GROUND-COUPLED HEAT PUMP SYSTEMS: A PUMPING ANALYSIS

by

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Abstract

Ground-coupled heat pump (GCHP) systems use the ground as a heat source or sink that absorbs heat from or rejects heat to the soil, respectively; this is referred to as the geothermal heat exchanger. Apart from the geothermal heat exchanger, there are two other main system components that make up a GCHP system: heat pumps and circulation pumps. This report studies four GCHP pumping systems and makes comparisons between the four using life-cycle cost analyses for six building models. The goal for this analysis was to discover commonalities between the models in order to provide designers insight into which pumping system is the most cost effective.

The analysis was performed by first creating energy models to obtain system and zone load information, as well as system part-load data and geothermal heat exchanger performance. From the zone load information, heat pump selections were then performed to indicate the worst case piping path that is required for pump head calculations. Piping layouts were created to establish pipe lengths for the pump head calculations as well. Other piping components such as valves and fittings and the air separator pressure drops were also calculated. Once the pump head calculations were complete for each system, pump schedules were created. From there initial unit and installation costs were determined for each pump, as well as their replacement costs. The part-load data from the energy models were then used to obtain annual pump energy consumption and pump utility cost. Finally, assumptions were made to establish regular and preventative maintenance requirements for each pumping system.

Initial and replacement unit costs, annual utility cost and regular and preventative maintenance costs were the components used in the life-cycle cost analysis. Each of these components was converted to 30-year projected costs and added to create a total life-cycle cost for each pumping system. Comparisons were then made and the results showed that a primary pumping system with VFD control and 100% redundancy was the most cost effective system. However, there are other considerations such as controllability, flexibility and availability that might persuade designers to choose one of the other alternate solutions.

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List of Abbreviations

A – Annual cost

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

Avg. – Average

B&G – Bell and Gossett

BHP – Break horse power

BMS – Building monitoring system

CFM – Cubic feet per minute

CLG – Cooling

COP – Coefficient of performance

DX – Direct expansion

EER – Energy efficiency ratio

Equiv. – Equivalent

EWT – Entering water temperature

F – Future cost

FT – Feet (foot)

FT of HD – Feet of head

GCHP – Ground-coupled heat pump

GPM – Gallons per minute

GSHP – Ground-source heat pump

HC – Heating capacity

HP – Heat pump or horse power

HTG - Heating

HVAC – Heating ventilating and air conditioning

i – Interest

IAQ – Indoor air quality

KW – Kilowatt

KWH – Kilowatt per hour

LWT – Leaving water temperature

MAINT. – Maintenance

MBH – One thousand BTU per hour

n – Number of years

P – Present cost

PD – Pressure differential

PLH – Part-load % per hour

P/S – Primary/secondary

RPM – Revolutions per minute

SC – Sensible capacity

SF – Square feet (foot)

TC – Total capacity

TYP – Typical

VFD – Variable frequency drive

W/ – With

WPD – Water pressure drop

Acknowledgements

I would like to acknowledge Fred Hasler as the major professor of this report; without his knowledge and guidance this report would not have been a success; and for that I am extremely grateful. Additionally, I would like to give a special thanks to the committee members involved in this masters process: Julia Keen and Thomas Logan.

Dedication

I would like to dedicate the completion of this work and the accomplishment it represents to my family. Specifically, I would like to dedicate this report to my parents, Ronald and Shari Mays, and my sister, and best friend, Taylor Mays. Their support pushed me through this difficult process and their love gave me the strength to finish. – I love you.

Chapter 1 - System Overview

Ground-source heat pumps (GSHP), also referred to as geothermal heat pumps, are a variety of heating, ventilating and air conditioning (HVAC) systems that use the ground, groundwater, and surface water as a heat source or sink, hereinafter referred to as the geothermal heat exchanger. Groundwater and surface water heat pumps are considered water-to-air heat pumps, whereas GSHPs that use the ground as their geothermal heat exchanger are referred to as ground-coupled heat pumps (GCHP). For this research, ground-coupled heat pumps were used. Refer to the heat pump sub-section in this chapter for more details.

This chapter is broken up into three sections: advantages/disadvantages, system components, and system controls. Firstly, the advantages/disadvantages section of this chapter lists some advantages and disadvantages of GCHP systems over conventional chilled and heating water systems. The main GCHP system components are heat pumps, pumps, piping loops and the geothermal heat exchanger. Other system components included in this section are the air separator, expansion tank, glycol feed assembly, and chemical pot feeder. Finally, the controls section discusses how the main system components are controlled.

Advantages/Disadvantages

Stephen P. Kavanaugh and Kevin Rafferty's *Ground-Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings* lists a number of advantages and disadvantages of GSHPs. Below is a version of that list with additional comments and some updated facts to focus on GCHPs (Kavanaugh, S. P., & Rafferty, K., pgs. 143-145 (1997)). The advantages include:

- High Efficiency and Stable Capacity – due to the mild liquid temperatures in the ground loop, GCHPs will operate with much higher efficiency and economy than conventional air source and fossil fuel equipment. This minimal variation in liquid temperature compared to outdoor temperature yields stable unit capacity. Chilled/heating water systems, which require both chilled water and hot water pumps, have to use a larger amount of pump energy to circulate each medium through the system. However, due to the ground loop being a natural heat source/sink, the mild liquid system temperatures, and refrigerant-to-water heat exchanger within the heat pump, GCHPs can operate with less pump energy than the conventional chilled/heating water systems. Furthermore, since the heat pumps are located at the zone level, the amount of fan energy required to condition the space is less than having an air-handling unit with one large fan that is sized to circulate the full system airflow located in a central location.

- Comfort and Air Quality –GCHPs are constant volume. Therefore, the heat pump constantly circulates the same volume of air to/from the space to maintain higher indoor air quality (IAQ), regardless of compressor operation. The high efficiency of the heat pump, the reversing valve, and the mild liquid temperatures from the geothermal heat exchanger also contribute to better air temperature control, as these components help the controllability of the heat pump coil.
- Simple Controls and Equipment – heat pumps can easily be locally controlled by a thermostat and the only central control required would be a variable frequency drive on the water pump and pressure drop sensors to regulate flow. It is unnecessary to use complex controls for GCHPs. Actually, since GCHPs have such a high initial cost, specifying expensive and complex controls at the heat pump isn't recommended in order to keep the system cost low. One exception, however, is providing a central control system that connects all heat pumps together for common control and ease of maintenance and troubleshooting. These systems do have a higher initial cost over simplistic controls, but can save on overall maintenance cost. If desired, a cost analysis should be performed to establish the test solution for the owner.
- Low Maintenance Cost –GCHP systems do not often require any outdoor equipment, which have a higher initial cost over similar indoor equipment. Additionally, high-maintenance cooling towers can be avoided in most cases.
- No Need for Auxiliary Heating –the selection of GCHPs are typically governed by the larger cooling load. Therefore, the equipment can handle the heating load at any given time and requires no additional heating equipment. The ground loop will typically have a higher heating capacity than cooling, so it is easy to create a system capacity that is sufficient enough to provide the heating required. It is

believed that the heating efficiencies and economy are unmatched with GCHPs compared to conventional equipment.

- Low-Cost Water Heating – If desired GCHPs can transfer waste heat from the evaporator plus the heat of compression to a water-cooled condenser. This condenser heat can then be used for heat recovery coils or domestic hot water (ASHRAE Handbook (2004)).
- No Outdoor Equipment – most GCHPs do not require outdoor equipment, nor do they require much central equipment since typically heat pump units are located at the zone level, in the plenum or within the space itself. This eliminates potential damage that may occur with conventional outdoor equipment and frees mechanical room space for other uses.
- Excellent Life-Cycle Cost –despite their higher initial cost, GCHPs have three characteristics that usually make them the best option when a life-cycle cost analysis is conducted: low energy and demand costs, low maintenance cost, and extended equipment life.

Some disadvantages include:

- Higher First Cost – this is due to the high expense associated with the installation of the vertical bore field.
- Performance Dependent on Ground Coil and Equipment – it is crucial to understand that GCHP system performance is based on the overall design of the system components. Some individuals will specify higher costing equipment and expect it to operate well regardless of the geothermal heat exchanger design and installation quality. On the other hand, some individuals will specify lower quality equipment, in order to lower initial cost, but still expect good system performance. Remember: if the system is not designed properly, the heat pumps will not meet their rated performance.
- Limited Number of Qualified Designers –at times designers can be caught between tightening construction budgets, increasing need for standards and code compliance, and having greater legal liability, therefore, they do not want to try something “new”. Especially if it requires them to spend time learning how to design GCHP systems.

- Limited Number of Qualified Contractors – there is significant time and equipment investment required for GCHP ground loop installations; and due to the job availability, employee turnover concerns and being blamed for the high initial system cost there is not much attraction for a contractor.

Over the years, GCHP systems have become more popular; and because of this, the last two disadvantages listed above are less of an issue. Also, manufacturers have further improved the efficiencies of their units making them even more designer friendly. Therefore, the advantages of GCHPs greatly outweigh the disadvantages, but it is important to remember that the performance of this system depends greatly on the proper design of all system components.

System Components

GCHP systems consist of components located centrally, like in a mechanical room, and locally, either within the space or in the plenum. The main system components of GCHP systems are: heat pumps, pumps, the geothermal heat exchanger and piping loops. The heat pumps are typically located in the plenum of the zone they serve, whereas the pumps are typically located within a central mechanical room. The geothermal heat exchanger is located below grade, outside the building perimeter. There are two loops that serve these components. The ground loop serves the geothermal heat exchanger and the building loop serves the heat pumps; with a by-pass that connects these two loops. Refer to Chapter 3 for the pumping systems designed for this research.

Apart from the main system components of GCHP systems, there are other pieces of equipment that are installed to support the system. These other system components include: an air separator, an expansion tank, a chemical pot feeder, and in some cases a glycol feed assembly. These components are located within a central mechanical room, typically upstream of the pump(s).

Heat Pumps

The four most common types of heat pumps are air-to-air, water-to-air, water-to-water and ground-coupled. Air-to-air heat pumps have an integral motor-driven or manually operated damper that causes the change from cooling to heating based on its positioning. In this system, there are two heat exchanger coils; one is the evaporator and the other the condenser. In cooling outdoor air passes over the condenser and conditioned air passes over the evaporator (ASHRAE

Handbook (2004)). Water-to-air heat pumps use water as the heat source/sink. For example, ground water heat pumps use ground water from wells, whereas surface water heat pumps use surface water from a lake, pond or stream, both of which are examples of water-to-air heat pumps. Water-to-water heat pumps replace the forced air system with another liquid loop. These heat pumps have an integral closed vapor compression cycle that acts as a heat exchanger between the two liquid loops (ASHRAE Handbook (2004)). In GCHP systems, water-to-water heat pumps are commonly used in radiant heating/cooling floors and slabs, dedicated domestic water heating, outdoor air preconditioning and snow-melt systems; in which the ground loop acts as the waste heat source and the other liquid loop serves the radiant floor or slab, domestic hot water, outdoor air coil or snow melt system (Kavanaugh, S. P., & Rafferty, K., (1997)).

This paper focuses on GCHPs. There are two types of ground-coupled heat pumps; one is direct expansion (DX), while the other has an integral refrigerant-to-water heat exchanger. DX ground-coupled heat pumps use large quantities of refrigerant for the geothermal heat exchanger. Some disadvantages to these heat pumps are the large quantities of refrigerant being used that can be expensive to repair if a leak occurs, as well as the concerns and restrictions when large amounts of refrigerant is being circulated within an occupied space. Refrigerant-to-water heat exchangers use a closed vapor compression cycle (refrigerant) and a closed-loop coil (water) that is piped in series with the geothermal heat exchanger. Figure 1.1 illustrates how a GCHP works. The geothermal heat exchanger acts as the heat source/sink that is piped through integral water-to-refrigerant coil, labeled as W-to-R in Figure 1.1. The refrigerant is then piped through a refrigerant-to-air coil, labeled as R-to-A in Figure 1.1. The airstream that passes through the heat pump either absorbs heat from or rejects heat to the refrigerant, then circulates through ductwork to condition the spaces the heat pump serves. The refrigerant then goes through a closed vapor compression cycle before passing back through the water-to-refrigerant coil, and the cycle begins again (ASHRAE Handbook (2004)). Refer to the controls section in this chapter for information on heat pump controls.

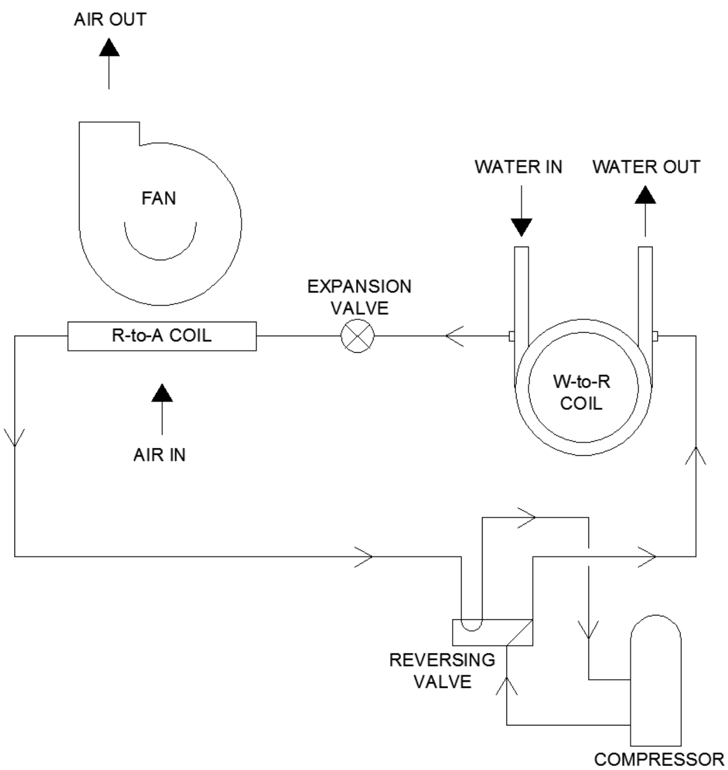

Figure 1.1 Ground-Coupled Heat Pump

Pumps

In a GCHP system pumps circulate hydronic liquid, typically water or a glycol and water mixture, from a geothermal heat exchanger through heat pumps located at the zone level within a building. There were three different types of pumps used in this research: base-mounted, end-suction, vertical in-line, and system lubricated circulators. The base-mounted, end suction pumps were used when sizing large system pumps, whereas the vertical in-line pumps were used when sizing small system pumps; in which a system pump refers to a pump that serves a series of system components such as all the heat pumps in the system and/or the geothermal heat exchanger. The system lubricated, or wet-rotor, circulator pumps were used when sizing dedicated pumps, called distributive pumps. Refer to Chapter 2 for further description on the pumping systems analyzed in this research.

Apart from a single pump, the most common pumping configuration is placing pumps in parallel. Parallel pumping is used for high flow, low head systems and is sized for half the system flow rate and the full calculated head (ASHRAE Handbook (2004)). This configuration can greatly improve pump efficiency in lieu of a single pump. Typically, manufacturers design pumps with a pump curve that places the highest efficiencies at the mid-point of its operating-range. Therefore, by operating at extreme limits, such as high flow/low head, the pump will be working at its lower efficiencies. Another reason parallel pumping would be proposed is to provide redundant pumping. This allows for one pump to be "lead" control, while the other is in "lag" control, meaning stand-by, or back-up. This allows one pump to be serviced without having to shut down the entire system. It is typical to find these parallel pumps sized the full pump load allowing 100% redundancy. Another design consideration would be to size these parallel pumps for two-thirds of the full load with VFDs, as at part-loads these pumps can be controlled in a "lead/lag" configuration and extend the life of each pump. For this research, 100% redundancy was assumed for all central pumps, meaning only one pump will operate at a time.

Base-Mounted, End-Suction

End-suction pumps get their name because the water enters the suction eye of the impeller at the end of the pump. Base-mounted refers to the fact that the pump, bearing assembly and motor are all mounted to a base that is ready to install on the floor. Once the water enters the pump impeller, the water leaves from a centerline discharge upwards (Bell & Gossett (1966)). GCHP systems use base-mounted, end-suction pumps for large central pumps. Bell and Gossett's Series 1510 base-mounted, end-suction pump is available in ½ horse-power (HP) to 150 HP at 1750 RPM and 2 HP to 150 HP at 3500 RPM (Bell & Gossett Series 1510, 2012). The advantage to base-mounted, end suction pumps is their large range of capacities; whereas some disadvantages are their equipment footprint, high noise levels compared to smaller pumps and regular maintenance requirements. Figure 1.2 shows a simple graphic of a base-mounted, end suction pump and its main components.

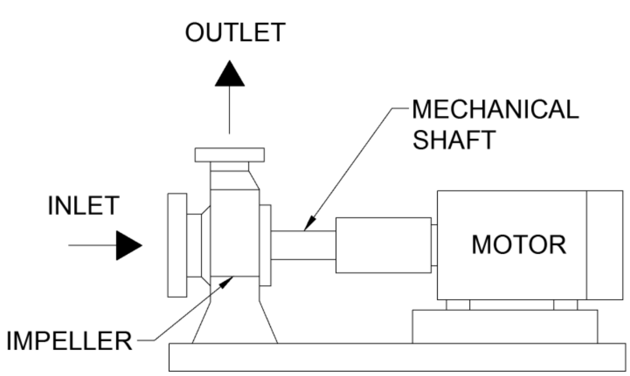

Figure 1.2 Base-Mounted, End-Suction Pump

Vertical In-Line

Vertical in-line pumps are installed directly in the pipe line and are typically mounted to the wall or hung from structure; if hung from structure, these pumps require support hangers to relieve the strain and allow for thermal growth of the piping (Bell & Gossett (1966)). Close coupled, in-line mounted pumps can be used for small capacity central pumps in a GCHP system. Bell and Gossett's Series 90 close-coupled, in-line pump is available in ¼ HP to 2HP at 1750 RPM and ½ HP to 15 HP at 3500 RPM (Bell & Gossett Series 90, 2012). One advantage to vertical in-line pumps is their equipment footprint; they can be easily installed and do not require floor space in a mechanical room. Another advantage is their relatively low noise levels compared to a base-mounted, end-suction pump. One disadvantage is that vertical in-line pumps, like base-mounted, end-suction pumps, require regular maintenance. Figure 1.3 shows a simple graphic of a vertical in-line pump and its main components.

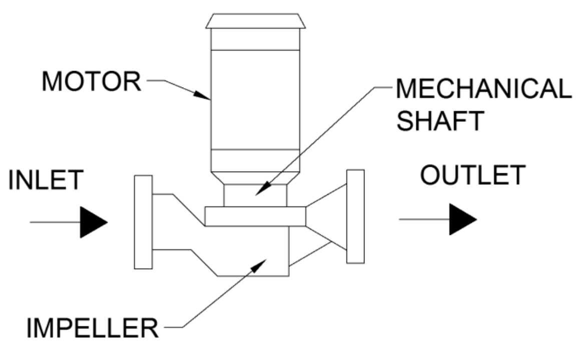

Figure 1.3 Vertical In-Line Pump

System Lubricated Circulators

GCHP systems typically use system lubricated, or wet-rotor, circulators for distributive pumps which serve a dedicated heat pump. These pumps use the system liquid rather than oil for lubrication. They are typically used in closed-loop applications so that their bearings can tolerate the small amount of particulate that can form due to corrosion. Therefore, these pumps never have to be serviced, except when there is a failure; in which case a new/replacement unit must be installed (Bell and Gossett (1966)). System lubricated circulators are typically used for small capacity, fractional HP applications. Bell and Gossett's Series NRF wet-rotor circulators are fractional HP pumps that range from 41 watts (W) at 2800 RPM to 270W at 3300 RPM (Bell & Gossett, 2011). The advantages to these pumps are that they are maintenance free, have small equipment footprints, produce minimal noise levels and can be installed in accessible plenums and chases. The disadvantage to these pumps is their small capacities. Figure 1.4 shows a simple graphic of a system lubricated circulator and its main components.

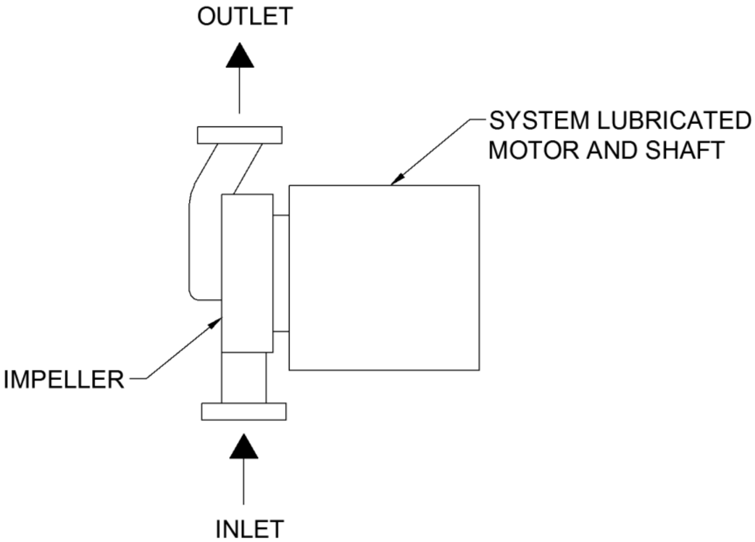

Figure 1.4 Circulator Pump

Geothermal Heat Exchanger

There are four common designs of geothermal heat exchangers used in conjunction with GCHPs. Three designs are considered horizontal geothermal heat exchangers: single pipe, multiple pipes, and coiled pipe. The fourth, and most common, is the vertical bore field design that places a supply and return pipe in a vertical bore connected by a U-bend in the bottom of the bore. This bore field design is typically used in commercial applications, due to its high exchanger performance and large range of load capacities.

Bore depths can vary based on the thermal properties of the soil and the diameter of the pipe. For this research the depth of each bore was assumed to be 250 feet with 1 inch diameter pipe, placed 20 feet on center in a reverse return configuration to create the ground loop. A reverse return was used as it provides better control and similar pipe distances for each bore on a series run. An example of a reverse return vertical bore field is illustrated in Figure 1.5.

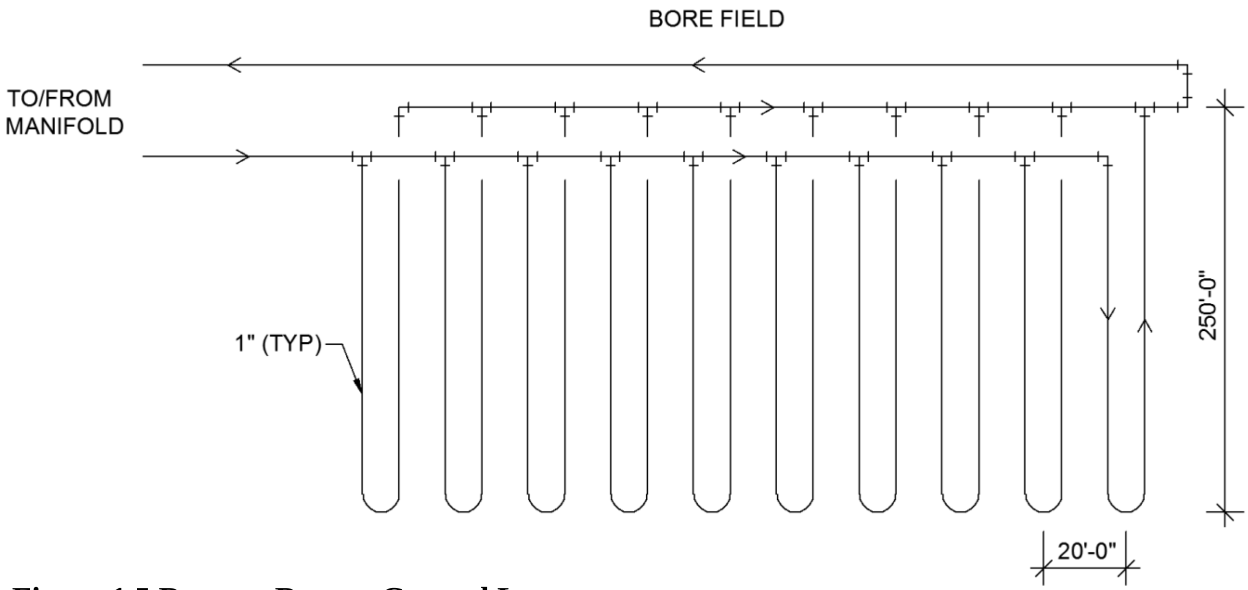

Figure 1.5 Reverse Return Ground Loop

A major advantage to vertical bore fields is the minimal variations in temperatures at their depth. This allows for more consistent temperatures that are delivered to the heat pumps and, therefore, yield better efficiencies. Additional advantages include they require relatively small plots of land and require the smallest amount of pipe and pumping energy (Kavanaugh, S. P., & Rafferty, K., (1997)). Since bore fields are buried underground, the surface of the ground can still be utilized for things like parking lots or play-grounds for schools. The main disadvantage, however, is their high expense due to the sophisticated equipment required and limited knowledgeable contractors to install them.

Piping Loops

There are two piping loops used in GCHP systems: the building loop and ground loop. The building loop serves the heat pumps, whereas the ground loop serves the geothermal heat exchanger. For both of these loops, a reverse return layout design was used in this research. The reverse-return design provides the same piping distance two and from the central pumps; meaning the supply and return pipe distances to each heat pump may vary but when added together each heat pumps is roughly the same total distance. This allows the heat pump with the largest pressure drop to be the worst case heat pump and be used for the central pumps' pump head calculations. The reverse return design of the ground loop allows each bore to be balanced within the loop, which saves from requiring balancing valves at each bore to balance the flow.

Other Components

Apart from the main system components described previously, there are four other components that are used in GCHP systems. These include an air separator, expansion tank, chemical pot feeder and glycol feed assembly. Figure 1.6 illustrates how these components can be installed.

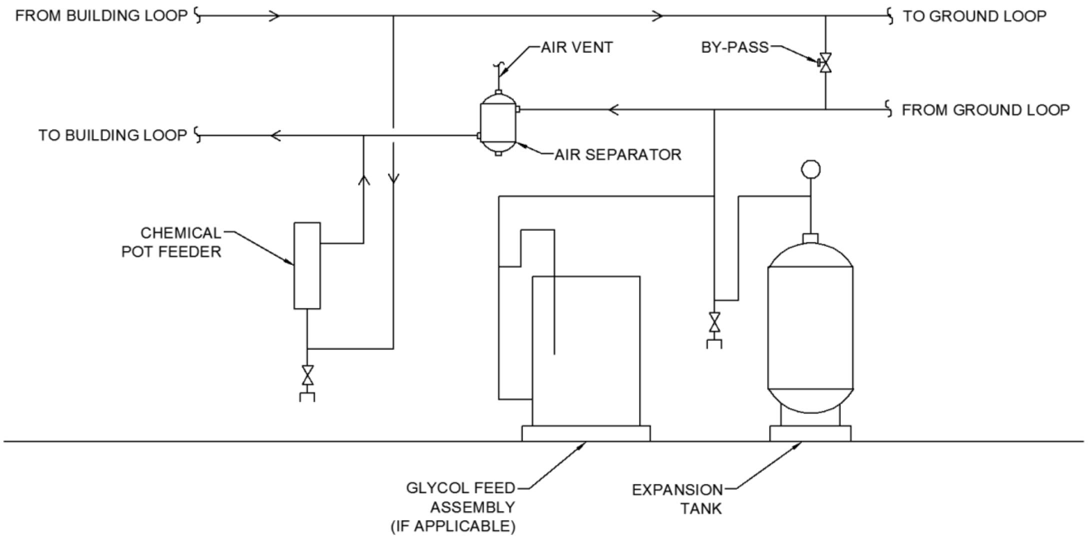

Figure 1.6 Other Component Layout

Air Separator

GCHP systems require air separators because they are closed-loop hydronic systems. Air separators simply remove entrained air from the closed-loop piping system. There are two types of air separators: one separates the entrained air from the water and vents it out of the system and the other separates the entrained air and returns it back to the expansion tank. If air separators are not provided the entrained air can cause air bound circuits, excess noise, poor pump performance, pump damage, and even a shorter system life. Therefore, it is crucial to specify this component in all closed-loop systems. Air separators are line-size, meaning they're sized to match the line size in which they're being installed. Also, as these devices are installed in-line with the pipe, a friction loss must be considered when calculating pump head (Bell & Gossett (1996)).

Expansion Tank

Expansion tanks, or compression tanks, are designed to absorb the expansion forces and control the pressure in GCHP systems. Since water is an incompressible substance, a closed-loop system must have a device to account for any fluctuation in volume as the temperature changes. For GCHP systems, expansion tanks are sized based on the total system volume, minimum and maximum temperatures, and initial and maximum system pressure seen by the system (Bell & Gossett (1996)).

Chemical Pot Feeder

Chemical pot feeders are used to introduce chemical treatment into a closed loop system. As a GCHP system is a closed loop system, a chemical pot feeder must be specified.

Glycol Feeder Assembly

A glycol feeder assembly is typically a prepackaged and ready to use piece of equipment that is only used in GCHP system with a water and glycol mixture. The two glycol solutions used in these assemblies are ethylene or propylene glycol. This component is designed to maintain minimum system pressure levels and provide system freeze protection. Depending on the percent glycol by total solution volume the freezing point varies; the higher the percent glycol the lower the freezing point of the solution (Bell & Gossett (1996)). This is the main reason a designer might consider using a water/glycol mixture as a medium instead of water.

System Controls

There are two main system components that require detailed controls to maintain proper system performance. The first is heat pump controls. To distinguish between heating and cooling modes, the closed vapor compression cycle is equipped with a reversing valve that is controlled by the zone thermostat that energizes and de-energizes from cooling to heating modes, respectively. GCHPs are also constant volume; they have an integral fan that circulates the air to/from the space when occupied in order to maintain high indoor air quality. Occupancy, or carbon-dioxide, sensors are often used to distinguish when a space is unoccupied and the heat pump fan can be de-energized. The heat pump compressor, however, only operates when the thermostat is dissatisfied, meaning it only operates when the air stream needs to be heated or cooled to satisfy the air temperature in the space. Another heat pump control component is located at the water-to-refrigerant coil, it is equipped with a control valve that is only open when the compressor is operating and is closed when the compressor is not operating. This helps to regulate flow to the heat pump only when needed (ASHRAE Handbook (2004)).

The next component that require controls are the pumps. The pump control assumed for this research was to have a variable frequency drive (VFD) at each central pump varying the speed of the pump based on pressure differential (PD) sensors. These sensors monitor the PD between the supply and return to the heat pumps and determine when the pump needs to speed up or slow down. As mentioned previously, there are controls located at each heat pump that regulate flow to that heat pump. When there is no flow required to a heat pump, the PD will decrease. This allows the PD sensors detect the change in system pressure and tell the pump to slow down. Once heat pumps begin to demand flow again, the PD sensors will detect that change and tell the pump to speed up (Tony Pianalto, personal communication, January 24, 2012). On the other hand, in some GCHP systems there can be dedicated circulator pumps located at each heat pump. These circulators are controlled along with the heat pump they serve; when the heat pump compressor is operating, the pump is energized to allow flow to the heat pump. The ground loop, however, is often controlled by temperature sensors. The required flow is based on maintaining constant temperatures to the heat pumps. These controls are essential to maintain system performance and reduce pump energy consumption.

Chapter 2 - Pumping Designs

There are multiple different ways GCHP systems can be pumped. The three pumping configurations this report focuses on are: primary, primary/secondary, and distributive. Primary systems have central pumps that serve the system loop; in which a system loop refers to a loop that serves the entire system. Primary/secondary systems have central pumps that serve two loops; the primary pump serves the geothermal heat exchanger loop, hereinafter referred to as the ground loop, and the secondary pump serves the heat pump loop, hereinafter referred to as the building loop. The term distributive simply means using an individual circulator pumps to serve each heat pump. For this research all central pumps were configured with an additional pump in parallel to provide 100% redundant pumping, as redundant pumping has become an industry standard on large pumping systems.

Primary Pumping System

In a primary system, there are central pumps that pump the entire system. Figure 2.1 illustrates the design of a primary GCHP system. There are two primary pumps shown in parallel that were sized to provide 100% redundancy. The by-pass separates the building and ground loop and is designed to allow the building loop to "by-pass" the ground loop when the heat pump simultaneous heating and cooling loads are maintaining a constant, mild liquid temperature and there is no need to reject heat to or absorb heat from the ground loop. When the by-pass is utilized it is considered to be at self-balancing mode. Therefore, it should be sized to match the total flow of the building loop. The pressure drop through the by-pass, however, can be neglected since the primary pump is sized with the ground loop pressure drop included, because it yields a larger head than the by-pass.

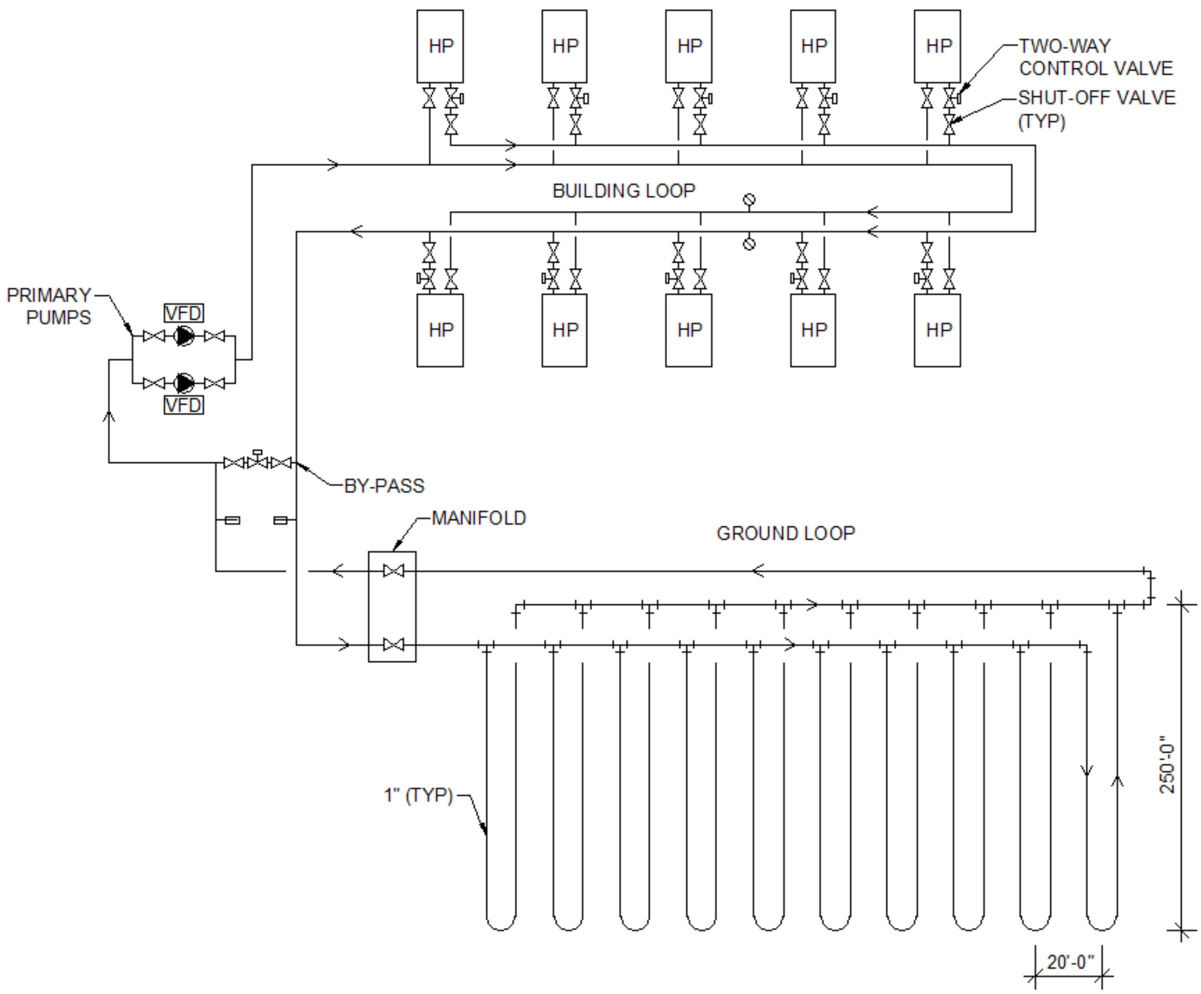

Figure 2.1 Primary Pumping System Diagram

The pump head calculation for the primary pumps is performed based on the total pipe length of the worst case heat pump and farthest bore. The primary pumps are controlled by pressure drop (PD) sensors located within the building loop, typically two-thirds of the total pipe length from the pumps. As the two-way control valves at each heat pump begin the close, the total pressure drop of the system will begin to decrease and the VFD on the pump will decrease the speed of the pump. Temperature sensors are also placed at the supply and return of the ground loop to monitor the temperature differential of the geothermal heat exchanger and the temperature being supplied to the heat pumps. Finally, when the building loop is in self-balancing mode, meaning the simultaneous heating and cooling loads are balancing each other out, the by-pass will be opened and the VFD of the primary pump will decrease the pump speed.

Primary/Secondary Pumping System

In a primary/secondary system, there are central pumps that serve two loops. Figure 2.2 shows a simple diagram of primary/secondary pumping. For this research two primary and two secondary pumps are installed in parallel and sized to provide 100% redundancy. The primary pumps serve the ground loop, whereas the secondary pumps serve the building loop. The common pipe in Figure 2.2, also referred to as the decoupling line or neutral bridge, is used to decouple the building and ground loops. It is recommended that the common pipe section should be kept as short as possible and sized to ensure almost negligible pressure drop. However, some thought should be applied to the overall length in order to avoid potential recirculation from entry or exit turbulence. There should also never be any valves, sensors or other fittings within this section to help minimize pressure drop. Typically, if these conditions are met and the pressure drop can be assumed to be zero, the loops can be designed independently of one another (ASHRAE Handbook (2004)).

Some advantages to this pumping configuration are (ASHRAE Handbook (2004)):

- They can improve total pump efficiency by providing two pumps at fewer feet of head, instead of one pump at higher feet of head.
- The loops are able to be designed for different flow characteristics. For example, the building loop can be designed using a VFD or two-way valves for better control while the ground loop operates at constant flow to protect equipment from freezing.

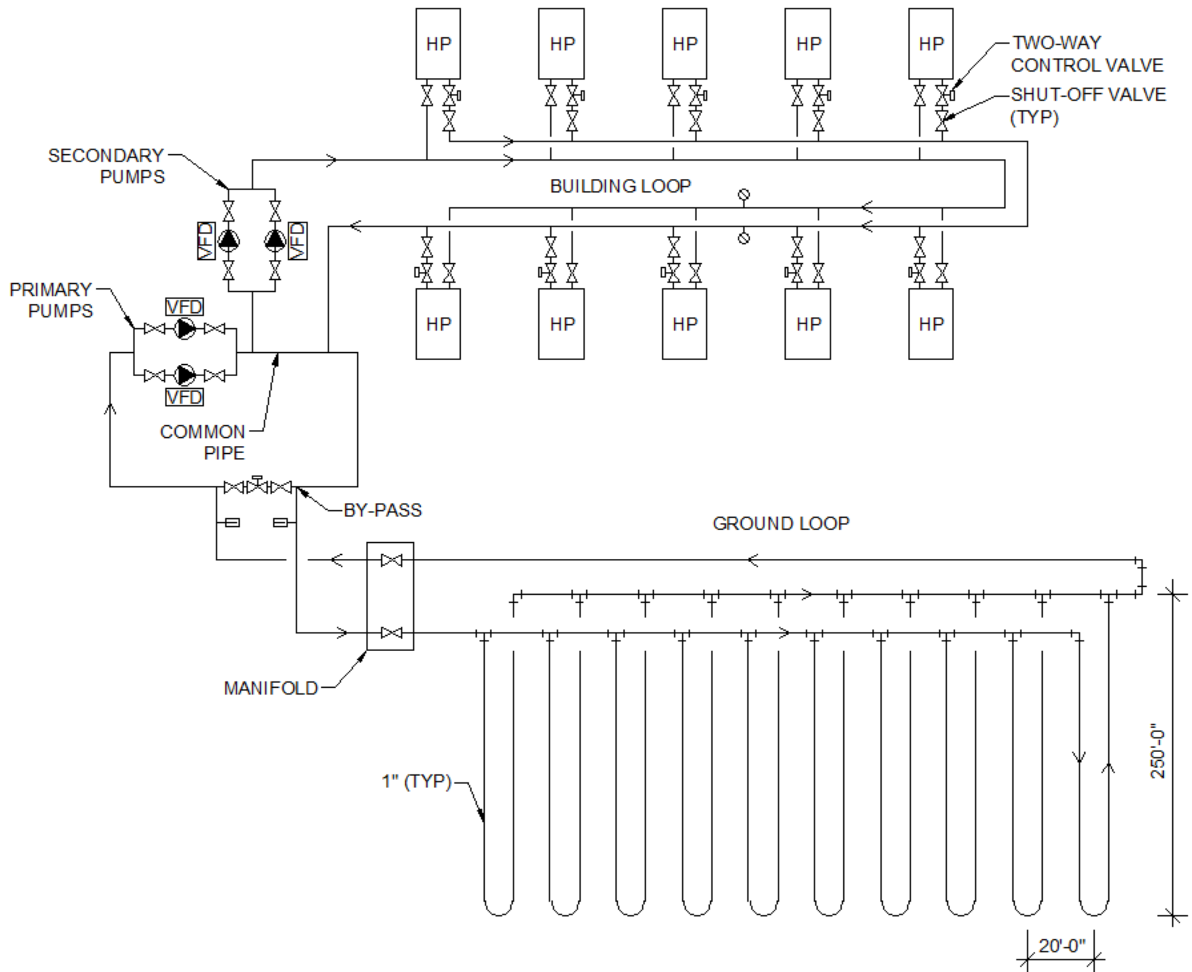

Figure 2.2 Primary/Secondary Pumping System Diagram

The pump head calculation for the secondary pumps is performed based on the total pipe length of the worst case heat pump. The secondary pumps are controlled by pressure drop (PD) sensors located within the building loop, typically two-thirds of the total pipe length from the pumps. As the two-way control valves at each heat pump begin the close, the total pressure drop of the system will begin to increase and the VFD on the pump will decrease the speed of the pump and as they begin to re-open the pressure drop will begin to decrease and the VFD will increase the pump speed.

The pump head calculation for the primary pumps is performed based on the total pipe length of the farthest bore and associated pipe fittings and accessories. Temperature sensors are located at the supply and return of the ground loop to monitor the temperature differential of the geothermal heat exchanger and the temperature being supplied to the heat pumps. As the temperature is being satisfied for the heat pumps, the primary pump VFD will decrease the speed of the pump. When the building loop is in self-balancing mode, meaning the simultaneous heating and cooling loads are balancing each other out, the by-pass will be opened and the VFD of the primary pump will decrease to the minimum pump speed.

Distributive Pumping System

Distributive pumping simply means distributing the pump load by placing circulators at each heat pump. There are two versions of distributive pumping that were analyzed for this research. The first was a distributive system coupled with primary pumps. In this design there are circulators that serve each heat pump and primary pumps that serve the building and ground loop. The primary pumps were installed in parallel and sized to provide 100% redundancy. The other distributive system is designed with a circulator at each heat pump that work together to circulate the hydronic liquid through the building and ground loop.

Distributive w/ Primary

In a distributive pumping system with primary pumps there are central pumps that serve the building and ground loop; while the heat pumps are served by individual distributive circulators. The circulators are sized based on the flow rate and pressure drop of that heat pump plus any pressure drop associated with valves or sensors installed at that heat pump; whereas the primary pumps within this system are then sized to handle the full pressure drop of both loops' piping and accessories, minus the heat pumps and associated valves. For this research the primary pumps were designed in parallel and provide 100% redundancy. Refer to Figure 2.3 for a graphical representation of this system.

The primary pumps are controlled by pressure differential (PD) sensors located within the building loop, typically two-thirds of the total pipe length from the pumps. As the two-way control valves at each heat pump begin the close, the total pressure drop of the system will begin to increase above the established pressure drop and the VFD on the pump will decrease the speed of the pump and as they begin to re-open the pressure drop will begin to decrease below the established pressure drop and the VFD will increase the pump speed. Additionally, temperature sensors are located at the supply and return of the ground loop to monitor the temperature differential of the geothermal heat exchanger and the temperature being supplied to the heat pumps. As the temperature is being satisfied for the heat pumps, the primary pump VFD will decrease the speed of the pump. Each distributive circulator is constant speed and operates simultaneously with the operation of the compressor within the heat pump it serves.

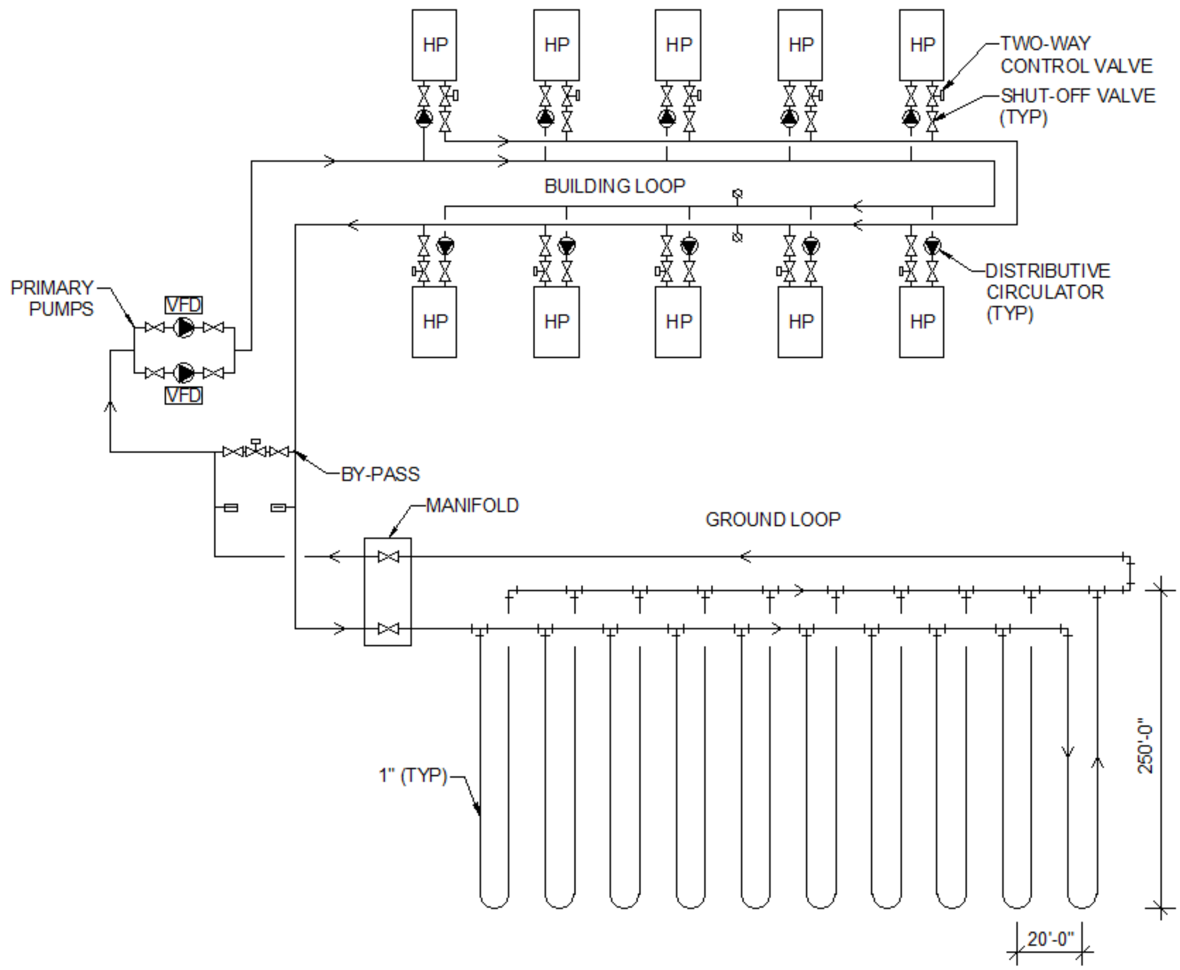

Figure 2.3 Distributive w/ Primary Pump System Diagram

Distributive

In this type of distributive system, circulators that serve their own individual heat pump also work together to circulate hydronic liquid through the building and ground loop. Figure 2.4 illustrates this system. For this research two pump head calculations of differing assumptions were performed in order to select the more conservative. The first calculation was based on a ratio of the system head divided among each circulator on the system, assuming all circulators were operating. This was done by first calculating the full system feet of head then splitting it evenly among each circulator; finally adding the worst case heat pump feet of head to obtain the total pump head. The second analysis was done with the assumption that the worst case circulator was operating on the system alone. It was done by reducing the pipe friction loss by establishing a ratio of the worst case heat pump GPM to the total system GPM, then multiplying it by the pipe friction loss. The reduced friction loss was then multiplied by the total equivalent length of pipe and added to the head at the worst case heat pump. This second calculation yielded the largest feet of head. Therefore, to be more conservative, the pump head calculation for this research was done assuming the worst case circulator was operating alone. Due to similar zone loads and small variations in heat pump size, this worst case pump head was then applied to each circulator. Each distributive circulator is constant speed and operates simultaneously with the operation of the compressor within the heat pump it serves.

