoor air to cool or heat the refrigerant, the efficiency of the system fluctuates with the outdoor temperature. If an ASHP unit is trying to cool a building on a 90°F day, then it is using 90°F air

to cool the refrigerant within the copper piping. Thus, the unit must run longer and at a higher level to cool a building on a hot day. However, a GSHP cools and heats the refrigerant at 50°F year round, regardless of the outdoor temperature; this leads to significantly lower utility bills. Unfortunately, due to the nature of the installation (burying pipes and welding the piping together), the GSHP suffers from a steeper initial cost. Another disadvantage of the ASHP is the

Table 1: ASHP-GSHP Comparison

	ASHP	**GSHP**
Installation Cost (we will compare the installation costs in Section V of this report)	Standard	Nearly twice as high
SEER	Best model has up to 18.0 SEER (Fluctuates with temperature)	Best model has up to 27.0 SEER (Does not fluctuate with temperature)
Noise	Outside unit contain fan blower; medium to large amount of noise	No noise created
Tax Refund on Purchase	None	Ranges from $1,000-3,000 depending on size of the unit and closed loop type; No tax refund is granted for direct exchange systems
Tax Depreciation	None	5 year tax depreciation; 50% of the total cost for the first year, 50% distributed evenly over the following 4 years
Installation time	Four days	Four days
Lifetime	Both the indoor and outdoor unit have an average lifetime of 25-30 years	The indoor unit has a lifetime of 25-30 years; polyurethane pipes have a lifetime of 50-60 years

amount of refrigerant it uses; because there must be a loop from the indoor to the outdoor unit, there will be much more refrigerant within the lines as opposed to a GSHP. In the case of a leak, not only would you pay more money to replace the refrigerant, but there is more environmental damage done as well. Also, within GSHPs, there is a component called a desuperheater, which consists of additional piping within the heat exchanger that leads to the water heater. When the refrigerant disperses heat to the ground loop, it will also give off much of that excess heat to the water within the desuperheater line. This equates to "free" hot water roughly 85% of the time.

IV. Equipment and Installation Recommendation

Figure 4 shows the placement of the indoor unit. For a 6500 square foot building, you will need at least 11 tons of heating and cooling capability from your heating and cooling system. However, because of the nature of the project, we suggest implementing a system capable of 13 tons; not only must we compensate for the warm Kansas City summer and the fact that this is a commercial building, but we must also keep in mind that at any given time, you may have well over ten animals in your facility, necessitating more heating and cooling power. We have concluded that, whether you choose an ASHP or GSHP system, we will be using two 5-ton units and a 3 ton unit. What follows are our equipment recommendations for both systems.

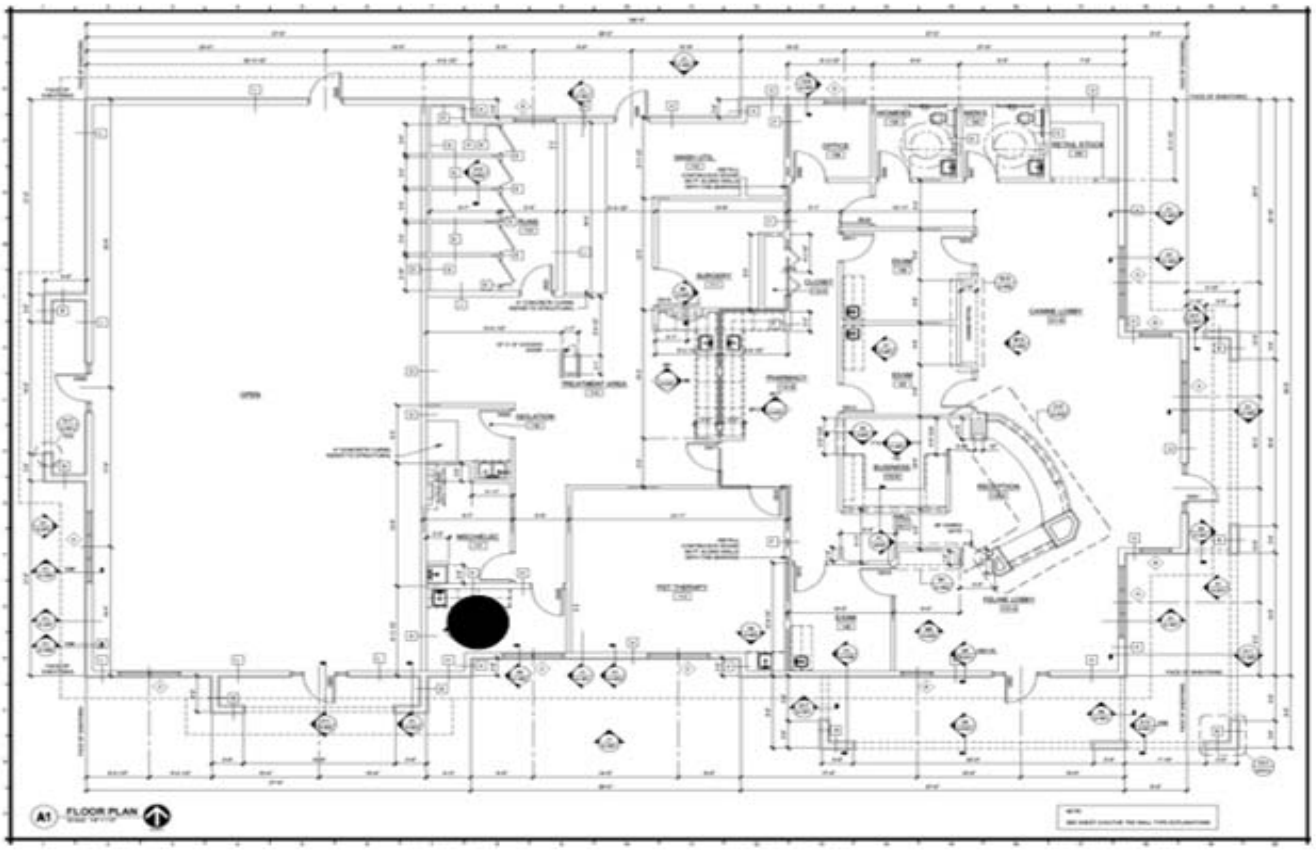

Figure 4: Inside Unit Placement

IV.a Air Source Heat Pump Equipment and Installation Recommendation

Figure 5: Bryant Evolution Heat Pump

The Bryant Evolution Heat Pump, shown in Figure 5[4], is the highest quality ASHP system that Bryant offers. It has up to 18 SEER, a 10 year limited parts warranty, and it's the quietest heat pump available[5]. Unfortunately, we would have to place the three units directly in front of your building, which is not the most aesthetically pleasing choice. However, given the significantly lower installation cost (discussed in the next section of this guide), we still consider this to be a viable option.

The installation of this system will be a three day process:

Day One: During the first day, we will begin the initial steps for the installation process, namely, installing the duct system. This consists of a three-man team assembling, connecting, and hanging the metal duct system throughout the building. In addition, on this first day we will place our three inside units and begin to wire them into the system.

Day Two: On the second day, the team will complete the duct system in the building and begin installing the outdoor units. We at Buckner's Heating and Cooling insist on only the safest installation techniques; therefore, we use separate breaker boxes for every outdoor system that we install. These breaker boxes allow the user to easily turn off power to each unit, whether for general maintenance by the owner, or electrical work by our technicians.

Day Three: On the third day, we will complete the installation of our system. Our team will run the copper piping through the exterior wall and weld it to both the indoor and outdoor units; the hole is cleanly sealed using clear, HVAC-insulating caulk. We then create a sturdy PVC drain system for each of your indoor units, as opposed to using plastic drain tubes, which are notorious for being easily clogged, causing water to pool within the unit.