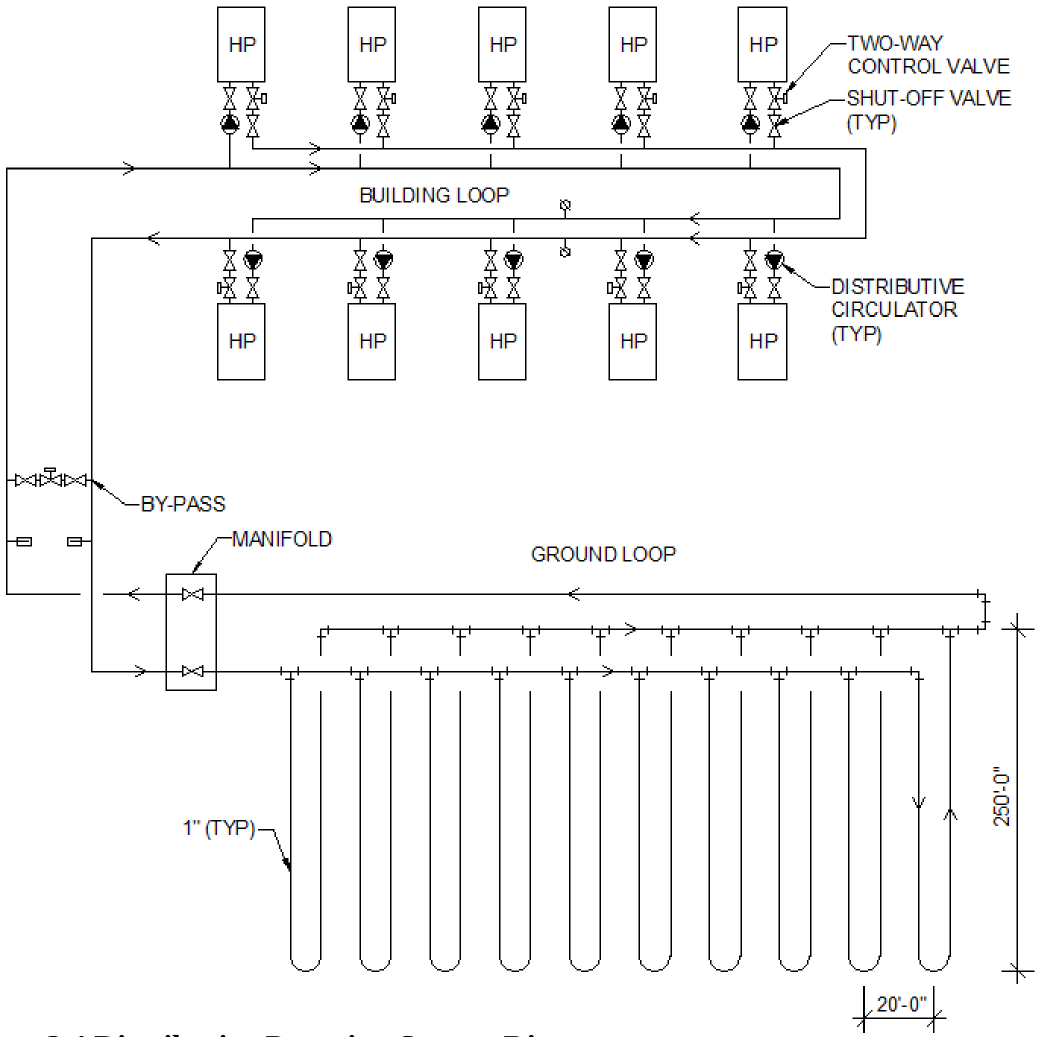

Figure 2.4 Distributive Pumping System Diagram

Chapter 3 - Design Analysis

HVAC systems can easily be defined by a single piece of equipment. For example, a chilled water system is typically associated with a chiller, a heating system to a boiler, GCHP system to heat pumps. However, it is the other components that ensure optimum performance. In GCHP systems it can be said that pumping equipment has one of the lowest efficiencies. Therefore, it is crucial for all pumps to be sized and selected properly to provide better system performance. This research explores how different GCHP pumping systems compare through life-cycle cost analyses. The life-cycle cost parameters evaluated were initial and replacement costs, annual utility cost, and regular and preventative maintenance costs for each pumping system. In hopes of producing more definitive results, six different models were analyzed. The goal of this analysis was to discover commonalities when comparing these four pumping systems through life-cycle cost analyses.

The first step taken in this research was to create energy models of all six buildings being analyzed. The energy modeling software used in this research was Trane TRACE 700, as it is the most common software used by HVAC system designers when analyzing building heating and cooling loads. The energy model outputs produced by the software then provided the cooling and heating peak and block loads for the system, peak loads for the zones, zone airflows, part-load data, and geothermal heat exchanger leaving water temperature (LWT). Refer to Appendix A for more information on design assumptions, how to create a GCHP system and central plant in TRACE 700 and example outputs used.

From there, heat pumps selections were made based on zone peak loads, airflows, and geothermal LWT, which is also the heat pump entering water temperature (EWT). This was done to determine the heat pump with the highest pressure drop and GPM, as it would be the worst case heat pump. ClimateMaster TS Series water-to-air heat pumps were used for this research, due to ClimateMaster being a large heat pump manufacturer and having easily accessible and user friendly performance charts online. Appendix B summarizes this process.

Next, piping layouts were designed and pipe distances were taken for both the building and ground loops. Appendix C provides example layouts and the parameters used for this research. The pipe distances were then recorded in pump head calculation tables and pump head calculations were performed for all four pumping systems. Appendix D provides more detail on these calculations and lists all assumptions made. It also contains an example of each system calculation. Once the pump head was determined, pumps were selected and data was inserted into a pump schedule along with the system flow rate, or GPM, from the heat pump selections table. Bell and Gossett (B&G) was used for all pump selections, due to being one of the largest pump manufacturers and having easily accessible and a user friendly pump selector tool and performance charts online. All base mounted, end-suction pumps were B&G Series 1510, the vertical in-line pumps were B&G Series 90, and the circulators were B&G Series NRF. Refer to Appendix E for example selections and schedules.

The total BHP of each system was then calculated and converted to KW for the utility cost analysis. Appendix F describes how the utility cost analysis was performed, along with all calculations and assumptions used in the life-cycle cost analysis. It also provides examples of each evaluation.

This chapter summarizes the six models analyzed for this research, provides an in-depth discussion of the components of the life-cycle cost analysis and lists the results of the life-cycle cost analysis performed for each.

Model Summary

This section provides a summary of each model. It shares building information and design outcomes; such as building area and space types and quantitative design load values, heat pump zones and vertical bores.

Model 1

Model 1 is a 22,500 SF, 2-story police department and city hall office building. It contains a medium security holding cell area, with Sallyport and kitchen, as well as classrooms, 911 dispatch, an open office, conference rooms, private offices, workout room, men and women locker rooms, server room and main entry lobby. The energy model calculated a system peak cooling load of 51.8 tons, or 621.7 MBH, block cooling load of 43.4 tons and total heating load of 672.5 MBH. It was designed with 32 heat pump zones and 45 vertical bores.

Model 2

Model 2 is a 34,000 SF, single story hospice center. It contains a chapel, patient rooms, lounges, medical supply and storage spaces, open offices, private offices, classrooms, food service, family dining area, storage rooms, mechanical and electrical rooms, and standard and ADA patient rooms. The energy model calculated a system peak cooling load of 78.3 tons, or 940.1 MBH, system block cooling load of 71.8 tons and total heating load of 1002.9 MBH. It was designed with 41 heat pump zones and 72 vertical bores.

Model 3

Model 3 is a 42,000 SF, 2-story public library. It contains large collection stacks, classrooms, entry lobby, small café, private offices, staff lounges and break rooms, technical room, mechanical and electrical spaces, toilet rooms and reception areas. The energy model calculated a system peak cooling load of 136.4 tons, or 1636.4 MBH, system block cooling load of 122.1 tons and total heating load of 1727.7 MBH. It was designed with 47 heat pump zones and 122 vertical bores.

Model 4

Model 4 is a 14,500 SF, 2-story summer camp academy facility. It contains classrooms, conference room, private offices, toilet rooms, mechanical and electrical rooms, storage spaces, a large food service kitchen with dish wash and dry storage, and a large dining hall. The energy model calculated a system peak cooling load of 61.9 tons, or 743.3 MBH, system block cooling load of 55.5 tons and total heating load of 796.9 MBH. It was designed with 24 heat pump zones and 55 vertical bores.

Model 5

Model 5 is a 80,000 SF, 2-story private and open office building. It contains open and private offices, conference rooms, mechanical and electrical spaces, storage spaces, break rooms, and toilet rooms. The energy model calculated a system peak cooling load of 212.5 tons, or 2550.5 MBH, block cooling load of 203.9 and total heating load of 2467.3 MBH. It was designed with 95 heat pump zones and 204 vertical bores.

Model 6

Model 6 is a 8,500 SF, 2-story office building. It contains private offices, mechanical and electrical rooms, main entry lobby, open offices, admin offices, conference room, break room, storage rooms and toilet rooms. The energy model calculated a system peak cooling load of 25.3 tons, or 303.7 MBH, block cooling load of 23.1 tons and total heating load of 302.7 MBH. It was designed with 12 heat pump zones and 24 vertical bores.

Life Cycle Cost Analysis Results

There were three components evaluated for each life-cycle cost analysis. These included: initial and replacement cost, annual utility cost and maintenance costs. Appendix F describes how each of these components was calculated.

The data for pump initial and replacement cost was taken from RSMeans Mechanical Cost Data, 2011. The B&G Series 1510 pumps were taken from the end suction pump list; whereas the B&G Series 90 pumps were taken from the close coupled vertical in-line pump list and the B&G Series NRF circulators were taken from the fractional vertical in-line pump list. All primary and secondary pump costs also include the cost of a VFD. RSMeans Electrical Cost Data: 2011 was used to determine the cost of each VFD. These costs were then inserted into the initial and replacement cost columns of the life-cycle cost analysis spread sheet. (Note: 2% annual inflation was then added to each column respectively). These costs were then projected to an equivalent 30-year cost. Refer to Appendix F for more information on how this 30-year projected cost was calculated.

Utility cost was calculated by first recreating a table based on the "Building Cool Heat Demand" TRACE output for each model. An example of this output can be found in Appendix A: Figure A.9. Table F.3 shows the recreated table for model 1. This table was used to calculate the simultaneous heating and cooling, or total, part-load percentages that occurred at each hour for every month during the TRACE simulation. These total part-load percentages were then superimposed into another table that calculated the average daily pump energy consumption each month; which was represented in KWH/Day. Appendix F: Table F.4 shows this table for the model 1 primary pumping system. (Note: this table was created for each of the four systems for every model). From there the total pump BHP for each system was converted into KW. The KW was then converted to KWH based on the part-load percentages for each hour. Refer to Appendix F for more detail on how this calculation was performed. These hourly consumption values were then added up to represent the daily consumption of an average day each month. Next, these values were superimposed into another table that calculated the annual utility cost of the pumping system. Table F.2 shows this table for the model 1 primary pumping system. The average daily consumption for each month was then multiplied by the number of days in that month and multiplied by the cost per KWH to attain monthly utility costs. The fixed utility cost per KWH was $0.09 for this research (Electric Power Monthly (2012)). These values were then added to obtain annual utility cost. This calculation was performed for all four systems for each model. The utility cost data was then entered into the utility: annual cost column of the life-cycle cost analysis spread sheet and projected to an equivalent 30-year cost. Refer to Appendix F for further information on how this 30-year projected cost was calculated.

There are two components of pump maintenance cost: regular and preventative. Regular maintenance is performed to keep each pump working properly; whereas preventative maintenance is performed to make sure there are no major pump failures. The components of regular maintenance include: motor and pump lubrication, packing and seal replacement. (Note: circulators do not require any regular maintenance). Pump monitoring was used as the preventative maintenance. Miles Smith, project engineer at P1 Group, Inc., was consulted for the quantitative assumptions used for each of these maintenance components. Refer to Appendix F for an explanation of these assumptions. Once the annual cost of each maintenance component was calculated they were entered into the life-cycle cost spread sheet for each system and converted to a 30-year projected cost. Refer to Appendix F for further information on how this 30-year projected cost was calculated.

This section provides tables and descriptions of results obtained from each model's life-cycle cost analysis spread sheet.

Model 1

Based on Table 3.1 the results of the life-cycle cost analysis for Model 1 show that the primary pumping system is the most cost effective; whereas the primary/secondary pumping system has the highest 30-year cost. Also, note there is minimal difference between the two distributive systems.

Table 3.1 Model 1: 30-Year Life-Cycle Cost Summary

SYSTEM	MODEL 1 30-YEAR PROJECTED COSTS				TOTAL 30-YEAR LIFE CYCLE COST
	INITIAL	REPLACEMENT	UTILITY	MAINT.	
PRIMARY ONLY	$ 141,655.17	$ 80,383.37	$ 15,413.18	$ 44,298.76	$ 280,345.48
PRIMARY/SECONDARY	$ 205,687.05	$ 117,055.60	$ 15,140.43	$ 75,827.71	$ 410,900.79
DISTRIBUTIVE W/ PRIMARY	$ 156,405.06	$ 88,407.80	$ 20,733.01	$ 98,343.98	$ 362,484.84
DISTRIBUTIVE	$ 176,062.49	$ 98,258.06	$ 23,597.29	$ 54,645.02	$ 352,562.86

Initial and Replacement Cost

Table 3.2 shows a breakdown of the initial and replacement cost components of the life-cycle cost analysis for model 1. (Note these cost include both pump and VFD costs where applicable). This table shows that the primary pumping system has the lowest 30-year projected cost, and that the primary/secondary system has the highest.

Table 3.2 Model 1: Initial and Replacement Cost Results

SYSTEM	INITIAL COST			REPLACEMENT COST		
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 22,389.00	$ 2,274.60	$ 141,655.17	$ 29,105.70	$ 4,435.47	$ 80,383.37
PRIMARY/SECONDARY	$ 32,293.20	$ 3,519.00	$ 205,687.05	$ 41,981.16	$ 6,862.05	$ 117,055.60
DISTRIBUTIVE W/ PRIMARY	$ 24,942.06	$ 2,289.65	$ 156,405.06	$ 32,424.68	$ 4,464.81	$ 88,407.80
DISTRIBUTIVE	$ 28,886.40	$ 1,767.86	$ 176,062.49	$ 37,552.32	$ 3,447.33	$ 98,258.06

Utility Cost

Table 3.3 shows a breakdown of the utility cost component of the life-cycle cost analysis performed for model 1. This table shows that the primary/secondary pumping system has the lowest 30-year projected cost; whereas the distributive pumping system has the highest. Also note that the primary and primary/secondary pumping systems and the distributive with primary and distributive pumping systems have similar annual utility costs.

Table 3.3 Model 1: Utility Cost Results

SYSTEM	UTILITY	
	ANNUAL COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 194.96	$ 15,413.18
PRIMARY/SECONDARY	$ 191.51	$ 15,140.43
DISTRIBUTIVE W/ PRIMARY	$ 262.25	$ 20,733.01
DISTRIBUTIVE	$ 298.48	$ 23,597.29

Maintenance

Table 3.4 shows a breakdown of the maintenance cost components of the life-cycle cost analysis performed for model 1. This table shows that the distributive with primary pumping system has the lowest regular maintenance 30-year projected cost, but the highest preventative maintenance 30-year projected cost. It also shows that the primary/secondary pumping system has the highest regular maintenance 30-year projected cost, but one of the lowest preventative maintenance 30-year projected cost. Finally, it shows that the primary pumping system has the lowest overall maintenance cost.

Table 3.4 Model 1: Maintenance Cost Results

SYSTEM	REGULAR MAINTENANCE				PREVENTATIVE MAINT.	
	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 600.00	$ 676.00	$ 1,880.00	$ 31,509.38	$ 144.00	$ 11,384.38
PRIMARY/SECONDARY	$ 1,200.00	$ 1,352.00	$ 2,580.00	$ 55,941.14	$ 216.00	$ 17,076.57
DISTRIBUTIVE W/ PRIMARY	$ 600.00	$ 676.00	$ 1,780.00	$ 30,909.58	$ 835.20	$ 66,029.40
DISTRIBUTIVE	$ -	$ -	$ -	$ -	$ 691.20	$ 54,645.02

Model 2

Based on Table 3.5 below, the results of the life-cycle cost analysis for Model 2 shows that the primary pumping system is the most cost effective; whereas the distributive with primary pumping system has the highest 30-year cost.

Table 3.5 Model 2: 30-Year Life-Cycle Cost Summary

SYSTEM	MODEL 2 30-YEAR PROJECTED COSTS					TOTAL 30-YEAR LIFE CYCLE COST
	INITIAL	REPLACEMENT	UTILITY	REGULAR MAINT.	PREVENTATIVE MAINTENANCE	
PRIMARY ONLY	$ 181,023.35	$ 102,485.22	$ 55,103.56	$ 32,109.18	$ 11,384.38	$ 382,105.68
PRIMARY/SECONDARY	$ 246,051.16	$ 139,983.68	$ 59,154.50	$ 58,940.13	$ 17,076.57	$ 521,206.04
DISTRIBUTIVE W/ PRIMARY	$ 322,961.48	$ 182,553.82	$ 70,599.75	$ 32,109.18	$ 81,398.31	$ 689,622.54
DISTRIBUTIVE	$ 273,120.30	$ 152,424.59	$ 72,014.10	$ -	$ 70,013.93	$ 567,572.93

Initial and Replacement Cost

Table 3.6 shows a breakdown of the initial and replacement cost components of the life-cycle cost analysis for model 2. This table shows that the primary pumping system has the lowest 30-year projected cost for both initial and replacement costs, and that the distributive with primary pumping system has the highest.

Table 3.6 Model 2: Initial and Replacement Cost Results

SYSTEM	INITIAL COST			REPLACEMENT COST		
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 28,764.00	$ 2,754.00	$ 181,023.35	$ 37,393.20	$ 5,370.30	$ 102,485.22
PRIMARY/SECONDARY	$ 38,658.00	$ 4,182.00	$ 246,051.16	$ 50,255.40	$ 8,154.90	$ 139,983.68
DISTRIBUTIVE W/ PRIMARY	$ 51,502.86	$ 4,728.01	$ 322,961.48	$ 66,953.72	$ 9,219.61	$ 182,553.82
DISTRIBUTIVE	$ 44,810.64	$ 2,742.37	$ 273,120.30	$ 58,253.83	$ 5,347.63	$ 152,424.59

Utility Cost

Table 3.7 shows a breakdown of the utility cost component of the life-cycle cost analysis performed for model 2. This table shows that the primary pumping system has the lowest 30-year projected cost; whereas the distributive pumping system has the highest. Also note that the primary and primary/secondary pumping systems and the distributive with primary and distributive pumping systems have similar annual utility costs.

Table 3.7 Model 2: Utility Cost Results

SYSTEM	UTILITY	
	ANNUAL COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 697.00	$ 55,103.56
PRIMARY/SECONDARY	$ 748.24	$ 59,154.50
DISTRIBUTIVE W/ PRIMARY	$ 893.01	$ 70,599.75
DISTRIBUTIVE	$ 910.90	$ 72,014.10

Maintenance

Table 3.8 shows a breakdown of the maintenance cost components of the life-cycle cost analysis performed for model 2. This table shows that the distributive with primary pumping system has the lowest regular maintenance 30-year projected cost, but the highest preventative maintenance 30-year projected cost. It also shows that the primary/secondary pumping system has the highest regular maintenance 30-year projected cost, but one of the lowest preventative maintenance 30-year projected cost. Finally, it shows that the primary pumping system has the lowest overall maintenance cost.

Table 3.8 Model 2: Maintenance Cost Results

SYSTEM	REGULAR MAINTENANCE				PREVENTATIVE MAINT.	
	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 600.00	$ 676.00	$ 1,980.00	$ 32,109.18	$ 144.00	$ 11,384.38
PRIMARY/SECONDARY	$ 1,200.00	$ 1,352.00	$ 3,080.00	$ 58,940.13	$ 216.00	$ 17,076.57
DISTRIBUTIVE W/ PRIMARY	$ 600.00	$ 676.00	$ 1,980.00	$ 32,109.18	$ 1,029.60	$ 81,398.31
DISTRIBUTIVE	$ -	$ -	$ -	$ -	$ 885.60	$ 70,013.93

Model 3

Based on Table 3.9 below, the results of the life-cycle cost analysis for Model 3 shows that the primary pumping system is the most cost effective; whereas the distributive with primary pump system has the highest 30-year cost. Also note the minimal difference in cost between the primary/secondary and distributive pumping systems.

Table 3.9 Model 3: 30-Year Life-Cycle Cost Summary

SYSTEM	MODEL 3 30-YEAR PROJECTED COSTS					TOTAL 30-YEAR LIFE CYCLE COST
	INITIAL	REPLACEMENT	UTILITY	REGULAR MAINT.	PREVENTATIVE MAINTENANCE	
PRIMARY	$ 190,748.23	$ 108,729.66	$ 58,703.08	$ 33,308.77	$ 11,384.38	$ 402,874.13
PRIMARY/SECONDARY	$ 316,351.49	$ 180,103.86	$ 62,190.33	$ 60,739.52	$ 17,076.57	$ 636,461.78
DISTRIBUTIVE W/ PRIMARY	$ 386,909.59	$ 218,700.27	$ 75,827.08	$ 33,308.77	$ 91,644.25	$ 806,389.97
DISTRIBUTIVE	$ 311,516.00	$ 173,852.74	$ 56,109.97	$ -	$ 80,259.87	$ 621,738.58

Initial and Replacement Cost

Table 3.10 shows a breakdown of the initial and replacement cost components of the life-cycle cost analysis for model 3. This table shows that the primary pumping system has the lowest 30-year projected cost for both initial and replacement costs, and that the distributive with primary pumping system has the highest.

Table 3.10 Model 3: Initial and Replacement Cost Results

SYSTEM	INITIAL COST			REPLACEMENT COST		
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 29,835.00	$ 3,376.20	$ 190,748.23	$ 38,785.50	$ 6,583.59	$ 108,729.66
PRIMARY/SECONDARY	$ 49,623.00	$ 5,457.00	$ 316,351.49	$ 64,509.90	$ 10,641.15	$ 180,103.86
DISTRIBUTIVE W/ PRIMARY	$ 61,700.82	$ 5,664.06	$ 386,909.59	$ 80,211.07	$ 11,044.92	$ 218,700.27
DISTRIBUTIVE	$ 51,110.16	$ 3,127.93	$ 311,516.00	$ 66,443.21	$ 6,099.47	$ 173,852.74

Utility Cost

Table 3.11 shows a breakdown of the utility cost component of the life-cycle cost analysis performed for model 3. This table shows that the distributive pumping system has the lowest 30-year projected cost; whereas the distributive with primary pumping system has the highest. Also note that the primary, primary/secondary pumping systems and the distributive pumping systems have similar annual utility costs.

Table 3.11 Model 3: Utility Cost Results

SYSTEM	UTILITY	
	ANNUAL COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 742.53	$ 58,703.08
PRIMARY/SECONDARY	$ 786.64	$ 62,190.33
DISTRIBUTIVE W/ PRIMARY	$ 959.13	$ 75,827.08
DISTRIBUTIVE	$ 709.73	$ 56,109.97

Maintenance

Table 3.12 shows a breakdown of the maintenance cost components of the life-cycle cost analysis performed for model 3. This table shows that the distributive with primary pumping system has the lowest regular maintenance 30-year projected cost, but the highest preventative maintenance 30-year projected cost. It also shows that the primary/secondary pumping system has the highest regular maintenance 30-year projected cost, but one of the lowest preventative maintenance 30-year projected cost. Finally, it shows that the primary pumping system has the lowest overall maintenance cost.

Table 3.12 Model 3: Maintenance Cost Results

SYSTEM	REGULAR MAINTENANCE				PREVENTATIVE MAINT.	
	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 600.00	$ 676.00	$ 2,180.00	$ 33,308.77	$ 144.00	$ 11,384.38
PRIMARY/SECONDARY	$ 1,200.00	$ 1,352.00	$ 3,380.00	$ 60,739.52	$ 216.00	$ 17,076.57
DISTRIBUTIVE W/ PRIMARY	$ 600.00	$ 676.00	$ 2,180.00	$ 33,308.77	$ 1,159.20	$ 91,644.25
DISTRIBUTIVE	$ -	$ -	$ -	$ -	$ 1,015.20	$ 80,259.87

Model 4

Based Table 3.13 below, the results of the life-cycle cost analysis for Model 4 shows that the primary pumping system is the most cost effective; whereas the primary/secondary system has the highest 30-year cost. Also note the minimal difference between the two distributive system costs.

Table 3.13 Model 4: 30-Year Life-Cycle Cost Summary

SYSTEM	MODEL 4 30-YEAR PROJECTED COSTS					TOTAL 30-YEAR LIFE CYCLE COST
	INITIAL	REPLACEMENT	UTILITY	REGULAR MAINT.	PREVENTATIVE MAINTENANCE	
PRIMARY ONLY	$ 141,655.17	$ 80,383.37	$ 21,842.20	$ 31,509.38	$ 11,384.38	$ 286,774.49
PRIMARY/SECONDARY	$ 204,163.88	$ 116,229.36	$ 23,073.13	$ 55,941.14	$ 17,076.57	$ 416,484.08
DISTRIBUTIVE W/ PRIMARY	$ 156,405.06	$ 88,407.80	$ 29,445.22	$ 30,909.58	$ 48,952.83	$ 354,120.49
DISTRIBUTIVE	$ 176,062.49	$ 98,258.06	$ 29,532.98	$ -	$ 37,568.45	$ 341,421.98

Initial and Replacement Cost

Table 3.14 shows a breakdown of the initial and replacement cost components of the life-cycle cost analysis for model 4. This table shows that the primary pumping system has the lowest 30-year projected cost, and that the primary/secondary pumping system has the highest.

Table 3.14 Model 4: Initial and Replacement Cost Results

SYSTEM	INITIAL COST			REPLACEMENT COST		
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 22,389.00	$ 2,274.60	$ 141,655.17	$ 29,105.70	$ 4,435.47	$ 80,383.37
PRIMARY/SECONDARY	$ 32,028.00	$ 3,519.00	$ 204,163.88	$ 41,636.40	$ 6,862.05	$ 116,229.36
DISTRIBUTIVE W/ PRIMARY	$ 24,942.06	$ 2,289.65	$ 156,405.06	$ 32,424.68	$ 4,464.81	$ 88,407.80
DISTRIBUTIVE	$ 28,886.40	$ 1,767.86	$ 176,062.49	$ 37,552.32	$ 3,447.33	$ 98,258.06

Utility Cost

Table 3.15 shows a breakdown of the utility cost component of the life-cycle cost analysis performed for model 4. This table shows that the primary pumping system has the lowest 30-year projected cost; whereas the distributive pumping system has the highest. Also note that the primary and primary/secondary pumping systems and the distributive with primary and distributive pumping systems have similar annual utility costs.

Table 3.15 Model 4: Utility Cost Results

SYSTEM	UTILITY	
	ANNUAL COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 276.28	$ 21,842.20
PRIMARY/SECONDARY	$ 291.85	$ 23,073.13
DISTRIBUTIVE W/ PRIMARY	$ 372.45	$ 29,445.22
DISTRIBUTIVE	$ 373.56	$ 29,532.98

Maintenance

Table 3.16 shows a breakdown of the maintenance cost components of the life-cycle cost analysis performed for model 4. This table shows that the distributive with primary pumping system has the lowest regular maintenance 30-year projected cost, but the highest preventative maintenance 30-year projected cost. It also shows that the primary/secondary pumping system has the highest regular maintenance 30-year projected cost, but one of the lowest preventative maintenance 30-year projected cost. Finally, it shows that the distributive pumping system has the lowest overall maintenance cost.

Table 3.16 Model 4: Maintenance Cost Results

SYSTEM	REGULAR MAINTENANCE				PREVENTATIVE MAINT.	
	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 600.00	$ 676.00	$ 1,880.00	$ 31,509.38	$ 144.00	$ 11,384.38
PRIMARY/SECONDARY	$ 1,200.00	$ 1,352.00	$ 2,580.00	$ 55,941.14	$ 216.00	$ 17,076.57
DISTRIBUTIVE W/ PRIMARY	$ 600.00	$ 676.00	$ 1,780.00	$ 30,909.58	$ 619.20	$ 48,952.83
DISTRIBUTIVE	$ -	$ -	$ -	$ -	$ 475.20	$ 37,568.45

Model 5

Based Table 3.17 below, the results of the life-cycle cost analysis for Model 5 shows that the primary pumping system is the most cost effective; whereas the distributive with primary pump system has the highest 30-year projected cost. Note the minimal difference in cost between the primary/secondary and distributive pumping systems.

Table 3.17 Model 5: 30-Year Life-Cycle Cost Summary

SYSTEM	MODEL 5 30-YEAR PROJECTED COSTS					TOTAL 30-YEAR LIFE CYCLE COST
	INITIAL	REPLACEMENT	UTILITY	REGULAR MAINT.	PREVENTATIVE MAINTENANCE	
PRIMARY ONLY	$ 309,965.88	$ 177,307.37	$ 218,776.14	$ 35,707.97	$ 11,384.38	$ 753,141.73
PRIMARY/SECONDARY	$ 405,867.25	$ 230,059.45	$ 220,843.51	$ 63,138.72	$ 17,076.57	$ 936,985.49
DISTRIBUTIVE W/ PRIMARY	$ 585,779.57	$ 331,111.54	$ 287,537.00	$ 35,707.97	$ 173,611.78	$ 1,413,747.85
DISTRIBUTIVE	$ 410,115.73	$ 228,879.84	$ 117,837.02	$ -	$ 162,227.40	$ 919,059.98

Initial and Replacement Cost

Table 3.18 shows a breakdown of the initial and replacement cost components of the life-cycle cost analysis for model 5. This table shows that the primary pumping system has the lowest 30-year projected cost, and that the distributive with primary pumping system has the highest.

Table 3.18 Model 5: Initial and Replacement Cost Results

SYSTEM	INITIAL COST			REPLACEMENT COST		
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 48,082.80	$ 5,885.40	$ 309,965.88	$ 62,507.64	$ 11,476.53	$ 177,307.37
PRIMARY/SECONDARY	$ 64,311.00	$ 6,354.60	$ 405,867.25	$ 83,604.30	$ 12,391.47	$ 230,059.45
DISTRIBUTIVE W/ PRIMARY	$ 93,414.66	$ 8,575.50	$ 585,779.57	$ 121,439.06	$ 16,722.22	$ 331,111.54
DISTRIBUTIVE	$ 67,287.36	$ 4,117.94	$ 410,115.73	$ 87,473.57	$ 8,029.99	$ 228,879.84

Utility Cost

Table 3.19 shows a breakdown of the utility cost component of the life-cycle cost analysis performed for model 5. This table shows that the distributive pumping system has the lowest 30-year projected cost; whereas the distributive with primary pumping system has the highest. Also note that the primary and primary/secondary pumping systems have similar annual utility costs.

Table 3.19 Model 5: Utility Cost Results

SYSTEM	UTILITY	
	ANNUAL COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 2,767.28	$ 218,776.14
PRIMARY/SECONDARY	$ 2,793.43	$ 220,843.51
DISTRIBUTIVE W/ PRIMARY	$ 3,637.03	$ 287,537.00
DISTRIBUTIVE	$ 1,490.51	$ 117,837.02

Maintenance

Table 3.20 shows a breakdown of the maintenance cost components of the life-cycle cost analysis performed for model 5. This table shows that the distributive with primary pumping system has the lowest regular maintenance 30-year projected cost, but the highest preventative maintenance 30-year projected cost. It also shows that the primary/secondary pumping system has the highest regular maintenance 30-year projected cost, but one of the lowest preventative maintenance 30-year projected cost. Finally, it shows that the primary pumping system has the lowest overall maintenance cost.

Table 3.20 Model 5: Maintenance Cost Results

SYSTEM	REGULAR MAINTENANCE				PREVENTATIVE MAINT.	
	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 600.00	$ 676.00	$ 2,580.00	$ 35,707.97	$ 144.00	$ 11,384.38
PRIMARY/SECONDARY	$ 1,200.00	$ 1,352.00	$ 3,780.00	$ 63,138.72	$ 216.00	$ 17,076.57
DISTRIBUTIVE W/ PRIMARY	$ 600.00	$ 676.00	$ 2,580.00	$ 35,707.97	$ 2,196.00	$ 173,611.78
DISTRIBUTIVE	$ -	$ -	$ -	$ -	$ 2,052.00	$ 162,227.40

Model 6

Based Table 3.21 below, the results of the life-cycle cost analysis for Model 6 shows that the primary pumping system is the most cost effective; whereas the distributive w/ primary system has the highest 30-year cost. Note the minimal difference in total life-cycle cost between the primary/secondary, distributive w/ primary and distributive pumping systems.

Table 3.21 Model 6: 30-Year Life-Cycle Cost Summary

SYSTEM	MODEL 6 30-YEAR PROJECTED COSTS					TOTAL 30-YEAR LIFE CYCLE COST
	INITIAL	REPLACEMENT	UTILITY	REGULAR MAINT.	PREVENTATIVE MAINTENANCE	
PRIMARY ONLY	$ 52,315.16	$ 31,206.35	$ 10,161.35	$ 29,709.98	$ 11,384.38	$ 134,777.23
PRIMARY/SECONDARY	$ 78,853.54	$ 46,745.97	$ 11,755.16	$ 53,541.94	$ 17,076.57	$ 207,973.18
DISTRIBUTIVE W/ PRIMARY	$ 96,243.20	$ 54,401.46	$ 17,017.27	$ 29,709.98	$ 31,876.26	$ 229,248.18
DISTRIBUTIVE	$ 110,561.33	$ 61,702.77	$ 26,628.38	$ -	$ 20,491.88	$ 219,384.37

Initial and Replacement Cost

Table 3.22 shows a breakdown of the initial and replacement cost components of the life-cycle cost analysis for model 6. This table shows that the primary pumping system has the lowest 30-year projected cost, and that the distributive pumping system has the highest.

Table 3.22 Model 6: Initial and Replacement Cost Results

SYSTEM	INITIAL COST			REPLACEMENT COST		
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 7,293.00	$ 1,815.60	$ 52,315.16	$ 9,480.90	$ 3,540.42	$ 31,206.35
PRIMARY/SECONDARY	$ 11,179.20	$ 2,550.00	$ 78,853.54	$ 14,532.96	$ 4,972.50	$ 46,745.97
DISTRIBUTIVE W/ PRIMARY	$ 15,347.94	$ 1,408.98	$ 96,243.20	$ 19,952.32	$ 2,747.51	$ 54,401.46
DISTRIBUTIVE	$ 18,139.68	$ 1,110.17	$ 110,561.33	$ 23,581.58	$ 2,164.83	$ 61,702.77

Utility Cost

Table 3.23 shows a breakdown of the utility cost component of the life-cycle cost analysis performed for model 6. This table shows that the primary pumping system has the lowest 30-year projected cost; whereas the distributive pumping system has the highest.

Table 3.23 Model 6: Utility Cost Results

SYSTEM	UTILITY	
	ANNUAL COST	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 128.53	$ 10,161.35
PRIMARY/SECONDARY	$ 148.69	$ 11,755.16
DISTRIBUTIVE W/ PRIMARY	$ 215.25	$ 17,017.27
DISTRIBUTIVE	$ 336.82	$ 26,628.38

Maintenance

Table 3.24 shows a breakdown of the maintenance cost components of the life-cycle cost analysis performed for model 6. This table shows that the distributive with primary pumping system has the lowest regular maintenance 30-year projected cost, but the highest preventative maintenance 30-year projected cost. It also shows that the primary/secondary pumping system has the highest regular maintenance 30-year projected cost, but one of the lowest preventative maintenance 30-year projected cost. Finally, it shows that the distributive pumping system has the lowest overall maintenance cost.

Table 3.24 Model 6: Maintenance Cost Results

SYSTEM	REGULAR MAINTENANCE				PREVENTATIVE MAINT.	
	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST
PRIMARY ONLY	$ 600.00	$ 676.00	$ 1,580.00	$ 29,709.98	$ 144.00	$ 11,384.38
PRIMARY/SECONDARY	$ 1,200.00	$ 1,352.00	$ 2,180.00	$ 53,541.94	$ 216.00	$ 17,076.57
DISTRIBUTIVE W/ PRIMARY	$ 600.00	$ 676.00	$ 1,580.00	$ 29,709.98	$ 403.20	$ 31,876.26
DISTRIBUTIVE	$ -	$ -	$ -	$ -	$ 259.20	$ 20,491.88

Chapter 4 - Conclusion

This section discusses the results of the research and identifies similarities between each of the six models. Apart from the life-cycle cost analysis, additional items should be considered such as availability, flexibility, controllability and system capacity when choosing the proper pumping design for a project. Finally, this section ends with a discussion of what could have been done differently and future research that could be conducted based on the conclusions of this report.

Research Results

The goal of this research was to discover similarities between the six models' 30-year life-cycle cost in order to provide designers insight into which pumping system is the most cost effective. The results proved that a primary pumping system with 100% redundancy and VFD control is the most cost effective system. Table 4.1 provides a research summary of the 30-year projected costs of all four systems from the life-cycle cost analysis for each model.

Table 4.1 Research Summary

RESEARCH SUMMARY						
SYSTEM	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
PRIMARY ONLY	$ 280,345.48	$ 382,105.68	$ 402,874.13	$ 286,774.49	$ 753,141.73	$ 134,777.23
PRIMARY/SECONDARY	$ 410,900.79	$ 521,206.04	$ 636,461.78	$ 416,484.08	$ 936,985.49	$ 207,973.18
DISTRIBUTIVE W/ PRIMARY	$ 362,484.84	$ 689,622.54	$ 806,389.97	$ 354,120.49	$ 1,413,747.85	$ 229,248.18
DISTRIBUTIVE	$ 352,562.86	$ 567,572.93	$ 621,738.58	$ 341,421.98	$ 919,059.98	$ 219,384.37

Six models were chosen of varying building sizes and space types in hopes of finding more definitive commonalities within their life-cycle cost analyses. 30-year life-cycle cost analysis was chosen as the comparative medium as it incorporates every cost component associated with a pumping system. These components included initial and replacement costs, annual utility costs and regular and preventative maintenance costs. It also helps to highlight the similarities and differences between the pumping systems such as pump types, VFD versus constant speed controls, regular and preventative maintenance practices, and total pumping system energy consumption.

Apart from discovering the most cost effective system between the four pumping systems being analyzed, there were other commonalities within the results. In most cases, the primary/secondary system is 25-35% higher in cost than the primary system. This is due to the initial and maintenance costs of four central pumps opposed to two, as well as their associated VFDs. The distributive pumping system, in every case is less than the distributive with primary pumping system. This is due to the additional primary pumps associated with the distributive with primary pumping system, as there are two primary pumps with VFDs that have high initial and replacements costs as well as higher maintenance costs. It is also interesting to note that as the model size increased the distributive with primary pumping system became increasingly more costly than the distributive pumping system. For example, model 5 was the largest building modeled at 80,000 SF, whereas model 6, 1, 4 and 2 were the four smaller models listed from smallest to largest. This shows that the distributive with primary pumping system should only be considered for small or light commercial buildings.

Additionally, from the utility cost tables in Chapter 3, the primary and primary/secondary pumping systems were almost always less than both the distributive pumping systems. This is most likely due to each primary and secondary pump being variable speed, whereas each circulator is constant speed. The constant speed control restricts each circulator to either being on or off, therefore are unable to take advantage of the part-load energy consumptions.

In conclusion, this research supports that a primary pumping system with 100% redundant pumping using base-mounted, end suction pumps yields the most cost effective solution over a primary/secondary, distributive with primary and distributive pumping systems. But why has distributive pumping become a new buzz-word? Why isn't every project being designed with a primary pumping system? There are other considerations that could persuade designers to look at these systems more closely and chose another system.

Additional Considerations

Even though the life-cycle cost analysis performed with this research suggests the primary pumping system is the most economical solution, there are additional considerations that support the selection of one of the other pumping systems that should be explored before making a final selection. Such considerations include: availability, flexibility, controllability and system capacity.

Availability

As pumps begin to fail and require replacement, the time it takes manufacturers to supply a new pump can vary. As circulators are small, fractional HP pumps they are typically "off-the-shelf" pieces of equipment, meaning they are readily available from a manufacturer; whereas base-mounted, end suction and large vertical in-line pumps may not be.

Furthermore, in situations where buildings have maintenance personnel they may store common equipment in storage rooms. This way certain pieces of equipment are on-hand when needed, instead of having to place an order and wait for delivery from a manufacturer. Circulator pumps have a small foot print and in buildings with many similar circulators they may choose to store a few for back-up purposes if a circulator were to fail. In most cases, base-mounted, end suction pumps and vertical in-line pumps would be too large and too expensive to have stored on sight, therefore could take longer to get a replacement if one were to fail.

Flexibility

In certain project situations it is the desire of the owner to consider possible ramifications if future expansions were to occur, meaning how would additional loads affect the system. If a primary or primary/secondary system is specified, additional loads could require upsizing equipment, which would mean replacing the pumps and potentially other components and piping depending on the magnitude of the retrofit. In regards to a distributive with primary pumping system additional spaces could be added that could potentially be fed from adjacent heat pumps without upsizing the heat pump or could be fed from a new heat pump with its own circulator without upsizing the building loop. If the building loop did need to be upsized and the total feet of head and new GPM increased enough to upsize the pump, additional costs would be associated. With distributive pumping, however, additional loads could be added without affecting the distribution of the pumping itself. This could be a very persuasive advantage to distributive pumping systems that could be proposed to an owner with a history of retrofits and expansion desires.

Controllability

In a primary or primary/secondary pumping system the pumps are located centrally; whereas in a distributive pumping system the circulators are located locally. Specifying a pump at each heat pump could yield better temperature control. This allows the heat pump to operate at more consistent liquid temperatures, provides quicker response time once the heat pump compressor energizes, and improves heat pump efficiency.

Additional cost savings could occur in the distributive pumping systems due to the controls themselves. If a central control system, such as a building monitoring system (BMS), were installed it could eliminate preventative maintenance costs for all of the circulators and not require weekly monitoring by personnel. However, there is a higher initial cost to BMS systems that might outweigh the annual preventative maintenance costs. Therefore a pay-back analysis should be performed to establish whether or not specifying BMS control would be a benefit to the owner.

System Capacity

If a project is a campus application, where there are multiple buildings or sub-systems that share a common central plant, it could affect the pumping system design chosen. Typically campus applications have a very large system capacity and long system life expectancy, such as universities and hospitals. A GCHP campus system could have one large geothermal heat exchanger that serves the entire campus or could have multiple that have centralized controls; in which each building or sub-system would have their own building loop. In any case, these systems will typically consider initial cost to be less of a concern and energy consumption and maintenance cost to be of higher concern.

Further Research

There were many assumptions made in this research to create a simpler process in order to find end results. Some of these assumptions include using reverse-return piping, vertical bore fields and ClimateMaster TS Series heat pumps. However, there are a few major assumptions that could be investigated or altered to either support or refute the results in this research. Bell and Gossett base-mounted, end-suction, vertical in-line and system lubricated circulator pumps were selected for this research. So maybe another manufacturer should be investigated or additional pump types be used. The pump replacement timeline was assumed to be 15 years for all pumps, so maybe contact pump manufacturers and establish if this timeline should vary based on pump type, size, or frequency of use. Other assumptions that could be explored include regular and preventative maintenance, RSMeans cost data, project location and piping configuration.

Finally, there are additional pumping system design types that could be analyzed. Another type of distributive pumping creates sub-central systems within a building by grouping similarly loaded spaces or zones and place them on common building and ground loops. This sub-central system would provide multiple, smaller central plants and lower distributive circulator pump head. There are also GCHP hybrid systems which provide supplemental heating or cooling in extreme climates. For example, if a project has a much larger heating load than cooling load a designer might choose to size the geothermal heat exchanger based on the cooling load and provide supplemental heating, such as a boiler, to add additional heating capacity that when added to the heating capacity of the geothermal heat exchanger it would match the required heating load. Additionally, primary/secondary pumping systems could have multiple building loops and, therefore, multiple secondary pumps coupled with a common ground loop. For example, in a three-story building each floor could be served by its own building loop, which would require smaller secondary pumps and an ability to shut down one floor without de-energizing the other two. There are multiple pumping system designs that could be analyzed and compared to either support or refute the results of this research. This research is simply a stepping stone that can be expanded upon. GCHP systems are being specified more often and designers are creating additional pumping systems to try and maximize performance and minimize cost.

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Appendix A - Creating Load Profiles

For this research, six energy models were created and analyzed using a ground source heat pump system in Topeka, KS. This location was chosen due to the wide range in seasonal temperatures and high probability for simultaneous heating and cooling. Other locations that are typically warm or cold weather dominant would yield different results due to mainly being in cooling or heating mode, respectively, throughout the year and would most likely require supplemental cooling or heating equipment to keep the cost of the geothermal heat exchanger down.

The energy models were created with Trane TRACE 700 software. This software was created by Trane to provide mechanical building system engineers with a tool for calculating heating and cooling loads. It permits the user to input physical information and design parameters about each space in a building. The design parameters used for each model included: ventilation, space design temperatures and zoning practices. Ventilation was entered within the "Airflows" tab in the "Create Rooms" window. The TRACE provided values from ASHRAE Standard 62.1-2004/2007 were used. The space design temperatures were set to 75 ºF in cooling and 70 ºF in heating, with 50% relative humidity, a cooling driftpoint of 81 ºF and a heating driftpoint of 64 ºF. Finally, the zoning practices of this research were to combine commonly loaded spaces, but still maintain high controllability by providing a higher number of zones.

Once the system is created the designer can then run a one-year simulation with weather data for the specified location. This simulation then yields an energy analysis of the building and its specific system. These results, or outputs, are referenced by the engineer/designer when selecting equipment, finalizing control schemes, consulting on possible energy consumption, etc. This appendix provides step-by-step instructions that were used to create all six energy models.

Getting Started

When first beginning an energy model in TRACE, it is important to "Select Weather Information" for the city/state that matches the actual project location. For this research the weather data applied in the one-year simulation was the software default values for Topeka, KS. If the desired city is not available in the drop down menu, however, then select the city closest to the project location, select “Overrides…” and input the correct weather data. Figure A.1 (Trane, 2012) shows this TRACE window.

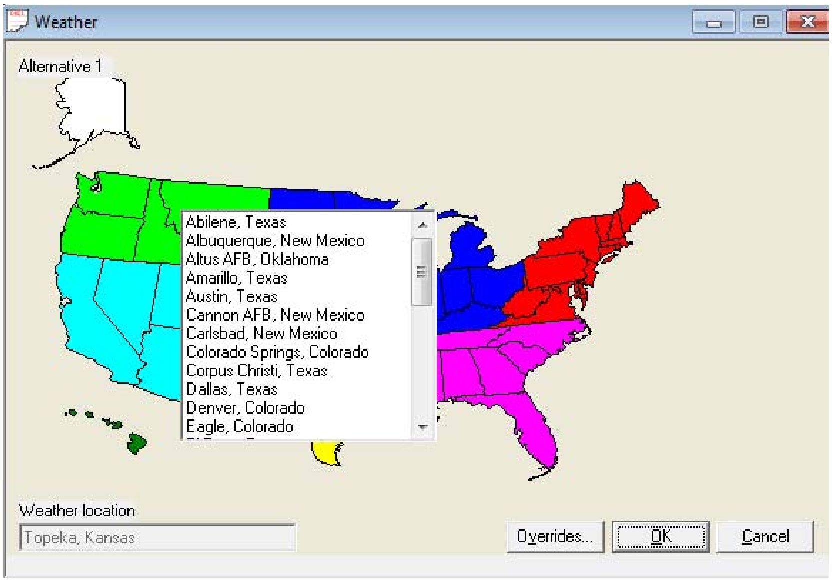

Figure A.1 Weather Location

Once the desired weather information is inserted, rooms can be created. If your project contains multiple spaces of similar loads, creating templates can be a useful tool. By creating templates for common spaces like offices, break rooms, conference rooms, open offices, and spaces with lighting internal loads only this step can help save time. Once template information is auto-populated in the “Create Rooms” window, space area and exterior wall dimensions are all that remain. If necessary, template inputs can be overridden within the “Create Rooms” window for spaces that might require a special input different from the template information. Once the rooms have been created, a system must be selected and a central plant be created.

Creating GCHP System

Below are step-by-step instructions for creating a GCHP system and central plant in TRACE 700. These instructions were developed based on a response from C.D.S. Help, the Trane: TRACE 700 software support group (C.D.S. Help, personal communication, August 16, 2012).

Step 1: Open the “Create Systems” window. Pick “Water Source Heat Pump” as System - 001. Then click “Apply” to save your entries.

Step 2: On the "Fans" tab (Figure A.2)(Trane, 2012), select "Hydronic in heat pump fan" and enter 0.5 for the static pressure. Then click "Apply" and "Close".

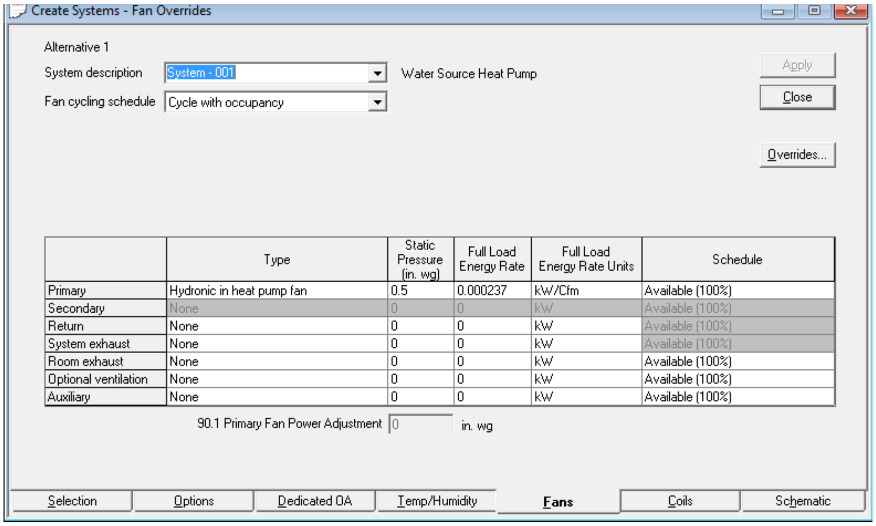

Figure A.2 Create Systems – Fan Overrides

Step 3: Open the "Assign Rooms to Systems" window, and assign rooms to zones within System – 001 (Figure A.3)(Trane, 2012). Then click "Close".

Note: To define desired spaces with thermostats, double-click each room within a zone, click on the "Rooms" tab. From the thermostat location drop down menu select "Room" when that space is the location desired and "Zone" for all other spaces within that zone.

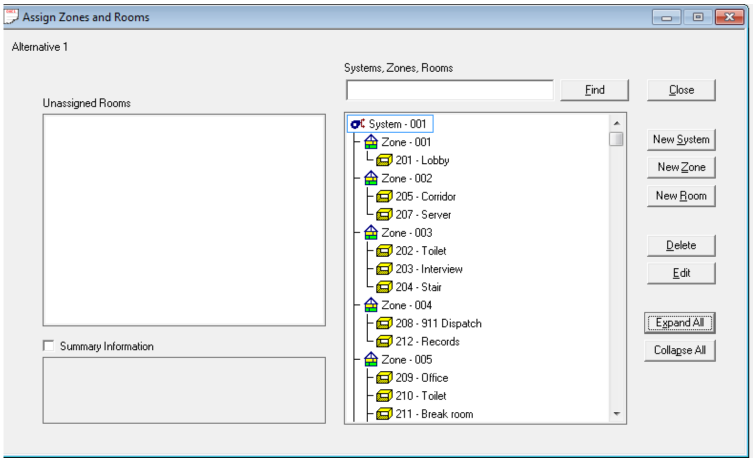

Figure A.3 Assign Zones and Rooms

Step 4: Open the "Create Plants" window. Drag the appropriate icons from the Equipment Category section to define each plant, "Water source heat pump – 001" to Cooling plants and "Boiler – 001" to Heating plants. Rename the cooling plant as Ground Source Heat Pump and the heating plant as Backup Boiler (Figure A.4)(Trane, 2012).

Note: Do not remove thermal storage from the tree. The water loop is modeled as a special thermal storage type in TRACE 700. Removing the thermal storage eliminates the water loop from the simulation.

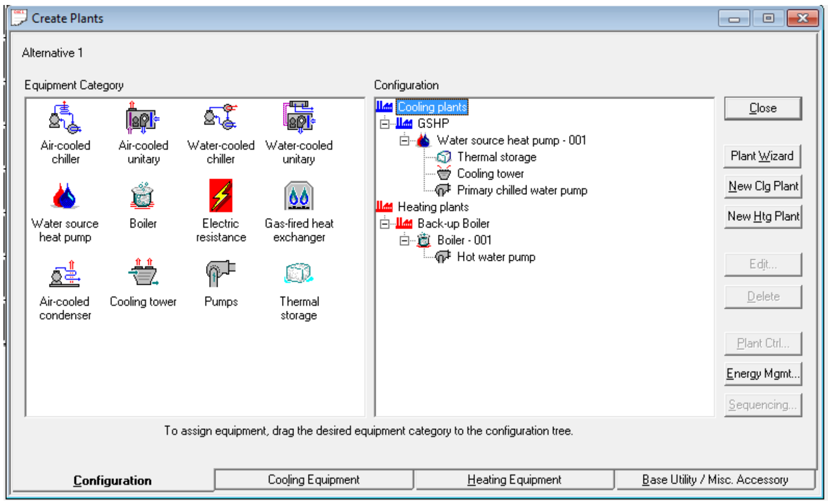

Figure A.4 Create Plants: Configuration

Step 5: Select the "Cooling Equipment" tab at the bottom of the screen. Choose the ground-source heat pump that best matches the desired target performance.

Note: The ability of the heat pump to produce heat is defined within the Heat Recovery section of the Operating Mode table on the Cooling Equipment tab in the Create Plants window. A value must be entered for both the Capacity and Energy rate for the Heat recovery operating mode; standard values are auto-populated with each selection, but can be overridden if specific values are known.

Step 6: Enter the full-load consumption of the "var vol chill water pump" which serves the primary loop.

Note: This information did not affect the Trace outputs for this report, regardless of the input value. Therefore, an arbitrary number can be entered. Otherwise, if known, enter the feet of head for the primary pump.

Step 7: Assign the Backup Boiler as the “Backup Heat Source”. A cooling tower is assigned automatically.

Note: TRACE requires both a cooling tower and a backup heating source when modeling ground source heat pumps. If the system demands more heating or cooling capacity than the designed ground loop can provide, a cooling tower or backup boiler is set to account for the excess capacity.

Step 8: Set the Reject condenser heat field to “Ground loop”.

Step 9: Select one of the GLHE options with the appropriate bore field entering and leaving water temperature difference in the Thermal Storage “Type” field.

Note: All water source heat pumps must have a Heat Pump Loop Storage tank specified in the Thermal Storage "Type" field. “GLHE designed for 10F (6C) TD wellfield” was selected as the design standard for this research; even though this information did not affect the Trace outputs for this report, regardless of the input values.

Step 10: “Apply” your changes.

Step 11: Click on the “Controls…” button at the right side of the screen.

Step 12: Click on the “Cooling Plant and Geothermal Controls” button at the right side of the screen.

Step 13: Select one of the TLoop Ent Bldg options in the Plant Controls - Geothermal Loop editor. “Vertical bore” was chosen from the TLoop Ent Bldg drop down menu for this research (Figure A.5)(Trane, 2012).

Note: This field defines the method TRACE 700 uses to compute the monthly ground loop temperatures.

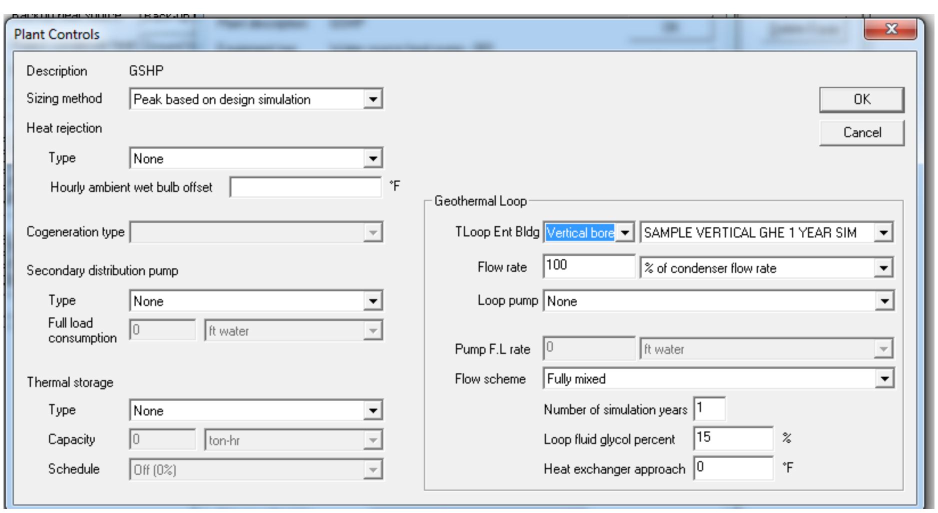

Figure A.5 Plant Controls

Step 14: Click "OK" twice and Click "Apply".

Step 15: Click on the Heating Equipment tab at the bottom of the Create Plants editor.

Step 16: Select a boiler.

Note: An Electric Hot Water Boiler was selected for this research.

Step 17: Enter the full-load energy consumption for the circulator pump.

Note: The full load consumption of the circulator pump does not affect the trace outputs for this research. Therefore, 5feet of head was assumed.

Step 18: Click "Apply", then "Close".

Step 19: Open the "Assign Systems to Plants" window and assign the cooling and heating coil to their corresponding plant.

Step 20: Click "Close".

Step 21: Open the "Calculate and View Results" window and Click "Calculate".

TRACE 700 Outputs

Once the simulation is complete an output box will appear. The TRACE 700 outputs used in this research were "System checksums" and "Zone checksums" within the **Design Reports** tab and "System load", "Building cooling/heating demand", and "Geothermal Summary" within the **Analysis Reports** tab. The following figures were taken from the Model 1 outputs. Refer to Appendix G for the compiled research for Model 1. The outputs were used as follows:

- System Checksums (Figure A.6)
    - Provides a system analysis at peak load. Peak load of a system represents a sum of all zone peak loads, which occur at a specific time in the year that produces the greatest load for that zone.
    - Used to confirm system was created properly and provides total building area.
- Design Cooling Capacity (Figure A.7)
    - Provides the cooling peak and block loads.

- Block load was used to size the bore field, 1 ton per vertical bore. Refer to Appendix C for more information.

- Load/Airflow Summary (Figure A.8)
  - Provides analysis at each zone peak load. It includes airflow, peak cooling MBH and peak heating MBH.
  - Used to size heat pumps. Refer to Appendix B for explanation.
- Building Cool Heat Demand (Figure A.9)
  - Provides hourly heating and cooling part-load data for an average day each month.
  - Used for utility cost analysis. Refer to Appendix F for more information.
- Geothermal Earth Temperature Summary (Figure A.10)
  - Used to select LWT from ground loop, therefore, EWT to heat pump. The minimum and maximum values in Figure A.10 represent the heating EWT and cooling EWT, respectively.

Other outputs consulted included: "Design cooling capacity", "Design heating capacity", and "Engineering checks" within the **Design Reports** and "Geothermal Summary" and "Geothermal Energy Transfer Summary" within the **Analysis Reports** tab. These were reviewed as support for the other reports described above.

System Checksums

By ACADEMIC

System - 001 — **Water Source Heat Pump**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 96 / 75 / 101

Clg Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	71,974	71,974	12	0	0
Glass Solar	135,756	0	135,756	22	147,695	40
Glass/Door Cond	11,686	0	11,686	2	9,078	2
Wall Cond	35,280	0	35,280	6	38,751	10
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	182,722	71,974	254,696	41	195,523	52
Internal Loads						
Lights	58,728	14,682	73,409	12	58,728	16
People	141,752	0	141,752	23	88,397	24
Misc	4,906	0	4,906	1	4,906	1
Sub Total ==>	205,386	14,682	220,068	35	152,031	41
Ceiling Load	22,758	-22,758	0	0	21,696	6
Ventilation Load	0	0	151,511	24	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	3,826		3,826	1	3,826	1
Exhaust Heat		-13,510	-13,510	-2		
Sup. Fan Heat			5,127	1		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	414,692	50,387	621,718	100.00	373,076	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-51,517	7.66
Glass Solar	0	0	0.00
Glass/Door Cond	-50,583	-50,583	7.52
Wall Cond	-52,838	-52,838	7.86
Partition/Door	0	0	0.00
Floor	-15,921	-15,921	2.37
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-119,342	-170,860	25.40
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-14,121	0	0.00
Ventilation Load	0	-270,351	40.19
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-239,612	-239,612	35.62
Exhaust Heat		8,212	-1.22
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-373,076	-672,611	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	78.2	68.0
Return	78.0	68.0
Ret/OA	82.0	53.9
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	17,305	17,305
Terminal	17,305	17,305
Main Fan	17,305	17,305
Sec Fan	0	0
Nom Vent	3,800	3,800
AHU Vent	3,800	3,800
Infil	0	0
MinStop/Rh	0	0
Return	17,305	17,305
Exhaust	3,800	3,800
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	22.0	22.0
cfm/ft²	0.77	0.77
cfm/ton	334.00	
ft²/ton	431.98	
Btu/hr·ft²	27.78	-30.05
No. People	353	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	51.8	621.7	497.8	17,305	81.9	64.5	66.2	55.0	52.3	56.0
~~**Aux Clg**~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0~~	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	51.8	621.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	22,381		
Part	0		
Int Door	0		
ExFlr	473		
Roof	10,727	0	0
Wall	11,858	1,260	11
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-672.5	17,305	54.0	90.0
~~**Aux Htg**~~	~~0.0~~	0	0.0	0.0
Preheat	-14.5	17,305	54.0	54.7
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-672.5			

Figure A.6 Model 1 System Checksums

SYSTEM SUMMARY
DESIGN COOLING CAPACITIES
By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

Plant	System	Peak Plant Loads: Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Peak Total ton	Block Plant Loads: Time Of Peak mo/hr	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Block Total ton
GSHP		51.8	0.0	0.0	0.0	0.0	0.0	0.0	51.8	8/15	43.4	0.0	0.0	0.0	0.0	0.0	0.0	43.4
	System - 001	51.8	0.0	0.0	0.0	0.0	0.0	0.0	51.8	8/15	43.4	0.0	0.0	0.0	0.0	0.0	0.0	43.4
Building totals		51.8	0.0	0.0	0.0	0.0	0.0	0.0	51.8		43.4	0.0	0.0	0.0	0.0	0.0	0.0	43.4

Building peak load is 51.8 tons.

Building maximum block load of 43.4 tons occurs in August at hour 15 based on system simulation.

Figure A.7 Model 1 Design Cooling Capacities

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure A.8 Model 1 Load/Airflow Summary

BUILDING COOL HEAT DEMAND

By ACADEMIC

January	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	6.2	5.4	-169,740	0.0	-217,485	0.0	-220,767	0.0	-220,754	0.0	-220,824	0.0
2	5.0	4.1	-172,395	0.0	-225,825	0.0	-228,854	0.0	-228,850	0.0	-228,951	0.0
3	4.2	3.3	-177,175	0.0	-232,234	0.0	-234,888	0.0	-234,890	0.0	-235,010	0.0
4	3.9	3.2	-180,323	0.0	-237,869	0.0	-237,868	0.0	-237,875	0.0	-238,005	0.0
5	4.3	3.5	-183,164	0.0	-237,741	0.0	-237,375	0.0	-237,394	0.0	-237,514	0.0
6	5.4	4.4	-182,052	0.0	-233,115	0.0	-232,800	0.0	-232,824	0.0	-232,928	0.0
7	7.1	6.2	-178,646	0.0	-225,192	0.0	-224,919	0.0	-224,935	0.0	-225,026	0.0
8	9.3	8.3	-170,619	0.0	-213,852	0.0	-213,616	0.0	-213,635	0.0	-213,693	0.0
9	11.8	10.8	-145,958	0.0	-193,193	0.0	-192,964	0.0	-192,984	0.0	-193,005	0.0
10	14.4	13.3	-111,132	0.0	-163,145	0.0	-162,985	0.0	-163,009	0.0	-163,020	0.0
11	16.9	15.4	-86,169	0.6	-133,824	0.0	-134,193	0.0	-135,604	0.0	-135,475	0.0
12	19.1	17.3	-55,084	2.6	-118,613	0.0	-118,278	0.0	-118,293	0.0	-118,231	0.0
13	20.8	18.6	-55,082	6.1	-106,006	0.5	-105,772	0.5	-105,833	0.5	-105,792	0.5
14	21.9	19.5	-31,413	7.2	-96,609	1.2	-96,690	1.2	-96,775	1.2	-96,746	1.2
15	22.3	19.6	-27,486	7.2	-90,880	1.1	-90,295	1.1	-90,769	1.1	-90,749	1.1
16	22.0	19.3	-37,386	6.7	-91,171	0.9	-91,567	0.9	-91,562	0.9	-91,548	0.9
17	21.2	18.7	-33,951	5.9	-96,591	0.6	-96,433	0.6	-96,469	0.6	-96,458	0.6
18	20.0	17.7	-56,024	2.3	-105,114	0.0	-105,004	0.0	-105,061	0.0	-105,052	0.0
19	18.3	16.4	-67,930	0.0	-115,553	0.0	-115,923	0.0	-115,990	0.0	-115,984	0.0
20	16.4	14.8	-82,816	0.0	-126,826	0.0	-126,647	0.0	-126,717	0.0	-126,712	0.0
21	14.2	13.0	-94,763	0.0	-146,193	0.0	-146,078	0.0	-144,702	0.0	-146,146	0.0
22	12.0	10.8	-106,322	0.0	-185,552	0.0	-185,220	0.0	-185,230	0.0	-185,240	0.0
23	9.9	8.8	-133,360	0.0	-197,905	0.0	-197,866	0.0	-197,889	0.0	-197,900	0.0
24	7.9	6.9	-153,386	0.0	-210,005	0.0	-209,981	0.0	-210,005	0.0	-210,073	0.0

February	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	17.2	16.3	-126,201	0.0	-134,387	0.0	-154,064	0.0	-154,544	0.0	-155,734	0.0
2	15.3	14.4	-132,926	0.0	-159,058	0.0	-165,890	0.0	-165,280	0.0	-166,003	0.0
3	13.7	12.7	-137,701	0.0	-171,891	0.0	-175,652	0.0	-175,729	0.0	-175,661	0.0
4	12.4	11.4	-142,303	0.0	-179,684	0.0	-183,884	0.0	-183,931	0.0	-183,866	0.0
5	11.3	10.5	-144,454	0.0	-187,344	0.0	-190,897	0.0	-190,938	0.0	-190,893	0.0
6	10.7	10.0	-143,288	0.0	-193,621	0.0	-195,590	0.0	-195,624	0.0	-195,597	0.0
7	10.5	9.9	-139,862	0.0	-196,204	0.0	-199,601	0.0	-198,297	0.0	-198,280	0.0
8	11.1	10.6	-130,167	0.0	-193,863	0.0	-197,150	0.0	-196,672	0.0	-198,184	0.0
9	12.8	12.2	-102,307	0.0	-176,505	0.0	-180,233	0.0	-181,054	0.0	-180,981	0.0
10	15.3	14.4	-61,927	0.0	-150,820	0.0	-152,504	0.0	-152,479	0.0	-152,470	0.0
11	18.5	16.9	-52,069	1.0	-120,887	0.0	-121,608	0.0	-121,531	0.0	-121,567	0.0
12	21.8	19.8	-24,438	3.4	-100,886	0.0	-101,957	0.0	-101,871	0.0	-101,925	0.0
13	25.0	22.6	-11,671	6.6	-83,372	0.7	-83,564	0.7	-83,455	0.7	-83,516	0.7
14	27.5	24.8	0	7.6	-58,581	1.2	-58,746	1.2	-58,636	1.2	-58,698	1.2
15	29.2	26.3	0	7.9	-63,328	1.2	-63,559	1.2	-63,459	1.2	-63,520	1.2
16	29.8	26.8	0	8.8	-47,751	1.8	-47,937	1.8	-47,840	1.8	-47,897	1.8
17	29.6	26.8	-4,007	7.6	-58,652	1.2	-58,868	1.2	-58,782	1.2	-58,837	1.2
18	29.0	26.4	-7,173	4.7	-50,165	0.9	-50,341	0.9	-50,259	0.9	-50,310	0.9
19	28.0	25.7	-20,335	1.5	-69,061	0.4	-69,160	0.4	-69,086	0.4	-69,134	0.4
20	26.6	25.0	-32,059	0.0	-65,506	0.0	-65,649	0.0	-65,582	0.0	-65,626	0.0
21	25.0	23.5	-41,213	0.0	-88,238	0.0	-88,411	0.0	-88,795	0.0	-88,839	0.0
22	23.1	21.9	-55,861	0.0	-95,864	0.0	-95,996	0.0	-95,493	0.0	-95,522	0.0
23	21.2	20.1	-78,663	0.0	-110,832	0.0	-109,671	0.0	-111,401	0.0	-111,418	0.0
24	19.1	18.2	-88,337	0.0	-138,261	0.0	-139,647	0.0	-136,730	0.0	-136,735	0.0

Figure A.9 Model 1 System Load Profiles

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - City Hall Offices and Police Department

GSHP

	Year 1				
Month	Average Earth Temp.°F	Average Fluid Leaving Temp.°F	Average Fluid Entering Temp.°F	Minimum Fluid Entering Temp.°F	Maximum Fluid Entering Temp.°F
Jan	52.70	49.20	47.50	45.40	56.00
Feb	52.60	50.10	48.80	46.60	55.70
Mar	54.40	55.00	55.20	49.20	60.60
Apr	55.80	57.50	58.30	55.50	65.30
May	58.20	62.30	64.30	58.90	71.60
Jun	61.90	69.60	73.30	65.90	79.10
Jul	65.70	76.20	81.30	74.50	86.30
Aug	67.50	77.10	81.80	76.60	89.70
Sep	66.50	72.40	75.30	69.90	86.50
Oct	64.70	67.40	68.70	65.60	80.60
Nov	62.70	62.80	62.90	61.00	71.60
Dec	61.80	61.20	60.90	58.70	67.80
Annual	60.40	63.40	64.90	45.40	89.70

Figure A.10 Model 1 Geothermal Earth Temperature Summary

Appendix B - Heat Pump Selection

After the energy model outputs are obtained, the next step is to select heat pumps based on the zone checksums and geothermal earth temperature summary data. This was done to determine the heat pump with the highest pressure drop and GPM, as it would be the worst case heat pump. The information required to select heat pumps are: space airflow (CFM), cooling capacity (tons), cooling total and sensible load (MBH), cooling entering water temperature, or EWT (ºF), total heating load (MBH), and heating EWT (ºF). This information can be found in the Load/Airflow Summary (Figure A.2) and Geothermal Earth Temperature Summary (Figure A.10) from the energy model outputs. Table B.2 shows the Model 1 Heat Pump Selection using the ClimateMaster TS Series heat pump performance chart and the worst case heat pump is shown in grey. (Note: this schedule shows the energy model load values used to select the heat pump, refer to ClimateMaster TS Series Performance Charts for nominal heat pump capacities)

Selecting Heat Pumps

Before discussing an example selection, it is important to set selection criteria. Figure B.1 (ClimateMaster, 2012) shows an enlarged view of Figure B.2 of the 80 ºF EWT row used in the following example and in the next section, "Selection Example", with the column headings superimposed for convenience.

1,950 CFM Nominal (Rated) Airflow Cooling, 1,950 CFM Nominal (Rated) Airflow Heating

EWT °F	GPM	WPD		Cooling - EAT 80/67°F						
		PSI	FT	Airflow CFM	TC	SC	Sens/Tot Ratio	kW	HR	EER
80	7.5	0.2	0.5	1465	58.6	38.1	0.65	4.23	73.1	13.9
	7.5	0.2	0.5	1950	61.1	45.6	0.75	4.37	76.0	14.0
	11.3	1.9	4.4	1465	60.7	38.9	0.64	3.96	74.2	15.3
	11.3	1.9	4.4	1950	63.2	46.6	0.74	4.09	77.2	15.4
	15.0	3.6	8.3	1465	61.7	39.2	0.64	3.83	74.8	16.1
	15.0	3.6	8.3	1950	64.3	47.0	0.73	3.96	77.8	16.2

Figure B.1 ClimateMaster TS 060 – 80 ºF EWT

Below is a detailed example of how to pinpoint the ideal selection criteria within a performance chart, Figure B.1. For this example the EWT is assumed to be 80 ºF when cooling, as it was the cooling EWT used to select all Model 1 heat pumps; taken from the Model 1 Geothermal Earth Temperature Summary. Refer to Appendix A: Figure A.10.

1. The example zone loads for cooling are as follows: Q_S = 48 MBH and Q_T = 52 MBH, find the ideal selection criteria.
    a. First, it is most important to make a selection where both the TC and SC heat pump capacities listed in the chart either meet or exceed the required zone loads. Therefore, for this example, at 1465 CFM, the sensible capacities are too small for the given loads.
    b. Note: the 11.3 GPM/1950 CFM and the 15 GPM/1950 CFM require more GPM and yield a larger WPD, which could lead to larger pipe and essentially larger pumps on an exaggerated scale.
    c. Therefore, the most ideal criteria would be the 7.5 GPM/1950 CFM.

Even though this example yielded a selection of the 7.5 GPM TS Series 060 unit, which provides the lowest GPM and WPD, there are negative aspects as well. By looking at the "KW" column, it is clear that the 7.5 GPM unit requires more power by a fractional amount. It also has a lower performance rate of 14.0 EER when looking at the "EER" column. Consequently, it is ultimately up to the designer/engineer to make the selection based on his/her engineering judgment. Some individuals would say to select within the middle row (11.3 GPM), as it yields a compromise between the two outlying options. However, for this research the heat pump energy consumption and efficiency was not being evaluated, therefore the lower GPM row was selected most often, unless the calculated load required otherwise.

Selection Example

Before making a selection, zone loads must be calculated. For this research, zone airflow, heat pump EWT, cooling and heating peak loads were obtained from the energy model outputs. Appendix A, Figure A.7 shows the Load/Airflow Summary for model 1 that was used to determine the zone airflow and cooling and heating peak loads. The last piece of information needed is the EWT to the heat pump. The Geothermal Earth Temperature Summary TRACE output was used to determine this information. Figure A.9 in Appendix A highlights the column that lists the LWT from the geothermal heat exchanger. The lowest temperature listed is reflected as the heating EWT and the highest temperature listed as the cooling EWT. Figure A.10 yields a 50 ºF EWT in heating and 80 ºF EWT in cooling for model 1 and was entered into the "EWT" column within the heat pump schedule, shown in Table B.1.

After the zone loads are determined, heat pump performance charts are used to make the selection. For this research, ClimateMaster TS Series performance charts were used when making final heat pump selections. Figure B.2 (ClimateMaster, 2012) shows the performance data for a ClimateMaster TS 060, or five ton, heat pump unit. This chart was used to select "HP-1", shown in Table B.1.

The selection for HP-1 is as follows:

1. From the energy model outputs:
    a. Airflow – 2020 CFM
    b. Cooling – 51.3 MBH (total), or 4.3 tons, and 48.4 MBH (sensible)
    c. Heating – 57.3 MBH (total)
2. Find the unit performance chart that best represents the above loads
    a. TS-060 is a 5 ton unit with nominal airflow of 1950 CFM (Figure B.2)
3. Find the "EWT" row on the chart (Figure B.2) that matches the cooling (CLG) EWT from the schedule
    a. "CLG EWT" from Table B.1 is 80 ºF.
4. Within that row, find the series that best matches the airflow and total and sensible cooling loads listed above. This is outlined in Figure B.2.
    a. Refer to previous section "Selecting Heat Pumps" for a prioritized list that was used in making this selection.
    b. Note the GPM, WPD and CFM.
5. Find the EWT row on the chart (Figure B.2) that matches the heating (HTG) EWT from the schedule
    a. "HTG EWT" from Table B.1 is 50 ºF.
6. Within that row, find the same GPM and CFM noted in step 4 and check that the listed HC is greater than the heating load above. This is outlined in Figure B.2.
    a. Note: If the listed HC is smaller than the load above, use engineering judgment to select another option. Otherwise, select the same option knowing the unit might be undersized when that zone is at peak load when heating and supplemental heating may need to be added.
7. Record the selection in the heat pump schedule (Table B.1).

a. Note: Record the largest WPD if it varies between the cooling and heating selections within the chart (Figure B.2).

Performance Data – TS H/V/D 060 (PSC Blower)

1,950 CFM Nominal (Rated) Airflow Cooling, 1,950 CFM Nominal (Rated) Airflow Heating — Performance capacities shown in thousands of Btuh

EWT °F	GPM	WPD		Cooling - EAT 80/67°F							Heating - EAT 70°F					
		PSI	FT	Airflow CFM	TC	SC	Sens/Tot Ratio	kW	HR	EER	Airflow CFM	HC	kW	HE	LAT	COP
20	15.0	5.0	11.6	Operation not recommended							1465	40.8	4.43	26.6	96	2.70
	15.0	5.0	11.6								1950	41.9	4.05	28.2	90	3.03
30	7.5	0.6	1.4	1465	61.8	36.2	0.59	2.64	70.8	23.4	1465	44.1	4.50	29.6	98	2.88
	7.5	0.6	1.4	1950	64.3	43.4	0.67	2.73	73.6	23.6	1950	45.3	4.11	31.4	92	3.23
	11.3	2.3	5.3	1465	63.0	36.5	0.58	2.63	72.0	23.9	1465	45.8	4.53	31.1	99	2.96
	11.3	2.3	5.3	1950	65.6	43.7	0.67	2.72	74.9	24.1	1950	47.0	4.14	33.0	92	3.33
	15.0	4.8	11.1	1465	64.9	37.4	0.58	2.60	73.8	24.9	1465	46.7	4.55	32.0	100	3.01
	15.0	4.8	11.1	1950	67.6	44.8	0.66	2.69	76.7	25.1	1950	48.0	4.16	33.9	93	3.38
40	7.5	0.5	1.2	1465	64.9	38.6	0.59	2.86	74.6	22.7	1465	50.0	4.61	34.9	102	3.18
	7.5	0.5	1.2	1950	67.5	46.2	0.68	2.96	77.6	22.9	1950	51.3	4.22	37.0	94	3.57
	11.3	2.2	5.1	1465	65.4	38.7	0.59	2.76	74.9	23.7	1465	52.1	4.65	36.8	103	3.28
	11.3	2.2	5.1	1950	68.2	46.3	0.68	2.85	77.8	23.9	1950	53.5	4.25	39.1	95	3.69
	15.0	4.5	10.4	1465	66.0	38.8	0.59	2.72	75.3	24.3	1465	53.3	4.67	37.9	104	3.34
	15.0	4.5	10.4	1950	68.8	46.4	0.67	2.81	78.3	24.5	1950	54.7	4.27	40.2	96	3.75
50	7.5	0.4	0.9	1465	65.4	39.8	0.61	3.15	76.2	20.8	1465	56.1	4.73	40.5	105	3.48
	7.5	0.4	0.9	1950	68.1	47.6	0.70	3.26	79.2	20.9	1950	57.6	4.32	43.0	97	3.91
	11.3	2.1	4.9	1465	66.1	39.8	0.60	2.97	76.2	22.2	1465	58.7	4.77	42.9	107	3.60
	11.3	2.1	4.9	1950	68.8	47.6	0.69	3.07	79.2	22.4	1950	60.3	4.37	45.5	99	4.05
	15.0	4.3	9.9	1465	66.4	39.8	0.60	2.91	76.3	22.9	1465	60.1	4.80	44.1	108	3.67
	15.0	4.3	9.9	1950	69.2	47.6	0.69	3.00	79.4	23.0	1950	61.7	4.39	46.8	99	4.12
60	7.5	0.3	0.7	1465	64.0	39.9	0.62	3.50	76.0	18.3	1465	62.5	4.84	46.3	109	3.78
	7.5	0.3	0.7	1950	66.7	47.8	0.72	3.62	79.0	18.4	1950	64.2	4.43	49.1	100	4.24
	11.3	2.1	4.9	1465	65.3	40.1	0.61	3.26	76.4	20.0	1465	65.5	4.90	49.0	111	3.92
	11.3	2.1	4.9	1950	68.0	48.0	0.71	3.37	79.4	20.2	1950	67.2	4.48	52.0	102	4.40
	15.0	4.1	9.5	1465	65.7	40.1	0.61	3.17	76.5	20.7	1465	67.1	4.93	50.5	112	3.99
	15.0	4.1	9.5	1950	68.4	48.0	0.70	3.27	79.5	20.9	1950	68.9	4.51	53.5	103	4.48
70	7.5	0.3	0.7	1465	61.6	39.2	0.64	3.84	74.7	16.0	1465	68.9	4.97	52.0	114	4.06
	7.5	0.3	0.7	1950	64.2	46.9	0.73	3.97	77.7	16.2	1950	70.7	4.54	55.2	104	4.56
	11.3	2.0	4.6	1465	63.4	39.7	0.63	3.61	75.7	17.6	1465	72.2	5.03	55.0	116	4.20
	11.3	2.0	4.6	1950	66.0	47.6	0.72	3.73	78.7	17.7	1950	74.1	4.60	58.4	105	4.72
	15.0	3.9	9.0	1465	64.1	39.9	0.62	3.49	76.1	18.4	1465	73.9	5.07	56.6	117	4.28
	15.0	3.9	9.0	1950	66.8	47.8	0.72	3.61	79.1	18.5	1950	75.9	4.63	60.1	106	4.80
80	7.5	0.2	0.5	1465	58.6	38.1	0.65	4.23	73.1	13.9	1465	75.1	5.09	57.7	117	4.32
	7.5	0.2	0.5	1950	61.1	45.6	0.75	4.37	76.0	14.0	1950	77.1	4.65	61.2	107	4.85
	11.3	1.9	4.4	1465	60.7	38.9	0.64	3.96	74.2	15.3	1465	78.6	5.16	60.8	120	4.46
	11.3	1.9	4.4	1950	63.2	46.6	0.74	4.09	77.2	15.4	1950	80.7	4.72	64.5	108	5.01
	15.0	3.6	8.3	1465	61.7	39.2	0.64	3.83	74.8	16.1	1465	80.4	5.21	62.5	121	4.53
	15.0	3.6	8.3	1950	64.3	47.0	0.73	3.96	77.8	16.2	1950	82.6	4.76	66.3	109	5.08
85	7.5	0.2	0.5	1465	56.9	37.4	0.66	4.44	72.1	12.8	1465	78.1	5.15	60.4	119	4.44
	7.5	0.2	0.5	1950	59.3	44.8	0.76	4.59	75.0	12.9	1950	80.1	4.71	64.0	108	4.98
	11.3	1.9	4.3	1465	59.1	38.3	0.65	4.16	73.3	14.2	1465	81.6	5.23	63.5	122	4.57
	11.3	1.9	4.3	1950	61.6	45.8	0.74	4.30	76.3	14.3	1950	83.7	4.79	67.4	110	5.13
	15.0	3.6	8.2	1465	60.2	38.7	0.64	4.03	73.9	14.9	1465	83.4	5.28	65.1	123	4.63
	15.0	3.6	8.2	1950	62.7	46.3	0.74	4.17	76.9	15.0	1950	85.6	4.83	69.1	111	5.20

Figure B.2 ClimateMaster TS 060 Performance Chart

Table B.1 Heat Pump Selections: Model 1

MODEL 1 - HEAT PUMP SELECTIONS											
			ENERGY MODEL OUTPUTS								
			COOLING					HEATING			
MARK	UNIT SIZE	UNIT AIR FLOW	AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG EWT	HTG Q_T	HTG EWT	UNIT GPM	UNIT WPD
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(ºF)	(MBH)	(ºF)		(FT)
1	060	1950	2020	4.3	48.4	51.3	80.0	-57.3	50.0	7.5	0.5
2	009	300	250	0.7	7.0	8.1	80.0	-8.7	50.0	1.4	1.4
3	018	600	630	1.4	15.7	16.6	80.0	-17.6	50.0	2.8	0.5
4	042	1050	580	3.2	26.9	37.9	80.0	-37.7	50.0	11.0	7.4
5	012	350	265	1.0	10.0	11.8	80.0	-9.8	50.0	1.8	0.7
6	060	1950	2110	3.9	46.3	46.8	80.0	-57.9	50.0	11.3	4.4
7	018	600	525	1.3	14.1	15.0	80.0	-15.0	50.0	2.8	0.5
8	024	640	600	2.0	18.7	24.4	80.0	-23.4	50.0	4.0	2.3
9	006	180	125	0.5	4.5	5.6	80.0	-5.4	50.0	1.0	0.5
10	012	350	350	1.0	10.2	11.5	80.0	-10.8	50.0	1.8	0.7
11	036	1250	700	2.7	24.4	32.3	80.0	-29.5	50.0	6.8	6.5
12	024	850	775	1.8	17.4	21.3	80.0	-24.4	50.0	4.0	2.3
13	006	180	75	0.3	2.0	3.0	80.0	-4.0	50.0	1.0	0.5
14	070	2100	1195	5.2	38.4	62.3	80.0	-76.6	50.0	8.3	3.7
15	009	300	205	0.7	5.4	7.9	80.0	-10.0	50.0	2.8	5.6
16	006	180	80	0.3	2.3	3.5	80.0	-4.8	50.0	1.0	0.5
17	006	180	50	0.2	1.4	2.1	80.0	-2.8	50.0	1.0	0.5
18	060	1465	960	4.1	31.1	49.7	80.0	-60.4	50.0	11.3	4.4
19	006	180	70	0.2	1.9	2.7	80.0	-3.4	50.0	1.0	0.5
20	006	180	35	0.2	1.1	1.8	80.0	-2.5	50.0	1.0	0.5
21	012	265	175	0.8	5.6	9.0	80.0	-11.6	50.0	1.8	1.1
22	009	300	160	0.7	4.9	7.8	80.0	-9.7	50.0	2.8	5.6
23	030	715	465	2.0	14.6	23.4	80.0	-29.2	50.0	8.0	8.1
24	024	640	560	1.9	19.3	23.0	80.0	-22.5	50.0	4.0	2.3
25	009	225	145	0.6	4.4	6.9	80.0	-8.5	50.0	1.4	1.4
26	030	950	875	2.1	21.8	25.7	80.0	-27.8	50.0	4.0	2.3
27	018	450	410	1.3	13.7	15.5	80.0	-13.3	50.0	2.8	0.5
28	024	640	315	1.7	15.9	19.9	80.0	-15.6	50.0	4.0	2.3
29	009	225	175	0.7	8.6	8.6	80.0	-4.1	50.0	2.1	2.6
30	009	225	185	0.7	8.0	8.1	80.0	-4.9	50.0	2.1	2.6
31	060	1950	2045	4.3	48.9	51.9	80.0	-54.8	50.0	7.5	0.5
32	009	225	200	0.6	5.0	6.7	80.0	-8.4	50.0	1.4	1.4
				51.8		622.1		-672.4		125.5	74.6

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

Appendix C - System Piping Layout

Figure C.1 shows the building loop pipe layout for Model 1. The piping configuration throughout this research is reverse-return; and due to this configuration the sum of the supply and return piping are approximately equivalent for each piece of equipment on the building loop. Therefore, the worst case pipe run is chosen based on which heat pump has the highest pressure drop. For Model 1 the worst case pipe run was chosen to be for HP-4 due to it having the largest WPD, as highlighted in Figure B.3. Once this run is established, the system piping layout can be designed. (Note: for models with multiple stories, each floor was designed with its own loop)

To design the ground loop, the quantity of vertical bores needs to be established. For this research, roughly 1 ton per vertical bore was assumed. This assumption was based on the rule of thumb, listed in Stephen P. Kavanaugh and Kevin Rafferty's *Ground-Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings*, that 247 feet of bore is equal to 1 ton of cooling (Kavanaugh, S. P., & Rafferty, K., (1997)). For example, model 1 the building peak load, also referred to as the system block load, and was calculated by TRACE 700 to be 43.4 tons, whereas the sum of the zone peak loads was calculated to be 51.8 tons. Refer to Appendix A: Figure A.7 for the TRACE output that yields these values.

Once these loads are consumed the geothermal heat exchanger can be designed. For Model 1 45 vertical bores at a depth of 250 feet, placed at 20 feet on center and 9 rows, were designed in order to allow control in 11% increments. The piping layout was then designed at a reverse return configuration; refer to Figure 1.5 for an example. A reverse return was used as it provides better control and similar pipe distances for each bore on a series run. Figure C.3 shows the ground loop layout for Model 1. The mechanical room shown is the location of the primary and/or secondary pumps when applicable for each system. Once the piping layout is complete, pipe distances can be calculated and recorded for pump head calculations. Refer Appendix D for more on pump head calculations for each system type.

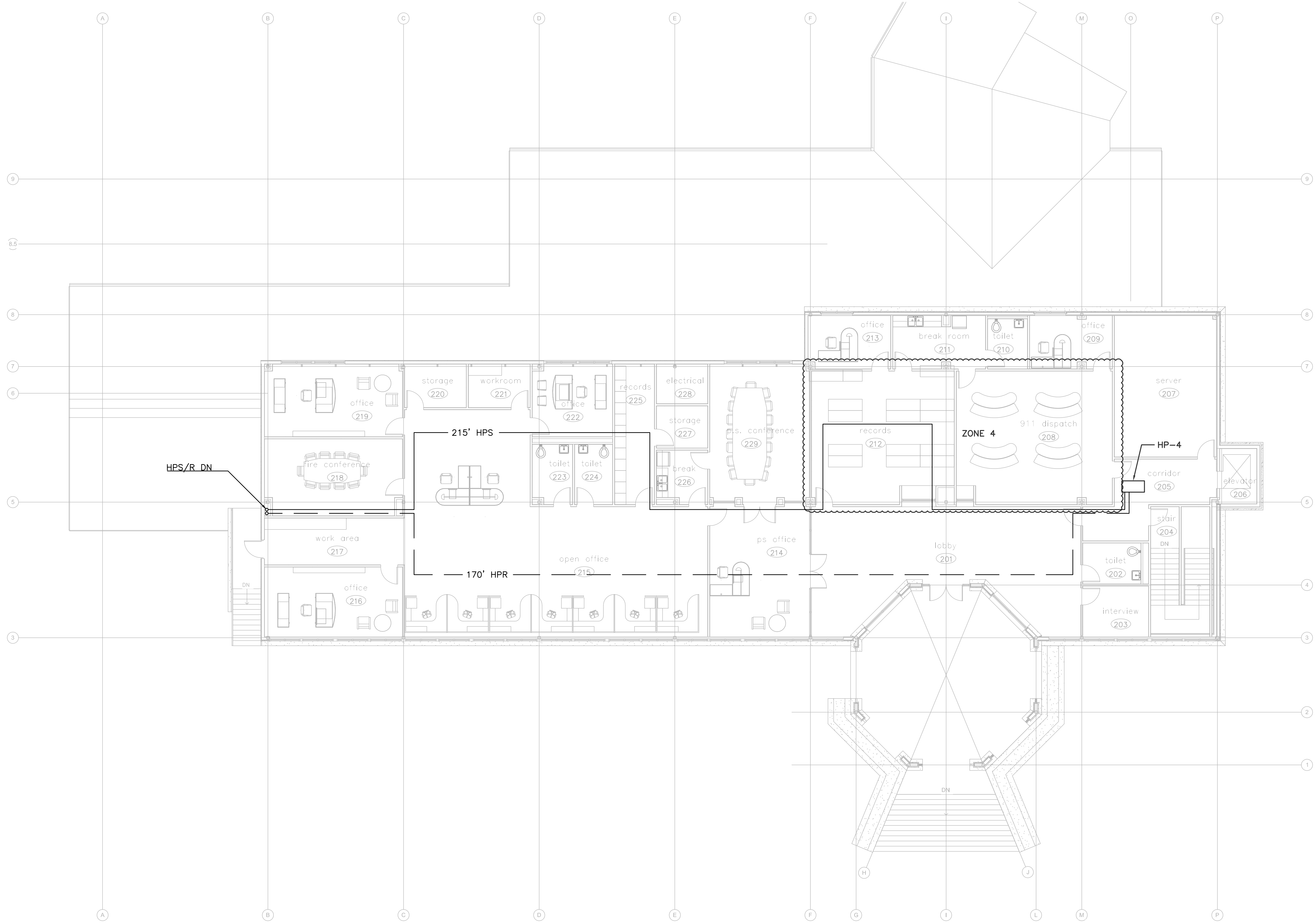

Figure C.1 Building Loop Piping Layout: Model 1

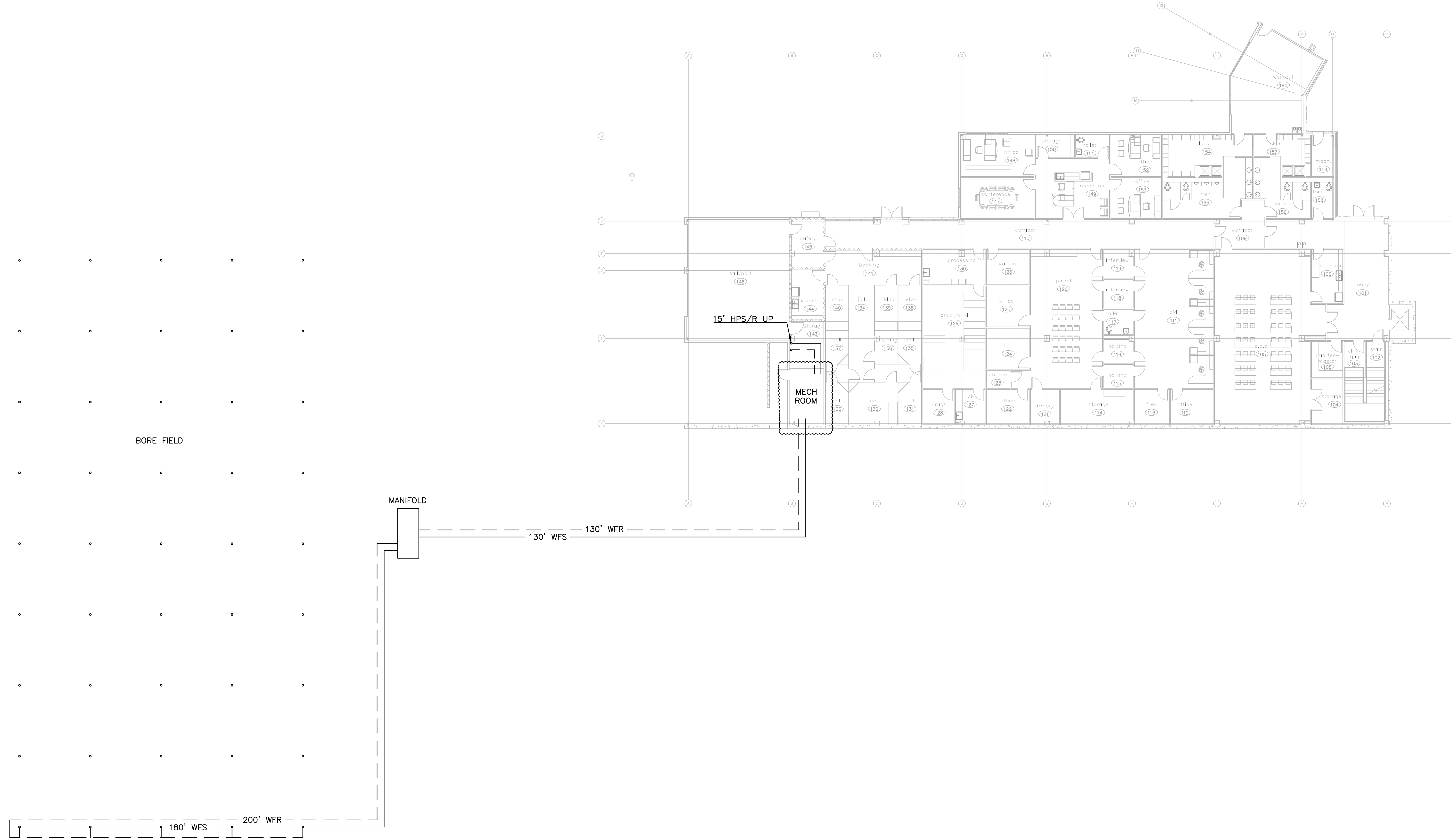

Figure C.2 Ground Loop Piping Layout: Model 1

Appendix D - Pump Head Calculation

The two values required when selecting pumps are the pump feet of head and GPM; whereas the system GPM was calculated as the sum of each heat pump GPM. For GCHP systems the components that contribute to the total system pump head typically include pipe, valves, pipe fittings, heat pumps and an air separator. First, pipe distances must be determined. Appendix C describes how these distances can be obtained. Next, find the equivalent lengths of all valves and pipe fittings. Then multiply the total pipe equivalent length by the same pipe friction loss that was used to size the pipe. For this research the pipe friction loss was assumed to be 3.3 feet per 100 linear feet of pipe. This calculation yields the total pipe feet of head. For GCHP systems there are two other system components that contribute to the total system pump head. These two components are the worst case heat pump and air separator. Once the pressure drop associated with these components are determined, they can be added to the total pipe feet of head to obtain the final system pump head.