IV.b Ground Source Heat Pump Equipment and Installation Recommendation

The Bryant GT-PX Ground Source Heat Pump, shown in Figure 6[5], is the highest quality GSHP unit that Bryant offers. It has up to 27 SEER, a 10 year limited parts warranty, and because it is a GSHP, it produces no outside noise. Also, because GSHPs require no outside unit, you will avoid placing machinery directly in front of your building; the only piece of HVAC equipment visible will be a small black box on the side of the building where the ground loop enters the building. The installation process for this unit will take three days, just like the ASHP; however, after the first day, which is the same for both systems, the installation process changes significantly

Figure 6: Bryant GT-PX Ground Source Heat Pump

Day Two: On the second day, we will place the ground loop, a process that will require either digger rig or a driller depending on the type of ground loop that you choose. Once the hole for

the ground loop as been made, we will place the ground loop and use either a handheld welding tool or torch and solder to connect the piping system. This is a day long process that will require additional members' help.

Day Three: On the third day, if we use the closed loop system, we will install the loop connection box on the outside of your building; if we use the direct exchange system, we will merely need to run copper piping into your building and seal it cleanly with clear, HVAC-insulating caulk. For the direct exchange system, we would merely need to weld the piping to the ground source unit and fill the system with refrigerant; however for a closed loop system, before connecting the pipes to the inside unit, we will need to pump the glycol-water mixture into the piping.

Next, we will discuss the pros and cons of the three ground loop options available to you for a GSHP system. There are three ground loop types available to you: direct exchange, horizontal closed loop, and vertical closed loop.

Direct Exchange Installation

A direct exchange loop system benefits from being the most efficient ground loop system for two reasons; both the copper piping, shown in Figure 7, and refrigerant fluid are more conducive to heat flow than their counterparts in a closed loop system, making them between 20-25% more efficient. Also, the size of the trench needed to bury the ground loop (6 ft. deep, 60 ft. wide, and 100 ft. long) is much more reasonable than for a horizontal closed loop for a system of the same size.

Figure 7: Direct Exchange Copper Piping

However, the direct exchange system has its own drawbacks, the first of which is the durability of the loop. Polyurethane pipes can withstand much more wear and tear than copper pipes can, and the general brittleness of copper piping makes leaks in the ground loop a very real possibility. The process of unearthing the ground loop can be a very time consuming and costly affair, especially considering the high costs of copper and the refrigerant that would be lost in such a leak. Finally, direct exchange systems do not qualify for any tax refunds, eliminating one of the strongest benefits of a GSHP unit. For these reasons, we do not advise installing a direct exchange GSHP system.

Horizontal Closed Loop Installation

A horizontal loop, shown in Figure 8[7], is the safest, if not the easiest, choice of the ground loop configurations. A 200 ft. long, 6 ft. deep trench would be made for each GSHP unit, in which the piping coiled. The biggest advantage of the horizontal loop is the fact that you're given the durability of the polyurethane piping. Also, it is the most common closed loop system used, as a vertical loop or pond loop are not always viable options due to the depth of the holes used in vertical loops and need for a body of water for a pond loop (clearly, we will not consider the option of a pond loop for your building). However, there are two disadvantages of this system, the first of which is the efficiency of heat exchange within the loop. Because the pipes are in contact with each other, and there will be tiny air pockets between the

Figure 8: Horizontal Ground Loop

soil and the pipes, they cannot exchange heat as well. Also, to bury three separate loops, the trench would need to be extremely large; the difficulty of digging and burying such a trench could potentially add another day of labor and machinery rental, driving the already high installation cost even higher.

Vertical Closed Loop Installation

A vertical loop system, shown in Figure 9, consists of a 3 ft. deep trench in which multiple, 200 ft. deep holes are drilled, 5 ft. apart from one another. The vertical ground loop has the highest benefit to downside ratio of the three loop configurations discussed. First, the vertical loop system is best suited for buildings that are confined by available space, as is the case with your building. Second, the vertical ground loop also benefits from the durability of polyurethane piping. Third, the vertical loop system qualifies for a significant tax refund, as well as five years of tax depreciation, easing the strain of the installation costs. Fourth, the vertical loop system is much more efficient than a horizontal loop for two reasons. There is no pipe-to-pipe contact within the loop, and once the loop is placed in the hole, the hole is filled with a clay mixture called bentotite; the bentotite seals a closer bond to the piping than if you were to just bury the line, as in a horizontal loop. The tight seal between pipe and clay removes any air pockets, giving direct contact and heat exchange from pipe to ground. However, the downside is that if there are any