To determine the equivalent length of pipe for all valves Bell and Gossett's "Hydronic System Design with the Bell & Gossett System Syzer" Table 2: Fitting Equivalent Length Table was consulted. This table provides equivalent length of pipe for different valves and pipe fittings based on their size, in inches. For any system with a primary and/or secondary pump the valves located at those pumps were assumed to be one balancing valve and two shut-off valves, where the sizes varied for each energy model. The valves located at the heat pump were assumed to be one control valve and two shut-off valves, where the size was assumed to be one inch due to the average heat pump connection size for each model. Finally, the valves and fittings assumed at the ground loop manifold included two branch tees, one balancing valve, and two shut-off valves. Each of the component pressure drop located in the manifold were determined with one inch pipe. As mentioned previously the vertical bores were designed with a one inch U-bend, 250 feet deep. These equivalent lengths were then added together and entered into the pump head calculation spread sheet under their corresponding component pressure drop column. Refer to Table D.1 through D.4 for the pump head calculations that were performed for model 1.

Now that the valves and fittings installed at the pumps, manifold, and heat pump have been defined, the pipe fittings throughout the loops need to be accounted for. For this research, a factor of 1.5 was used to account for the pressure drop in all pipe fittings. Another way to account for fittings is to perform an in-depth pipe pressure drop calculation by using Table 2 from Bell and Gossett's "Hydronic System Design with the Bell & Gossett System Syzer", mentioned above, to establish each fitting's equivalent pipe length. However, in order to save time during this research the 1.5 factor was applied, as it is an industry standard for preliminary pump head calculations. The total pipe with fittings equivalent length was then added to the sum of all equivalent length components and then multiplied by the pipe friction loss, as mentioned above, to obtain the pipe feet of head.

Once the pipe feet of head is determined, two other component pressure drops must be analyzed to finalize the pump head calculation. These two components are the worst case heat pump and the air separator, as mentioned previously. For this research, the Taco "4900" Series pressure drop chart was consulted, due to being very easily accessible online. Each system air separator was assumed to be line size equal to the building loop, as it was assumed to be installed on the building loop. Therefore, the size and pressure drop of the air separator in each energy model varied. This pressure drop was then entered into the "Air Separator PD" column within the pump head calculation spread sheet (Table D.1 through D.4). The worst case heat pump WPD was then taken from the heat pump schedule and entered into the spread sheet. Finally the total system pump head calculation was finalized by adding the total pipe feet of head, air separator PD and the worst case heat pump WPD.

Primary Pumping System

In a primary system, a pump head calculation must be made for the primary pump. First record pipe distances for the worst case path. This path is determined based on the heat pump with the largest pressure drop, as the total pipe distances are the same for all heat pumps due to a reverse return configuration. Next, account for pipe fittings and other pipe components' pressure drop. For primary systems these components are valves at the manifold, pump, and heat pump. Once the final pipe loss is calculated add the air separator and heat pump feet of head to obtain the pump head. Finally, the pump GPM is based on the sum of all heat pump GPMs. The final primary pump head calculations for this research can be found in Table D.1.

Primary/Secondary Pumping System

In a primary/secondary system, a pump head calculation must be made for the primary and secondary pump. The primary pump will be sized based on the pipe friction loss in the ground loop, accounting for valves at the manifold and primary pump and fittings; whereas the secondary pump is sized based on the pipe friction loss in the building loop, accounting for valves at the secondary pump and heat pump and pipe fittings, as well as the air separator and heat pump pressure drop. The GPM for both pumps is equivalent to the sum of all heat pump GPMs. Refer to Table D.2 for the final primary/secondary pump head calculation for each model.

Distributive w/ Primary Pumping System

In a distributive system with a primary pump, a pump head calculation must be made for the primary pump and each distributive pump. The primary pump head calculation is performed the same as it is for the primary pump in a primary system, except this primary pump doesn't account for the pressure drop at the heat pump. The GPM for the primary pump is equivalent to the sum of all heat pump GPMs. Table D.3 shows the final primary pump head calculations for the distributive system with primary pump used in this research. (Note: Each distributive pump is sized based on the GPM and pressure drop of the heat pump it serves plus any piping and coil accessories at that heat pump)

Distributive Pumping System

In a distributive pumping system that doesn't have a central pump; a pump head calculation must be made for each distributive pump. For this research, a more conservative approach was taken by sizing each distributive pump based on the feet of head of the worst case pump as if it was the only pump on in the system. The worst case distributive pump was chosen as the one that serves the heat pump with the largest pressure drop. The concept of this calculation is similar to that of a primary pump calculation, whereas it accounts for pipe length, pipe fittings and valves at the manifold and heat pump to obtain total equivalent length. The complexity comes in determining the pipe friction loss. Since the pipe is sized based on the full system, the friction loss in the pipe will be much smaller if only a single pump is operating. This is calculated based on a ratio of the heat pump GPM of the distributive pump in question to the total system GPM. That ratio percentage is then multiplied by the pipe friction loss assumed for sizing (3.3ft/100ft) to acquire the friction loss through the pipe for the smaller GPM. This is then multiplied by the equivalent length previously calculated to obtain the system friction loss. Finally, add the air separator and worst case heat pump pressure drop for the final distributive pump head. Refer to Table D.4 for the distributive pump head calculation used for each model in this research. (Note: the GPM each distributive pump is sized on is equal to the GPM of the heat pump it serves)

MODEL	PRIMARY SYSTEM PUMP HEAD CALCULATIONS															PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table D.1 Primary Pump Head Calculations: All Models

Table D.2 Primary/Secondary Pump Head Calculations: All Models

MODEL	PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS — PRIMARY LOOP										
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL: SUPPLY	DISTANCE TO WELL: RETURN	DISTANCE DOWN/UP WELL	TOTAL PRIMARY LOOP PIPE LENGTH	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD	TOTAL HEAT PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

MODEL	SECONDARY LOOP										
	DISTANCE TO HEAT PUMP: SUPPLY	DISTANCE TO HEAT PUMP: RETURN	TOTAL P/S LOOP PIPE LENGTH	P/S LENGTH W/ FITTINGS (TOTAL*1.5)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	SECONDARY LOOP PUMP HEAD
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	(FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL SUPPLY	DISTANCE TO WELL RETURN	DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP SUPPLY	DISTANCE TO HEAT PUMP RETURN	TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD	PUMP HEAD	PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

Table title: DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table D.3 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS															CIRCULATOR PUMP HEAD
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD	
		SUPPLY	RETURN		SUPPLY	RETURN										
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4	16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2	16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3	13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7	16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9	9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3	21.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM
		(%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table D.4 Distributive Circulator Pump Head Calculations: All Models

Appendix E - Pump Selection

There were three pump types used in this research: base-mounted end suction, vertical in-line, and wet-rotor circulator. The base-mounted, end suction pumps were sized using Bell and Gossett Series 1510 for large primary and secondary pumps. The vertical in-line is a close coupled in-line mounted Bell and Gossett Series 90 pump; sized for small primary and secondary pumps. Bell and Gossett Series NRF circulators were sized for all distributive pumps.

Primary & Secondary Pump Selection

Figure E.1 (Bell & Gossett, 2012) shows the first window in the Bell and Gossett Online Pump Selection tool. Start by entering the calculated pump head and flow. Then choose the pump types to be analyzed. Then click “Run Pump Selection”. Figure E.2 (Bell & Gossett, 2012) shows the next window in the selector tool that lists Bell and Gossett’s potential selection options based on the input parameters.

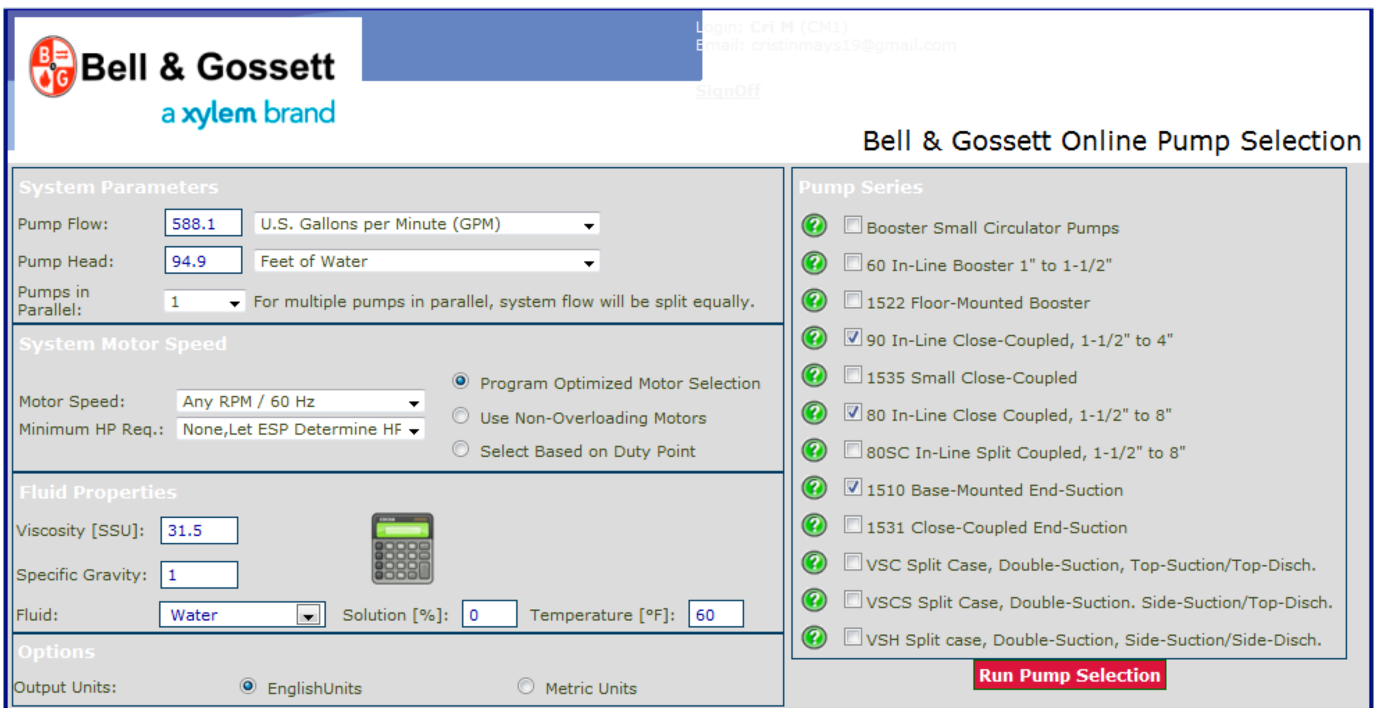

Figure E.1 Bell & Gossett Online Pump Selector: System Parameters

Bell & Gossett
a xylem brand

Bell & Gossett Online Pump Selection

Input Parameters

Flow [GPM]: **588.1** Pump Flow: **588.1**
Head [ft]: **94.9** Parallel Pumps: **1**

Selection Details

Pump Series : **1510** Triple Duty Valve :
Pump Model : **4E** Suction Diffuser :

Selection	Pump Series	Pump Model	Motor Size [HP]	Duty Point [BHP]	Motor Speed [RPM]	Pump Eff. [%]	End of Curve [%]	Impeller [in]	Weight [lb]	Cost Index
Select	1510	3AC	20.00	18.76	3500	75.18	77	5.875	395	100
Select	1510	4AC	25.00	19.66	3550	74.61	58	5.625	480	120
Select	1510	4E	20.00	17.52	1750	80.52	65	10.625	520	128
Select	1510	3G	25.00	21.95	1750	65.28	98	12.125	690	131
Select	1510	5A	30.00	25.83	3550	55.47	45	5.75	630	136
Select	1510	4GB	25.00	18.54	1750	77.64	62	10.625	730	139
Select	80	4x4x7	20.00	19.47	3500	73.07	82	6.25	485	141
Select	1510	5E	25.00	18.49	1750	77.18	44	10	645	146
Select	1510	5G	25.00	18.72	1750	76.39	56	10.125	845	157
Select	80	5x5x7	25.00	21.35	3550	68.32	64	5.625	440	170
Select	1510	6E	50.00	26.29	1770	54.64	25	10.25	1050	188
Select	80	6x6x11	30.00	19.3	1750	73.26	41	10.125	685	210
Select	80	6x6x7	30.00	26.38	3550	54.13	44	5.75	560	213
Select	80	8x8x11	40.00	27.3	1770	51.66	25	10	835	267
Select	1510	8G	60.00	40.73	1770	35.01	17	10.375	1530	304
Selection	Pump Series	Pump Model	Motor Size	Duty Point	Motor Speed [RPM]	Pump Eff. [%]	End of Curve [%]	Impeller	Weight	Cost Index

Figure E.2 Bell & Gossett Online Pump Selector: Selection Suggestions

Selection Criteria

After Bell and Gossett presents their selection suggestions, it is up to the designer/engineer to make the final selection. The selection criteria used for this research are as follows:

- "End of Curve" lists the position on the pump curve.
    - For example: 65% means it is 15% over the highest pump curve efficiency, located at the center of the curve (assumed to be 50%).
    - This is an important criterion since these pumps are being selected with variable speed drives. Therefore, they must be selected past the center of the curve, so that part-load speeds are at the higher efficiencies.
- "Pump Efficiency" lists the efficiency of the pump at full speed.

- The higher the pump efficiency and end of curve percentage at full speed proves that at part-load the pump could run at even higher efficiencies. (Note: at the lower part-loads the pump efficiency will begin to decrease again)

- "Duty Point" lists the BHP of the pump at full speed.
    - Choosing a pump with the lowest BHP was important for this research due to the pump energy analysis being performed.
- "Motor Size" lists the nominal motor HP for the pump.
    - This is the criterion that defines the HP for which the pump initial costs are listed in the RSMeans Mechanical Cost Data book.

The same selector tool and selection criteria were used when selecting the Series 90 vertical in-line pumps. The Series 90 pumps proved to be the best selection for lower GPM and feet of head parameters. Table E.1 shows the pump schedule for the primary pumps of the distributive system, which showcases this fact.

Table E.1 Distributive w/ Primary System – Primary Pump Schedule: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY	BARE COST
			(FT)					(%)	($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table E.2 and E.3 are the primary and primary/secondary system pump schedules, respectively. The BHP listed was then converted to KW and used to calculate the annual utility costs for each system and models.

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table E.2 Primary System Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table E.3 Primary/Secondary System Pump Schedules: All Models

Circulator Pump Selection

Bell and Gossett Series NRF wet-rotor circulators were used for both distributive systems. Each circulator within the distributive systems is controlled simultaneously with their respective heat pump; when the heat pump is on the pump is on, and vise-versa. Figure E.3 (Bell & Gossett, 2011) shows the pump curves for all NRF models. (Note: all circulator pumps are constant speed). Table E.4 and Table E.5 show the pump schedules for the model 1 distributive w/ primary system and distributive system, respectively.

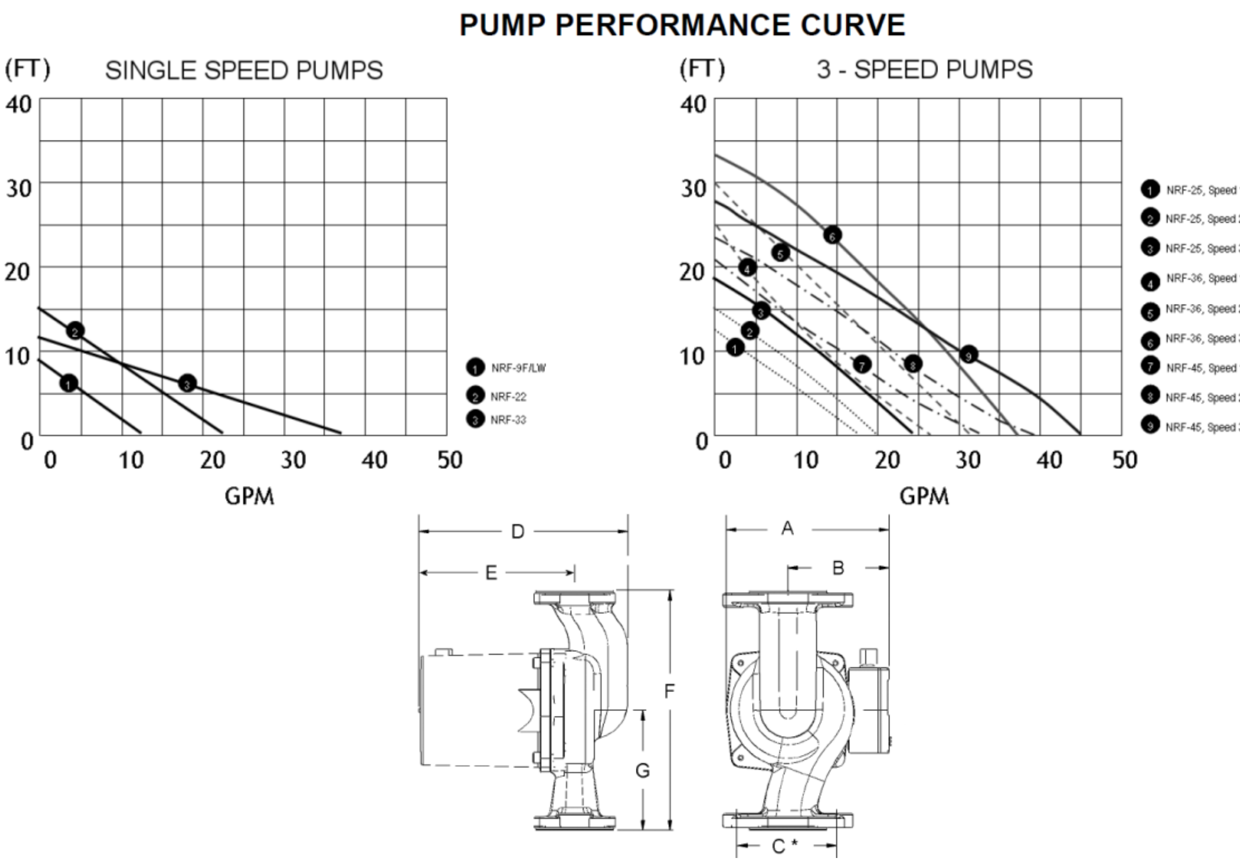

Figure E.3 NRF Circulator Pump Performance Curves

Table E.4 Distributive w/ Primary – Circulator Pump Schedule: Model 1

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
2	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
3	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
4	B & G	NRF-22	11.0	7.4	2940	0.123	92	115	$ 664.00
5	B & G	NRF-9F/LW	1.8	0.7	2800	0.055	41	115	$ 449.00
6	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
7	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
8	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
9	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
10	B & G	NRF-9F/LW	1.8	0.7	2800	0.055	41	115	$ 449.00
11	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
12	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
13	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
14	B & G	NRF-9F/LW	8.3	3.7	2800	0.055	41	115	$ 449.00
15	B & G	NRF-9F/LW	2.8	5.6	2800	0.055	41	115	$ 449.00
16	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
17	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
18	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
19	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
20	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
21	B & G	NRF-9F/LW	1.8	1.1	2800	0.055	41	115	$ 449.00
22	B & G	NRF-9F/LW	2.8	5.6	2800	0.055	41	115	$ 449.00
23	B & G	NRF-22	8.0	8.1	2940	0.123	92	115	$ 664.00
24	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
25	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
26	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
27	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
28	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
29	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
30	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
31	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
32	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
						0.78	584		$ 15,443.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table E.5 Distributive – Circulator Pump Schedule: Model 1

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-36	7.5	16.4	3300	0.362	270	115	$ 1,368.00
2	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
3	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
4	B & G	NRF-36	11.0	16.4	3300	0.362	270	115	$ 1,368.00
5	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
6	B & G	NRF-36	11.3	16.4	3300	0.362	270	115	$ 1,368.00
7	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
8	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
9	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
10	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
11	B & G	NRF-36	6.8	16.4	3300	0.362	270	115	$ 1,368.00
12	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
13	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
14	B & G	NRF-36	8.3	16.4	3300	0.362	270	115	$ 1,368.00
15	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
16	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
17	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
18	B & G	NRF-36	11.3	16.4	3300	0.362	270	115	$ 1,368.00
19	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
20	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
21	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
22	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
23	B & G	NRF-36	8.0	16.4	3300	0.362	270	115	$ 1,368.00
24	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
25	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
26	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
27	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
28	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
29	B & G	NRF-25	2.1	16.4	2950	0.168	125	115	$ 724.00
30	B & G	NRF-25	2.1	16.4	2950	0.168	125	115	$ 724.00
31	B & G	NRF-36	7.5	16.4	3300	0.362	270	115	$ 1,368.00
32	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
						2.57	1915		$ 28,320.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Appendix F - Life Cycle Cost Analysis

In order to complete the life-cycle cost analysis for each model, pump initial cost, replacement cost, utility cost, regular maintenance cost, and preventative maintenance cost was considered. Below is a detailed description of how each of these costs was estimated. (Note: this analysis was formed for comparative purposes only; therefore, some assumptions were made for ease of calculation and consistency. One assumption is that the interest (i) was 6% for all calculations).

All calculations were projected to a 30-year future cost in order to obtain a final 30-year life-cycle cost for each system. The equations used to calculate future cost (F) are shown in Table F.1 (NCEES, (X)).

Table F.1 Engineering Economics Formulas

CONVERTS	SYMBOL	FORMULA
to F, given P	(F/P, i%, n)	$F=A*(1+i)^n$
to F, given A	(F/A, i%, n)	$F=A*(((1+i)^n-1) \div i)$
to P, given A	(P/A, i%, n)	$P=A*(((1+i)^n-1) \div i*(1+i)^n)$
to A, given F	(A/F, i%, n)	$A=F*(i \div ((1+i)^n-1))$

Refer to Table F.5 for the 30-Year Life-Cycle Cost Analysis for Model 1. (Note: No maintenance is required for wet-rotor circulators, 100% redundant pumping was used for all primary and secondary pumps and VFD costs were included for all primary and secondary pumps)

Initial Cost

RSMeans Mechanical Cost Data: 2011 was used to attain initial and installation cost data for all pumps. If a particular pump size was not given, interpolation was used for a rough cost estimate. RSMeans Electrical Cost Data: 2011 was used to attain initial and installation costs for all VFDs (Note: all primary and secondary pumps include a VFD). All pumps and VFDs, when applicable, were added together to obtain total unit and install costs for each system. In order to convert these to current 2012 costs, a 2% inflation rate was assumed. Refer to Appendix E pump schedules for bare cost information. Table F.5 shows the total initial cost information for model 1.

30-Year Projected Cost

The initial cost is considered to be a present cost (P); whereas the projected cost is a future cost (F) after 30-years. Therefore, the equation that should be used is (F/P, i%, n) from Table F.1 above, where n=30. Figure F.1 shows the time-line considered for further clarification of this calculation.

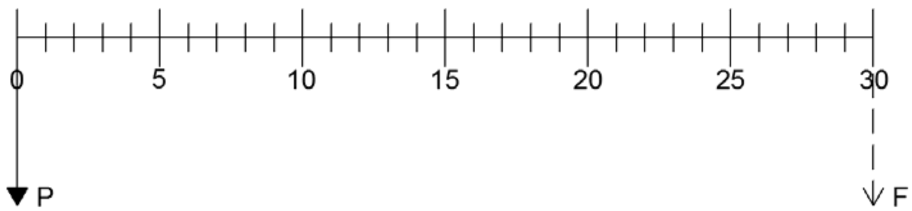

Figure F.1 Initial Cost: 30-Year Projected Cost Time-line

Replacement Cost

From Table F.5 Replacement "total new unit cost" was calculated assuming the initial unit cost multiplied by a 2% per year inflation rate for 15 years. The labor cost was calculated assuming the "total install cost" multiplied by a 2% per year inflation rate, then multiplied by 1.5 to account for the labor required to remove the original pump.

30-Year Projected Cost

The replacement costs are considered to be a present cost (P); whereas the projected cost is a future cost (F) after 15-years. Therefore, the equation that should be used is (F/P, i%, n) from Table F.1 above, where n=15. Figure F.2 shows the time-line considered for further clarification of this calculation.

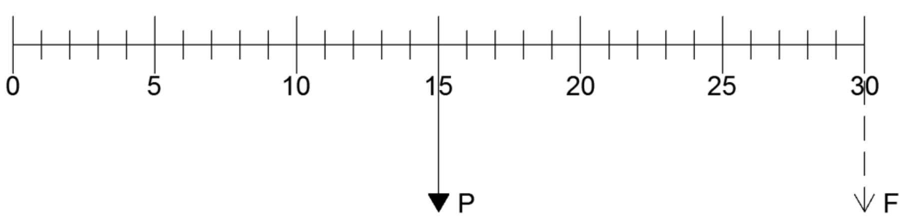

Figure F.2 Replacement Cost: 30-Year Projected Cost Time-line

Utility Cost

Utility cost was calculated based on the “Building Cool Heat Demand” energy model output for each model. Refer to Appendix A: Figure A.9 for the model 1 “Building Cool Heat Demand” output as an example. Table F.3 shows a recreation of the “Building Cool Heat Demand” output and the corresponding part-load percentage at each hour each month for cooling and heating for Model 1. The part-load percentages were calculated based on a ratio of the part-load tons for cooling or MBH for heating, respectively, to the cooling tons or heating MBH, respectively, design peak. These percentages were then added together to represent simultaneous heating and cooling needs each hour, shown in the “Total %” column; these are then listed for each month. This column was then superimposed into the “Part-Load % Each Hour” columns in Table F.4. From there the percentages were then used to calculate the pump consumption each hour (KWH). Assuming these part-load percentages are based on the speed (RPM) at which the pump is working each hour, an affinity law can be applied to account for the relationship between KW, BHP, RPM, Part-Load % Per Hour (PLH) and KWH shown in Figure F.3 below.

1.) $1\ KW = 0.746 * BHP$

2.) $BHP_2 = BHP_1 * (RPM_2/RPM_1)^3$

3.) $RPM_2 = PLH * RPM_1$

4.) $\therefore KWH = KW * (PLH)^3$

Figure F.3 KWH Calculation Using Affinity Law

Once the KWH was calculated for each hour in a given month, they were added up to represent the average daily consumption each month (shown in grey). These values were then super imposed into Table F.2, shown below, under the “Avg. Daily Consumption” column. From this table the annual utility cost for system total pump consumption is calculated. (Note: Table F.2, F.3 and F.4 are the primary system calculations for model 1; these tables were created for each system for all 6 models)

Table F.2 Primary System Annual Utility Cost: Model 1

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	0.94	31	29	$ 0.09	$ 2.63
FEBRUARY	2.08	28	58	$ 0.09	$ 5.25
MARCH	1.00	31	31	$ 0.09	$ 2.78
APRIL	1.94	30	58	$ 0.09	$ 5.23
MAY	4.53	31	141	$ 0.09	$ 12.65
JUNE	10.82	30	325	$ 0.09	$ 29.22
JULY	18.58	31	576	$ 0.09	$ 51.84
AUGUST	16.86	31	523	$ 0.09	$ 47.05
SEPTEMBER	8.51	30	255	$ 0.09	$ 22.99
OCTOBER	3.84	31	119	$ 0.09	$ 10.72
NOVEMBER	0.96	30	29	$ 0.09	$ 2.60
DECEMBER	0.72	31	22	$ 0.09	$ 2.01
ANNUAL UTILITY CONSUMPTION & COST			2166	KWH	$ 194.96

GENERAL NOTES:
1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.07 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

30-Year Projected Cost

The utility cost is considered to be an annual cost (A); whereas the projected cost is a future cost (F) after 30-years. Therefore, the equation that should be used is (F/A, i%, n) from Table F.1 above, where n=30. Figure F.2 shows the time-line considered for further clarification of this calculation.

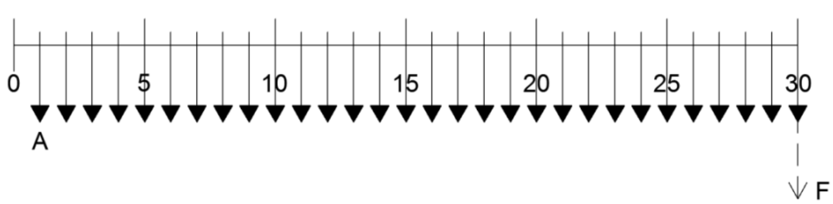

Figure F.4 Utility Cost: 30-Year Projected Cost Time-line

Regular Maintenance Cost

The primary and secondary pump regular maintenance consists of regular lubrication, packing, and seal replacement. Regular lubrication was assumed to take 30 minutes with $5 of material cost; where motors require lubrication once a year and pumps need lubrication 13-times a year. Packing was assumed to take a full-day and $50 of material cost; where regular packing is required every 3-years. Finally, seal replacement was assumed to take a full-day and vary in material cost from $400 to $1000 depending on the size of the pump (hp) from smallest to largest, respectively; where seal replacement is required once every 10 years. (Note: $36 per hour was assumed for labor in all maintenance calculations and 100% redundancy assumed for all primary and secondary pumps). These regular maintenance assumptions were provided by Miles Smith, project engineer at P1 Group, Inc. (Miles Smith, personal communication, September 17, 2012).

30-Year Projected Cost

The lubrication cost is considered to be an annual cost (A); whereas the projected cost is a future cost (F) after 30 years. Therefore, the equation that should be used is (F/A, i%, n) from Table F.1 above, where n=30. Figure F.5 shows the time-line considered for further clarification of this calculation.

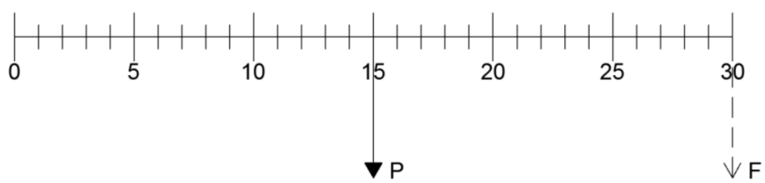

Figure F.5 Lubrication Cost: 30-Year Projected Cost Time-line

The packing cost is considered to be a future cost (F') every 3 years. In order to convert this to a future cost (F) after 30 years, an equivalent annual cost (A') was calculated. The equation that should be used is (A/F, i%, n) from Table F.1, where n=3. The annual cost (A') calculated was then converted to a future cost (F) after 30 years using the equation (F/A, i%, n), where n=30. Figure F.6 shows the time-line considered for further clarification of this calculation.

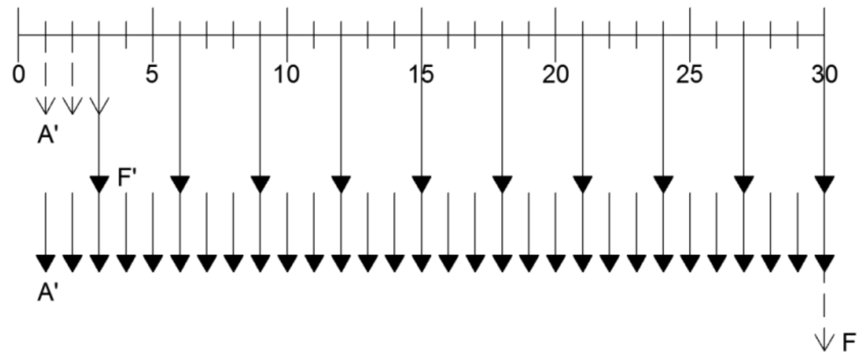

Figure F.6 Packing Cost: 30-Year Projected Cost Time-line

The seal replacement cost is considered to be a future cost (F') every 10 years. In order to convert this to a future cost (F) after 30 years, an equivalent annual cost (A') was calculated. The equation that should be used is (A/F, i%, n) from Table F.1, where n=10. The annual cost (A') calculated was then converted to a future cost (F) after 30 years using the equation (F/A, i%, n), where n=30. Figure F.7 shows the time-line considered for further clarification of this calculation.

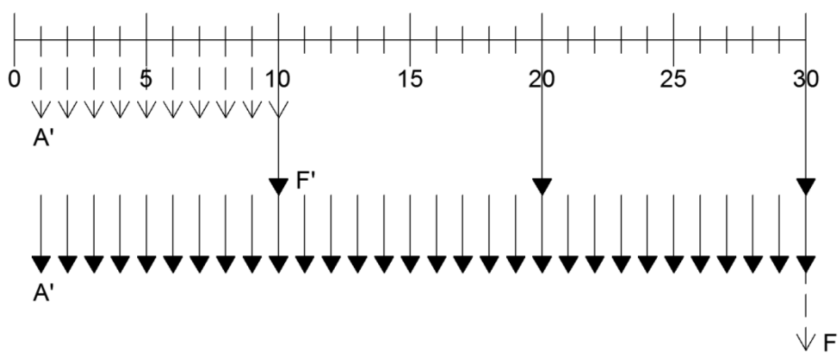

Figure F.7 Seal Replacement Cost: 30-Year Projected Cost Time-line

Preventative Maintenance Cost

The preventative maintenance consists of monitoring each pump on a regular basis. Pump monitoring was assumed to take 3 minutes once a month for circulator pumps, 10 minutes twice a month for the primary pumps and an additional 5 minutes twice a month for the secondary pumps, when applicable. (Note: $36 per hour was assumed for labor in all maintenance calculations). These preventative maintenance assumptions were established based on a recommended monitoring schedule from Miles Smith, project engineer at P1 Group, Inc. (Miles Smith, personal communication, September 17, 2012). No other preventative maintenance was assumed due to wanting to keep calculations consistent, as other maintenance practices vary on a case-by-case basis.

30-Year Projected Cost

The monitoring cost is considered to be an annual cost (A); whereas the projected cost is a future cost (F) after 30 years. Therefore, the equation that should be used is (F/A, i%, n) from Table F.1 above, where n=30. Figure F.5 shows the time-line considered for further clarification of this calculation.

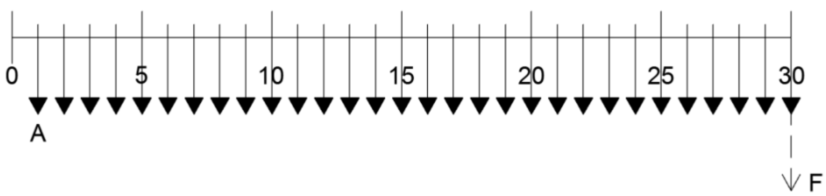

Figure F.8 Monitoring Cost: 30-Year Projected Cost Time-line

MODEL 1 - MONTHLY SIMULTANEOUS HEATING AND COOLING PUMP PART-LOAD % PER HOUR

AVERAGE DAY HOURS	COOLING DESIGN PEAK TONS	HEATING DESIGN PEAK MBH	JANUARY CLG DESIGN TONS PER HOUR	JANUARY CLG %	JANUARY HTG DESIGN MBH PER HOUR	JANUARY HTG %	JANUARY TOTAL %	FEBRUARY CLG DESIGN TONS PER HOUR	FEBRUARY CLG %	FEBRUARY HTG DESIGN MBH PER HOUR	FEBRUARY HTG %	FEBRUARY TOTAL %	MARCH CLG DESIGN TONS PER HOUR	MARCH CLG %	MARCH HTG DESIGN MBH PER HOUR	MARCH HTG %	MARCH TOTAL %
1	51.8	672.5	0.0	0.0%	169.7	25.2%	25.2%	0.0	0.0%	217.5	32.3%	32.3%	0.0	0.0%	15.8	2.3%	2.3%
2	51.8	672.5	0.0	0.0%	172.4	25.6%	25.6%	0.0	0.0%	225.8	33.6%	33.6%	0.0	0.0%	14.9	2.2%	2.2%
3	51.8	672.5	0.0	0.0%	177.2	26.3%	26.3%	0.0	0.0%	232.2	34.5%	34.5%	0.0	0.0%	16.1	2.4%	2.4%
4	51.8	672.5	0.0	0.0%	180.3	26.8%	26.8%	0.0	0.0%	237.9	35.4%	35.4%	0.0	0.0%	18.4	2.7%	2.7%
5	51.8	672.5	0.0	0.0%	183.2	27.2%	27.2%	0.0	0.0%	237.7	35.3%	35.3%	0.0	0.0%	20.1	3.0%	3.0%
6	51.8	672.5	0.0	0.0%	182.1	27.1%	27.1%	0.0	0.0%	233.1	34.7%	34.7%	0.0	0.0%	18.0	2.7%	2.7%
7	51.8	672.5	0.0	0.0%	178.6	26.6%	26.6%	0.0	0.0%	225.2	33.5%	33.5%	0.3	0.6%	26.1	3.9%	4.5%
8	51.8	672.5	0.0	0.0%	170.6	25.4%	25.4%	0.0	0.0%	213.9	31.8%	31.8%	0.4	0.8%	15.2	2.3%	3.0%
9	51.8	672.5	0.0	0.0%	146.0	21.7%	21.7%	0.0	0.0%	193.2	28.7%	28.7%	0.5	1.0%	7.0	1.0%	2.0%
10	51.8	672.5	0.0	0.0%	111.1	16.5%	16.5%	0.0	0.0%	163.1	24.3%	24.3%	0.9	1.7%	2.0	0.3%	2.0%
11	51.8	672.5	0.6	1.2%	86.2	12.8%	14.0%	1.0	1.9%	133.8	19.9%	21.8%	3.9	7.5%	0.2	0.0%	7.6%
12	51.8	672.5	2.6	5.0%	55.1	8.2%	13.2%	3.4	6.6%	118.6	17.6%	24.2%	9.1	17.6%	0.1	0.0%	17.6%
13	51.8	672.5	6.1	11.8%	55.1	8.2%	20.0%	6.6	12.7%	106.0	15.8%	28.5%	12.0	23.2%	0.0	0.0%	23.2%
14	51.8	672.5	7.2	13.9%	31.4	4.7%	18.6%	7.6	14.7%	96.6	14.4%	29.0%	14.4	27.8%	0.0	0.0%	27.8%
15	51.8	672.5	7.2	13.9%	27.5	4.1%	18.0%	7.9	15.3%	90.9	13.5%	28.8%	17.1	33.0%	0.0	0.0%	33.0%
16	51.8	672.5	6.7	12.9%	37.5	5.6%	18.5%	8.8	17.0%	91.2	13.6%	30.5%	17.3	33.4%	0.0	0.0%	33.4%
17	51.8	672.5	5.9	11.4%	34.0	5.0%	16.4%	7.6	14.7%	96.6	14.4%	29.0%	15.9	30.7%	0.0	0.0%	30.7%
18	51.8	672.5	2.3	4.4%	56.0	8.3%	12.8%	4.7	9.1%	105.1	15.6%	24.7%	12.9	24.9%	0.0	0.0%	24.9%
19	51.8	672.5	0.0	0.0%	67.9	10.1%	10.1%	1.5	2.9%	115.6	17.2%	20.1%	8.8	17.0%	0.0	0.0%	17.0%
20	51.8	672.5	0.0	0.0%	82.8	12.3%	12.3%	0.0	0.0%	126.8	18.9%	18.9%	5.3	10.2%	0.8	0.1%	10.4%
21	51.8	672.5	0.0	0.0%	94.8	14.1%	14.1%	0.0	0.0%	146.2	21.7%	21.7%	3.0	5.8%	2.8	0.4%	6.2%
22	51.8	672.5	0.0	0.0%	106.3	15.8%	15.8%	0.0	0.0%	185.6	27.6%	27.6%	1.8	3.5%	4.5	0.7%	4.1%
23	51.8	672.5	0.0	0.0%	133.4	19.8%	19.8%	0.0	0.0%	197.9	29.4%	29.4%	1.5	2.9%	6.1	0.9%	3.8%
24	51.8	672.5	0.0	0.0%	153.4	22.8%	22.8%	0.0	0.0%	210.0	31.2%	31.2%	1.2	2.3%	7.4	1.1%	3.4%

AVERAGE DAY HOURS	APRIL CLG DESIGN TONS PER HOUR	APRIL CLG %	APRIL HTG DESIGN MBH PER HOUR	APRIL HTG %	APRIL TOTAL %	MAY CLG DESIGN TONS PER HOUR	MAY CLG %	MAY HTG DESIGN MBH PER HOUR	MAY HTG %	MAY TOTAL %	JUNE CLG DESIGN TONS PER HOUR	JUNE CLG %	JUNE HTG DESIGN MBH PER HOUR	JUNE HTG %	JUNE TOTAL %
1	1.7	3.3%	1.0	0.1%	3.4%	8.1	15.6%	0.0	0.0%	15.6%	15.2	29.3%	0.0	0.0%	29.3%
2	2.2	4.2%	1.4	0.2%	4.5%	7.7	14.9%	0.0	0.0%	14.9%	14.6	28.2%	0.0	0.0%	28.2%
3	2.1	4.1%	2.0	0.3%	4.4%	7.3	14.1%	0.0	0.0%	14.1%	14.1	27.2%	0.0	0.0%	27.2%
4	2.0	3.9%	2.4	0.4%	4.2%	6.9	13.3%	0.0	0.0%	13.3%	13.7	26.4%	0.0	0.0%	26.4%
5	2.0	3.9%	2.6	0.4%	4.2%	6.7	12.9%	0.0	0.0%	12.9%	13.4	25.9%	0.0	0.0%	25.9%
6	2.1	4.1%	2.4	0.4%	4.4%	6.8	13.1%	0.0	0.0%	13.1%	13.8	26.6%	0.0	0.0%	26.6%
7	2.3	4.4%	1.7	0.3%	4.7%	7.8	15.1%	0.0	0.0%	15.1%	15.4	29.7%	0.0	0.0%	29.7%
8	2.8	5.4%	0.8	0.1%	5.5%	9.7	18.7%	0.0	0.0%	18.7%	17.7	34.2%	0.0	0.0%	34.2%
9	4.7	9.1%	0.2	0.0%	9.1%	12.2	23.6%	0.0	0.0%	23.6%	20.5	39.6%	0.0	0.0%	39.6%
10	7.7	14.9%	2.0	0.3%	15.2%	15.5	29.9%	0.0	0.0%	29.9%	23.5	45.4%	0.0	0.0%	45.4%
11	12.2	23.6%	0.0	0.0%	23.6%	19.5	37.6%	0.0	0.0%	37.6%	27.5	53.1%	0.0	0.0%	53.1%
12	15.9	30.7%	0.0	0.0%	30.7%	23.5	45.4%	0.0	0.0%	45.4%	31.2	60.2%	0.0	0.0%	60.2%
13	18.8	36.3%	0.0	0.0%	36.3%	26.2	50.6%	0.0	0.0%	50.6%	34.3	66.2%	0.0	0.0%	66.2%
14	21.0	40.5%	0.0	0.0%	40.5%	28.1	54.2%	0.0	0.0%	54.2%	36.3	70.1%	0.0	0.0%	70.1%
15	22.3	43.1%	0.0	0.0%	43.1%	28.9	55.8%	0.0	0.0%	55.8%	37.1	71.6%	0.0	0.0%	71.6%
16	22.5	43.4%	0.0	0.0%	43.4%	28.7	55.4%	0.0	0.0%	55.4%	36.9	71.2%	0.0	0.0%	71.2%
17	21.0	40.5%	0.0	0.0%	40.5%	27.7	53.5%	0.0	0.0%	53.5%	35.2	68.0%	0.0	0.0%	68.0%
18	18.4	35.5%	0.0	0.0%	35.5%	25.7	49.6%	0.0	0.0%	49.6%	33.2	64.1%	0.0	0.0%	64.1%
19	14.8	28.6%	0.0	0.0%	28.6%	22.7	43.8%	0.0	0.0%	43.8%	30.5	58.9%	0.0	0.0%	58.9%
20	10.9	21.0%	0.0	0.0%	21.0%	18.8	36.3%	0.0	0.0%	36.3%	26.7	51.5%	0.0	0.0%	51.5%
21	7.8	15.1%	0.0	0.0%	15.1%	15.2	29.3%	0.0	0.0%	29.3%	23.1	44.6%	0.0	0.0%	44.6%
22	5.8	11.2%	0.0	0.0%	11.2%	12.2	23.6%	0.0	0.0%	23.6%	19.9	38.4%	0.0	0.0%	38.4%
23	4.7	9.1%	0.5	0.1%	9.1%	10.6	20.5%	0.0	0.0%	20.5%	17.7	34.2%	0.0	0.0%	34.2%
24	3.9	7.5%	0.8	0.1%	7.6%	9.6	18.5%	0.0	0.0%	18.5%	16.5	31.9%	0.0	0.0%	31.9%

AVERAGE DAY HOURS	COOLING DESIGN PEAK TONS	HEATING DESIGN PEAK MBH	JULY CLG DESIGN TONS PER HOUR	JULY CLG %	JULY HTG DESIGN MBH PER HOUR	JULY HTG %	JULY TOTAL %	AUGUST CLG DESIGN TONS PER HOUR	AUGUST CLG %	AUGUST HTG DESIGN MBH PER HOUR	AUGUST HTG %	AUGUST TOTAL %	SEPTEMBER CLG DESIGN TONS PER HOUR	SEPTEMBER CLG %	SEPTEMBER HTG DESIGN MBH PER HOUR	SEPTEMBER HTG %	SEPTEMBER TOTAL %
1	51.8	672.5	21.1	40.7%	0.0	0.0%	40.7%	19.4	37.5%	0.0	0.0%	37.5%	11.2	21.6%	0.0	0.0%	21.6%
2	51.8	672.5	20.4	39.4%	0.0	0.0%	39.4%	18.4	35.5%	0.0	0.0%	35.5%	10.2	19.7%	0.0	0.0%	19.7%
3	51.8	672.5	19.9	38.4%	0.0	0.0%	38.4%	17.8	34.4%	0.0	0.0%	34.4%	9.4	18.1%	0.0	0.0%	18.1%
4	51.8	672.5	19.6	37.8%	0.0	0.0%	37.8%	17.2	33.2%	0.0	0.0%	33.2%	8.8	17.0%	0.0	0.0%	17.0%
5	51.8	672.5	19.3	37.3%	0.0	0.0%	37.3%	17.1	33.0%	0.0	0.0%	33.0%	8.4	16.2%	0.0	0.0%	16.2%
6	51.8	672.5	19.5	37.6%	0.0	0.0%	37.6%	17.2	33.2%	0.0	0.0%	33.2%	8.5	16.4%	0.0	0.0%	16.4%
7	51.8	672.5	21.0	40.5%	0.0	0.0%	40.5%	18.0	34.7%	0.0	0.0%	34.7%	9.0	17.4%	0.0	0.0%	17.4%
8	51.8	672.5	23.3	45.0%	0.0	0.0%	45.0%	19.9	38.4%	0.0	0.0%	38.4%	10.9	21.0%	0.0	0.0%	21.0%
9	51.8	672.5	26.3	50.8%	0.0	0.0%	50.8%	23.2	44.8%	0.0	0.0%	44.8%	14.5	28.0%	0.0	0.0%	28.0%
10	51.8	672.5	29.7	57.3%	0.0	0.0%	57.3%	27.7	53.5%	0.0	0.0%	53.5%	20.0	38.6%	0.0	0.0%	38.6%
11	51.8	672.5	33.4	64.5%	0.0	0.0%	64.5%	33.1	63.9%	0.0	0.0%	63.9%	26.3	50.8%	0.0	0.0%	50.8%
12	51.8	672.5	37.4	72.2%	0.0	0.0%	72.2%	37.9	73.2%	0.0	0.0%	73.2%	31.2	60.2%	0.0	0.0%	60.2%
13	51.8	672.5	40.4	78.0%	0.0	0.0%	78.0%	40.9	79.0%	0.0	0.0%	79.0%	33.9	65.4%	0.0	0.0%	65.4%
14	51.8	672.5	42.3	81.7%	0.0	0.0%	81.7%	42.6	82.2%	0.0	0.0%	82.2%	35.8	69.1%	0.0	0.0%	69.1%
15	51.8	672.5	42.9	82.8%	0.0	0.0%	82.8%	43.4	83.8%	0.0	0.0%	83.8%	37.3	72.0%	0.0	0.0%	72.0%
16	51.8	672.5	42.4	81.9%	0.0	0.0%	81.9%	42.6	82.2%	0.0	0.0%	82.2%	36.6	70.7%	0.0	0.0%	70.7%
17	51.8	672.5	40.5	78.2%	0.0	0.0%	78.2%	39.8	76.8%	0.0	0.0%	76.8%	33.6	64.9%	0.0	0.0%	64.9%
18	51.8	672.5	38.2	73.7%	0.0	0.0%	73.7%	36.6	70.7%	0.0	0.0%	70.7%	29.1	56.2%	0.0	0.0%	56.2%
19	51.8	672.5	35.8	69.1%	0.0	0.0%	69.1%	32.9	63.5%	0.0	0.0%	63.5%	24.2	46.7%	0.0	0.0%	46.7%
20	51.8	672.5	32.0	61.8%	0.0	0.0%	61.8%	28.9	55.8%	0.0	0.0%	55.8%	20.1	38.8%	0.0	0.0%	38.8%
21	51.8	672.5	28.6	55.2%	0.0	0.0%	55.2%	25.9	50.0%	0.0	0.0%	50.0%	16.7	32.2%	0.0	0.0%	32.2%
22	51.8	672.5	25.7	49.6%	0.0	0.0%	49.6%	23.0	44.4%	0.0	0.0%	44.4%	14.5	28.0%	0.0	0.0%	28.0%
23	51.8	672.5	23.7	45.8%	0.0	0.0%	45.8%	21.0	40.5%	0.0	0.0%	40.5%	12.9	24.9%	0.0	0.0%	24.9%
24	51.8	672.5	22.3	43.1%	0.0	0.0%	43.1%	19.6	37.8%	0.0	0.0%	37.8%	11.7	22.6%	0.0	0.0%	22.6%

AVERAGE DAY HOURS	OCTOBER CLG DESIGN TONS PER HOUR	OCTOBER CLG %	OCTOBER HTG DESIGN MBH PER HOUR	OCTOBER HTG %	OCTOBER TOTAL %	NOVEMBER CLG DESIGN TONS PER HOUR	NOVEMBER CLG %	NOVEMBER HTG DESIGN MBH PER HOUR	NOVEMBER HTG %	NOVEMBER TOTAL %	DECEMBER CLG DESIGN TONS PER HOUR	DECEMBER CLG %	DECEMBER HTG DESIGN MBH PER HOUR	DECEMBER HTG %	DECEMBER TOTAL %
1	5.3	10.2%	0.4	0.1%	10.3%	0.6	1.2%	11.1	1.7%	2.8%	0.0	0.0%	30.1	4.5%	4.5%
2	4.5	8.7%	0.1	0.0%	8.7%	0.4	0.8%	9.2	1.4%	2.1%	0.0	0.0%	33.1	4.9%	4.9%
3	4.1	7.9%	0.8	0.1%	8.0%	0.6	1.2%	10.2	1.5%	2.7%	0.0	0.0%	30.6	4.6%	4.6%
4	3.7	7.1%	0.7	0.1%	7.2%	0.4	0.8%	10.6	1.6%	2.3%	0.0	0.0%	38.0	5.7%	5.7%
5	3.5	6.8%	1.1	0.2%	6.9%	0.3	0.6%	10.8	1.6%	2.2%	0.0	0.0%	42.8	6.4%	6.4%
6	3.7	7.1%	1.3	0.2%	7.3%	0.5	1.0%	10.7	1.6%	2.6%	0.0	0.0%	48.0	7.1%	7.1%
7	3.9	7.5%	0.3	0.0%	7.6%	0.6	1.2%	9.7	1.4%	2.6%	0.0	0.0%	46.6	6.9%	6.9%
8	5.5	10.6%	0.3	0.0%	10.7%	0.7	1.4%	8.2	1.2%	2.6%	0.0	0.0%	44.5	6.6%	6.6%
9	8.7	16.8%	0.0	0.0%	16.8%	0.8	1.5%	6.1	0.9%	2.5%	0.0	0.0%	27.9	4.1%	4.1%
10	13.3	25.7%	0.0	0.0%	25.7%	2.6	5.0%	3.9	0.6%	5.6%	0.4	0.8%	14.2	2.1%	2.9%
11	18.6	35.9%	0.0	0.0%	35.9%	6.4	12.4%	1.6	0.2%	12.6%	2.6	5.0%	5.3	0.8%	5.8%
12	23.8	45.9%	0.0	0.0%	45.9%	11.0	21.2%	0.2	0.0%	21.3%	7.0	13.5%	2.9	0.4%	13.9%
13	26.9	51.9%	0.0	0.0%	51.9%	13.8	26.6%	0.0	0.0%	26.6%	10.0	19.3%	0.8	0.1%	19.4%
14	28.7	55.4%	0.0	0.0%	55.4%	16.0	30.9%	0.0	0.0%	30.9%	11.8	22.8%	0.0	0.0%	22.8%
15	29.5	56.9%	0.0	0.0%	56.9%	17.2	33.2%	0.0	0.0%	33.2%	13.6	26.3%	0.0	0.0%	26.3%
16	28.3	54.6%	0.0	0.0%	54.6%	16.3	31.5%	0.0	0.0%	31.5%	13.0	25.1%	0.0	0.0%	25.1%
17	25.4	49.0%	0.0	0.0%	49.0%	13.0	25.1%	0.0	0.0%	25.1%	10.1	19.5%	0.0	0.0%	19.5%
18	20.4	39.4%	0.0	0.0%	39.4%	8.5	16.4%	0.0	0.0%	16.4%	6.3	12.2%	1.2	0.2%	12.3%
19	15.5	29.9%	0.0	0.0%	29.9%	4.9	9.5%	0.9	0.1%	9.6%	3.0	5.8%	4.2	0.6%	6.4%
20	11.8	22.8%	0.0	0.0%	22.8%	2.9	5.6%	3.4	0.5%	6.1%	1.3	2.5%	5.6	0.8%	3.3%
21	9.6	18.5%	0.0	0.0%	18.5%	1.7	3.3%	4.8	0.7%	4.0%	0.8	1.5%	7.9	1.2%	2.7%
22	8.1	15.6%	0.0	0.0%	15.6%	1.4	2.7%	6.8	1.0%	3.7%	0.4	0.8%	9.9	1.5%	2.2%
23	6.8	13.1%	0.1	0.0%	13.1%	0.9	1.7%	8.7	1.3%	3.0%	0.3	0.6%	9.5	1.4%	2.0%
24	5.9	11.4%	0.2	0.0%	11.4%	0.9	1.7%	10.7	1.6%	3.3%	0.0	0.0%	17.5	2.6%	2.6%

GENERAL NOTES:

1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table F.3 Model 1 Monthly Simultaneous Heating and Cooling Pump Part-Load %

MODEL 1 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION		
	4.52	**BHP**
	3.37	**KW**

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	25.2%	0.05	32.3%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.3%	0.09
2	25.6%	0.06	33.6%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03	28.2%	0.08
3	26.3%	0.06	34.5%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	27.2%	0.07
4	26.8%	0.06	35.4%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.4%	0.06
5	27.2%	0.07	35.3%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	25.9%	0.06
6	27.1%	0.07	34.7%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.6%	0.06
7	26.6%	0.06	33.5%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.7%	0.09
8	25.4%	0.06	31.8%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	34.2%	0.13
9	21.7%	0.03	28.7%	0.08	20.0%	0.03	20.0%	0.03	23.6%	0.04	39.6%	0.21
10	20.0%	0.03	24.3%	0.05	20.0%	0.03	20.0%	0.03	29.9%	0.09	45.4%	0.31
11	20.0%	0.03	21.8%	0.04	20.0%	0.03	23.6%	0.04	37.6%	0.18	53.1%	0.50
12	20.0%	0.03	24.2%	0.05	20.0%	0.03	30.7%	0.10	45.4%	0.31	60.2%	0.74
13	20.0%	0.03	28.5%	0.08	23.2%	0.04	36.3%	0.16	50.6%	0.44	66.2%	0.98
14	20.0%	0.03	29.0%	0.08	27.8%	0.07	40.5%	0.22	54.2%	0.54	70.1%	1.16
15	20.0%	0.03	28.8%	0.08	33.0%	0.12	43.1%	0.27	55.8%	0.59	71.6%	1.24
16	20.0%	0.03	30.5%	0.10	33.4%	0.13	43.4%	0.28	55.4%	0.57	71.2%	1.22
17	20.0%	0.03	29.0%	0.08	30.7%	0.10	40.5%	0.22	53.5%	0.52	68.0%	1.06
18	20.0%	0.03	24.7%	0.05	24.9%	0.05	35.5%	0.15	49.6%	0.41	64.1%	0.89
19	20.0%	0.03	20.1%	0.03	20.0%	0.03	28.6%	0.08	43.8%	0.28	58.9%	0.69
20	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.0%	0.03	36.3%	0.16	51.5%	0.46
21	20.0%	0.03	21.7%	0.03	20.0%	0.03	20.0%	0.03	29.3%	0.09	44.6%	0.30
22	20.0%	0.03	27.6%	0.07	20.0%	0.03	20.0%	0.03	23.6%	0.04	38.4%	0.19
23	20.0%	0.03	29.4%	0.09	20.0%	0.03	20.0%	0.03	20.5%	0.03	34.2%	0.13
24	22.8%	0.04	31.2%	0.10	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.9%	0.11
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		0.94		2.08		1.00		1.94		4.53		10.82

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	40.7%	0.23	37.5%	0.18	21.6%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
2	39.4%	0.21	35.5%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
3	38.4%	0.19	34.4%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
4	37.8%	0.18	33.2%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
5	37.3%	0.17	33.0%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
6	37.6%	0.18	33.2%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
7	40.5%	0.22	34.7%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
8	45.0%	0.31	38.4%	0.19	21.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
9	50.8%	0.44	44.8%	0.30	28.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
10	57.3%	0.64	53.5%	0.52	38.6%	0.19	25.7%	0.06	20.0%	0.03	20.0%	0.03
11	64.5%	0.90	63.9%	0.88	50.8%	0.44	35.9%	0.16	20.0%	0.03	20.0%	0.03
12	72.2%	1.27	73.2%	1.32	60.2%	0.74	45.9%	0.33	21.3%	0.03	20.0%	0.03
13	78.0%	1.60	79.0%	1.66	65.4%	0.94	51.9%	0.47	26.6%	0.06	20.0%	0.03
14	81.7%	1.84	82.2%	1.87	69.1%	1.11	55.4%	0.57	30.9%	0.10	22.8%	0.04
15	82.8%	1.91	83.8%	1.98	72.0%	1.26	56.9%	0.62	33.2%	0.12	26.3%	0.06
16	81.9%	1.85	82.2%	1.87	70.7%	1.19	54.6%	0.55	31.5%	0.11	25.1%	0.05
17	78.2%	1.61	76.8%	1.53	64.9%	0.92	49.0%	0.40	25.1%	0.05	20.0%	0.03
18	73.7%	1.35	70.7%	1.19	56.2%	0.60	39.4%	0.21	20.0%	0.03	20.0%	0.03
19	69.1%	1.11	63.5%	0.86	46.7%	0.34	29.9%	0.09	20.0%	0.03	20.0%	0.03
20	61.8%	0.79	55.8%	0.59	38.8%	0.20	22.8%	0.04	20.0%	0.03	20.0%	0.03
21	55.2%	0.57	50.0%	0.42	32.2%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03
22	49.6%	0.41	44.4%	0.30	28.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
23	45.8%	0.32	40.5%	0.22	24.9%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03
24	43.1%	0.27	37.8%	0.18	22.6%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		18.58		16.86		8.51		3.84		0.96		0.72

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table F.4 Daily Pump Consumption (Primary): Model 1

MODEL 1 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 22,389.00	$ 2,274.60	$ 141,655.17	$ 29,105.70	$ 4,435.47	$ 80,383.37	$ 194.96	$ 15,413.18	$ 600.00	$ 676.00	$ 1,880.00	$ 31,509.38	$ 144.00	$ 11,384.38	$ 280,345.48
PRIMARY/SECONDARY	$ 32,293.20	$ 3,519.00	$ 205,687.05	$ 41,981.16	$ 6,862.05	$ 117,055.60	$ 191.51	$ 15,140.43	$ 1,200.00	$ 1,352.00	$ 2,580.00	$ 55,941.14	$ 216.00	$ 17,076.57	$ 410,900.79
DISTRIBUTIVE W/ PRIMARY	$ 24,942.06	$ 2,289.65	$ 156,405.06	$ 32,424.68	$ 4,464.81	$ 88,407.80	$ 262.25	$ 20,733.01	$ 600.00	$ 676.00	$ 1,780.00	$ 30,909.58	$ 835.20	$ 66,029.40	$ 362,484.84
DISTRIBUTIVE	$ 28,886.40	$ 1,767.86	$ 176,062.49	$ 37,552.32	$ 3,447.33	$ 98,258.06	$ 298.48	$ 23,597.29	$ -	$ -	$ -	$ -	$ 691.20	$ 54,645.02	$ 352,562.86

GENERAL NOTES:

1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. 100% REDUNDANCY WAS ASSUMED FOR ALL PRIMARY AND SECONDARY PUMPING CONFIGURATIONS
13. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table F.5 30-Year Life-Cycle Cost Analysis: Model 1

Appendix G - Compiled Research

System Checksums
By ACADEMIC

System - 001 | **Water Source Heat Pump**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 96 / 75 / 101

CLG Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	71,974	71,974	12	0	0
Glass Solar	135,756	0	135,756	22	147,695	40
Glass/Door Cond	11,686	0	11,686	2	9,078	2
Wall Cond	35,280	0	35,280	6	38,751	10
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	182,722	71,974	254,696	41	195,523	52
Internal Loads						
Lights	58,728	14,682	73,409	12	58,728	16
People	141,752	0	141,752	23	88,397	24
Misc	4,906	0	4,906	1	4,906	1
Sub Total ==>	205,386	14,682	220,068	35	152,031	41
Ceiling Load	22,758	-22,758	0	0	21,696	6
Ventilation Load	0	0	151,511	24	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	3,826		3,826	1	3,826	1
Exhaust Heat		-13,510	-13,510	-2		
Sup. Fan Heat			5,127	1		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	414,692	50,387	621,718	100.00	373,076	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-51,517	7.66
Glass Solar	0	0	0.00
Glass/Door Cond	-50,583	-50,583	7.52
Wall Cond	-52,838	-52,838	7.86
Partition/Door	0	0	0.00
Floor	-15,921	-15,921	2.37
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-119,342	-170,860	25.40
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-14,121	0	0.00
Ventilation Load	0	-270,351	40.19
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-239,612	-239,612	35.62
Exhaust Heat		8,212	-1.22
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-373,076	-672,611	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	78.2	68.0
Return	78.0	68.0
Ret/OA	82.0	53.9
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	17,305	17,305
Terminal	17,305	17,305
Main Fan	17,305	17,305
Sec Fan	0	0
Nom Vent	3,800	3,800
AHU Vent	3,800	3,800
Infil	0	0
MinStop/Rh	0	0
Return	17,305	17,305
Exhaust	3,800	3,800
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	22.0	22.0
cfm/ft²	0.77	0.77
cfm/ton	334.00	
ft²/ton	431.98	
Btu/hr·ft²	27.78	-30.05
No. People	353	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	51.8	621.7	497.8	17,305	81.9	64.5	66.2	55.0	52.3	56.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	51.8	621.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	22,381		
Part	0		
Int Door	0		
ExFlr	473		
Roof	10,727	0	0
Wall	11,858	1,260	11
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-672.5	17,305	54.0	90.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-14.5	17,305	54.0	54.7
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-672.5			

Figure G.1 System Checksums: Model 1

SYSTEM SUMMARY
DESIGN COOLING CAPACITIES
By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

Plant	System	Peak Plant Loads: Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Peak Total ton	Block Plant Loads: Time Of Peak mo/hr	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Block Total ton
GSHP		51.8	0.0	0.0	0.0	0.0	0.0	0.0	51.8	8/15	43.4	0.0	0.0	0.0	0.0	0.0	0.0	43.4
	System - 001	51.8	0.0	0.0	0.0	0.0	0.0	0.0	51.8	8/15	43.4	0.0	0.0	0.0	0.0	0.0	0.0	43.4
Building totals		51.8	0.0	0.0	0.0	0.0	0.0	0.0	51.8		43.4	0.0	0.0	0.0	0.0	0.0	0.0	43.4

Building peak load is 51.8 tons.

Building maximum block load of 43.4 tons occurs in August at hour 15 based on system simulation.

Figure G.2 Design Cooling Capacities: Model 1

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure G.3 Load/Airflow Summary (1 of 4): Model 1

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		224 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
	Zone - 009		Zn Peak	600	2.0	4,451	5,573	127			0	5,362	127	26.7	26.7
	Zone - 009		Zn Block	600	2.0	4,464	5,571	127			0	-6,669	127	26.7	26.7
		220 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		221 - Workroom	Rm Peak	100	0.0	881	1,057	38	2.27	0	0	1,311	38	15.9	15.9
		222 - Office	Rm Peak	225	1.1	7,699	8,435	274	7.29	0	0	-7,808	274	7.0	7.0
	Zone - 010		Zn Peak	425	1.1	10,224	11,473	349			0	-10,845	349	10.6	10.6
	Zone - 010		Zn Block	425	1.1	10,224	11,473	349			0	-11,936	349	10.6	10.6
		225 - Records	Rm Peak	175	0.0	2,172	2,471	42	1.45	0	0	-1,728	42	24.8	24.8
		226 - Breakroom	Rm Peak	100	2.5	1,974	2,690	46	2.78	0	0	-2,375	46	39.9	39.9
		227 - Storage	Rm Peak	100	0.0	1,217	1,531	17	1.04	0	0	-1,239	17	69.2	69.2
		228 - Electrical	Rm Peak	100	0.0	1,530	1,707	38	2.27	0	0	-1,311	38	15.9	15.9
		229 - Conference	Rm Peak	450	22.5	17,536	23,862	557	7.43	0	0	-22,848	557	25.0	25.0
	Zone - 011		Zn Peak	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
	Zone - 011		Zn Block	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
		214 - PS Office	Rm Peak	425	12.1	17,365	21,270	777	10.97	0	0	-24,383	777	11.1	11.1
	Zone - 012		Zn Peak	425	12.1	17,365	21,270	777			0	-24,303	777	11.1	11.1
	Zone - 012		Zn Block	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
		103 - Elev Equip	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		104 - Storage	Rm Peak	150	0.0	978	1,497	34	1.37	0	0	-2,055	34	52.5	52.5
		108 - Quartermaster	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 013		Zn Peak	350	0.5	2,040	3,008	75			0	-4,015	75	43.5	43.5
	Zone - 013		Zn Block	350	0.5	2,045	3,007	75			0	-5,425	75	43.5	43.5
		105 - EOC	Rm Peak	1,250	83.3	38,434	62,341	1,194	5.73	0	0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Peak	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Block	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
		111 - CID	Rm Peak	880	4.4	5,432	7,902	204	1.39	0	0	-9,988	204	36.8	36.8
	Zone - 015		Zn Peak	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
	Zone - 015		Zn Block	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
		112 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		113 - Files	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		114 - Storage	Rm Peak	200	0.0	1,110	1,749	35	1.04	0	0	-2,478	35	69.2	69.2
	Zone - 016		Zn Peak	400	1.0	2,345	3,545	81			0	-4,748	81	50.7	50.7
	Zone - 016		Zn Block	400	1.0	2,345	3,545	81			0	-5,571	81	50.7	50.7
		121 - Armory	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		122 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		123 - Storage	Rm Peak	36	0.0	200	315	6	1.04	0	0	-446	6	69.2	69.2
	Zone - 017		Zn Peak	236	0.5	1,372	2,087	47			0	-2,820	47	53.1	53.1
	Zone - 017		Zn Block	236	0.5	1,372	2,087	47			0	-4,760	47	53.1	53.1
		115 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		116 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9

* This report does not display heating only systems .

Figure G.4 Load/Airflow Summary (2 of 4): Model 1

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		117 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
		118 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		119 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		120 - Patrol	Rm Peak	800	53.3	24,457	39,651	757	5.68	0	0	-48,864	757	59.2	59.2
	Zone - 018		Zn Peak	1,300	63.3	31,126	49,652	960			0	-60,431	960	56.9	56.9
	Zone - 018		Zn Block	1,300	63.3	31,115	49,641	960			0	-60,430	960	56.9	56.9
		124 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		125 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		126 - Warrant	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 019		Zn Peak	300	1.5	1,852	2,694	69			0	-3,405	69	36.8	36.8
	Zone - 019		Zn Block	300	1.5	1,852	2,694	69			0	-5,298	69	36.8	36.8
		127 - Lab	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		128 - Drugs	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
	Zone - 020		Zn Peak	200	0.0	1,110	1,749	35			0	-2,478	35	69.2	69.2
	Zone - 020		Zn Block	200	0.0	1,110	1,749	35			0	-4,474	35	69.2	69.2
		129 - Prop/Evid	Rm Peak	360	0.0	1,999	3,148	62	1.04	0	0	-4,460	62	69.2	69.2
		130 - Processing	Rm Peak	150	7.5	3,606	5,821	113	4.52	0	0	-7,181	113	57.8	57.8
	Zone - 021		Zn Peak	510	7.5	5,604	8,969	175			0	-11,641	175	61.8	61.8
	Zone - 021		Zn Block	510	7.5	5,604	8,968	175			0	-11,641	175	61.8	61.8
		131 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		132 - Cell	Rm Peak	180	4.5	2,555	4,055	83	2.78	0	0	-5,020	83	52.9	52.9
		133 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
	Zone - 022		Zn Peak	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
	Zone - 022		Zn Block	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
		134 - Jail	Rm Peak	175	0.0	972	1,530	30	1.04	0	0	-2,168	30	69.2	69.2
		135 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		136 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		137 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		138 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		139 - Holding	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		140 - Irtox	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		141 - Booking	Rm Peak	270	13.5	6,491	10,477	203	4.52	0	0	-12,926	203	57.8	57.8
	Zone - 023		Zn Peak	949	26.1	14,617	23,360	467			0	-29,150	467	56.1	56.1
	Zone - 023		Zn Block	949	26.1	14,617	23,360	467			0	-29,149	467	56.1	56.1
		142 - Mech	Rm Peak	150	0.0	1,176	1,452	49	1.41	0	0	-1,704	49	10.2	10.2
		143 - Storage	Rm Peak	150	0.0	940	1,424	31	1.23	0	0	-1,971	31	58.6	58.6
		146 - Sallyport	Rm Peak	900	0.0	17,172	20,087	481	3.21	0	0	-18,860	481	22.5	22.5
	Zone - 024		Zn Peak	1,200	0.0	19,287	22,963	561			0	-22,535	561	24.1	24.1
	Zone - 024		Zn Block	1,200	0.0	18,920	22,838	561			0	-22,622	561	24.1	24.1
		144 - Kitchen	Rm Peak	150	0.0	667	919	26	1.04	0	0	-1,238	26	34.6	34.6
		145 - Safety	Rm Peak	150	7.5	3,690	5,939	117	4.68	0	0	-7,276	117	55.8	55.8

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Figure G.5 Load/Airflow Summary (3 of 4): Model 1

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
	Zone - 025		Zn Peak	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
	Zone - 025		Zn Block	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
		110 - Corridor	Rm Peak	475	0.0	12,940	13,837	577	7.29	0	0	-15,659	577	4.9	4.9
		147 - Conference	Rm Peak	240	12.0	8,839	11,895	296	7.41	0	0	-12,162	296	25.1	25.1
	Zone - 026		Zn Peak	715	12.0	21,779	25,733	874			0	-27,821	874	11.8	11.8
	Zone - 026		Zn Block	715	12.0	21,017	25,322	874			0	-27,821	874	11.8	11.8
		148 - Office	Rm Peak	240	1.2	7,223	7,990	259	6.47	0	0	-7,551	259	7.9	7.9
		150 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		151 - Toilet	Rm Peak	100	0.0	1,418	1,418	38	2.27	0	0	-897	38	0.0	0.0
		152 - Office	Rm Peak	225	1.1	3,401	4,066	78	2.07	0	0	-3,165	78	24.6	24.6
	Zone - 027		Zn Peak	665	2.3	13,685	15,454	412			0	-13,338	412	12.5	12.5
	Zone - 027		Zn Block	665	2.3	13,622	15,439	412			0	-13,436	412	12.5	12.5
		109 - Corridor	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		110 - Corridor (Int)	Rm Peak	475	0.0	2,111	2,911	82	1.04	0	0	-3,919	82	34.6	34.6
		149 - Reception	Rm Peak	320	9.1	10,443	12,832	161	3.03	0	0	-8,308	161	40.2	40.2
		153 - Office	Rm Peak	225	1.1	2,875	3,498	52	1.39	0	0	-2,554	52	36.8	36.8
	Zone - 028		Zn Peak	1,120	10.3	15,873	19,854	313			0	-15,606	313	37.9	37.9
	Zone - 028		Zn Block	1,120	10.3	15,802	19,639	313			0	-15,606	313	37.9	37.9
		154 - Locker	Rm Peak	400	0.0	4,656	4,656	104	1.55	0	0	-2,458	104	0.0	0.0
		155 - Men	Rm Peak	400	0.0	3,963	3,963	69	1.04	0	0	-1,644	69	0.0	0.0
	Zone - 029		Zn Peak	800	0.0	8,619	8,619	173			0	-4,102	173	0.0	0.0
	Zone - 029		Zn Block	800	0.0	8,619	8,619	173			0	-7,754	173	0.0	0.0
		156 - Women	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		157 - Locker	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		158 - Toilet	Rm Peak	100	0.0	1,691	1,691	55	3.28	0	0	-1,298	55	0.0	0.0
		159 - Mech	Rm Peak	100	0.0	1,796	1,963	55	3.28	0	0	-1,712	55	11.0	11.0
	Zone - 030		Zn Peak	650	0.0	7,946	8,113	187			0	-4,860	187	3.2	3.2
	Zone - 030		Zn Block	650	0.0	7,777	7,962	187			0	-8,098	187	3.2	3.2
		160 - Workout	Rm Peak	575	2.9	48,899	51,906	2,044	21.33	0	0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Peak	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Block	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
		101 - Lobby (Ext)	Rm Peak	420	0.0	2,973	3,712	128	1.82	0	0	-4,763	128	19.8	19.8
		101 - Lobby (Int)	Rm Peak	154	0.0	684	944	27	1.04	0	0	-1,271	27	34.6	34.6
		106 - Breakroom	Rm Peak	100	2.5	1,309	2,034	46	2.78	0	0	-2,375	46	39.9	39.9
	Zone - 032		Zn Peak	674	2.5	4,966	6,691	201			0	-8,409	201	26.4	26.4
	Zone - 032		Zn Block	674	2.5	4,977	6,689	201			0	-8,409	201	26.4	26.4
System - 001			**Sys Peak**	**22,381**	**353.3**	**497,753**	**621,719**	**17,305**				**-672,528**	**17,305**	**22.0**	**22.0**
System - 001			**Sys Block**	**22,381**	**353.3**	**439,737**	**574,626**	**17,305**				**-672,612**	**17,305**	**22.0**	**22.0**

* This report does not display heating only systems .

Figure G.6 Load/Airflow Summary (4 of 4): Model 1

BUILDING COOL HEAT DEMAND

By ACADEMIC

January Hour	Typical Weather (°F) OADB	OAWB	Design Htg (Btuh)	Design Clg (Tons)	Weekday Htg (Btuh)	Weekday Clg (Tons)	Saturday Htg (Btuh)	Saturday Clg (Tons)	Sunday Htg (Btuh)	Sunday Clg (Tons)	Monday Htg (Btuh)	Monday Clg (Tons)
1	6.2	5.4	-169,740	0.0	-217,485	0.0	-220,767	0.0	-220,754	0.0	-220,824	0.0
2	5.0	4.1	-172,395	0.0	-225,825	0.0	-228,854	0.0	-228,850	0.0	-228,951	0.0
3	4.2	3.3	-177,175	0.0	-232,234	0.0	-234,888	0.0	-234,890	0.0	-235,010	0.0
4	3.9	3.2	-180,323	0.0	-237,869	0.0	-237,868	0.0	-237,875	0.0	-238,005	0.0
5	4.3	3.5	-183,164	0.0	-237,741	0.0	-237,375	0.0	-237,394	0.0	-237,514	0.0
6	5.4	4.4	-182,052	0.0	-233,115	0.0	-232,800	0.0	-232,824	0.0	-232,928	0.0
7	7.1	6.2	-178,646	0.0	-225,192	0.0	-224,919	0.0	-224,935	0.0	-225,026	0.0
8	9.3	8.3	-170,619	0.0	-213,852	0.0	-213,616	0.0	-213,635	0.0	-213,693	0.0
9	11.8	10.8	-145,958	0.0	-193,193	0.0	-192,964	0.0	-192,984	0.0	-193,005	0.0
10	14.4	13.3	-111,132	0.0	-163,145	0.0	-162,985	0.0	-163,009	0.0	-163,020	0.0
11	16.9	15.4	-86,169	0.6	-133,824	0.0	-134,193	0.0	-135,604	0.0	-135,475	0.0
12	19.1	17.3	-55,084	2.6	-118,613	0.0	-118,278	0.0	-118,293	0.0	-118,231	0.0
13	20.8	18.6	-55,082	6.1	-106,006	0.5	-105,772	0.5	-105,833	0.5	-105,792	0.5
14	21.9	19.5	-31,413	7.2	-96,609	1.2	-96,690	1.2	-96,775	1.2	-96,746	1.2
15	22.3	19.6	-27,486	7.2	-90,880	1.1	-90,295	1.1	-90,769	1.1	-90,749	1.1
16	22.0	19.3	-37,386	6.7	-91,171	0.9	-91,567	0.9	-91,562	0.9	-91,548	0.9
17	21.2	18.7	-33,951	5.9	-96,591	0.6	-96,433	0.6	-96,469	0.6	-96,458	0.6
18	20.0	17.7	-56,024	2.3	-105,114	0.0	-105,004	0.0	-105,061	0.0	-105,052	0.0
19	18.3	16.4	-67,930	0.0	-115,553	0.0	-115,923	0.0	-115,990	0.0	-115,984	0.0
20	16.4	14.8	-82,816	0.0	-126,826	0.0	-126,647	0.0	-126,717	0.0	-126,712	0.0
21	14.2	13.0	-94,763	0.0	-146,193	0.0	-146,078	0.0	-144,702	0.0	-146,146	0.0
22	12.0	10.8	-106,322	0.0	-185,552	0.0	-185,220	0.0	-185,230	0.0	-185,240	0.0
23	9.9	8.8	-133,360	0.0	-197,905	0.0	-197,866	0.0	-197,889	0.0	-197,900	0.0
24	7.9	6.9	-153,386	0.0	-210,005	0.0	-209,981	0.0	-210,005	0.0	-210,073	0.0

February Hour	Typical Weather (°F) OADB	OAWB	Design Htg (Btuh)	Design Clg (Tons)	Weekday Htg (Btuh)	Weekday Clg (Tons)	Saturday Htg (Btuh)	Saturday Clg (Tons)	Sunday Htg (Btuh)	Sunday Clg (Tons)	Monday Htg (Btuh)	Monday Clg (Tons)
1	17.2	16.3	-126,201	0.0	-134,387	0.0	-154,064	0.0	-154,544	0.0	-155,734	0.0
2	15.3	14.4	-132,926	0.0	-159,058	0.0	-165,890	0.0	-165,280	0.0	-166,003	0.0
3	13.7	12.7	-137,701	0.0	-171,891	0.0	-175,652	0.0	-175,729	0.0	-175,661	0.0
4	12.4	11.4	-142,303	0.0	-179,684	0.0	-183,884	0.0	-183,931	0.0	-183,866	0.0
5	11.3	10.5	-144,454	0.0	-187,344	0.0	-190,897	0.0	-190,938	0.0	-190,893	0.0
6	10.7	10.0	-143,288	0.0	-193,621	0.0	-195,590	0.0	-195,624	0.0	-195,597	0.0
7	10.5	9.9	-139,862	0.0	-196,204	0.0	-199,601	0.0	-198,297	0.0	-198,280	0.0
8	11.1	10.6	-130,167	0.0	-193,863	0.0	-197,150	0.0	-196,672	0.0	-198,184	0.0
9	12.8	12.2	-102,307	0.0	-176,505	0.0	-180,233	0.0	-181,054	0.0	-180,981	0.0
10	15.3	14.4	-61,927	0.0	-150,820	0.0	-152,504	0.0	-152,479	0.0	-152,470	0.0
11	18.5	16.9	-52,069	1.0	-120,887	0.0	-121,608	0.0	-121,531	0.0	-121,567	0.0
12	21.8	19.8	-24,438	3.4	-100,886	0.0	-101,957	0.0	-101,871	0.0	-101,925	0.0
13	25.0	22.6	-11,671	6.6	-83,372	0.7	-83,564	0.7	-83,455	0.7	-83,516	0.7
14	27.5	24.8	0	7.6	-58,581	1.2	-58,746	1.2	-58,636	1.2	-58,698	1.2
15	29.2	26.3	0	7.9	-63,328	1.2	-63,559	1.2	-63,459	1.2	-63,520	1.2
16	29.8	26.8	0	8.8	-47,751	1.8	-47,937	1.8	-47,840	1.8	-47,897	1.8
17	29.6	26.8	-4,007	7.6	-58,652	1.2	-58,868	1.2	-58,782	1.2	-58,837	1.2
18	29.0	26.4	-7,173	4.7	-50,165	0.9	-50,341	0.9	-50,259	0.9	-50,310	0.9
19	28.0	25.7	-20,335	1.5	-69,061	0.4	-69,160	0.4	-69,086	0.4	-69,134	0.4
20	26.6	25.0	-32,059	0.0	-65,506	0.0	-65,649	0.0	-65,582	0.0	-65,626	0.0
21	25.0	23.5	-41,213	0.0	-88,238	0.0	-88,411	0.0	-88,795	0.0	-88,839	0.0
22	23.1	21.9	-55,861	0.0	-95,864	0.0	-95,996	0.0	-95,493	0.0	-95,522	0.0
23	21.2	20.1	-78,663	0.0	-110,832	0.0	-109,671	0.0	-111,401	0.0	-111,418	0.0
24	19.1	18.2	-88,337	0.0	-138,261	0.0	-139,647	0.0	-136,730	0.0	-136,735	0.0

Figure G.7 Building Cool Heat Demand (1 of 6): Model 1

BUILDING COOL HEAT DEMAND

By ACADEMIC

March	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.4	33.4	-15,780	0.0	-11,582	0.0	-20,698	0.0	-20,773	0.0	-20,821	0.0
2	33.9	31.9	-14,918	0.0	-614	0.0	-12,295	0.0	-22,903	0.0	-12,414	0.0
3	32.9	31.1	-16,117	0.0	-706	0.0	-18,447	0.0	-23,851	0.0	-24,145	0.0
4	32.6	31.1	-18,433	0.0	-763	0.0	-28,709	0.0	-32,520	0.0	-32,698	0.0
5	32.9	31.5	-20,148	0.0	-5,669	0.0	-41,336	0.0	-42,691	0.0	-42,806	0.0
6	33.9	32.5	-18,014	0.0	-15,196	0.0	-44,653	0.0	-45,024	0.0	-45,111	0.0
7	35.4	34.2	-26,091	0.3	-28,982	0.0	-43,534	0.0	-43,866	0.0	-43,938	0.0
8	37.4	36.1	-15,221	0.4	-27,903	0.0	-37,658	0.0	-37,944	0.0	-38,005	0.0
9	39.7	37.9	-6,969	0.5	-19,179	0.0	-25,439	0.0	-25,689	0.4	-25,743	0.4
10	42.1	39.6	-2,044	0.9	-8,274	0.0	-13,750	0.4	-13,727	0.0	-13,767	0.0
11	44.6	41.5	-245	3.9	-5,451	0.5	-6,405	0.5	-6,503	0.5	-6,518	0.5
12	46.9	43.0	-110	9.1	-5,963	1.7	-5,827	1.7	-5,725	1.7	-9,220	1.7
13	48.9	44.3	0	12.0	-3,255	3.9	-3,144	3.9	-3,141	3.9	-3,143	3.9
14	50.4	45.0	0	14.4	-2,550	5.8	-2,572	5.7	-2,576	5.7	-2,572	5.7
15	51.4	45.4	0	17.1	-1,530	6.1	-1,514	6.0	-1,522	6.0	-1,513	6.0
16	51.7	45.5	0	17.3	-1,286	6.5	-1,264	6.4	-1,275	6.4	-1,264	6.4
17	51.4	45.1	0	15.9	-1,661	6.1	-1,735	6.1	-1,753	6.1	-1,740	6.1
18	50.4	44.2	0	12.9	-2,199	5.1	-2,206	5.1	-2,220	5.1	-2,206	5.1
19	48.9	43.4	0	8.8	-3,404	3.4	-3,381	3.3	-3,388	3.4	-3,371	3.4
20	46.9	42.8	-819	5.3	-4,697	1.9	-4,687	1.9	-4,695	1.9	-4,679	1.9
21	44.6	41.4	-2,825	3.0	-6,423	0.8	-10,308	0.8	-10,407	1.0	-10,526	1.0
22	42.1	39.6	-4,489	1.8	-15,258	0.5	-15,205	0.7	-15,065	0.5	-15,106	0.5
23	39.7	37.4	-6,074	1.5	-18,740	0.5	-18,540	0.4	-18,593	0.4	-18,623	0.4
24	37.4	35.0	-7,419	1.2	-19,626	0.0	-19,720	0.0	-19,779	0.0	-19,786	0.0

April	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	48.1	46.0	-1,033	1.7	-4,352	1.8	-4,953	1.7	-4,943	1.7	-4,908	1.5
2	45.9	44.2	-1,407	2.2	-6,840	1.3	-7,233	1.0	-7,390	1.2	-7,408	1.2
3	44.1	42.4	-1,968	2.1	-9,116	0.8	-9,862	1.0	-9,766	0.8	-9,770	0.8
4	42.5	40.9	-2,416	2.0	-11,279	0.7	-11,930	0.5	-12,130	0.7	-11,975	0.5
5	41.3	39.8	-2,592	2.0	-12,820	0.6	-9,715	0.6	-9,550	0.4	-9,725	0.6
6	40.6	39.3	-2,374	2.1	-10,023	0.4	-10,159	0.4	-10,175	0.4	-10,177	0.6
7	40.4	39.1	-1,678	2.3	-10,254	0.4	-10,579	0.6	-10,585	0.6	-10,354	0.4
8	41.1	39.7	-752	2.8	-9,688	0.4	-9,970	0.6	-9,973	0.6	-9,786	0.4
9	43.0	40.8	-195	4.7	-8,244	0.7	-8,329	0.7	-8,331	0.7	-8,345	0.7
10	45.9	42.4	0	7.7	-5,892	0.9	-5,984	0.9	-5,983	0.9	-5,982	0.9
11	49.6	44.5	0	12.2	-3,324	2.5	-3,386	2.5	-3,384	2.5	-3,375	2.5
12	53.4	47.5	0	15.9	-1,213	5.1	-1,083	5.1	-1,086	5.1	-1,086	5.1
13	57.0	50.1	0	18.8	0	8.6	0	8.5	0	8.5	0	8.5
14	60.0	52.3	0	21.0	0	10.9	0	10.9	0	10.9	0	10.9
15	61.9	53.7	0	22.3	0	12.3	0	12.3	0	12.3	0	12.3
16	62.6	53.9	0	22.5	0	12.3	0	12.3	0	12.3	0	12.3
17	62.3	53.9	0	21.0	0	11.4	0	11.4	0	11.4	0	11.4
18	61.6	53.4	0	18.4	0	10.2	0	10.3	0	10.3	0	10.3
19	60.5	52.6	0	14.8	0	8.8	0	8.8	0	8.8	0	8.8
20	58.9	52.7	0	10.9	0	7.0	0	7.1	0	7.1	0	7.1
21	57.0	52.5	0	7.8	-358	5.5	-355	5.5	-354	5.5	-354	5.5
22	54.9	51.5	0	5.8	-550	4.1	-553	4.2	-553	4.2	-553	4.2
23	52.6	50.0	-548	4.7	-2,051	3.3	-2,069	3.3	-2,069	3.3	-2,059	3.3
24	50.3	48.0	-754	3.9	-3,756	2.3	-3,720	2.1	-3,721	2.3	-3,778	2.3

Figure G.8 Building Cool Heat Demand (2 of 6): Model 1

BUILDING COOL HEAT DEMAND

By ACADEMIC

May	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	59.2	56.0	0	8.1	0	7.0	-301	7.1	-317	7.1	-319	7.1
2	56.8	53.8	0	7.7	-297	5.5	-75	5.5	-74	5.5	-74	5.5
3	54.8	52.2	0	7.3	-673	4.5	-1,304	4.6	-1,323	4.6	-1,324	4.6
4	53.3	50.9	0	6.9	-2,717	3.9	-1,712	3.7	-1,715	3.7	-1,716	3.7
5	52.3	50.2	0	6.7	-1,877	3.1	-1,884	3.1	-1,898	3.1	-1,904	3.1
6	52.0	50.3	0	6.8	-2,420	3.1	-2,468	3.2	-2,483	3.2	-2,488	3.2
7	52.5	50.8	0	7.8	-1,524	3.3	-1,552	3.2	-1,565	3.2	-1,570	3.2
8	53.8	51.6	0	9.7	-2,086	4.1	-1,847	4.3	-1,874	4.3	-1,876	4.3
9	55.9	52.4	0	12.2	-577	5.3	-605	5.5	-613	5.5	-614	5.5
10	58.5	53.8	0	15.5	0	7.4	0	7.5	0	7.5	0	7.5
11	61.6	55.1	0	19.5	0	10.1	0	10.2	0	10.2	0	10.2
12	64.7	56.6	0	23.5	0	13.0	0	13.3	0	13.3	0	13.3
13	67.8	58.2	0	26.2	0	15.7	0	16.0	0	16.0	0	16.0
14	70.4	59.6	0	28.1	0	18.1	0	18.4	0	18.5	0	18.5
15	72.5	61.1	0	28.9	0	19.9	0	20.1	0	20.2	0	20.2
16	73.8	62.4	0	28.7	0	20.3	0	20.5	0	20.5	0	20.5
17	74.3	62.8	0	27.7	0	19.7	0	19.9	0	20.0	0	20.0
18	74.0	62.6	0	25.7	0	18.5	0	18.7	0	18.8	0	18.8
19	73.0	62.1	0	22.7	0	17.4	0	17.5	0	17.5	0	17.5
20	71.5	62.0	0	18.8	0	15.6	0	15.7	0	15.7	0	15.8
21	69.5	63.0	0	15.2	0	14.3	0	14.4	0	14.4	0	14.4
22	67.1	61.9	0	12.2	0	12.3	0	12.3	0	12.4	0	12.4
23	64.5	59.9	0	10.6	0	10.4	0	10.5	0	10.5	0	10.5
24	61.8	58.0	0	9.6	0	8.7	0	8.7	0	8.7	0	8.7

June	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	68.3	64.8	0	15.2	0	14.5	0	14.8	0	14.8	0	14.8
2	66.4	63.3	0	14.6	0	13.1	0	13.3	0	13.3	0	13.3
3	64.8	62.3	0	14.1	0	11.9	0	11.9	0	11.9	0	11.9
4	63.6	61.5	0	13.7	0	11.1	0	11.0	0	11.0	0	11.0
5	62.9	61.0	0	13.4	0	10.5	0	10.3	0	10.3	0	10.3
6	62.6	60.8	0	13.8	0	10.1	0	10.0	0	10.0	0	10.0
7	63.1	61.4	0	15.4	0	10.9	0	10.9	0	10.9	0	10.9
8	64.5	61.6	0	17.7	0	12.1	0	12.2	0	12.2	0	12.2
9	66.8	62.3	0	20.5	0	13.7	0	13.9	0	13.9	0	13.9
10	69.6	63.9	0	23.5	0	16.3	0	16.6	0	16.7	0	16.7
11	72.7	66.0	0	27.5	0	20.1	0	20.7	0	20.7	0	20.8
12	75.8	67.7	0	31.2	0	24.1	0	24.8	0	24.9	0	24.9
13	78.7	69.7	0	34.3	0	27.7	0	28.4	0	28.5	0	28.5
14	80.9	71.1	0	36.3	0	30.3	0	30.9	0	31.0	0	31.0
15	82.3	71.7	0	37.1	0	31.8	0	32.3	0	32.3	0	32.3
16	82.8	72.0	0	36.9	0	31.6	0	32.0	0	32.0	0	32.0
17	82.6	71.4	0	35.2	0	30.2	0	30.4	0	30.4	0	30.4
18	81.8	71.1	0	33.2	0	28.6	0	28.8	0	28.8	0	28.8
19	80.6	70.5	0	30.5	0	27.1	0	27.3	0	27.3	0	27.3
20	79.0	70.3	0	26.7	0	24.9	0	25.1	0	25.1	0	25.1
21	77.1	70.2	0	23.1	0	22.8	0	22.9	0	22.9	0	22.9
22	75.0	69.6	0	19.9	0	20.7	0	20.7	0	20.7	0	20.7
23	72.7	68.0	0	17.7	0	18.5	0	18.5	0	18.5	0	18.5
24	70.5	66.8	0	16.5	0	16.9	0	16.9	0	16.9	0	16.9