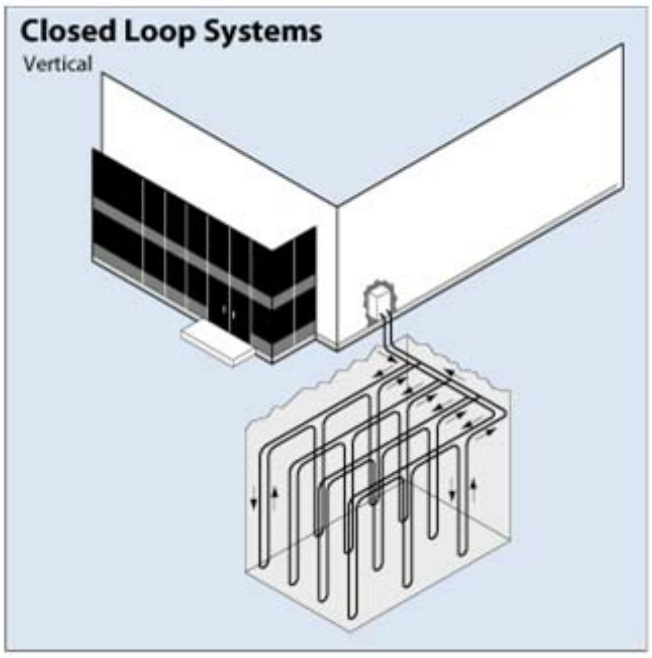

Figure 9: Vertical Loop System

deposits of hard rock within the trench space, we will not be able to implement this loop configuration. Fortunately, our initial digs that you authorized found limestone all the way down to the 200 ft. mark; limestone is easily drilled and the availability of the vertical loop has been assured.

V. Cost Evaluation and Comparison: Air Source Versus Ground Source

V.a Initial Cost Comparison

Table 2: Initial Installation Costs		
	ASHP (Including Labor)	GSHP (Including Labor and Drilling)
5-ton Unit	$11,923	$26,923
3-ton Unit	$7,153	$16,153
Total System Cost	$31,000	$70,000

Table 2 shows the installation costs of both the five and three ton units, which include the cost consideration of labor and drill rental. At the price of $31,000, the ASHP system is clearly the best short-term solution, $39,000 less than the GSHP system; however, with the GSHP system, there is an income tax credit of $7,000, effectively lowering the price differential to only $32,000, a number that we will use in future calculations.

V.b Annual Cost Comparison

Table 3: Average Annual Utilities Costs		
	ASHP	GSHP
5-ton	$1,936	$858
3-ton	$,1162	$515
Total System Cost	$5,034	$2,231

Table 3 shows the average annual utility costs for 5-ton and 3-ton units, as well as the summed utility costs for our two proposed sytems. This clearly shows the GSHP's long-term superiority over the ASHP, as the GSHP system's annual run cost is $2,803 cheaper than for the ASHP. However, these numbers do not take into account the increased utility bills of commercial buildings; a commercial building's utilities bill can be up to three times that of a residential building. This results from the constant foot traffic in and out of the building; because the door is continually opened throughout the day, warm or cool air, depending on the

season, is constantly flowing out of the building. Taking this multiplier into account, we find that the average annual utilities cost of your building to be $15,102 with an ASHP system, and $6,693 with a GSHP system. Additionally, the desuperheater would save you $400 annually, independent of heating and cooling costs. Using these numbers, the GSHP system would now save you $8,809 a year.

V.c Additional Cost Considerations

We understand that the initial $70,000 price tag for the GSHP is more than a little daunting, however, we hope that we can show you that such an investment will more than pay for itself. First off, for our subsequent calculations, let us subtract the $7,000 tax credit from the GSHP system's installation costs, setting the initial price at $63,000. Next, we consider the resulting price differential of $32,000; in the most basic terms, paying more for a GSHP system is like paying for annual utilities savings. If we divide the price difference by your utilities savings, $8,809, we find that it takes only 3.6 years to pay back the extra cost of the GSHP system; going further, it will only take eight years for the GSHP system to pay for itself, or more simply, save in utilities costs what you paid initially for the system.

On top of these savings, we can also consider the tax depreciation given for purchasing a GSHP system. The government grants a five year tax depreciation for a GSHP system, with 50% of the system's cost depreciated the first year and the remaining 50% of the cost depreciated over the remaining four years. What this means is, during the first year you have this system, $35,000 is deducted from your profits when the government calculates your income taxes, and $8,750 is deducted for the following four years. Unfortunately, without knowing the annual profits for your business, we cannot calculate how much money the tax depreciation would save you.

VI. Final Recommendation

We at Buckner's Heating and Cooling strongly suggest that two 5-ton and one 3-ton GSHP units be installed in the Tiffany Springs Animal Hospital. One of the myriad advantages of the GSHP unit is its aesthetic advantage. If you were to choose an ASHP system, there would be three large, noisy units sitting directly in front of your building, detracting greatly from the landscaping you have planned on your blueprints. On the other hand, if you choose a GSHP system, the only heating and cooling equipment visible will be three small black boxes where the ground loop enters the building.

Because of its availability and its clear superiority over the other available loop types, we recommend the vertical closed loop configuration. For your two 5-ton and one 3-ton system, we would need thirteen holes placed within the same trench. Figure 10 shows a cartoon version of the configuration we have in mind.

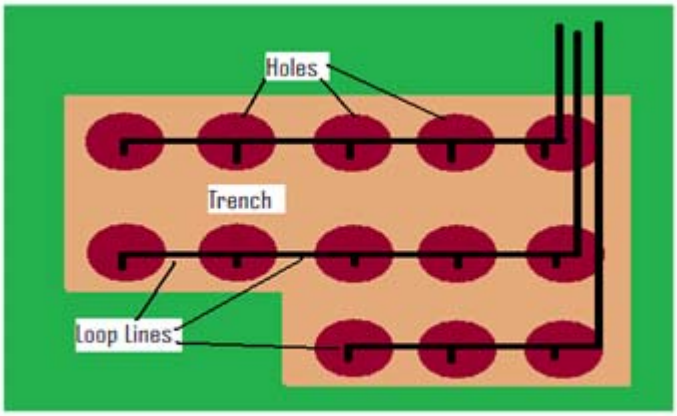

Figure 10: Cartoon of Vertical Loop Trench

The vertical loop configuration bests both the other options in two ways; first, it offers the smallest excavation site, requiring only a 30 X 20 ft. trench. Second, it offers the durability and low replacement cost of a closed ground loop; the polyurethane piping has a very low chance of rupturing, and the glycol-water mixture is much less expensive to replace in case of a leak than the refrigerant of a direct exchange system.

The GSHP system is also the most financially sound heating and cooling investment available to a building this size. The GSHP system will save the Tiffany Springs Animal

Hospital $8,809 annually in utilities bills, on top of the $7,000 tax credit and five year tax depreciation. We calculated that this system will pay for its own cost in utilities savings over nine years; however, if you were to pay off the system's costs before the tax depreciation expires, you could potentially pay off the $70,000 price in five years with what you save on both taxes and utility bills.

In a more long-term view, we should consider the cost of replacing the entire heating and cooling system. Both ASHP and GSHP units have 25-30 year lifetimes; however, for ASHP systems, this takes into account both the indoor and outdoor units. Thus, when an ASHP fails after 25 years, you must pay for a completely new system. For a GSHP system, the indoor unit has a lifetime of 25-30 years, but a closed ground loop has an average lifetime of 60 years. Taking into consideration that the majority of a GSHP's installation cost arises from the cost of drilling and digging, we see that it is much less expensive to replace a GSHP unit with a ground loop already in place as opposed to replacing both the inside and outside units of an ASHP.

Finally, with the current trends of America, we as a society are making an enormous push for sustainability, especially in the realm of business, with small businesses being no exception. The geothermal energy utilizing technology of GSHPs is one of the most sustainable options for heating and cooling available, as it both decreases the energy requirement of your home and does less damage to the environment in the case of a leak because it uses less refrigerant than an ASHP. By making it known to your customers that you use sustainable heating and cooling methods (perhaps a small sign in the lobby), you can potentially improve the public opinion of your business, which would lead to more new customers and repeat business with former customers. As any business owner knows, sometimes public opinion is the one thing that money can't buy; in this case though, it can.

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