Figure G.9 Building Cool Heat Demand (3 of 6): Model 1

BUILDING COOL HEAT DEMAND

By ACADEMIC

July	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	74.2	70.8	0	21.1	0	21.0	0	21.8	0	21.8	0	21.8
2	72.8	69.4	0	20.4	0	19.5	0	20.1	0	20.1	0	20.1
3	71.6	68.6	0	19.9	0	18.4	0	18.9	0	19.0	0	19.0
4	70.6	67.9	0	19.6	0	17.6	0	18.0	0	18.0	0	18.0
5	70.1	67.6	0	19.3	0	17.2	0	17.6	0	17.6	0	17.6
6	69.9	67.5	0	19.5	0	17.0	0	17.2	0	17.2	0	17.2
7	70.2	68.0	0	21.0	0	17.7	0	17.9	0	17.9	0	17.9
8	71.3	68.5	0	23.3	0	19.0	0	19.3	0	19.3	0	19.3
9	73.1	69.1	0	26.3	0	20.9	0	21.2	0	21.2	0	21.2
10	75.2	70.2	0	29.7	0	23.9	0	24.2	0	24.3	0	24.3
11	77.6	71.2	0	33.4	0	27.7	0	28.1	0	28.1	0	28.2
12	80.0	72.8	0	37.4	0	32.1	0	32.4	0	32.4	0	32.4
13	82.2	74.4	0	40.4	0	35.4	0	35.7	0	35.8	0	35.8
14	83.9	76.0	0	42.3	0	37.6	0	37.9	0	37.9	0	37.9
15	85.0	76.6	0	42.9	0	38.5	0	38.7	0	38.8	0	38.8
16	85.4	76.6	0	42.4	0	37.6	0	37.8	0	37.8	0	37.8
17	85.2	76.4	0	40.5	0	36.0	0	36.2	0	36.2	0	36.2
18	84.6	76.2	0	38.2	0	34.5	0	34.6	0	34.6	0	34.6
19	83.7	75.8	0	35.8	0	33.1	0	33.2	0	33.2	0	33.2
20	82.4	76.2	0	32.0	0	31.3	0	31.4	0	31.4	0	31.4
21	81.0	76.1	0	28.6	0	29.3	0	29.4	0	29.4	0	29.4
22	79.3	75.3	0	25.7	0	27.3	0	27.3	0	27.3	0	27.3
23	77.6	73.9	0	23.7	0	25.4	0	25.5	0	25.5	0	25.5
24	75.9	72.5	0	22.3	0	23.7	0	23.8	0	23.8	0	23.8
August	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	73.5	69.6	0	19.4	0	19.7	0	20.3	0	20.3	0	20.4
2	71.7	68.0	0	18.4	0	17.9	0	18.4	0	18.4	0	18.4
3	70.1	66.8	0	17.8	0	16.7	0	17.0	0	17.0	0	17.1
4	68.8	65.7	0	17.2	0	15.5	0	15.8	0	15.8	0	15.8
5	67.8	65.2	0	17.1	0	14.8	0	14.8	0	14.8	0	14.8
6	67.2	64.7	0	17.2	0	14.2	0	14.2	0	14.2	0	14.2
7	66.9	64.4	0	18.0	0	13.9	0	13.9	0	13.9	0	13.9
8	67.5	64.6	0	19.9	0	14.6	0	14.6	0	14.7	0	14.7
9	69.2	64.9	0	23.2	0	16.0	0	16.2	0	16.3	0	16.3
10	71.7	66.0	0	27.7	0	19.0	0	19.7	0	19.7	0	19.7
11	74.8	67.8	0	33.1	0	24.1	0	24.9	0	24.9	0	24.9
12	78.0	70.0	0	37.9	0	29.6	0	30.3	0	30.4	0	30.4
13	81.1	72.2	0	40.9	0	33.8	0	34.4	0	34.4	0	34.4
14	83.6	73.7	0	42.6	0	36.4	0	36.9	0	36.9	0	36.9
15	85.3	74.8	0	43.4	0	37.9	0	38.2	0	38.2	0	38.2
16	85.9	75.3	0	42.6	0	37.1	0	37.3	0	37.3	0	37.3
17	85.6	75.0	0	39.8	0	35.1	0	35.2	0	35.3	0	35.3
18	85.0	74.8	0	36.6	0	33.0	0	33.1	0	33.1	0	33.1
19	84.0	75.0	0	32.9	0	31.0	0	31.1	0	31.1	0	31.1
20	82.7	75.4	0	28.9	0	29.2	0	29.3	0	29.3	0	29.3
21	81.1	75.8	0	25.9	0	27.9	0	28.0	0	28.0	0	28.0
22	79.3	74.7	0	23.0	0	26.1	0	26.2	0	26.2	0	26.2
23	77.4	73.1	0	21.0	0	24.1	0	24.2	0	24.2	0	24.2
24	75.4	71.1	0	19.6	0	22.1	0	22.2	0	22.2	0	22.2

Figure G.10 Building Cool Heat Demand (4 of 6): Model 1

BUILDING COOL HEAT DEMAND

By ACADEMIC

September	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	62.0	58.8	0	11.2	0	9.2	0	9.4	0	9.4	0	9.4
2	59.5	56.4	0	10.2	0	7.4	-170	7.5	-169	7.5	-169	7.5
3	57.3	54.7	0	9.4	-328	6.1	0	6.0	0	6.0	0	6.0
4	55.7	53.3	0	8.8	-220	5.1	-708	5.2	-712	5.3	-712	5.3
5	54.7	52.7	0	8.4	-1,681	4.5	-909	4.4	-912	4.5	-912	4.5
6	54.4	52.4	0	8.5	-1,296	4.1	-1,326	4.2	-1,328	4.2	-1,328	4.2
7	55.0	53.1	0	9.0	-718	4.2	-1,596	4.5	-1,597	4.5	-1,597	4.5
8	57.0	54.8	0	10.9	-625	5.5	-237	5.5	-238	5.5	-238	5.5
9	60.0	56.2	0	14.5	-171	7.8	-99	7.9	-100	7.9	-100	7.9
10	63.7	57.6	0	20.0	0	10.9	0	11.0	0	11.0	0	11.0
11	67.9	59.7	0	26.3	0	15.3	0	15.8	0	15.9	0	15.9
12	72.1	61.7	0	31.2	0	20.5	0	21.3	0	21.4	0	21.4
13	75.9	64.1	0	33.9	0	25.8	0	26.5	0	26.6	0	26.6
14	78.9	65.7	0	35.8	0	28.2	0	28.7	0	28.7	0	28.7
15	80.8	66.9	0	37.3	0	28.5	0	28.9	0	28.9	0	29.0
16	81.5	67.1	0	36.6	0	27.5	0	27.9	0	27.9	0	27.9
17	81.1	67.1	0	33.6	0	26.1	0	26.3	0	26.3	0	26.3
18	80.1	67.3	0	29.1	0	24.0	0	24.2	0	24.2	0	24.2
19	78.5	68.0	0	24.2	0	22.0	0	22.1	0	22.1	0	22.1
20	76.4	69.9	0	20.1	0	21.4	0	21.5	0	21.5	0	21.5
21	73.8	68.7	0	16.7	0	19.1	0	19.2	0	19.2	0	19.2
22	70.9	66.5	0	14.5	0	16.7	0	16.7	0	16.7	0	16.7
23	67.9	64.2	0	12.9	0	14.2	0	14.2	0	14.3	0	14.3
24	64.9	61.3	0	11.7	0	11.5	0	11.6	0	11.6	0	11.6

October	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	46.2	40.6	-352	5.3	-6,126	1.4	-6,878	1.3	-6,931	1.3	-6,937	1.3
2	44.9	39.9	-85	4.5	-7,975	0.9	-8,605	0.9	-8,647	0.9	-8,651	0.9
3	44.5	39.9	-803	4.1	-8,974	1.0	-9,604	1.0	-9,650	1.0	-9,656	1.0
4	44.9	40.5	-740	3.7	-8,824	1.0	-9,215	1.0	-9,256	1.0	-9,261	1.0
5	46.2	41.5	-1,088	3.5	-7,510	1.2	-7,846	1.2	-7,883	1.2	-7,887	1.2
6	48.3	43.8	-1,348	3.7	-5,396	1.5	-5,694	1.5	-5,728	1.5	-5,733	1.4
7	51.0	46.5	-324	3.9	-2,726	1.8	-2,965	1.8	-2,991	1.8	-2,995	1.8
8	54.2	49.8	-284	5.5	-782	2.5	-788	2.5	-789	2.5	-790	2.5
9	57.6	52.1	0	8.7	0	4.1	0	4.1	0	4.1	0	4.1
10	61.0	53.5	0	13.3	-105	6.4	-87	6.6	-74	6.6	-74	6.6
11	64.1	55.0	0	18.6	0	10.7	0	10.6	0	10.6	0	10.6
12	66.9	56.1	0	23.8	0	13.3	0	13.4	0	13.4	0	13.4
13	68.9	57.1	0	26.9	0	15.5	0	15.5	0	15.5	0	15.5
14	70.3	57.3	0	28.7	0	16.6	0	16.7	0	16.7	0	16.7
15	70.7	57.2	0	29.5	0	16.9	0	16.9	0	16.9	0	16.9
16	70.3	56.4	0	28.3	0	16.3	0	16.3	0	16.3	0	16.3
17	68.9	55.3	0	25.4	0	14.6	0	14.7	0	14.7	0	14.7
18	66.9	53.9	0	20.4	0	12.0	0	12.0	0	12.1	0	12.1
19	64.1	52.7	0	15.5	0	9.3	0	9.4	0	9.4	0	9.4
20	61.0	52.0	0	11.8	0	7.0	0	7.0	0	7.0	0	7.1
21	57.6	49.8	0	9.6	-320	5.3	-320	5.3	-713	5.3	-705	5.3
22	54.2	47.5	0	8.1	-941	3.8	-930	3.8	-929	3.8	-929	3.8
23	51.0	44.9	-120	6.8	-2,910	2.6	-2,858	2.4	-2,858	2.4	-2,858	2.4
24	48.3	42.6	-217	5.9	-4,445	1.5	-4,519	1.8	-4,524	1.8	-4,526	1.8

Figure G.11 Building Cool Heat Demand (5 of 6): Model 1

BUILDING COOL HEAT DEMAND

By ACADEMIC

November	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.9	33.1	-11,056	0.6	-11,653	0.0	-20,594	0.0	-25,585	0.0	-29,471	0.0
2	33.9	31.2	-9,186	0.4	-717	0.0	-34,179	0.0	-35,060	0.0	-33,852	0.0
3	32.3	29.8	-10,191	0.6	-5,881	0.0	-31,710	0.0	-32,425	0.0	-31,956	0.0
4	31.0	28.8	-10,616	0.4	-8,193	0.0	-40,741	0.0	-41,426	0.0	-41,278	0.0
5	30.3	27.9	-10,835	0.3	-15,472	0.0	-48,335	0.0	-50,149	0.0	-50,147	0.0
6	30.0	27.7	-10,707	0.5	-29,737	0.0	-55,890	0.0	-56,203	0.0	-56,257	0.0
7	30.5	28.4	-9,732	0.6	-45,296	0.0	-63,564	0.0	-63,955	0.0	-64,028	0.0
8	32.0	30.0	-8,239	0.7	-47,151	0.0	-60,698	0.0	-61,101	0.0	-61,180	0.0
9	34.3	32.0	-6,122	0.8	-33,466	0.0	-45,701	0.0	-46,079	0.0	-46,230	0.0
10	37.1	34.0	-3,893	2.6	-23,594	0.0	-30,676	0.0	-31,109	0.0	-31,116	0.0
11	40.3	36.2	-1,589	6.4	-13,980	0.0	-19,317	0.0	-19,631	0.0	-19,705	0.0
12	43.5	38.3	-159	11.0	-7,153	1.8	-10,914	1.8	-11,095	1.8	-11,160	1.8
13	46.4	40.1	0	13.8	-4,604	3.3	-5,104	3.3	-5,279	3.3	-5,337	3.3
14	48.6	41.4	0	16.0	-6,025	4.7	-5,582	4.7	-5,554	4.7	-5,551	4.7
15	50.1	42.5	0	17.2	-2,800	4.9	-2,707	4.9	-2,699	4.9	-2,698	4.9
16	50.6	42.6	0	16.3	-2,871	5.3	-2,766	5.3	-2,758	5.3	-2,757	5.3
17	50.3	42.5	0	13.0	-2,469	4.4	-2,390	4.3	-2,383	4.3	-2,382	4.3
18	49.6	42.8	0	8.5	-2,825	3.0	-2,735	3.0	-2,728	3.0	-2,727	3.0
19	48.4	42.9	-857	4.9	-3,619	1.7	-7,112	1.7	-7,158	1.7	-3,535	1.7
20	46.7	42.2	-3,361	2.9	-9,225	1.2	-9,094	1.2	-9,199	1.2	-9,149	1.2
21	44.8	41.1	-4,761	1.7	-11,432	1.0	-11,483	1.0	-11,608	1.0	-11,625	0.9
22	42.6	39.3	-6,765	1.4	-14,415	0.5	-14,154	0.7	-14,277	0.7	-14,348	0.5
23	40.3	37.4	-8,724	0.9	-17,605	0.4	-17,148	0.4	-17,308	0.4	-17,588	0.6
24	38.0	35.3	-10,687	0.9	-17,628	0.0	-18,470	0.0	-18,570	0.0	-18,621	0.0

December	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	23.5	20.5	-30,134	0.0	-17,788	0.0	-77,514	0.0	-77,811	0.0	-77,847	0.0
2	22.9	20.1	-33,091	0.0	-35,125	0.0	-109,738	0.0	-109,999	0.0	-110,031	0.0
3	23.2	20.5	-30,646	0.0	-61,645	0.0	-116,606	0.0	-117,660	0.0	-117,709	0.0
4	24.1	21.7	-37,977	0.0	-105,925	0.0	-104,211	0.0	-105,877	0.0	-105,899	0.0
5	25.5	23.2	-42,778	0.0	-92,296	0.0	-113,913	0.0	-115,373	0.0	-115,792	0.0
6	27.4	25.1	-47,920	0.0	-100,489	0.0	-92,577	0.0	-94,271	0.0	-94,608	0.0
7	29.7	27.4	-46,599	0.0	-78,930	0.0	-95,877	0.0	-96,231	0.0	-96,380	0.0
8	32.3	30.1	-44,473	0.0	-69,144	0.0	-72,712	0.0	-73,190	0.0	-73,254	0.0
9	34.9	32.8	-27,911	0.0	-48,364	0.0	-52,904	0.0	-53,737	0.0	-53,754	0.0
10	37.6	34.9	-14,178	0.4	-33,326	0.0	-34,502	0.0	-34,607	0.0	-34,624	0.0
11	40.1	36.4	-5,292	2.6	-22,780	0.0	-23,615	0.0	-23,705	0.0	-23,721	0.0
12	42.4	37.4	-2,946	7.0	-13,070	1.3	-15,931	1.3	-16,011	1.3	-16,025	1.3
13	44.3	38.1	-780	10.0	-8,872	2.5	-8,648	2.5	-8,670	2.5	-8,676	2.5
14	45.7	38.4	0	11.8	-4,942	4.2	-4,919	4.2	-4,928	4.2	-4,935	4.2
15	46.6	38.6	0	13.6	-10,431	4.5	-10,240	4.5	-10,225	4.5	-10,226	4.5
16	46.9	38.6	0	13.0	-4,571	4.1	-4,476	4.1	-4,468	4.1	-4,464	4.1
17	46.3	38.2	0	10.1	-8,146	3.4	-8,040	3.4	-8,040	3.4	-8,044	3.4
18	44.6	37.6	-1,195	6.3	-11,573	1.7	-11,535	1.6	-11,535	1.6	-11,539	1.6
19	42.0	36.6	-4,191	3.0	-14,941	0.7	-14,866	0.7	-14,868	0.7	-14,872	0.7
20	38.6	34.1	-5,587	1.3	-24,439	0.0	-25,746	0.0	-25,913	0.0	-25,939	0.0
21	34.9	30.9	-7,872	0.8	-30,890	0.0	-31,639	0.0	-31,727	0.0	-31,742	0.0
22	31.2	27.6	-9,860	0.4	-30,648	0.0	-31,231	0.0	-31,294	0.0	-31,305	0.0
23	27.9	24.4	-9,486	0.3	-39,582	0.0	-40,027	0.0	-40,077	0.0	-40,087	0.0
24	25.2	22.1	-17,522	0.0	-47,963	0.0	-48,216	0.0	-48,255	0.0	-48,263	0.0

Figure G.12 Building Cool Heat Demand (6 of 6): Model 1

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - City Hall Offices and Police Department

GSHP

	Year 1				
Month	Average Earth Temp °F	Average Fluid Leaving Temp °F	Average Fluid Entering Temp °F	Minimum Fluid Entering Temp °F	Maximum Fluid Entering Temp °F
Jan	52.70	49.20	47.50	45.40	56.00
Feb	52.60	50.10	48.80	46.60	55.70
Mar	54.40	55.00	55.20	49.20	60.60
Apr	55.80	57.50	58.30	55.50	65.80
May	58.20	62.30	64.30	58.90	71.60
Jun	61.90	69.60	73.30	65.90	79.10
Jul	65.70	76.20	81.30	74.50	86.30
Aug	67.50	77.10	81.80	76.60	89.70
Sep	66.50	72.40	75.30	69.90	86.50
Oct	64.70	67.40	68.70	65.60	80.60
Nov	62.70	62.80	62.90	61.00	71.60
Dec	61.80	61.20	60.90	58.70	67.80
Annual	60.40	63.40	64.90	45.40	89.70

Figure G.13 Geothermal Earth Temperature Summary: Model 1

Table G.1 Heat Pump Selections: Model 1

MODEL 1 - HEAT PUMP SELECTIONS											
			ENERGY MODEL OUTPUTS								
			COOLING					HEATING			
MARK	UNIT SIZE	UNIT AIR FLOW	AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG EWT	HTG Q_T	HTG EWT	UNIT GPM	UNIT WPD
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(°F)	(MBH)	(°F)		(FT)
1	060	1950	2020	4.3	48.4	51.3	80.0	-57.3	50.0	7.5	0.5
2	009	300	250	0.7	7.0	8.1	80.0	-8.7	50.0	1.4	1.4
3	018	600	630	1.4	15.7	16.6	80.0	-17.6	50.0	2.8	0.5
4	042	1050	580	3.2	26.9	37.9	80.0	-37.7	50.0	11.0	7.4
5	012	350	265	1.0	10.0	11.8	80.0	-9.8	50.0	1.8	0.7
6	060	1950	2110	3.9	46.3	46.8	80.0	-57.9	50.0	11.3	4.4
7	018	600	525	1.3	14.1	15.0	80.0	-15.0	50.0	2.8	0.5
8	024	640	600	2.0	18.7	24.4	80.0	-23.4	50.0	4.0	2.3
9	006	180	125	0.5	4.5	5.6	80.0	-5.4	50.0	1.0	0.5
10	012	350	350	1.0	10.2	11.5	80.0	-10.8	50.0	1.8	0.7
11	036	1250	700	2.7	24.4	32.3	80.0	-29.5	50.0	6.8	6.5
12	024	850	775	1.8	17.4	21.3	80.0	-24.4	50.0	4.0	2.3
13	006	180	75	0.3	2.0	3.0	80.0	-4.0	50.0	1.0	0.5
14	070	2100	1195	5.2	38.4	62.3	80.0	-76.6	50.0	8.3	3.7
15	009	300	205	0.7	5.4	7.9	80.0	-10.0	50.0	2.8	5.6
16	006	180	80	0.3	2.3	3.5	80.0	-4.8	50.0	1.0	0.5
17	006	180	50	0.2	1.4	2.1	80.0	-2.8	50.0	1.0	0.5
18	060	1465	960	4.1	31.1	49.7	80.0	-60.4	50.0	11.3	4.4
19	006	180	70	0.2	1.9	2.7	80.0	-3.4	50.0	1.0	0.5
20	006	180	35	0.2	1.1	1.8	80.0	-2.5	50.0	1.0	0.5
21	012	265	175	0.8	5.6	9.0	80.0	-11.6	50.0	1.8	1.1
22	009	300	160	0.7	4.9	7.8	80.0	-9.7	50.0	2.8	5.6
23	030	715	465	2.0	14.6	23.4	80.0	-29.2	50.0	8.0	8.1
24	024	640	560	1.9	19.3	23.0	80.0	-22.5	50.0	4.0	2.3
25	009	225	145	0.6	4.4	6.9	80.0	-8.5	50.0	1.4	1.4
26	030	950	875	2.1	21.8	25.7	80.0	-27.8	50.0	4.0	2.3
27	018	450	410	1.3	13.7	15.5	80.0	-13.3	50.0	2.8	0.5
28	024	640	315	1.7	15.9	19.9	80.0	-15.6	50.0	4.0	2.3
29	009	225	175	0.7	8.6	8.6	80.0	-4.1	50.0	2.1	2.6
30	009	225	185	0.7	8.0	8.1	80.0	-4.9	50.0	2.1	2.6
31	060	1950	2045	4.3	48.9	51.9	80.0	-54.8	50.0	7.5	0.5
32	009	225	200	0.6	5.0	6.7	80.0	-8.4	50.0	1.4	1.4
				51.8		622.1		-672.4		125.5	74.6

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

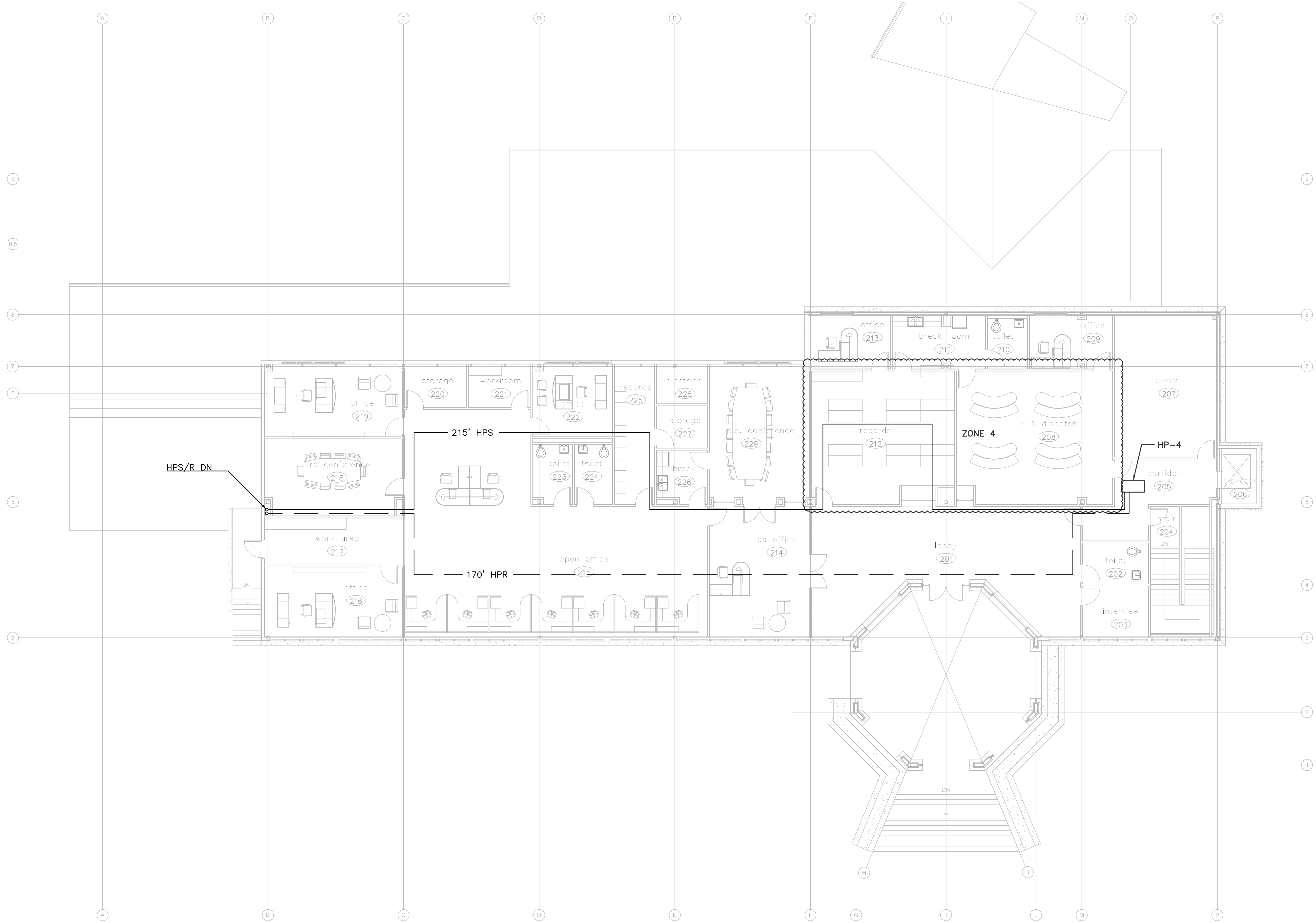


Figure G.14 Building Loop Piping Layout: Model 1

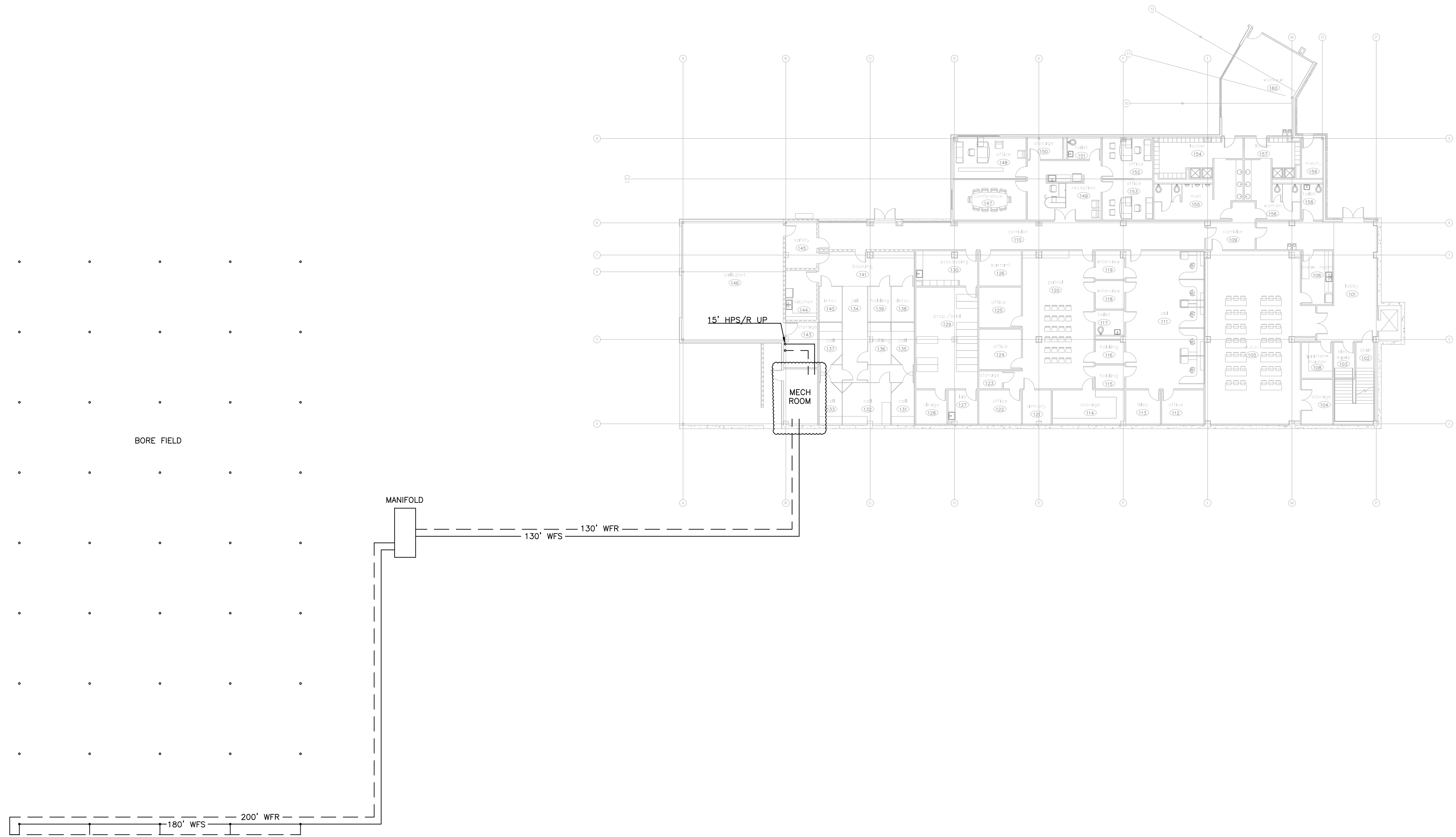


Figure G.15 Ground Loop Piping Layout: Model 1

MODEL	PRIMARY SYSTEM PUMP HEAD CALCULATIONS															PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.2 Primary Pump Head Calculations: All Models

Table G.3 Primary/Secondary Pump Head Calculations: All Models

MODEL	PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS — PRIMARY LOOP										
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL: SUPPLY	DISTANCE TO WELL: RETURN	DISTANCE DOWN/UP WELL	TOTAL PRIMARY LOOP PIPE LENGTH	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD	TOTAL HEAT PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

MODEL	SECONDARY LOOP										
	DISTANCE TO HEAT PUMP: SUPPLY	DISTANCE TO HEAT PUMP: RETURN	TOTAL P/S LOOP PIPE LENGTH	P/S LENGTH W/ FITTINGS (TOTAL*1.5)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	SECONDARY LOOP PUMP HEAD
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	(FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD	PUMP HEAD	PUMP GPM
		SUPPLY	RETURN		SUPPLY	RETURN									
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.4 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS																CIRCULATOR PUMP HEAD
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4		16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2		16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3		13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7		16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9		9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3		21.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM
		(%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table G.5 Distributive Circulator Pump Head Calculations: All Models

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.6 Primary Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.7 Primary/Secondary Pump Schedules: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.8 Distributive w/ Primary - Primary Pump Schedules: All Models

Table G.9 Distributive w/ Primary - Circulator Schedule: Model 1

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
2	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
3	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
4	B & G	NRF-22	11.0	7.4	2940	0.123	92	115	$ 664.00
5	B & G	NRF-9F/LW	1.8	0.7	2800	0.055	41	115	$ 449.00
6	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
7	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
8	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
9	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
10	B & G	NRF-9F/LW	1.8	0.7	2800	0.055	41	115	$ 449.00
11	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
12	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
13	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
14	B & G	NRF-9F/LW	8.3	3.7	2800	0.055	41	115	$ 449.00
15	B & G	NRF-9F/LW	2.8	5.6	2800	0.055	41	115	$ 449.00
16	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
17	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
18	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
19	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
20	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
21	B & G	NRF-9F/LW	1.8	1.1	2800	0.055	41	115	$ 449.00
22	B & G	NRF-9F/LW	2.8	5.6	2800	0.055	41	115	$ 449.00
23	B & G	NRF-22	8.0	8.1	2940	0.123	92	115	$ 664.00
24	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
25	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
26	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
27	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
28	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
29	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
30	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
31	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
32	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
						0.78	584		$ 15,443.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table G.10 Distributive - Circulator Schedule: Model 1

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-36	7.5	16.4	3300	0.362	270	115	$ 1,368.00
2	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
3	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
4	B & G	NRF-36	11.0	16.4	3300	0.362	270	115	$ 1,368.00
5	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
6	B & G	NRF-36	11.3	16.4	3300	0.362	270	115	$ 1,368.00
7	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
8	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
9	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
10	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
11	B & G	NRF-36	6.8	16.4	3300	0.362	270	115	$ 1,368.00
12	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
13	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
14	B & G	NRF-36	8.3	16.4	3300	0.362	270	115	$ 1,368.00
15	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
16	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
17	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
18	B & G	NRF-36	11.3	16.4	3300	0.362	270	115	$ 1,368.00
19	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
20	B & G	NRF-25	1.0	16.4	2950	0.168	125	115	$ 724.00
21	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
22	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
23	B & G	NRF-36	8.0	16.4	3300	0.362	270	115	$ 1,368.00
24	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
25	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
26	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
27	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
28	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
29	B & G	NRF-25	2.1	16.4	2950	0.168	125	115	$ 724.00
30	B & G	NRF-25	2.1	16.4	2950	0.168	125	115	$ 724.00
31	B & G	NRF-36	7.5	16.4	3300	0.362	270	115	$ 1,368.00
32	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
						2.57	1915		$ 28,320.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

MODEL 1 - MONTHLY SIMULTANEOUS HEATING AND COOLING PUMP PART-LOAD % PER HOUR

AVERAGE DAY HOURS	COOLING DESIGN PEAK TONS	HEATING DESIGN PEAK MBH	JANUARY					FEBRUARY					MARCH				
			CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %
1	51.8	672.5	0.0	0.0%	169.7	25.2%	25.2%	0.0	0.0%	217.5	32.3%	32.3%	0.0	0.0%	15.8	2.3%	2.3%
2	51.8	672.5	0.0	0.0%	172.4	25.6%	25.6%	0.0	0.0%	225.8	33.6%	33.6%	0.0	0.0%	14.9	2.2%	2.2%
3	51.8	672.5	0.0	0.0%	177.2	26.3%	26.3%	0.0	0.0%	232.2	34.5%	34.5%	0.0	0.0%	16.1	2.4%	2.4%
4	51.8	672.5	0.0	0.0%	180.3	26.8%	26.8%	0.0	0.0%	237.9	35.4%	35.4%	0.0	0.0%	18.4	2.7%	2.7%
5	51.8	672.5	0.0	0.0%	183.2	27.2%	27.2%	0.0	0.0%	237.7	35.3%	35.3%	0.0	0.0%	20.1	3.0%	3.0%
6	51.8	672.5	0.0	0.0%	182.1	27.1%	27.1%	0.0	0.0%	233.1	34.7%	34.7%	0.0	0.0%	18.0	2.7%	2.7%
7	51.8	672.5	0.0	0.0%	178.6	26.6%	26.6%	0.0	0.0%	225.2	33.5%	33.5%	0.3	0.6%	26.1	3.9%	4.5%
8	51.8	672.5	0.0	0.0%	170.6	25.4%	25.4%	0.0	0.0%	213.9	31.8%	31.8%	0.4	0.8%	15.2	2.3%	3.0%
9	51.8	672.5	0.0	0.0%	146.0	21.7%	21.7%	0.0	0.0%	193.2	28.7%	28.7%	0.5	1.0%	7.0	1.0%	2.0%
10	51.8	672.5	0.0	0.0%	111.1	16.5%	16.5%	0.0	0.0%	163.1	24.3%	24.3%	0.9	1.7%	2.0	0.3%	2.0%
11	51.8	672.5	0.6	1.2%	86.2	12.8%	14.0%	1.0	1.9%	133.8	19.9%	21.8%	3.9	7.5%	0.2	0.0%	7.6%
12	51.8	672.5	2.6	5.0%	55.1	8.2%	13.2%	3.4	6.6%	118.6	17.6%	24.2%	9.1	17.6%	0.1	0.0%	17.6%
13	51.8	672.5	6.1	11.8%	55.1	8.2%	20.0%	6.6	12.7%	106.0	15.8%	28.5%	12.0	23.2%	0.0	0.0%	23.2%
14	51.8	672.5	7.2	13.9%	31.4	4.7%	18.6%	7.6	14.7%	96.6	14.4%	29.0%	14.4	27.8%	0.0	0.0%	27.8%
15	51.8	672.5	7.2	13.9%	27.5	4.1%	18.0%	7.9	15.3%	90.9	13.5%	28.8%	17.1	33.0%	0.0	0.0%	33.0%
16	51.8	672.5	6.7	12.9%	37.5	5.6%	18.5%	8.8	17.0%	91.2	13.6%	30.5%	17.3	33.4%	0.0	0.0%	33.4%
17	51.8	672.5	5.9	11.4%	34.0	5.0%	16.4%	7.6	14.7%	96.6	14.4%	29.0%	15.9	30.7%	0.0	0.0%	30.7%
18	51.8	672.5	2.3	4.4%	56.0	8.3%	12.8%	4.7	9.1%	105.1	15.6%	24.7%	12.9	24.9%	0.0	0.0%	24.9%
19	51.8	672.5	0.0	0.0%	67.9	10.1%	10.1%	1.5	2.9%	115.6	17.2%	20.1%	8.8	17.0%	0.0	0.0%	17.0%
20	51.8	672.5	0.0	0.0%	82.8	12.3%	12.3%	0.0	0.0%	126.8	18.9%	18.9%	5.3	10.2%	0.8	0.1%	10.4%
21	51.8	672.5	0.0	0.0%	94.8	14.1%	14.1%	0.0	0.0%	146.2	21.7%	21.7%	3.0	5.8%	2.8	0.4%	6.2%
22	51.8	672.5	0.0	0.0%	106.3	15.8%	15.8%	0.0	0.0%	185.6	27.6%	27.6%	1.8	3.5%	4.5	0.7%	4.1%
23	51.8	672.5	0.0	0.0%	133.4	19.8%	19.8%	0.0	0.0%	197.9	29.4%	29.4%	1.5	2.9%	6.1	0.9%	3.8%
24	51.8	672.5	0.0	0.0%	153.4	22.8%	22.8%	0.0	0.0%	210.0	31.2%	31.2%	1.2	2.3%	7.4	1.1%	3.4%

AVERAGE DAY HOURS	APRIL					MAY					JUNE				
	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %
1	1.7	3.3%	1.0	0.1%	3.4%	8.1	15.6%	0.0	0.0%	15.6%	15.2	29.3%	0.0	0.0%	29.3%
2	2.2	4.2%	1.4	0.2%	4.5%	7.7	14.9%	0.0	0.0%	14.9%	14.6	28.2%	0.0	0.0%	28.2%
3	2.1	4.1%	2.0	0.3%	4.4%	7.3	14.1%	0.0	0.0%	14.1%	14.1	27.2%	0.0	0.0%	27.2%
4	2.0	3.9%	2.4	0.4%	4.2%	6.9	13.3%	0.0	0.0%	13.3%	13.7	26.4%	0.0	0.0%	26.4%
5	2.0	3.9%	2.6	0.4%	4.2%	6.7	12.9%	0.0	0.0%	12.9%	13.4	25.9%	0.0	0.0%	25.9%
6	2.1	4.1%	2.4	0.4%	4.4%	6.8	13.1%	0.0	0.0%	13.1%	13.8	26.6%	0.0	0.0%	26.6%
7	2.3	4.4%	1.7	0.3%	4.7%	7.8	15.1%	0.0	0.0%	15.1%	15.4	29.7%	0.0	0.0%	29.7%
8	2.8	5.4%	0.8	0.1%	5.5%	9.7	18.7%	0.0	0.0%	18.7%	17.7	34.2%	0.0	0.0%	34.2%
9	4.7	9.1%	0.2	0.0%	9.1%	12.2	23.6%	0.0	0.0%	23.6%	20.5	39.6%	0.0	0.0%	39.6%
10	7.7	14.9%	2.0	0.3%	15.2%	15.5	29.9%	0.0	0.0%	29.9%	23.5	45.4%	0.0	0.0%	45.4%
11	12.2	23.6%	0.0	0.0%	23.6%	19.5	37.6%	0.0	0.0%	37.6%	27.5	53.1%	0.0	0.0%	53.1%
12	15.9	30.7%	0.0	0.0%	30.7%	23.5	45.4%	0.0	0.0%	45.4%	31.2	60.2%	0.0	0.0%	60.2%
13	18.8	36.3%	0.0	0.0%	36.3%	26.2	50.6%	0.0	0.0%	50.6%	34.3	66.2%	0.0	0.0%	66.2%
14	21.0	40.5%	0.0	0.0%	40.5%	28.1	54.2%	0.0	0.0%	54.2%	36.3	70.1%	0.0	0.0%	70.1%
15	22.3	43.1%	0.0	0.0%	43.1%	28.9	55.8%	0.0	0.0%	55.8%	37.1	71.6%	0.0	0.0%	71.6%
16	22.5	43.4%	0.0	0.0%	43.4%	28.7	55.4%	0.0	0.0%	55.4%	36.9	71.2%	0.0	0.0%	71.2%
17	21.0	40.5%	0.0	0.0%	40.5%	27.7	53.5%	0.0	0.0%	53.5%	35.2	68.0%	0.0	0.0%	68.0%
18	18.4	35.5%	0.0	0.0%	35.5%	25.7	49.6%	0.0	0.0%	49.6%	33.2	64.1%	0.0	0.0%	64.1%
19	14.8	28.6%	0.0	0.0%	28.6%	22.7	43.8%	0.0	0.0%	43.8%	30.5	58.9%	0.0	0.0%	58.9%
20	10.9	21.0%	0.0	0.0%	21.0%	18.8	36.3%	0.0	0.0%	36.3%	26.7	51.5%	0.0	0.0%	51.5%
21	7.8	15.1%	0.0	0.0%	15.1%	15.2	29.3%	0.0	0.0%	29.3%	23.1	44.6%	0.0	0.0%	44.6%
22	5.8	11.2%	0.0	0.0%	11.2%	12.2	23.6%	0.0	0.0%	23.6%	19.9	38.4%	0.0	0.0%	38.4%
23	4.7	9.1%	0.5	0.1%	9.1%	10.6	20.5%	0.0	0.0%	20.5%	17.7	34.2%	0.0	0.0%	34.2%
24	3.9	7.5%	0.8	0.1%	7.6%	9.6	18.5%	0.0	0.0%	18.5%	16.5	31.9%	0.0	0.0%	31.9%

AVERAGE DAY HOURS	COOLING DESIGN PEAK TONS	HEATING DESIGN PEAK MBH	JULY					AUGUST					SEPTEMBER				
			CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %
1	51.8	672.5	21.1	40.7%	0.0	0.0%	40.7%	19.4	37.5%	0.0	0.0%	37.5%	11.2	21.6%	0.0	0.0%	21.6%
2	51.8	672.5	20.4	39.4%	0.0	0.0%	39.4%	18.4	35.5%	0.0	0.0%	35.5%	10.2	19.7%	0.0	0.0%	19.7%
3	51.8	672.5	19.9	38.4%	0.0	0.0%	38.4%	17.8	34.4%	0.0	0.0%	34.4%	9.4	18.1%	0.0	0.0%	18.1%
4	51.8	672.5	19.6	37.8%	0.0	0.0%	37.8%	17.2	33.2%	0.0	0.0%	33.2%	8.8	17.0%	0.0	0.0%	17.0%
5	51.8	672.5	19.3	37.3%	0.0	0.0%	37.3%	17.1	33.0%	0.0	0.0%	33.0%	8.4	16.2%	0.0	0.0%	16.2%
6	51.8	672.5	19.5	37.6%	0.0	0.0%	37.6%	17.2	33.2%	0.0	0.0%	33.2%	8.5	16.4%	0.0	0.0%	16.4%
7	51.8	672.5	21.0	40.5%	0.0	0.0%	40.5%	18.0	34.7%	0.0	0.0%	34.7%	9.0	17.4%	0.0	0.0%	17.4%
8	51.8	672.5	23.3	45.0%	0.0	0.0%	45.0%	19.9	38.4%	0.0	0.0%	38.4%	10.9	21.0%	0.0	0.0%	21.0%
9	51.8	672.5	26.3	50.8%	0.0	0.0%	50.8%	23.2	44.8%	0.0	0.0%	44.8%	14.5	28.0%	0.0	0.0%	28.0%
10	51.8	672.5	29.7	57.3%	0.0	0.0%	57.3%	27.7	53.5%	0.0	0.0%	53.5%	20.0	38.6%	0.0	0.0%	38.6%
11	51.8	672.5	33.4	64.5%	0.0	0.0%	64.5%	33.1	63.9%	0.0	0.0%	63.9%	26.3	50.8%	0.0	0.0%	50.8%
12	51.8	672.5	37.4	72.2%	0.0	0.0%	72.2%	37.9	73.2%	0.0	0.0%	73.2%	31.2	60.2%	0.0	0.0%	60.2%
13	51.8	672.5	40.4	78.0%	0.0	0.0%	78.0%	40.9	79.0%	0.0	0.0%	79.0%	33.9	65.4%	0.0	0.0%	65.4%
14	51.8	672.5	42.3	81.7%	0.0	0.0%	81.7%	42.6	82.2%	0.0	0.0%	82.2%	35.8	69.1%	0.0	0.0%	69.1%
15	51.8	672.5	42.9	82.8%	0.0	0.0%	82.8%	43.4	83.8%	0.0	0.0%	83.8%	37.3	72.0%	0.0	0.0%	72.0%
16	51.8	672.5	42.4	81.9%	0.0	0.0%	81.9%	42.6	82.2%	0.0	0.0%	82.2%	36.6	70.7%	0.0	0.0%	70.7%
17	51.8	672.5	40.5	78.2%	0.0	0.0%	78.2%	39.8	76.8%	0.0	0.0%	76.8%	33.6	64.9%	0.0	0.0%	64.9%
18	51.8	672.5	38.2	73.7%	0.0	0.0%	73.7%	36.6	70.7%	0.0	0.0%	70.7%	29.1	56.2%	0.0	0.0%	56.2%
19	51.8	672.5	35.8	69.1%	0.0	0.0%	69.1%	32.9	63.5%	0.0	0.0%	63.5%	24.2	46.7%	0.0	0.0%	46.7%
20	51.8	672.5	32.0	61.8%	0.0	0.0%	61.8%	28.9	55.8%	0.0	0.0%	55.8%	20.1	38.8%	0.0	0.0%	38.8%
21	51.8	672.5	28.6	55.2%	0.0	0.0%	55.2%	25.9	50.0%	0.0	0.0%	50.0%	16.7	32.2%	0.0	0.0%	32.2%
22	51.8	672.5	25.7	49.6%	0.0	0.0%	49.6%	23.0	44.4%	0.0	0.0%	44.4%	14.5	28.0%	0.0	0.0%	28.0%
23	51.8	672.5	23.7	45.8%	0.0	0.0%	45.8%	21.0	40.5%	0.0	0.0%	40.5%	12.9	24.9%	0.0	0.0%	24.9%
24	51.8	672.5	22.3	43.1%	0.0	0.0%	43.1%	19.6	37.8%	0.0	0.0%	37.8%	11.7	22.6%	0.0	0.0%	22.6%

AVERAGE DAY HOURS	OCTOBER					NOVEMBER					DECEMBER				
	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %	CLG DESIGN TONS PER HOUR	CLG %	HTG DESIGN MBH PER HOUR	HTG %	TOTAL %
1	5.3	10.2%	0.4	0.1%	10.3%	0.6	1.2%	11.1	1.7%	2.8%	0.0	0.0%	30.1	4.5%	4.5%
2	4.5	8.7%	0.1	0.0%	8.7%	0.4	0.8%	9.2	1.4%	2.1%	0.0	0.0%	33.1	4.9%	4.9%
3	4.1	7.9%	0.8	0.1%	8.0%	0.6	1.2%	10.2	1.5%	2.7%	0.0	0.0%	30.6	4.6%	4.6%
4	3.7	7.1%	0.7	0.1%	7.2%	0.4	0.8%	10.6	1.6%	2.3%	0.0	0.0%	38.0	5.7%	5.7%
5	3.5	6.8%	1.1	0.2%	6.9%	0.3	0.6%	10.8	1.6%	2.2%	0.0	0.0%	42.8	6.4%	6.4%
6	3.7	7.1%	1.3	0.2%	7.3%	0.5	1.0%	10.7	1.6%	2.6%	0.0	0.0%	48.0	7.1%	7.1%
7	3.9	7.5%	0.3	0.0%	7.6%	0.6	1.2%	9.7	1.4%	2.6%	0.0	0.0%	46.6	6.9%	6.9%
8	5.5	10.6%	0.3	0.0%	10.7%	0.7	1.4%	8.2	1.2%	2.6%	0.0	0.0%	44.5	6.6%	6.6%
9	8.7	16.8%	0.0	0.0%	16.8%	0.8	1.5%	6.1	0.9%	2.5%	0.0	0.0%	27.9	4.1%	4.1%
10	13.3	25.7%	0.0	0.0%	25.7%	2.6	5.0%	3.9	0.6%	5.6%	0.4	0.8%	14.2	2.1%	2.9%
11	18.6	35.9%	0.0	0.0%	35.9%	6.4	12.4%	1.6	0.2%	12.6%	2.6	5.0%	5.3	0.8%	5.8%
12	23.8	45.9%	0.0	0.0%	45.9%	11.0	21.2%	0.2	0.0%	21.3%	7.0	13.5%	2.9	0.4%	13.9%
13	26.9	51.9%	0.0	0.0%	51.9%	13.8	26.6%	0.0	0.0%	26.6%	10.0	19.3%	0.8	0.1%	19.4%
14	28.7	55.4%	0.0	0.0%	55.4%	16.0	30.9%	0.0	0.0%	30.9%	11.8	22.8%	0.0	0.0%	22.8%
15	29.5	56.9%	0.0	0.0%	56.9%	17.2	33.2%	0.0	0.0%	33.2%	13.6	26.3%	0.0	0.0%	26.3%
16	28.3	54.6%	0.0	0.0%	54.6%	16.3	31.5%	0.0	0.0%	31.5%	13.0	25.1%	0.0	0.0%	25.1%
17	25.4	49.0%	0.0	0.0%	49.0%	13.0	25.1%	0.0	0.0%	25.1%	10.1	19.5%	0.0	0.0%	19.5%
18	20.4	39.4%	0.0	0.0%	39.4%	8.5	16.4%	0.0	0.0%	16.4%	6.3	12.2%	1.2	0.2%	12.3%
19	15.5	29.9%	0.0	0.0%	29.9%	4.9	9.5%	0.9	0.1%	9.6%	3.0	5.8%	4.2	0.6%	6.4%
20	11.8	22.8%	0.0	0.0%	22.8%	2.9	5.6%	3.4	0.5%	6.1%	1.3	2.5%	5.6	0.8%	3.3%
21	9.6	18.5%	0.0	0.0%	18.5%	1.7	3.3%	4.8	0.7%	4.0%	0.8	1.5%	7.9	1.2%	2.7%
22	8.1	15.6%	0.0	0.0%	15.6%	1.4	2.7%	6.8	1.0%	3.7%	0.4	0.8%	9.9	1.5%	2.2%
23	6.8	13.1%	0.1	0.0%	13.1%	0.9	1.7%	8.7	1.3%	3.0%	0.3	0.6%	9.5	1.4%	2.0%
24	5.9	11.4%	0.2	0.0%	11.4%	0.9	1.7%	10.7	1.6%	3.3%	0.0	0.0%	17.5	2.6%	2.6%

GENERAL NOTES:
1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table G.11 Monthly Simultaneous Heating and Cooling Part-Load % Per Hour: Model 1

MODEL 1 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION	
4.52	**BHP**
3.37	**KW**

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	25.2%	0.05	32.3%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.3%	0.09
2	25.6%	0.06	33.6%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03	28.2%	0.08
3	26.3%	0.06	34.5%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	27.2%	0.07
4	26.8%	0.06	35.4%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.4%	0.06
5	27.2%	0.07	35.3%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	25.9%	0.06
6	27.1%	0.07	34.7%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.6%	0.06
7	26.6%	0.06	33.5%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.7%	0.09
8	25.4%	0.06	31.8%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	34.2%	0.13
9	21.7%	0.03	28.7%	0.08	20.0%	0.03	20.0%	0.03	23.6%	0.04	39.6%	0.21
10	20.0%	0.03	24.3%	0.05	20.0%	0.03	20.0%	0.03	29.9%	0.09	45.4%	0.31
11	20.0%	0.03	21.8%	0.04	20.0%	0.03	23.6%	0.04	37.6%	0.18	53.1%	0.50
12	20.0%	0.03	24.2%	0.05	20.0%	0.03	30.7%	0.10	45.4%	0.31	60.2%	0.74
13	20.0%	0.03	28.5%	0.08	23.2%	0.04	36.3%	0.16	50.6%	0.44	66.2%	0.98
14	20.0%	0.03	29.0%	0.08	27.8%	0.07	40.5%	0.22	54.2%	0.54	70.1%	1.16
15	20.0%	0.03	28.8%	0.08	33.0%	0.12	43.1%	0.27	55.8%	0.59	71.6%	1.24
16	20.0%	0.03	30.5%	0.10	33.4%	0.13	43.4%	0.28	55.4%	0.57	71.2%	1.22
17	20.0%	0.03	29.0%	0.08	30.7%	0.10	40.5%	0.22	53.5%	0.52	68.0%	1.06
18	20.0%	0.03	24.7%	0.05	24.9%	0.05	35.5%	0.15	49.6%	0.41	64.1%	0.89
19	20.0%	0.03	20.1%	0.03	20.0%	0.03	28.6%	0.08	43.8%	0.28	58.9%	0.69
20	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.0%	0.03	36.3%	0.16	51.5%	0.46
21	20.0%	0.03	21.7%	0.03	20.0%	0.03	20.0%	0.03	29.3%	0.09	44.6%	0.30
22	20.0%	0.03	27.6%	0.07	20.0%	0.03	20.0%	0.03	23.6%	0.04	38.4%	0.19
23	20.0%	0.03	29.4%	0.09	20.0%	0.03	20.0%	0.03	20.5%	0.03	34.2%	0.13
24	22.8%	0.04	31.2%	0.10	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.9%	0.11
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		0.94		2.08		1.00		1.94		4.53		10.82

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	40.7%	0.23	37.5%	0.18	21.6%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
2	39.4%	0.21	35.5%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
3	38.4%	0.19	34.4%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
4	37.8%	0.18	33.2%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
5	37.3%	0.17	33.0%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
6	37.6%	0.18	33.2%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
7	40.5%	0.22	34.7%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
8	45.0%	0.31	38.4%	0.19	21.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
9	50.8%	0.44	44.8%	0.30	28.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
10	57.3%	0.64	53.5%	0.52	38.6%	0.19	25.7%	0.06	20.0%	0.03	20.0%	0.03
11	64.5%	0.90	63.9%	0.88	50.8%	0.44	35.9%	0.16	20.0%	0.03	20.0%	0.03
12	72.2%	1.27	73.2%	1.32	60.2%	0.74	45.9%	0.33	21.3%	0.03	20.0%	0.03
13	78.0%	1.60	79.0%	1.66	65.4%	0.94	51.9%	0.47	26.6%	0.06	20.0%	0.03
14	81.7%	1.84	82.2%	1.87	69.1%	1.11	55.4%	0.57	30.9%	0.10	22.8%	0.04
15	82.8%	1.91	83.8%	1.98	72.0%	1.26	56.9%	0.62	33.2%	0.12	26.3%	0.06
16	81.9%	1.85	82.2%	1.87	70.7%	1.19	54.6%	0.55	31.5%	0.11	25.1%	0.05
17	78.2%	1.61	76.8%	1.53	64.9%	0.92	49.0%	0.40	25.1%	0.05	20.0%	0.03
18	73.7%	1.35	70.7%	1.19	56.2%	0.60	39.4%	0.21	20.0%	0.03	20.0%	0.03
19	69.1%	1.11	63.5%	0.86	46.7%	0.34	29.9%	0.09	20.0%	0.03	20.0%	0.03
20	61.8%	0.79	55.8%	0.59	38.8%	0.20	22.8%	0.04	20.0%	0.03	20.0%	0.03
21	55.2%	0.57	50.0%	0.42	32.2%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03
22	49.6%	0.41	44.4%	0.30	28.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
23	45.8%	0.32	40.5%	0.22	24.9%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03
24	43.1%	0.27	37.8%	0.18	22.6%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		18.58		16.86		8.51		3.84		0.96		0.72

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.12 Daily Pump Consumption (Primary): Model 1

Table G.13 Primary System Annual Utility Cost: Model 1

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	0.94	31	29	$ 0.09	$ 2.63
FEBRUARY	2.08	28	58	$ 0.09	$ 5.25
MARCH	1.00	31	31	$ 0.09	$ 2.78
APRIL	1.94	30	58	$ 0.09	$ 5.23
MAY	4.53	31	141	$ 0.09	$ 12.65
JUNE	10.82	30	325	$ 0.09	$ 29.22
JULY	18.58	31	576	$ 0.09	$ 51.84
AUGUST	16.86	31	523	$ 0.09	$ 47.05
SEPTEMBER	8.51	30	255	$ 0.09	$ 22.99
OCTOBER	3.84	31	119	$ 0.09	$ 10.72
NOVEMBER	0.96	30	29	$ 0.09	$ 2.60
DECEMBER	0.72	31	22	$ 0.09	$ 2.01
ANNUAL UTILITY CONSUMPTION & COST			2166	KWH	$ 194.96

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 1 - DAILY PUMP CONSUMPTION		
TOTAL PRIMARY + SECONDARY PUMP CONSUMPTION	4.44	BHP
	3.31	KW

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	25.2%	0.05	32.3%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.3%	0.08
2	25.6%	0.06	33.6%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03	28.2%	0.07
3	26.3%	0.06	34.5%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	27.2%	0.07
4	26.8%	0.06	35.4%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.4%	0.06
5	27.2%	0.07	35.3%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	25.9%	0.06
6	27.1%	0.07	34.7%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.6%	0.06
7	26.6%	0.06	33.5%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.7%	0.09
8	25.4%	0.05	31.8%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	34.2%	0.13
9	21.7%	0.03	28.7%	0.08	20.0%	0.03	20.0%	0.03	23.6%	0.04	39.6%	0.21
10	20.0%	0.03	24.3%	0.05	20.0%	0.03	20.0%	0.03	29.9%	0.09	45.4%	0.31
11	20.0%	0.03	21.8%	0.03	20.0%	0.03	23.6%	0.04	37.6%	0.18	53.1%	0.50
12	20.0%	0.03	24.2%	0.05	20.0%	0.03	30.7%	0.10	45.4%	0.31	60.2%	0.72
13	20.0%	0.03	28.5%	0.08	23.2%	0.04	36.3%	0.16	50.6%	0.43	66.2%	0.96
14	20.0%	0.03	29.0%	0.08	27.8%	0.07	40.5%	0.22	54.2%	0.53	70.1%	1.14
15	20.0%	0.03	28.8%	0.08	33.0%	0.12	43.1%	0.26	55.8%	0.57	71.6%	1.22
16	20.0%	0.03	30.5%	0.09	33.4%	0.12	43.4%	0.27	55.4%	0.56	71.2%	1.20
17	20.0%	0.03	29.0%	0.08	30.7%	0.10	40.5%	0.22	53.5%	0.51	68.0%	1.04
18	20.0%	0.03	24.7%	0.05	24.9%	0.05	35.5%	0.15	49.6%	0.40	64.1%	0.87
19	20.0%	0.03	20.1%	0.03	20.0%	0.03	28.6%	0.08	43.8%	0.28	58.9%	0.68
20	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.0%	0.03	36.3%	0.16	51.5%	0.45
21	20.0%	0.03	21.7%	0.03	20.0%	0.03	20.0%	0.03	29.3%	0.08	44.6%	0.29
22	20.0%	0.03	27.6%	0.07	20.0%	0.03	20.0%	0.03	23.6%	0.04	38.4%	0.19
23	20.0%	0.03	29.4%	0.08	20.0%	0.03	20.0%	0.03	20.5%	0.03	34.2%	0.13
24	22.8%	0.04	31.2%	0.10	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.9%	0.11
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		0.93		2.05		0.98		1.90		4.45		10.63

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	40.7%	0.22	37.5%	0.17	21.6%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
2	39.4%	0.20	35.5%	0.15	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
3	38.4%	0.19	34.4%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
4	37.8%	0.18	33.2%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
5	37.3%	0.17	33.0%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
6	37.6%	0.18	33.2%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
7	40.5%	0.22	34.7%	0.14	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
8	45.0%	0.30	38.4%	0.19	21.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
9	50.8%	0.43	44.8%	0.30	28.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
10	57.3%	0.62	53.5%	0.51	38.6%	0.19	25.7%	0.06	20.0%	0.03	20.0%	0.03
11	64.5%	0.89	63.9%	0.86	50.8%	0.43	35.9%	0.15	20.0%	0.03	20.0%	0.03
12	72.2%	1.25	73.2%	1.30	60.2%	0.72	45.9%	0.32	21.3%	0.03	20.0%	0.03
13	78.0%	1.57	79.0%	1.63	65.4%	0.93	51.9%	0.46	26.6%	0.06	20.0%	0.03
14	81.7%	1.80	82.2%	1.84	69.1%	1.09	55.4%	0.56	30.9%	0.10	22.8%	0.04
15	82.8%	1.88	83.8%	1.95	72.0%	1.24	56.9%	0.61	33.2%	0.12	26.3%	0.06
16	81.9%	1.82	82.2%	1.84	70.7%	1.17	54.6%	0.54	31.5%	0.10	25.1%	0.05
17	78.2%	1.58	76.8%	1.50	64.9%	0.90	49.0%	0.39	25.1%	0.05	20.0%	0.03
18	73.7%	1.33	70.7%	1.17	56.2%	0.59	39.4%	0.20	20.0%	0.03	20.0%	0.03
19	69.1%	1.09	63.5%	0.85	46.7%	0.34	29.9%	0.09	20.0%	0.03	20.0%	0.03
20	61.8%	0.78	55.8%	0.57	38.8%	0.19	22.8%	0.04	20.0%	0.03	20.0%	0.03
21	55.2%	0.56	50.0%	0.41	32.2%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03
22	49.6%	0.40	44.4%	0.29	28.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
23	45.8%	0.32	40.5%	0.22	24.9%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03
24	43.1%	0.26	37.8%	0.18	22.6%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		18.25		16.57		8.36		3.77		0.95		0.71

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.14 Daily Pump Consumption (Primary/Secondary): Model 1

Table G.15 Primary/Secondary System Annual Utility Cost: Model 1

PRIMARY/SECONDARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	0.93	31	29	$ 0.09	$ 2.58
FEBRUARY	2.05	28	57	$ 0.09	$ 5.16
MARCH	0.98	31	30	$ 0.09	$ 2.73
APRIL	1.90	30	57	$ 0.09	$ 5.13
MAY	4.45	31	138	$ 0.09	$ 12.43
JUNE	10.63	30	319	$ 0.09	$ 28.71
JULY	18.25	31	566	$ 0.09	$ 50.92
AUGUST	16.57	31	514	$ 0.09	$ 46.22
SEPTEMBER	8.36	30	251	$ 0.09	$ 22.58
OCTOBER	3.77	31	117	$ 0.09	$ 10.53
NOVEMBER	0.95	30	28	$ 0.09	$ 2.55
DECEMBER	0.71	31	22	$ 0.09	$ 1.97
ANNUAL UTILITY CONSUMPTION & COST			2128	KWH	$ 191.51

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 1 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS AND PRIMARY PUMP CONSUMPTION		
	6.08	BHP
	4.53	KW

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	25.2%	0.07	32.3%	0.15	20.0%	0.04	20.0%	0.04	20.0%	0.04	29.3%	0.11
2	25.6%	0.08	33.6%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04	28.2%	0.10
3	26.3%	0.08	34.5%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	27.2%	0.09
4	26.8%	0.09	35.4%	0.20	20.0%	0.04	20.0%	0.04	20.0%	0.04	26.4%	0.08
5	27.2%	0.09	35.3%	0.20	20.0%	0.04	20.0%	0.04	20.0%	0.04	25.9%	0.08
6	27.1%	0.09	34.7%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	26.6%	0.09
7	26.6%	0.08	33.5%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04	29.7%	0.12
8	25.4%	0.07	31.8%	0.15	20.0%	0.04	20.0%	0.04	20.0%	0.04	34.2%	0.18
9	21.7%	0.05	28.7%	0.11	20.0%	0.04	20.0%	0.04	23.6%	0.06	39.6%	0.28
10	20.0%	0.04	24.3%	0.06	20.0%	0.04	20.0%	0.04	29.9%	0.12	45.4%	0.42
11	20.0%	0.04	21.8%	0.05	20.0%	0.04	23.6%	0.06	37.6%	0.24	53.1%	0.68
12	20.0%	0.04	24.2%	0.06	20.0%	0.04	30.7%	0.13	45.4%	0.42	60.2%	0.99
13	20.0%	0.04	28.5%	0.10	23.2%	0.06	36.3%	0.22	50.6%	0.59	66.2%	1.32
14	20.0%	0.04	29.0%	0.11	27.8%	0.10	40.5%	0.30	54.2%	0.72	70.1%	1.56
15	20.0%	0.04	28.8%	0.11	33.0%	0.16	43.1%	0.36	55.8%	0.79	71.6%	1.67
16	20.0%	0.04	30.5%	0.13	33.4%	0.17	43.4%	0.37	55.4%	0.77	71.2%	1.64
17	20.0%	0.04	29.0%	0.11	30.7%	0.13	40.5%	0.30	53.5%	0.69	68.0%	1.42
18	20.0%	0.04	24.7%	0.07	24.9%	0.07	35.5%	0.20	49.6%	0.55	64.1%	1.19
19	20.0%	0.04	20.1%	0.04	20.0%	0.04	28.6%	0.11	43.8%	0.38	58.9%	0.93
20	20.0%	0.04	20.0%	0.04	20.0%	0.04	21.0%	0.04	36.3%	0.22	51.5%	0.62
21	20.0%	0.04	21.7%	0.05	20.0%	0.04	20.0%	0.04	29.3%	0.11	44.6%	0.40
22	20.0%	0.04	27.6%	0.10	20.0%	0.04	20.0%	0.04	23.6%	0.06	38.4%	0.26
23	20.0%	0.04	29.4%	0.12	20.0%	0.04	20.0%	0.04	20.5%	0.04	34.2%	0.18
24	22.8%	0.05	31.2%	0.14	20.0%	0.04	20.0%	0.04	20.0%	0.04	31.9%	0.15
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		1.27		2.80		1.34		2.60		6.10		14.56

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	40.7%	0.31	37.5%	0.24	21.6%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
2	39.4%	0.28	35.5%	0.20	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
3	38.4%	0.26	34.4%	0.18	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
4	37.8%	0.25	33.2%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
5	37.3%	0.23	33.0%	0.16	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
6	37.6%	0.24	33.2%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
7	40.5%	0.30	34.7%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
8	45.0%	0.41	38.4%	0.26	21.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
9	50.8%	0.59	44.8%	0.41	28.0%	0.10	20.0%	0.04	20.0%	0.04	20.0%	0.04
10	57.3%	0.85	53.5%	0.69	38.6%	0.26	25.7%	0.08	20.0%	0.04	20.0%	0.04
11	64.5%	1.22	63.9%	1.18	50.8%	0.59	35.9%	0.21	20.0%	0.04	20.0%	0.04
12	72.2%	1.71	73.2%	1.78	60.2%	0.99	45.9%	0.44	21.3%	0.04	20.0%	0.04
13	78.0%	2.15	79.0%	2.23	65.4%	1.27	51.9%	0.63	26.6%	0.09	20.0%	0.04
14	81.7%	2.47	82.2%	2.52	69.1%	1.50	55.4%	0.77	30.9%	0.13	22.8%	0.05
15	82.8%	2.58	83.8%	2.67	72.0%	1.69	56.9%	0.84	33.2%	0.17	26.3%	0.08
16	81.9%	2.49	82.2%	2.52	70.7%	1.60	54.6%	0.74	31.5%	0.14	25.1%	0.07
17	78.2%	2.17	76.8%	2.06	64.9%	1.24	49.0%	0.53	25.1%	0.07	20.0%	0.04
18	73.7%	1.82	70.7%	1.60	56.2%	0.80	39.4%	0.28	20.0%	0.04	20.0%	0.04
19	69.1%	1.50	63.5%	1.16	46.7%	0.46	29.9%	0.12	20.0%	0.04	20.0%	0.04
20	61.8%	1.07	55.8%	0.79	38.8%	0.26	22.8%	0.05	20.0%	0.04	20.0%	0.04
21	55.2%	0.76	50.0%	0.57	32.2%	0.15	20.0%	0.04	20.0%	0.04	20.0%	0.04
22	49.6%	0.55	44.4%	0.40	28.0%	0.10	20.0%	0.04	20.0%	0.04	20.0%	0.04
23	45.8%	0.43	40.5%	0.30	24.9%	0.07	20.0%	0.04	20.0%	0.04	20.0%	0.04
24	43.1%	0.36	37.8%	0.25	22.6%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		24.99		22.69		11.45		5.17		1.29		0.97

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.16 Daily Pump Consumption (Distributive w/ Primary): Model 1

Table G.17 Distributive w/ Primary System Annual Utility Cost: Model 1

DISTRIBUTIVE W/ PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.27	31	39	$ 0.09	$ 3.54
FEBRUARY	2.80	28	78	$ 0.09	$ 7.06
MARCH	1.34	31	42	$ 0.09	$ 3.74
APRIL	2.60	30	78	$ 0.09	$ 7.03
MAY	6.10	31	189	$ 0.09	$ 17.02
JUNE	14.56	30	437	$ 0.09	$ 39.31
JULY	24.99	31	775	$ 0.09	$ 69.73
AUGUST	22.69	31	703	$ 0.09	$ 63.29
SEPTEMBER	11.45	30	344	$ 0.09	$ 30.92
OCTOBER	5.17	31	160	$ 0.09	$ 14.42
NOVEMBER	1.29	30	39	$ 0.09	$ 3.50
DECEMBER	0.97	31	30	$ 0.09	$ 2.70
ANNUAL UTILITY CONSUMPTION & COST			2914	KWH	$ 262.25

GENERAL NOTES:
1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 1 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS CONSUMPTION	**6.92**	**BHP**
	5.16	**KW**

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	25.2%	0.08	32.3%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04	29.3%	0.13
2	25.6%	0.09	33.6%	0.20	20.0%	0.04	20.0%	0.04	20.0%	0.04	28.2%	0.12
3	26.3%	0.09	34.5%	0.21	20.0%	0.04	20.0%	0.04	20.0%	0.04	27.2%	0.10
4	26.8%	0.10	35.4%	0.23	20.0%	0.04	20.0%	0.04	20.0%	0.04	26.4%	0.10
5	27.2%	0.10	35.3%	0.23	20.0%	0.04	20.0%	0.04	20.0%	0.04	25.9%	0.09
6	27.1%	0.10	34.7%	0.21	20.0%	0.04	20.0%	0.04	20.0%	0.04	26.6%	0.10
7	26.6%	0.10	33.5%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	29.7%	0.14
8	25.4%	0.08	31.8%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04	34.2%	0.21
9	21.7%	0.05	28.7%	0.12	20.0%	0.04	20.0%	0.04	23.6%	0.07	39.6%	0.32
10	20.0%	0.04	24.3%	0.07	20.0%	0.04	20.0%	0.04	29.9%	0.14	45.4%	0.48
11	20.0%	0.04	21.8%	0.05	20.0%	0.04	23.6%	0.07	37.6%	0.28	53.1%	0.77
12	20.0%	0.04	24.2%	0.07	20.0%	0.04	30.7%	0.15	45.4%	0.48	60.2%	1.13
13	20.0%	0.04	28.5%	0.12	23.2%	0.06	36.3%	0.25	50.6%	0.67	66.2%	1.50
14	20.0%	0.04	29.0%	0.13	27.8%	0.11	40.5%	0.34	54.2%	0.82	70.1%	1.78
15	20.0%	0.04	28.8%	0.12	33.0%	0.19	43.1%	0.41	55.8%	0.90	71.6%	1.90
16	20.0%	0.04	30.5%	0.15	33.4%	0.19	43.4%	0.42	55.4%	0.88	71.2%	1.87
17	20.0%	0.04	29.0%	0.13	30.7%	0.15	40.5%	0.34	53.5%	0.79	68.0%	1.62
18	20.0%	0.04	24.7%	0.08	24.9%	0.08	35.5%	0.23	49.6%	0.63	64.1%	1.36
19	20.0%	0.04	20.1%	0.04	20.0%	0.04	28.6%	0.12	43.8%	0.43	58.9%	1.05
20	20.0%	0.04	20.0%	0.04	20.0%	0.04	21.0%	0.05	36.3%	0.25	51.5%	0.71
21	20.0%	0.04	21.7%	0.05	20.0%	0.04	20.0%	0.04	29.3%	0.13	44.6%	0.46
22	20.0%	0.04	27.6%	0.11	20.0%	0.04	20.0%	0.04	23.6%	0.07	38.4%	0.29
23	20.0%	0.04	29.4%	0.13	20.0%	0.04	20.0%	0.04	20.5%	0.04	34.2%	0.21
24	22.8%	0.06	31.2%	0.16	20.0%	0.04	20.0%	0.04	20.0%	0.04	31.9%	0.17
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		1.44		3.19		1.52		2.96		6.94		16.57

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	40.7%	0.35	37.5%	0.27	21.6%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
2	39.4%	0.32	35.5%	0.23	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
3	38.4%	0.29	34.4%	0.21	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
4	37.8%	0.28	33.2%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
5	37.3%	0.27	33.0%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
6	37.6%	0.28	33.2%	0.19	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
7	40.5%	0.34	34.7%	0.22	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
8	45.0%	0.47	38.4%	0.29	21.0%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
9	50.8%	0.68	44.8%	0.46	28.0%	0.11	20.0%	0.04	20.0%	0.04	20.0%	0.04
10	57.3%	0.97	53.5%	0.79	38.6%	0.30	25.7%	0.09	20.0%	0.04	20.0%	0.04
11	64.5%	1.38	63.9%	1.35	50.8%	0.68	35.9%	0.24	20.0%	0.04	20.0%	0.04
12	72.2%	1.94	73.2%	2.02	60.2%	1.13	45.9%	0.50	21.3%	0.05	20.0%	0.04
13	78.0%	2.45	79.0%	2.54	65.4%	1.45	51.9%	0.72	26.6%	0.10	20.0%	0.04
14	81.7%	2.81	82.2%	2.87	69.1%	1.70	55.4%	0.88	30.9%	0.15	22.8%	0.06
15	82.8%	2.93	83.8%	3.03	72.0%	1.93	56.9%	0.95	33.2%	0.19	26.3%	0.09
16	81.9%	2.83	82.2%	2.87	70.7%	1.82	54.6%	0.84	31.5%	0.16	25.1%	0.08
17	78.2%	2.47	76.8%	2.34	64.9%	1.41	49.0%	0.61	25.1%	0.08	20.0%	0.04
18	73.7%	2.07	70.7%	1.82	56.2%	0.91	39.4%	0.32	20.0%	0.04	20.0%	0.04
19	69.1%	1.70	63.5%	1.32	46.7%	0.53	29.9%	0.14	20.0%	0.04	20.0%	0.04
20	61.8%	1.22	55.8%	0.90	38.8%	0.30	22.8%	0.06	20.0%	0.04	20.0%	0.04
21	55.2%	0.87	50.0%	0.65	32.2%	0.17	20.0%	0.04	20.0%	0.04	20.0%	0.04
22	49.6%	0.63	44.4%	0.45	28.0%	0.11	20.0%	0.04	20.0%	0.04	20.0%	0.04
23	45.8%	0.49	40.5%	0.34	24.9%	0.08	20.0%	0.04	20.0%	0.04	20.0%	0.04
24	43.1%	0.41	37.8%	0.28	22.6%	0.06	20.0%	0.04	20.0%	0.04	20.0%	0.04
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		28.44		25.82		13.03		5.88		1.47		1.10

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.18 Daily Pump Consumption (Distributive): Model 1

Table G.19 Distributive System Annual Utility Cost: Model 1

DISTRIBUTIVE SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.44	31	45	$ 0.09	$ 4.03
FEBRUARY	3.19	28	89	$ 0.09	$ 8.04
MARCH	1.52	31	47	$ 0.09	$ 4.25
APRIL	2.96	30	89	$ 0.09	$ 8.00
MAY	6.94	31	215	$ 0.09	$ 19.37
JUNE	16.57	30	497	$ 0.09	$ 44.74
JULY	28.44	31	882	$ 0.09	$ 79.36
AUGUST	25.82	31	800	$ 0.09	$ 72.04
SEPTEMBER	13.03	30	391	$ 0.09	$ 35.19
OCTOBER	5.88	31	182	$ 0.09	$ 16.41
NOVEMBER	1.47	30	44	$ 0.09	$ 3.98
DECEMBER	1.10	31	34	$ 0.09	$ 3.08
ANNUAL UTILITY CONSUMPTION & COST			3316	KWH	$ 298.48

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 1 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 22,389.00	$ 2,274.60	$ 141,655.17	$ 29,105.70	$ 4,435.47	$ 80,383.37	$ 194.96	$ 15,413.18	$ 600.00	$ 676.00	$ 1,880.00	$ 31,509.38	$ 144.00	$ 11,384.38	$ 280,345.48
PRIMARY/SECONDARY	$ 32,293.20	$ 3,519.00	$ 205,687.05	$ 41,981.16	$ 6,862.05	$ 117,055.60	$ 191.51	$ 15,140.43	$ 1,200.00	$ 1,352.00	$ 2,580.00	$ 55,941.14	$ 216.00	$ 17,076.57	$ 410,900.79
DISTRIBUTIVE W/ PRIMARY	$ 24,942.06	$ 2,289.65	$ 156,405.06	$ 32,424.68	$ 4,464.81	$ 88,407.80	$ 262.25	$ 20,733.01	$ 600.00	$ 676.00	$ 1,780.00	$ 30,909.58	$ 835.20	$ 66,029.40	$ 362,484.84
DISTRIBUTIVE	$ 28,886.40	$ 1,767.86	$ 176,062.49	$ 37,552.32	$ 3,447.33	$ 98,258.06	$ 298.48	$ 23,597.29	$ -	$ -	$ -	$ -	$ 691.20	$ 54,645.02	$ 352,562.86

GENERAL NOTES:

1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. 100% REDUNDANCY WAS ASSUMED FOR ALL PRIMARY AND SECONDARY PUMPING CONFIGURATIONS
13. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table G.20 30-Year Life-Cycle Cost Analysis: Model 1

System Checksums

By ACADEMIC

System - 002 | Water Source Heat Pump

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 96 / 75 / 101

Clg Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	150,350	150,350	16	0	0
Glass Solar	92,259	0	92,259	10	107,465	19
Glass/Door Cond	11,353	0	11,353	1	8,379	1
Wall Cond	36,423	15,466	51,889	6	36,806	6
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	140,035	165,817	305,852	33	152,660	27
Internal Loads						
Lights	83,963	13,394	97,358	10	83,963	15
People	135,434	0	135,434	14	71,990	13
Misc	211,603	0	211,603	23	211,603	37
Sub Total ==>	431,000	13,394	444,395	47	367,556	64
Ceiling Load	49,298	-49,298	0	0	46,537	8
Ventilation Load	0	0	196,460	21	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	8,270		8,270	1	8,270	1
Exhaust Heat		-23,201	-23,201	-2		
Sup. Fan Heat			8,312	1		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	628,603	106,712	940,087	100.00	575,013	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-111,886	11.07
Glass Solar	0	0	0.00
Glass/Door Cond	-45,697	-45,697	4.52
Wall Cond	-43,445	-62,543	6.19
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-89,142	-220,126	21.78
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-33,326	0	0.00
Ventilation Load	0	-315,129	31.18
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-490,827	-490,827	48.56
Exhaust Heat		15,301	-1.51
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-613,295	-1,010,781	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	79.7	66.7
Return	79.6	66.7
Ret/OA	82.2	56.8
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	28,052	28,052
Terminal	28,052	28,052
Main Fan	28,052	28,052
Sec Fan	0	0
Nom Vent	4,429	4,429
AHU Vent	4,429	4,429
Infil	0	0
MinStop/Rh	0	0
Return	27,981	27,981
Exhaust	4,358	4,358
Rm Exh	71	71
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	15.8	15.8
cfm/ft²	0.86	0.86
cfm/ton	358.08	
ft²/ton	414.66	
Btu/hr·ft²	28.94	-30.87
No. People	289	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	78.3	940.1	777.5	28,052	82.3	64.1	63.2	55.0	52.6	57.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	78.3	940.1								

AREAS

	Gross Total	Glass ft²	(%)
Floor	32,485		
Part	0		
Int Door	0		
ExFlr	0		
Roof	32,128	0	0
Wall	16,639	1,604	10
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-1,002.9	28,052	56.8	90.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-1,002.9			

Figure G.16 System Checksums: Model 2

SYSTEM SUMMARY

DESIGN COOLING CAPACITIES

By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

		Peak Plant Loads								Block Plant Loads									
						Stg 1	Stg 2			Time					Stg 1	Stg 2			
		Main	Aux	Opt Vent	Misc	Desic	Desic	Base	Peak	Of	Main	Aux	Opt Vent	Misc	Desic	Desic	Base	Block
		Coil	Coil	Coil	Load	Cond	Cond	Utility	Total	Peak	Coil	Coil	Coil	Load	Cond	Cond	Utility	Total
Plant	System	ton	ton	ton	ton	ton	ton	ton	ton	mo/hr	ton	ton	ton	ton	ton	ton	ton	ton
GCHP		78.3	0.0	0.0	0.0	0.0	0.0	0.0	78.3	7/15	71.8	0.0	0.0	0.0	0.0	0.0	0.0	71.8
	System - 002	78.3	0.0	0.0	0.0	0.0	0.0	0.0	78.3	7/15	71.8	0.0	0.0	0.0	0.0	0.0	0.0	71.8
Building totals		78.3	0.0	0.0	0.0	0.0	0.0	0.0	78.3		71.8	0.0	0.0	0.0	0.0	0.0	0.0	71.8

Building peak load is 78.3 tons.

Building maximum block load of 71.8 tons occurs in July at hour 15 based on system simulation

Figure G.17 Design Cooling Capacities: Model 2

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure G.18 Load/Airflow Summary (1 of 4): Model 2

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		224 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
	Zone - 009		Zn Peak	600	2.0	4,451	5,573	127			0	-5,362	127	26.7	26.7
	Zone - 009		Zn Block	600	2.0	4,464	5,571	127			0	-6,669	127	26.7	26.7
		220 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		221 - Workroom	Rm Peak	100	0.0	881	1,057	38	2.27	0	0	-1,311	38	15.9	15.9
		222 - Office	Rm Peak	225	1.1	7,699	8,435	274	7.29	0	0	-7,808	274	7.0	7.0
	Zone - 010		Zn Peak	425	1.1	10,224	11,473	349			0	-10,845	349	10.6	10.6
	Zone - 010		Zn Block	425	1.1	10,224	11,473	349			0	-11,936	349	10.6	10.6
		225 - Records	Rm Peak	175	0.0	2,172	2,471	42	1.45	0	0	-1,728	42	24.8	24.8
		226 - Breakroom	Rm Peak	100	2.5	1,974	2,690	46	2.78	0	0	-2,375	46	39.9	39.9
		227 - Storage	Rm Peak	100	0.0	1,217	1,531	17	1.04	0	0	-1,239	17	69.2	69.2
		228 - Electrical	Rm Peak	100	0.0	1,530	1,707	38	2.27	0	0	-1,311	38	15.9	15.9
		229 - Conference	Rm Peak	450	22.5	17,536	23,862	557	7.43	0	0	-22,848	557	25.0	25.0
	Zone - 011		Zn Peak	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
	Zone - 011		Zn Block	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
		214 - PS Office	Rm Peak	425	12.1	17,365	21,270	777	10.97	0	0	-24,383	777	11.1	11.1
	Zone - 012		Zn Peak	425	12.1	17,365	21,270	777			0	-24,303	777	11.1	11.1
	Zone - 012		Zn Block	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
		103 - Elev Equip	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		104 - Storage	Rm Peak	150	0.0	978	1,497	34	1.37	0	0	-2,055	34	52.5	52.5
		108 - Quartermaster	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 013		Zn Peak	350	0.5	2,040	3,008	75			0	-4,015	75	43.5	43.5
	Zone - 013		Zn Block	350	0.5	2,045	3,007	75			0	-5,425	75	43.5	43.5
		105 - EOC	Rm Peak	1,250	83.3	38,434	62,341	1,194	5.73	0	0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Peak	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Block	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
		111 - CID	Rm Peak	880	4.4	5,432	7,902	204	1.39	0	0	-9,988	204	36.8	36.8
	Zone - 015		Zn Peak	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
	Zone - 015		Zn Block	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
		112 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		113 - Files	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		114 - Storage	Rm Peak	200	0.0	1,110	1,749	35	1.04	0	0	-2,478	35	69.2	69.2
	Zone - 016		Zn Peak	400	1.0	2,345	3,545	81			0	-4,748	81	50.7	50.7
	Zone - 016		Zn Block	400	1.0	2,345	3,545	81			0	-5,571	81	50.7	50.7
		121 - Armory	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		122 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		123 - Storage	Rm Peak	36	0.0	200	315	6	1.04	0	0	-446	6	69.2	69.2
	Zone - 017		Zn Peak	236	0.5	1,372	2,087	47			0	-2,820	47	53.1	53.1
	Zone - 017		Zn Block	236	0.5	1,372	2,087	47			0	-4,760	47	53.1	53.1
		115 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		116 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9

* This report does not display heating only systems .

Figure G.19 Load/Airflow Summary (2 of 4): Model 2

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		117 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
		118 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		119 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		120 - Patrol	Rm Peak	800	53.3	24,457	39,651	757	5.68	0	0	-48,864	757	59.2	59.2
	Zone - 018		Zn Peak	1,300	63.3	31,126	49,652	960			0	-60,431	960	56.9	56.9
	Zone - 018		Zn Block	1,300	63.3	31,115	49,641	960			0	-60,430	960	56.9	56.9
		124 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		125 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		126 - Warrant	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 019		Zn Peak	300	1.5	1,852	2,694	69			0	-3,405	69	36.8	36.8
	Zone - 019		Zn Block	300	1.5	1,852	2,694	69			0	-5,298	69	36.8	36.8
		127 - Lab	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		128 - Drugs	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
	Zone - 020		Zn Peak	200	0.0	1,110	1,749	35			0	-2,478	35	69.2	69.2
	Zone - 020		Zn Block	200	0.0	1,110	1,749	35			0	-4,474	35	69.2	69.2
		129 - Prop/Evid	Rm Peak	360	0.0	1,999	3,148	62	1.04	0	0	-4,460	62	69.2	69.2
		130 - Processing	Rm Peak	150	7.5	3,606	5,821	113	4.52	0	0	-7,181	113	57.8	57.8
	Zone - 021		Zn Peak	510	7.5	5,604	8,969	175			0	-11,641	175	61.8	61.8
	Zone - 021		Zn Block	510	7.5	5,604	8,968	175			0	-11,641	175	61.8	61.8
		131 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		132 - Cell	Rm Peak	180	4.5	2,555	4,055	83	2.78	0	0	-5,020	83	52.9	52.9
		133 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
	Zone - 022		Zn Peak	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
	Zone - 022		Zn Block	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
		134 - Jail	Rm Peak	175	0.0	972	1,530	30	1.04	0	0	-2,168	30	69.2	69.2
		135 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		136 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		137 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		138 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		139 - Holding	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		140 - Irtox	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		141 - Booking	Rm Peak	270	13.5	6,491	10,477	203	4.52	0	0	-12,926	203	57.8	57.8
	Zone - 023		Zn Peak	949	26.1	14,617	23,360	467			0	-29,150	467	56.1	56.1
	Zone - 023		Zn Block	949	26.1	14,617	23,360	467			0	-29,149	467	56.1	56.1
		142 - Mech	Rm Peak	150	0.0	1,176	1,452	49	1.41	0	0	-1,704	49	10.2	10.2
		143 - Storage	Rm Peak	150	0.0	940	1,424	31	1.23	0	0	-1,971	31	58.6	58.6
		146 - Sallyport	Rm Peak	900	0.0	17,172	20,087	481	3.21	0	0	-18,860	481	22.5	22.5
	Zone - 024		Zn Peak	1,200	0.0	19,287	22,963	561			0	-22,535	561	24.1	24.1
	Zone - 024		Zn Block	1,200	0.0	18,920	22,838	561			0	-22,622	561	24.1	24.1
		144 - Kitchen	Rm Peak	150	0.0	667	919	26	1.04	0	0	-1,238	26	34.6	34.6
		145 - Safety	Rm Peak	150	7.5	3,690	5,939	117	4.68	0	0	-7,276	117	55.8	55.8

* This report does not display heating only systems .

Figure G.20 Load/Airflow Summary (3 of 4): Model 2

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
	Zone - 025		Zn Peak	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
	Zone - 025		Zn Block	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
		110 - Corridor	Rm Peak	475	0.0	12,940	13,837	577	7.29	0	0	-15,659	577	4.9	4.9
		147 - Conference	Rm Peak	240	12.0	8,839	11,895	296	7.41	0	0	-12,162	296	25.1	25.1
	Zone - 026		Zn Peak	715	12.0	21,779	25,733	874			0	-27,821	874	11.8	11.8
	Zone - 026		Zn Block	715	12.0	21,017	25,322	874			0	-27,821	874	11.8	11.8
		148 - Office	Rm Peak	240	1.2	7,223	7,990	259	6.47	0	0	-7,551	259	7.9	7.9
		150 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		151 - Toilet	Rm Peak	100	0.0	1,418	1,418	38	2.27	0	0	-897	38	0.0	0.0
		152 - Office	Rm Peak	225	1.1	3,401	4,066	78	2.07	0	0	-3,165	78	24.6	24.6
	Zone - 027		Zn Peak	665	2.3	13,685	15,454	412			0	-13,338	412	12.5	12.5
	Zone - 027		Zn Block	665	2.3	13,622	15,439	412			0	-13,436	412	12.5	12.5
		109 - Corridor	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		110 - Corridor (Int)	Rm Peak	475	0.0	2,111	2,911	82	1.04	0	0	-3,919	82	34.6	34.6
		149 - Reception	Rm Peak	320	9.1	10,443	12,832	161	3.03	0	0	-8,308	161	40.2	40.2
		153 - Office	Rm Peak	225	1.1	2,875	3,498	52	1.39	0	0	-2,554	52	36.8	36.8
	Zone - 028		Zn Peak	1,120	10.3	15,873	19,854	313			0	-15,606	313	37.9	37.9
	Zone - 028		Zn Block	1,120	10.3	15,802	19,639	313			0	-15,606	313	37.9	37.9
		154 - Locker	Rm Peak	400	0.0	4,656	4,656	104	1.55	0	0	-2,458	104	0.0	0.0
		155 - Men	Rm Peak	400	0.0	3,963	3,963	69	1.04	0	0	-1,644	69	0.0	0.0
	Zone - 029		Zn Peak	800	0.0	8,619	8,619	173			0	-4,102	173	0.0	0.0
	Zone - 029		Zn Block	800	0.0	8,619	8,619	173			0	-7,754	173	0.0	0.0
		156 - Women	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		157 - Locker	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		158 - Toilet	Rm Peak	100	0.0	1,691	1,691	55	3.28	0	0	-1,298	55	0.0	0.0
		159 - Mech	Rm Peak	100	0.0	1,796	1,963	55	3.28	0	0	-1,712	55	11.0	11.0
	Zone - 030		Zn Peak	650	0.0	7,946	8,113	187			0	-4,860	187	3.2	3.2
	Zone - 030		Zn Block	650	0.0	7,777	7,962	187			0	-8,098	187	3.2	3.2
		160 - Workout	Rm Peak	575	2.9	48,899	51,906	2,044	21.33	0	0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Peak	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Block	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
		101 - Lobby (Ext)	Rm Peak	420	0.0	2,973	3,712	128	1.82	0	0	-4,763	128	19.8	19.8
		101 - Lobby (Int)	Rm Peak	154	0.0	684	944	27	1.04	0	0	-1,271	27	34.6	34.6
		106 - Breakroom	Rm Peak	100	2.5	1,309	2,034	46	2.78	0	0	-2,375	46	39.9	39.9
	Zone - 032		Zn Peak	674	2.5	4,966	6,691	201			0	-8,409	201	26.4	26.4
	Zone - 032		Zn Block	674	2.5	4,977	6,689	201			0	-8,409	201	26.4	26.4
System - 001			**Sys Peak**	**22,381**	**353.3**	**497,753**	**621,719**	**17,305**				**-672,528**	**17,305**	**22.0**	**22.0**
System - 001			**Sys Block**	**22,381**	**353.3**	**439,737**	**574,626**	**17,305**				**-672,612**	**17,305**	**22.0**	**22.0**

* This report does not display heating only systems .

Figure G.21 Load/Airflow Summary (4 of 4): Model 2

BUILDING COOL HEAT DEMAND

By ACADEMIC

January	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	CADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	6.2	5.4	-178,349	4.8	-214,089	10.3	-226,462	10.6	-226,542	10.6	-226,533	10.6
2	5.0	4.1	-182,748	5.2	-226,218	10.1	-234,381	10.4	-234,453	10.4	-234,445	10.4
3	4.2	3.3	-187,280	5.9	-236,308	9.9	-240,272	10.2	-240,340	10.2	-240,333	10.2
4	3.9	3.2	-189,633	6.0	-242,253	9.9	-243,288	10.1	-243,342	10.1	-243,335	10.1
5	4.3	3.5	-191,963	6.0	-241,988	9.9	-243,355	10.0	-243,449	10.0	-243,418	10.0
6	5.4	4.4	-190,856	8.4	-237,740	9.9	-238,383	10.1	-238,418	10.0	-238,413	10.0
7	7.1	6.2	-198,593	9.7	-230,154	10.0	-231,204	10.2	-231,254	10.1	-231,233	10.1
8	9.3	8.3	-179,045	9.9	-219,274	10.2	-219,679	10.3	-219,703	10.3	-219,700	10.3
9	11.0	10.0	-157,509	10.2	-201,364	10.6	-201,728	10.7	-201,748	10.6	-201,743	10.6
10	14.4	13.3	-134,267	10.9	-178,022	11.1	-178,355	11.2	-178,812	11.2	-178,374	11.2
11	16.9	15.4	-101,280	12.1	-157,018	11.9	-157,317	12.0	-157,297	12.0	-157,335	12.0
12	10.1	17.3	76,665	13.6	138,046	12.8	138,301	12.8	138,284	12.8	138,318	12.8
13	20.8	18.6	-61,607	16.4	-121,378	13.5	-121,822	13.5	-121,794	13.5	-121,824	13.5
14	21.9	19.5	-52,020	18.1	-115,098	14.1	-115,275	14.1	-115,263	14.1	-115,293	14.1
15	22.3	19.6	-48,142	19.7	-109,276	14.7	-109,363	14.7	-109,337	14.7	-109,364	14.7
16	22.0	19.3	-48,746	20.4	-109,773	14.8	-111,285	14.8	-111,264	14.8	-111,289	14.8
17	21.2	18.7	-53,900	19.7	-116,430	14.6	-114,283	14.6	-114,260	14.5	-114,283	14.5
18	20.0	17.7	-65,631	17.6	-128,952	13.9	-129,043	13.9	-129,043	13.8	-129,067	13.8
19	18.3	16.4	-86,816	15.5	-146,076	13.0	-147,072	13.0	-147,064	13.0	-147,085	13.0
20	16.4	14.8	-108,925	14.0	-162,670	12.3	-162,896	12.3	-162,890	12.3	-162,909	12.3
21	14.2	13.0	-122,829	12.9	-175,735	11.9	-175,902	11.9	-175,894	11.8	-175,912	11.8
22	12.0	10.8	-134,143	12.5	-190,858	11.5	-190,980	11.5	-190,971	11.5	-190,988	11.5
23	9.9	8.8	-153,110	12.0	-204,178	11.2	-204,278	11.2	-204,269	11.1	-204,285	11.1
24	7.9	6.9	-160,078	11.5	-215,974	10.9	-216,062	10.9	-216,054	10.9	-216,068	10.8
February	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	CADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	17.2	16.3	-136,028	12.7	-149,120	12.2	-159,126	12.4	-159,241	12.4	-159,123	12.4
2	15.3	14.4	-141,287	12.6	-160,302	11.9	-171,154	12.1	-171,248	12.1	-171,178	12.1
3	13.7	12.7	-146,342	12.4	-170,725	11.7	-179,568	11.6	-179,677	11.6	-179,616	11.6
4	12.4	11.4	-150,415	12.3	-181,783	11.2	-188,909	11.7	-189,001	11.7	-188,974	11.7
5	11.3	10.5	-151,801	12.3	-182,215	11.0	-197,139	11.2	-197,210	11.2	-197,207	11.2
6	10.7	10.0	-150,711	12.2	-197,421	10.9	-202,227	11.1	-202,871	11.1	-202,917	11.1
7	10.5	9.9	-146,713	12.2	-203,189	10.8	-206,112	11.0	-205,219	11.0	-205,241	11.0
8	11.1	10.6	-137,003	12.5	-201,032	10.8	-202,350	10.9	-202,443	10.9	-202,456	10.9
9	12.8	12.2	-116,882	13.0	-185,827	11.1	-186,959	11.2	-187,041	11.2	-187,051	11.2
10	15.3	14.4	-90,499	14.3	-165,928	11.7	-166,866	11.8	-166,939	11.8	-166,948	11.8
11	18.5	16.9	-60,990	16.3	-142,842	12.5	-143,226	12.6	-143,268	12.6	-143,273	12.6
12	21.8	19.8	-42,164	20.0	-119,636	13.4	-119,937	13.5	-119,976	13.5	-119,981	13.5
13	25.0	22.0	-28,094	21.0	-99,558	14.6	-100,423	14.8	-100,444	14.8	-100,440	14.8
14	27.5	24.8	-20,639	22.7	-86,453	15.5	-85,984	15.5	-86,001	15.5	-86,003	15.5
15	29.2	26.3	-17,493	23.8	-77,546	16.1	-77,672	16.1	-77,687	16.1	-77,689	16.1
16	29.0	26.0	-16,633	24.2	-73,440	16.5	-73,555	16.5	-73,569	16.5	-73,570	16.5
17	29.6	26.8	-20,133	23.9	-73,177	16.6	-73,278	16.6	-73,291	16.6	-73,293	16.6
18	29.0	26.4	-29,801	21.9	-76,796	16.3	-76,889	16.3	-76,901	16.3	-76,902	16.3
10	28.0	26.7	30,380	18.9	87,327	15.5	87,632	15.5	87,682	15.5	87,680	15.6
20	26.6	25.0	-59,228	16.3	-100,056	14.6	-100,262	14.6	-100,294	14.6	-100,299	14.6
21	25.0	23.5	-76,616	14.8	-114,428	13.9	-114,586	13.9	-114,610	13.9	-114,613	13.9
22	23.1	21.9	-95,464	13.9	-124,986	13.3	-125,900	13.3	-125,922	13.3	-125,926	13.3
23	21.2	20.1	-105,806	13.4	-137,478	13.1	-136,685	13.1	-137,473	13.1	-137,476	13.1
24	19.1	18.2	-119,443	13.0	-148,412	12.7	-148,689	12.7	-148,467	12.7	-148,469	12.7

Figure G.22 Building Cool Heat Demand (1 of 6): Model 2

BUILDING COOL HEAT DEMAND

By ACADEMIC

March	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.4	33.4	-29,916	17.0	-11,701	15.7	-49,665	15.8	-50,179	15.8	-50,184	15.8
2	33.9	31.9	-32,580	16.8	-21,768	15.2	-59,366	15.3	-59,700	15.3	-59,705	15.3
3	32.9	31.1	-35,429	16.6	-48,172	14.9	-70,557	15.0	-70,785	15.0	-70,787	15.0
4	32.6	31.1	-37,548	16.4	-61,819	14.6	-76,794	14.7	-77,097	14.8	-77,100	14.8
5	32.9	31.5	-38,593	16.5	-70,000	14.5	-78,524	14.7	-78,899	14.7	-78,903	14.7
6	33.9	32.5	-37,922	16.6	-70,743	14.6	-76,209	14.7	-76,421	14.7	-76,422	14.7
7	35.4	34.2	-34,684	16.8	-67,844	14.8	-71,129	14.9	-71,250	14.9	-71,251	14.9
8	37.4	36.1	-28,039	18.0	-59,055	15.5	-61,882	15.6	-61,890	15.6	-61,891	15.6
9	39.7	37.9	-15,779	20.3	-46,501	16.9	-48,729	17.0	-48,942	17.0	-48,948	17.0
10	42.1	39.6	-6,311	23.1	-33,061	18.4	-34,905	18.5	-34,927	18.5	-34,931	18.5
11	44.6	41.5	0	25.8	-22,472	19.6	-23,950	19.7	-23,955	19.7	-23,956	19.7
12	46.9	43.0	0	29.2	-14,255	20.7	-14,737	20.8	-14,680	20.9	-14,680	20.9
13	48.9	44.3	0	32.0	-8,649	21.9	-8,736	22.0	-8,735	22.0	-8,736	22.0
14	50.4	45.0	-151	34.8	-5,057	22.7	-5,040	22.8	-5,039	22.8	-5,039	22.8
15	51.4	45.4	0	36.5	0	23.1	-27	23.2	-30	23.2	-30	23.2
16	51.7	45.5	0	36.8	0	23.7	0	23.7	0	23.7	0	23.7
17	51.4	45.1	0	35.8	0	23.7	0	23.7	0	23.7	0	23.8
18	50.4	44.2	-70	33.5	0	22.7	0	22.8	0	22.8	0	22.8
19	48.9	43.4	-347	29.4	-6,103	21.4	-6,095	21.4	-6,097	21.4	-6,097	21.4
20	46.9	42.8	-625	24.7	-9,829	19.8	-9,855	19.8	-9,857	19.8	-9,857	19.8
21	44.6	41.4	-68	21.6	-17,076	18.6	-17,084	18.6	-17,084	18.6	-17,085	18.6
22	42.1	39.6	-231	20.0	-27,255	17.7	-27,393	17.7	-27,400	17.7	-27,400	17.7
23	39.7	37.4	-334	18.9	-34,832	17.1	-34,362	17.0	-34,368	17.0	-34,368	17.0
24	37.4	35.0	-540	18.3	-40,119	16.3	-40,127	16.3	-40,135	16.3	-40,136	16.3

April	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	48.1	46.0	-7,015	20.3	-105	19.4	-178	19.6	-182	19.6	-182	19.6
2	45.9	44.2	-8,255	19.9	-407	18.7	-466	18.8	-469	18.8	-469	18.8
3	44.1	42.4	-10,324	19.8	-769	18.1	-5,614	18.2	-5,612	18.1	-5,611	18.1
4	42.5	40.9	-11,854	19.8	-655	17.5	-16,230	17.6	-16,644	17.7	-16,663	17.7
5	41.3	39.8	-12,592	19.6	-11,263	17.2	-26,422	17.2	-26,632	17.2	-26,639	17.2
6	40.6	39.3	-12,191	19.6	-20,937	16.8	-30,306	16.8	-31,223	16.9	-31,253	16.9
7	40.4	39.1	-9,849	20.5	-22,598	17.0	-34,560	17.1	-34,648	17.0	-34,678	17.0
8	41.1	39.7	-5,361	22.7	-23,635	17.7	-33,524	17.8	-34,660	17.8	-34,666	17.8
9	43.0	40.8	0	25.9	-22,854	19.1	-26,802	19.2	-26,992	19.2	-27,032	19.2
10	45.9	42.4	-202	29.5	-15,926	20.6	-17,248	20.6	-17,517	20.6	-17,527	20.6
11	49.6	44.5	0	33.5	-7,273	22.1	-7,903	22.1	-7,916	22.2	-7,918	22.2
12	53.4	47.5	0	36.6	0	23.9	0	23.9	0	23.9	0	23.9
13	57.0	50.1	0	39.7	0	26.0	0	26.1	0	26.1	0	26.1
14	60.0	52.3	0	41.8	-122	28.1	-58	28.2	-54	28.3	-54	28.3
15	61.9	53.7	-28	43.1	0	30.1	0	30.2	0	30.2	0	30.2
16	62.6	53.9	0	44.7	0	30.8	0	30.8	0	30.8	0	30.9
17	62.3	53.9	-23	44.8	-59	30.1	-57	30.2	-61	30.2	-67	30.2
18	61.6	53.4	0	42.5	-142	29.1	-141	29.1	-141	29.1	-141	29.1
19	60.5	52.6	0	37.8	-224	27.6	-223	27.6	-223	27.6	-223	27.7
20	58.9	52.7	-172	32.1	-318	25.7	-317	25.8	-317	25.8	-317	25.8
21	57.0	52.5	-260	27.2	-416	24.0	-417	24.1	-417	24.1	-417	24.1
22	54.9	51.5	-641	24.4	-562	22.6	-563	22.6	-563	22.6	-564	22.6
23	52.6	50.0	-603	22.8	-90	21.5	-91	21.5	-91	21.5	-91	21.5
24	50.3	48.0	-599	21.7	-139	20.5	-11	20.5	-11	20.5	-11	20.5

Figure G.23 Building Cool Heat Demand (2 of 6): Model 2

BUILDING COOL HEAT DEMAND

By ACADEMIC

May	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	59.2	56.0	-17	26.4	-612	25.1	-611	26.0	-611	26.1	-611	26.2
2	56.8	53.8	-88	26.3	-939	23.6	-937	24.3	-937	24.4	-938	24.4
3	54.8	52.2	-132	25.9	-590	22.5	-589	23.0	-589	23.1	-589	23.1
4	53.3	50.9	-166	25.5	-90	21.8	-90	22.0	-90	22.0	-90	22.0
5	52.3	50.2	-179	25.3	-110	21.0	-110	21.4	-110	21.4	-110	21.4
6	52.0	50.3	-165	25.4	0	20.8	0	21.1	0	21.1	0	21.1
7	52.5	50.8	-111	27.1	-595	21.5	-593	21.7	-593	21.8	-593	21.8
8	53.8	51.6	0	30.4	-102	22.8	-102	23.0	-102	23.1	-102	23.1
9	55.9	52.4	0	35.1	-404	24.9	-404	25.3	-405	25.4	-405	25.4
10	58.5	53.8	0	39.2	-333	27.5	-333	27.9	-333	28.0	-333	28.1
11	61.6	55.1	0	43.0	-127	30.0	-127	30.5	-127	30.5	-127	30.6
12	64.7	56.6	0	47.2	0	32.6	0	32.9	0	33.0	0	33.0
13	67.8	58.2	0	50.8	0	35.0	0	35.3	0	35.3	0	35.4
14	70.4	59.6	0	53.2	0	37.0	0	37.3	0	37.4	0	37.4
15	72.5	61.1	0	54.6	0	39.5	0	39.8	0	39.9	0	39.9
16	73.8	62.4	0	54.7	0	41.0	0	41.3	0	41.4	0	41.4
17	74.3	62.8	0	53.7	0	42.0	0	42.3	0	42.4	0	42.4
18	74.0	62.6	0	51.0	0	40.6	0	40.9	0	41.0	0	41.0
19	73.0	62.1	0	47.0	0	38.8	0	39.0	0	39.1	0	39.1
20	71.5	62.0	0	41.0	0	30.0	0	30.7	0	30.8	0	30.8
21	69.5	63.0	0	36.6	0	34.3	0	35.0	0	35.0	0	35.0
22	67.1	61.9	0	32.5	-16	32.3	-17	32.4	-17	32.5	-17	32.5
23	64.5	59.9	-11	30.1	-144	30.0	-144	30.1	-144	30.1	-144	30.2
24	61.8	58.0	-32	28.7	-206	27.8	-206	27.9	-206	28.0	-206	28.0

June	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	68.3	64.8	0	35.8	0	34.5	0	35.3	0	35.4	0	35.4
2	66.4	63.3	0	35.2	-30	32.8	-34	33.3	-34	33.4	-34	33.4
3	64.8	62.3	0	34.5	-134	31.4	-136	31.8	-137	31.8	-137	31.8
4	63.6	61.5	0	34.0	-212	29.8	-215	30.6	-215	30.7	-215	30.7
5	62.9	61.0	0	33.6	-259	29.1	-166	29.7	-166	29.7	-166	29.8
6	62.6	60.8	0	34.1	-185	28.8	-186	29.4	-186	29.4	-186	29.4
7	63.1	61.4	0	36.6	244	30.2	241	30.8	241	30.0	241	30.0
8	64.5	61.6	0	41.1	-151	32.4	-153	33.1	-153	33.1	-153	33.1
9	66.8	62.3	0	46.7	-23	35.4	-24	36.0	-24	36.0	-24	36.0
10	69.6	63.9	0	51.8	0	39.4	0	39.9	0	40.0	0	40.0
11	72.7	66.0	0	56.6	0	44.1	0	44.7	0	44.8	0	44.8
12	75.8	67.7	0	59.8	0	48.7	0	49.3	0	49.3	0	49.4
13	78.7	69.7	0	62.5	0	52.4	0	52.9	0	53.0	0	53.0
14	80.9	71.1	0	64.5	0	55.3	0	55.7	0	55.8	0	55.8
15	82.3	71.7	0	65.4	0	57.3	0	57.8	0	57.9	0	57.9
16	82.8	72.0	0	65.3	0	58.0	0	58.5	0	58.6	0	58.6
17	82.6	71.4	0	63.9	0	56.6	0	57.1	0	57.2	0	57.2
18	81.8	71.1	0	61.1	0	54.6	0	55.0	0	55.1	0	55.1
19	80.6	70.5	0	56.9	0	52.1	0	52.5	0	52.5	0	52.5
20	79.0	70.3	0	51.3	0	49.0	0	49.3	0	49.3	0	49.3
21	77.1	70.2	0	45.9	0	45.9	0	46.1	0	46.2	0	46.2
22	75.0	69.6	0	41.8	0	43.3	0	43.4	0	43.5	0	43.5
23	72.7	68.0	0	39.0	0	40.2	0	40.3	0	40.4	0	40.4
24	70.5	66.8	0	37.3	0	38.0	0	38.1	0	38.2	0	38.2

Figure G.24 Building Cool Heat Demand (3 of 6): Model 2

BUILDING COOL HEAT DEMAND

By ACADEMIC

July	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	74.2	70.8	0	43.6	0	43.2	0	43.8	0	43.9	0	43.9
2	72.8	69.4	0	42.5	0	41.1	0	41.6	0	41.7	0	41.7
3	71.6	68.6	0	41.9	0	39.9	0	40.1	0	40.2	0	40.2
4	70.6	67.9	0	41.5	0	38.6	0	38.9	0	38.9	0	38.9
5	70.1	67.6	0	41.2	0	37.6	0	38.3	0	38.4	0	38.4
6	69.9	67.5	0	41.4	0	37.2	0	37.9	0	37.9	0	37.9
7	70.2	68.0	0	43.9	0	38.6	0	39.2	0	39.2	0	39.3
8	71.3	68.5	0	48.4	0	41.3	0	41.8	0	41.9	0	41.9
9	73.1	69.1	0	54.1	0	44.9	0	45.4	0	45.5	0	45.5
10	75.2	70.2	0	59.0	0	49.4	0	49.9	0	49.9	0	50.0
11	77.6	71.2	0	63.0	0	53.8	0	54.3	0	54.4	0	54.4
12	80.0	72.8	0	66.7	0	58.4	0	58.9	0	58.9	0	58.9
13	82.2	74.4	0	69.3	0	61.6	0	62.1	0	62.1	0	62.1
14	83.9	76.0	0	71.2	0	64.6	0	65.0	0	65.0	0	65.0
15	85.0	76.6	0	71.8	0	66.1	0	66.5	0	66.5	0	66.5
16	85.4	76.6	0	71.5	0	66.3	0	66.6	0	66.7	0	66.7
17	85.2	76.4	0	70.2	0	65.2	0	65.6	0	65.6	0	65.6
18	84.6	76.2	0	67.5	0	63.5	0	63.7	0	63.7	0	63.7
19	83.7	75.8	0	63.7	0	61.0	0	61.2	0	61.2	0	61.2
20	82.4	76.2	0	59.3	0	58.4	0	58.6	0	58.6	0	58.6
21	81.0	76.1	0	53.5	0	55.6	0	55.8	0	55.8	0	55.8
22	79.3	75.3	0	49.2	0	52.0	0	52.1	0	52.1	0	52.2
23	77.6	73.9	0	46.5	0	49.1	0	49.2	0	49.2	0	49.2
24	75.9	72.5	0	44.7	0	46.5	0	46.6	0	46.6	0	46.6

August	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	73.5	69.6	0	41.1	0	41.4	0	42.2	0	42.3	0	42.3
2	71.7	68.0	0	39.8	0	39.3	0	39.8	0	39.9	0	39.9
3	70.1	66.8	0	39.0	0	37.4	0	37.9	0	38.0	0	38.0
4	68.8	65.7	0	38.2	0	35.5	0	36.3	0	36.3	0	36.4
5	67.8	65.2	0	38.0	-17	34.5	-20	35.2	-20	35.3	-20	35.3
6	67.2	64.7	0	38.2	-22	33.9	-24	34.5	-24	34.5	-24	34.5
7	66.9	64.4	0	39.8	-28	34.0	-29	34.5	-29	34.5	-29	34.5
8	67.5	64.6	0	43.8	-17	35.7	-18	36.2	-19	36.2	-19	36.2
9	69.2	64.9	0	49.6	0	38.6	0	39.0	0	39.0	0	39.1
10	71.7	66.0	0	55.0	0	42.9	0	43.4	0	43.4	0	43.4
11	74.8	67.8	0	60.2	0	48.0	0	48.4	0	48.5	0	48.5
12	78.0	70.0	0	64.8	0	53.3	0	53.7	0	53.8	0	53.8
13	81.1	72.2	0	68.1	0	57.6	0	58.0	0	58.1	0	58.1
14	83.6	73.7	0	69.8	0	60.8	0	61.2	0	61.3	0	61.3
15	85.3	74.8	0	70.4	0	63.3	0	63.7	0	63.7	0	63.7
16	85.9	75.3	0	70.2	0	64.1	0	64.5	0	64.5	0	64.5
17	85.6	75.0	0	68.7	0	62.8	0	63.2	0	63.2	0	63.2
18	85.0	74.8	0	65.4	0	60.7	0	61.0	0	61.1	0	61.1
19	84.0	75.0	0	60.9	0	58.4	0	58.6	0	58.6	0	58.6
20	82.7	75.4	0	54.7	0	55.8	0	56.0	0	56.0	0	56.0
21	81.1	75.8	0	49.9	0	53.6	0	53.8	0	53.8	0	53.8
22	79.3	74.7	0	46.0	0	50.8	0	50.9	0	50.9	0	50.9
23	77.4	73.1	0	43.2	0	47.7	0	47.0	0	47.0	0	47.0
24	75.4	71.1	0	41.3	0	44.7	0	44.8	0	44.8	0	44.8

Figure G.25 Building Cool Heat Demand (4 of 6): Model 2

BUILDING COOL HEAT DEMAND

By ACADEMIC

September	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	62.0	58.8	0	30.9	-196	27.8	-201	28.6	-202	28.7	-202	28.7
2	59.5	56.4	-25	29.4	-567	25.9	-566	26.5	-566	26.6	-566	26.6
3	57.3	54.7	-70	28.5	-680	24.4	-682	24.9	-682	24.9	-682	24.9
4	55.7	53.3	-125	27.8	-544	23.2	-545	23.6	-545	23.6	-545	23.6
5	54.7	52.7	-145	27.4	-76	22.4	-76	22.7	-76	22.7	-76	22.8
6	54.4	52.4	-112	27.5	-601	22.1	-604	22.4	-604	22.4	-604	22.4
7	55.0	53.1	-36	28.1	-88	22.1	-88	22.3	-88	22.4	-88	22.4
8	57.0	54.8	0	30.8	-408	23.8	-470	24.1	-470	24.1	-470	24.1
9	60.0	56.2	0	35.9	-289	26.7	-290	27.2	-290	27.2	-290	27.2
10	63.7	57.6	0	42.5	-40	30.4	-41	30.9	-41	30.9	-41	30.9
11	67.9	59.7	0	48.6	0	34.8	0	35.2	0	35.3	0	35.3
12	72.1	61.7	0	53.5	0	39.1	0	39.5	0	39.5	0	39.5
13	75.9	64.1	0	57.4	0	43.9	0	44.3	0	44.4	0	44.4
14	78.9	65.7	0	59.9	0	47.7	0	48.1	0	48.1	0	48.1
15	80.8	66.9	0	60.9	0	50.3	0	50.6	0	50.7	0	50.7
16	81.5	67.1	0	60.4	0	50.7	0	51.0	0	51.1	0	51.1
17	81.1	67.1	0	58.5	0	49.5	0	49.8	0	49.9	0	49.9
18	80.1	67.3	0	54.8	0	47.6	0	47.0	0	47.0	0	47.0
19	78.5	68.0	0	48.9	0	45.4	0	45.6	0	45.6	0	45.6
20	76.4	69.9	0	43.5	0	44.4	0	44.6	0	44.6	0	44.6
21	73.8	68.7	0	38.5	0	41.1	0	41.3	0	41.3	0	41.3
22	70.9	66.5	0	35.2	0	37.8	0	37.9	0	37.9	0	37.9
23	67.9	64.2	0	33.0	-5	34.5	-5	34.6	-5	34.6	-5	34.6
24	64.9	61.3	0	31.0	-126	31.3	-126	31.3	-126	31.4	-126	31.4

October	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	46.2	40.6	773	23.7	200	18.0	306	18.0	300	18.0	300	18.0
2	44.9	39.9	-601	22.9	-617	18.3	-680	18.3	-682	18.3	-683	18.3
3	44.5	39.9	-61	22.1	-760	17.9	-7,956	17.9	-7,954	17.9	-7,954	17.9
4	44.9	40.5	-552	21.8	-758	17.7	-13,827	17.8	-13,825	17.8	-13,825	17.8
5	46.2	41.5	-94	21.4	-595	17.8	-13,898	17.9	-15,500	17.9	-15,500	17.9
6	48.3	43.8	-569	21.5	-7,515	18.1	-11,369	18.2	-15,850	18.2	-15,850	18.2
7	51.0	46.5	-534	21.8	-8,561	18.7	-10,864	18.8	-12,294	18.8	-12,294	18.8
8	54.2	49.8	-381	23.5	-5,581	20.3	-8,101	20.4	-8,100	20.4	-8,140	20.4
9	57.6	52.1	-113	26.7	0	22.4	0	22.5	0	22.5	0	22.5
10	61.0	53.5	-108	31.5	0	24.8	0	24.9	0	24.9	0	24.9
11	64.1	55.0	0	36.7	-55	27.6	-16	27.7	-12	27.7	-12	27.7
12	66.9	56.1	0	41.0	0	30.4	0	30.4	0	30.4	0	30.4
13	68.9	57.1	0	45.1	0	32.4	0	32.4	0	32.4	0	32.4
14	70.3	57.3	0	48.3	0	34.1	0	34.1	0	34.1	0	34.1
15	70.7	57.2	0	49.8	-55	34.6	0	34.7	0	34.7	0	34.7
16	70.3	56.4	0	49.8	0	34.5	0	34.5	0	34.5	0	34.5
17	68.9	55.3	0	47.9	-40	33.4	0	33.4	0	33.4	0	33.4
18	66.9	53.9	0	43.2	-41	31.4	0	31.3	0	31.3	0	31.3
19	64.1	52.7	0	37.0	-137	28.9	-72	28.8	-72	28.8	-72	28.8
20	61.0	52.0	0	32.4	-243	26.3	-242	26.3	-242	26.3	-242	26.3
21	57.6	49.8	-53	29.2	-719	24.3	-717	24.3	-717	24.3	-717	24.3
22	54.2	47.5	-234	27.0	-611	22.5	-611	22.5	-611	22.5	-611	22.5
23	51.0	44.9	-260	25.3	-107	21.0	-107	21.0	-107	21.0	-107	21.0
24	40.3	42.6	-559	24.2	-115	19.9	-110	19.9	-118	19.9	-119	19.8

Figure G.26 Building Cool Heat Demand (5 of 6): Model 2

BUILDING COOL HEAT DEMAND

By ACADEMIC

November	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.9	33.1	-634	17.3	-36,398	15.8	-52,072	15.9	-52,364	15.9	-52,370	15.9
2	33.9	31.2	-1,227	17.1	-46,526	15.3	-60,443	15.4	-60,509	15.4	-60,512	15.4
3	32.3	29.8	-19,070	16.7	-59,435	14.9	-74,308	15.0	-74,350	15.0	-74,352	15.0
4	31.0	28.8	-24,653	16.5	-74,812	14.6	-82,625	14.7	-82,695	14.7	-82,697	14.7
5	30.3	27.9	-32,077	16.3	-82,493	14.3	-89,044	14.4	-89,063	14.4	-89,065	14.4
6	30.0	27.7	-36,965	16.4	-87,352	14.2	-92,357	14.3	-92,373	14.3	-92,374	14.3
7	30.5	28.4	35,242	16.4	98,318	14.2	01,788	14.3	01,770	14.3	01,780	14.3
8	32.0	30.0	-32,417	16.8	-83,187	14.3	-88,395	14.3	-88,529	14.3	-88,560	14.3
9	34.3	32.0	-22,856	18.2	-73,299	14.7	-74,609	14.7	-76,013	14.7	-76,028	14.7
10	37.1	34.0	-14,042	20.4	-56,767	15.9	-59,064	16.0	-57,984	16.0	-57,985	16.0
11	40.3	36.2	-5,794	23.1	-38,782	17.6	-39,703	17.7	-39,708	17.7	-39,709	17.7
12	43.5	38.3	0	26.3	-28,357	18.9	-28,999	19.0	-29,004	19.0	-29,004	19.0
13	46.4	40.1	0	30.7	-18,958	19.8	-19,165	19.8	-19,167	19.8	-19,167	19.8
14	48.0	41.4	0	32.9	-13,144	20.0	-13,107	20.0	-13,108	20.0	-13,108	20.0
15	50.1	42.5	0	33.7	-9,655	21.4	-9,505	21.3	-9,512	21.4	-9,514	21.4
16	50.6	42.6	0	33.4	-7,373	21.8	-7,387	21.8	-7,405	21.8	-7,406	21.8
17	50.3	42.5	0	31.0	-7,701	21.6	-7,786	21.6	-7,771	21.6	-7,771	21.6
18	49.6	42.8	-193	27.4	-9,799	20.7	-9,821	20.7	-9,821	20.7	-9,821	20.7
19	48.4	42.9	-547	23.7	-13,671	19.7	-13,702	19.7	-13,704	19.7	-13,704	19.7
20	46.7	42.2	-105	21.2	-17,841	18.9	-17,882	18.9	-17,886	18.9	-17,886	18.9
21	44.8	41.1	-87	19.8	-22,705	18.3	-22,864	18.3	-22,891	18.3	-22,892	18.3
22	42.6	39.3	-361	18.8	-28,662	17.6	-28,632	17.6	-28,636	17.6	-28,636	17.6
23	40.3	37.4	-8,538	18.1	-34,514	17.0	-34,513	17.0	-34,516	17.1	-34,517	17.1
24	30.0	36.3	-16,972	17.5	-41,255	16.4	-41,330	16.4	-41,335	16.4	-41,336	16.4

December	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	23.5	20.5	-53,670	15.6	-89,856	13.5	-118,701	13.6	-118,741	13.6	-118,746	13.6
2	22.9	20.1	-59,699	15.2	-111,368	13.1	-126,201	13.2	-126,307	13.2	-126,344	13.2
3	23.2	20.5	-70,115	15.0	-122,358	13.0	-127,071	13.1	-127,143	13.1	-127,165	13.1
4	24.1	21.7	-76,229	14.8	-121,454	12.9	-124,751	13.0	-124,808	13.0	-124,822	13.0
5	25.5	23.2	-79,055	14.6	-116,909	13.1	-119,708	13.2	-119,756	13.2	-119,766	13.2
6	27.4	25.1	-79,104	14.6	-112,223	13.3	-112,030	13.4	-112,072	13.4	-112,080	13.4
7	29.7	27.4	-75,347	14.7	-102,220	13.0	-102,210	13.7	-102,248	13.7	-102,255	13.7
8	32.3	30.1	-67,493	15.0	-90,788	14.0	-90,851	14.0	-90,885	14.0	-90,892	14.0
9	34.9	32.8	-52,253	15.9	-76,817	14.5	-76,910	14.5	-76,942	14.5	-76,947	14.5
10	37.8	34.9	-33,960	18.0	-59,331	15.2	-59,478	15.3	-59,496	15.3	-59,499	15.3
11	40.1	36.4	-19,134	20.6	-42,092	16.3	-42,222	16.3	-42,239	16.3	-42,241	16.3
12	42.4	37.4	-7,426	23.0	-32,776	18.0	-32,831	17.9	-32,834	17.9	-32,834	17.9
13	44.3	38.1	0	25.4	-25,570	19.0	-25,624	19.0	-25,626	19.0	-25,626	19.0
14	45.7	38.4	0	29.3	-19,500	19.9	-19,576	19.8	-19,560	19.8	-19,560	19.8
15	46.6	38.6	-97	30.9	-16,577	20.3	-16,580	20.3	-16,580	20.3	-16,580	20.3
16	46.9	38.6	0	30.6	-15,003	20.5	-15,003	20.5	-15,003	20.5	-15,003	20.5
17	46.3	38.2	-112	20.8	-16,430	20.1	-16,433	20.1	-16,434	20.1	-16,434	20.1
18	44.6	37.6	-433	25.0	-20,842	19.2	-20,599	19.1	-20,775	19.1	-20,775	19.1
19	42.0	36.6	-37	21.4	-29,387	18.1	-29,042	18.0	-28,953	18.0	-28,954	18.0
20	38.6	34.1	-7,293	19.3	-37,973	17.0	-38,595	17.1	-37,981	17.0	-38,551	17.1
21	34.9	30.9	-17,054	18.0	-48,743	16.1	-48,763	16.1	-48,794	16.1	-48,802	16.1
22	31.2	27.6	-28,969	17.2	-70,112	15.3	-70,185	15.2	-70,183	15.2	-70,184	15.2
23	27.9	24.4	-36,335	16.4	-88,036	14.6	-88,093	14.6	-88,095	14.6	-88,096	14.6
24	25.2	22.1	-40,986	15.9	-104,893	14.0	-104,941	14.0	-104,945	14.0	-104,946	14.0

Figure G.27 Building Cool Heat Demand (6 of 6): Model 2

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - M2 - Denver Hospice

GCHP

	Year 1				
Month	Average Earth Temp. °F	Average Fluid Leaving Temp. °F	Average Fluid Entering Temp. °F	Minimum Fluid Entering Temp. °F	Maximum Fluid Entering Temp. °F
Jan	55.70	56.10	56.30	55.00	60.60
Feb	56.50	57.80	58.40	56.20	63.60
Mar	59.00	63.20	65.20	59.10	70.00
Apr	61.10	66.70	69.40	66.00	76.70
May	64.00	71.70	75.40	70.50	81.90
Jun	68.10	79.00	84.30	77.10	89.50
Jul	72.30	85.80	92.30	85.70	96.70
Aug	74.40	87.10	93.20	88.70	99.60
Sep	74.00	83.20	87.70	83.40	96.70
Oct	73.00	79.40	82.40	79.90	91.60
Nov	71.60	75.40	77.30	75.40	84.20
Dec	71.20	74.30	75.80	73.90	81.70
Annual	66.70	73.30	76.50	55.00	99.60

Figure G.28 Geothermal Earth Temperature Summary: Model 2

Table G.21 Heat Pump Selections: Model 2

MODEL 2 - HEAT PUMP SELECTIONS												
HEAT PUMP	**UNIT SIZE	UNIT AIR FLOW	COOLING					HEATING		GPM	WPD
			AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG LWT	HTG Q_T	HTG LWT		
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(ºF)	(MBH)	(ºF)		(FT)
1	042	1050	615	2.9	23.0	34.8	90.0	-41.5	55.0	11.0	7.2
2	036	1250	1020	2.4	27.2	29.3	90.0	-31.2	55.0	4.5	2.1
3	060	1465	1070	4.7	36.1	56.9	90.0	-67.4	55.0	15.0	8.2
4	042	1050	690	2.7	23.7	32.9	90.0	-36.0	55.0	5.5	1.6
5	036	1250	1105	2.6	27.4	31.0	90.0	-35.0	55.0	9.0	10.2
6	036	1250	1150	2.6	27.7	30.6	90.0	-34.7	55.0	9.0	10.2
7	048	1600	1485	3.5	39.2	41.4	90.0	-41.0	55.0	12.0	8.1
8	012	350	285	1.0	10.4	11.9	90.0	-10.2	55.0	3.5	6.0
9	009	225	205	0.7	6.4	8.0	90.0	-8.0	55.0	1.4	1.3
10A	048	1600	2060	2.7	31.6	31.6	90.0	-51.7	55.0	6.0	2.1
10B	048	1600	2060	2.7	31.6	31.6	91.0	-51.7	56.0	6.0	2.1
11	006	180	135	0.4	4.4	5.1	90.0	-4.6	55.0	1.5	2.3
12	012	265	120	0.8	7.2	9.4	90.0	-8.6	55.0	1.8	0.6
13	018	600	570	1.6	16.8	18.6	90.0	-20.2	55.0	5.5	4.6
14	018	450	305	1.3	11.3	15.1	90.0	-14.8	55.0	2.8	0.5
15	018	450	330	1.4	13.2	16.8	90.0	-16.2	55.0	2.8	0.5
16	009	225	210	0.7	7.2	8.8	90.0	-8.3	55.0	2.8	4.3
17	018	450	335	1.2	11.4	13.8	90.0	-13.0	55.0	2.8	0.5
18	060	1465	1560	4.2	41.2	50.9	90.0	-54.2	55.0	7.5	0.5
19	006	180	140	0.4	4.1	5.1	90.0	-5.3	55.0	1.5	1.8
20	018	450	445	1.6	14.8	19.2	90.0	-20.4	55.0	5.5	4.6
21	018	450	355	1.0	10.1	12.2	90.0	-14.9	55.0	2.8	0.5
22	048	1200	1050	3.8	30.5	45.3	90.0	-49.6	55.0	12.0	8.1
23	042	1050	600	3.0	26.3	35.9	90.0	-36.7	55.0	11.0	6.7
24	012	350	405	1.0	10.6	11.7	90.0	-11.0	55.0	3.5	6.0
25	018	600	620	1.5	16.1	17.6	90.0	-15.6	55.0	4.1	2.5
26	012	350	335	0.8	8.8	9.6	90.0	-8.4	55.0	2.6	3.3
27	018	450	380	1.2	11.8	13.7	90.0	-12.3	55.0	2.8	0.5
28	024	640	400	1.7	14.2	19.8	90.0	-24.1	55.0	4.0	2.3
29	018	450	425	1.3	12.9	15.9	90.0	-17.8	55.0	2.8	0.5
30	024	640	430	1.7	15.1	21.3	90.0	-24.2	55.0	4.0	2.3
31	042	1400	1200	3.2	33.7	37.8	90.0	-33.4	55.0	11.0	7.2
32	018	450	495	1.3	13.7	15.1	90.0	-13.5	55.0	2.8	0.5
33	036	1250	1040	2.6	28.2	31.2	90.0	-26.1	55.0	6.8	6.0
34	042	1400	1240	2.9	32.0	34.9	90.0	-31.0	55.0	8.3	4.2
35	018	450	255	1.2	10.0	14.9	90.0	-18.4	55.0	2.8	0.5
36	018	450	450	1.2	11.5	14.4	90.0	-16.3	55.0	2.8	0.5
37	024	850	780	2.0	21.2	23.4	90.0	-19.6	55.0	6.0	4.9
38	006	180	130	0.4	4.6	4.8	90.0	-3.9	55.0	1.5	2.3
39	018	450	405	1.1	11.4	12.6	90.0	-11.4	55.0	2.8	0.5

Table G.22 Heat Pump Selections (2 of 2): Model 2

MODEL 2 - HEAT PUMP SELECTIONS											
40	030	950	925	2.2	24.0	26.2	90.0	-23.3	55.0	6.0	4.9
41	018	450	240	1.6	14.9	19.4	90.0	-17.7	55.0	4.1	2.5
				78.4		940.4		-1003.1		221.9	146.0

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

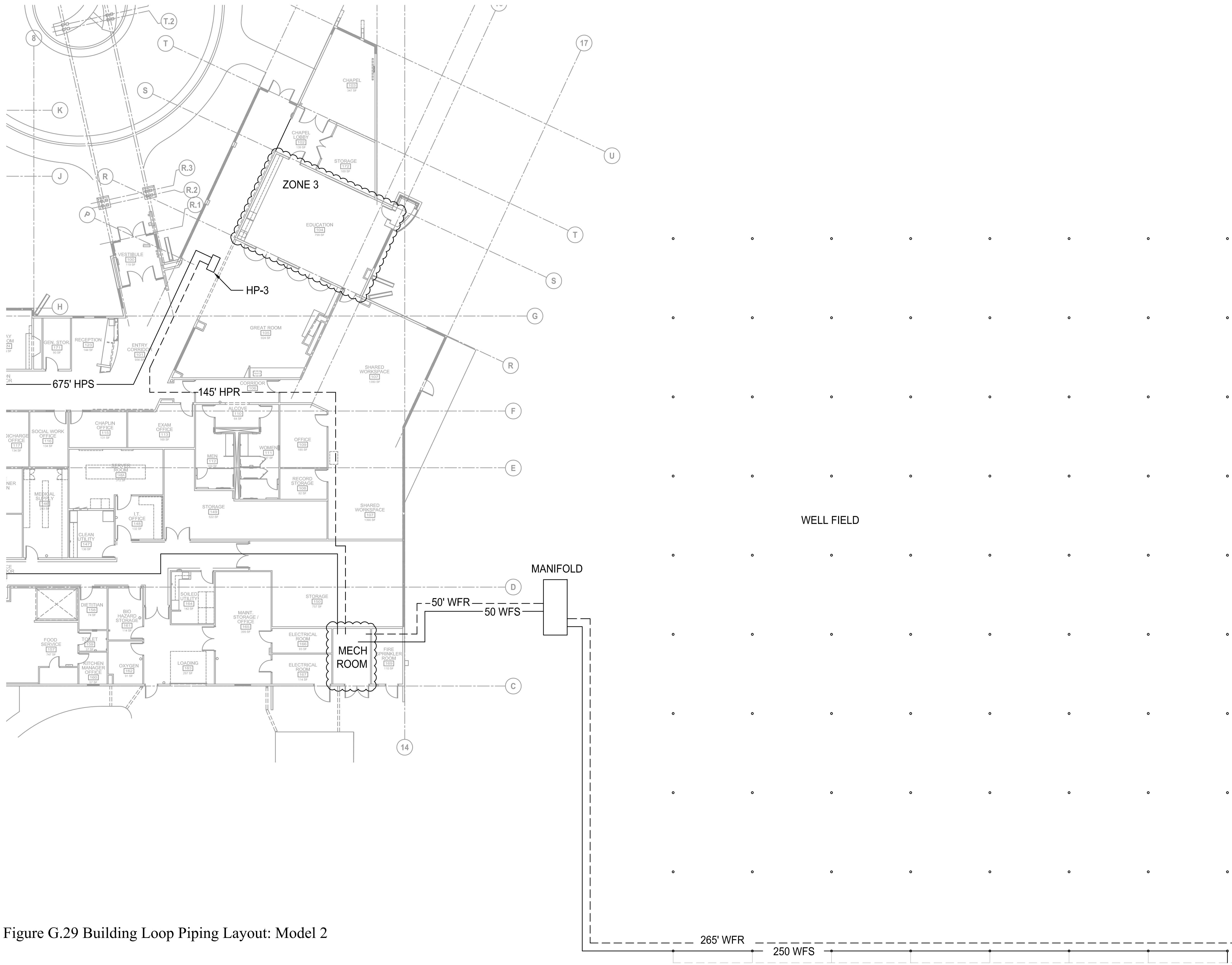


Figure G.29 Building Loop Piping Layout: Model 2

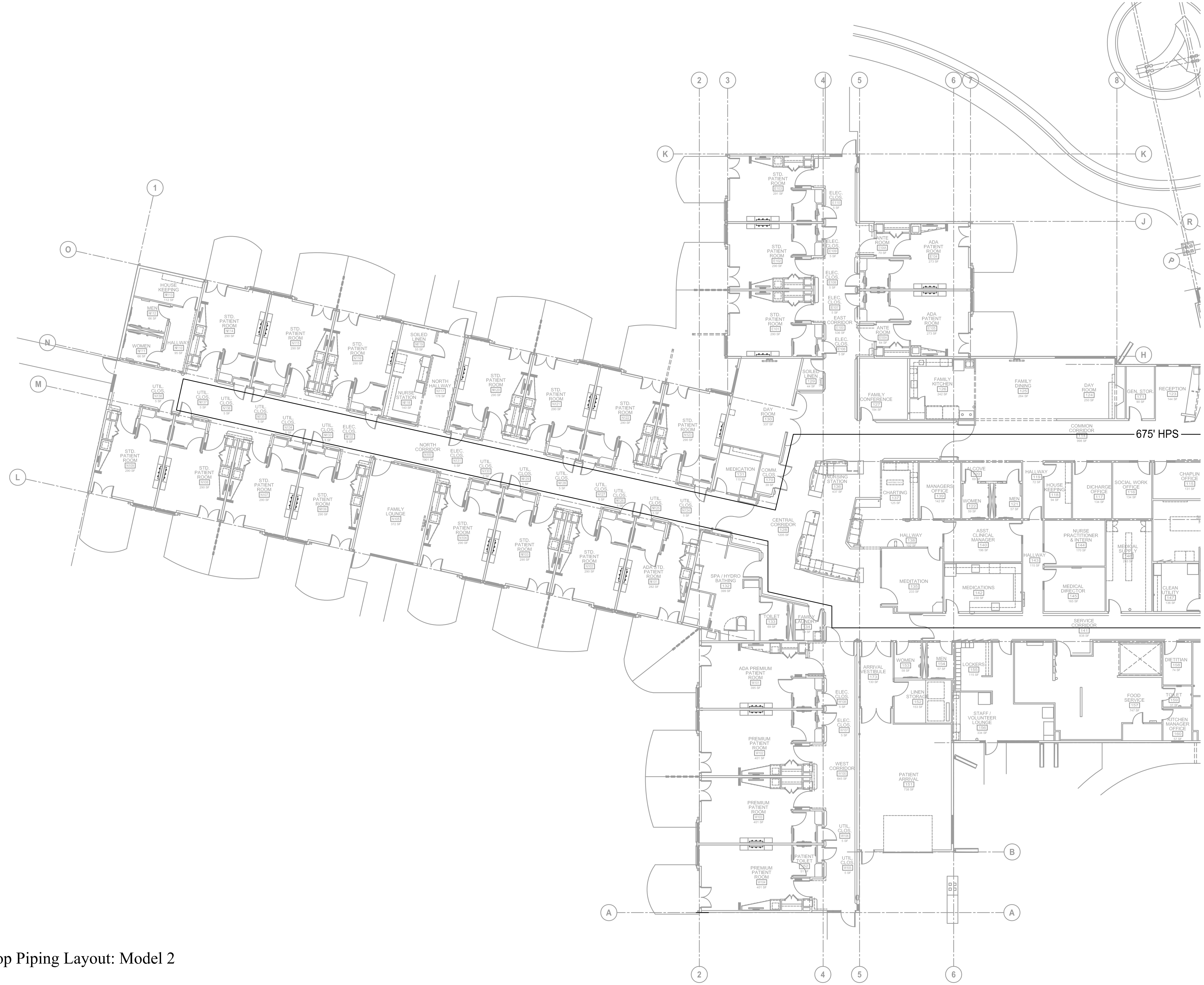


Figure G.30 Ground Loop Piping Layout: Model 2

MODEL	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

PRIMARY SYSTEM PUMP HEAD CALCULATIONS

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.23 Primary Pump Head Calculations: All Models

Table G.24 Primary/Secondary Pump Head Calculations: All Models

MODEL	PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS — PRIMARY LOOP: SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL: SUPPLY	DISTANCE TO WELL: RETURN	DISTANCE DOWN/UP WELL	TOTAL PRIMARY LOOP PIPE LENGTH	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD	TOTAL HEAT PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

MODEL	SECONDARY LOOP — DISTANCE TO HEAT PUMP: SUPPLY	DISTANCE TO HEAT PUMP: RETURN	TOTAL P/S LOOP PIPE LENGTH	P/S LENGTH W/ FITTINGS (TOTAL*1.5)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	SECONDARY LOOP PUMP HEAD
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	(FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL SUPPLY	DISTANCE TO WELL RETURN	DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP SUPPLY	DISTANCE TO HEAT PUMP RETURN	TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD	PUMP HEAD	PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

(Table title row: DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS)

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.25 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS																CIRCULATOR PUMP HEAD
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD	
		SUPPLY	RETURN		SUPPLY	RETURN										
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4	16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2	16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3	13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7	16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9	9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3	21.7

<u>GENERAL NOTES:</u>
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM
		(%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table G.26 Distributive Circulator Pump Head Calculations: All Models

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.27 Primary Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.28 Primary/Secondary Pump Schedules: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

<u>GENERAL NOTES:</u>

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.29 Distributive w/ Primary - Primary Pump Schedules: All Models

Table G.30 Distributive w/ Primary - Circulator Schedule: Model 2

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-22	11.0	7.2	2940	0.123	92	115	$ 664.00
2	B & G	NRF-9F/LW	4.5	2.1	2800	0.055	41	115	$ 449.00
3	B & G	NRF-22	15.0	8.2	2940	0.123	92	115	$ 664.00
4	B & G	NRF-9F/LW	5.5	1.6	2800	0.055	41	115	$ 449.00
5	B & G	NRF-22	9.0	10.2	2940	0.123	92	115	$ 664.00
6	B & G	NRF-22	9.0	10.2	2940	0.123	92	115	$ 664.00
7	B & G	NRF-22	12.0	8.1	2940	0.123	92	115	$ 664.00
8	B & G	NRF-9F/LW	3.5	6.0	2800	0.055	41	115	$ 449.00
9	B & G	NRF-9F/LW	1.4	1.3	2800	0.055	41	115	$ 449.00
10	B & G	NRF-9F/LW	6.0	2.1	2800	0.055	41	115	$ 449.00
11	B & G	NRF-9F/LW	6.0	2.1	2800	0.055	41	115	$ 449.00
12	B & G	NRF-9F/LW	1.5	2.3	2800	0.055	41	115	$ 449.00
13	B & G	NRF-9F/LW	1.8	0.6	2800	0.055	41	115	$ 449.00
14	B & G	NRF-9F/LW	5.5	4.6	2800	0.055	41	115	$ 449.00
15	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
16	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
17	B & G	NRF-9F/LW	2.8	4.3	2800	0.055	41	115	$ 449.00
18	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
19	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
20	B & G	NRF-9F/LW	1.5	1.8	2800	0.055	41	115	$ 449.00
21	B & G	NRF-9F/LW	5.5	4.6	2800	0.055	41	115	$ 449.00
22	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
23	B & G	NRF-22	12.0	8.1	2940	0.123	92	115	$ 664.00
24	B & G	NRF-22	11.0	6.7	2940	0.123	92	115	$ 664.00
25	B & G	NRF-9F/LW	3.5	6.0	2800	0.055	41	115	$ 449.00
26	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
27	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
28	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
29	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
30	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
31	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
32	B & G	NRF-22	11.0	7.2	2940	0.123	92	115	$ 664.00
33	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
34	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
35	B & G	NRF-9F/LW	8.3	4.2	2800	0.055	41	115	$ 449.00
36	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
37	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
38	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
39	B & G	NRF-9F/LW	1.5	2.3	2800	0.055	41	115	$ 449.00
40	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
41	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
42	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
						2.92	2181		$ 20,793.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table G.31 Distributive - Circulator Schedule: Model 2

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-36	11.0	16.4	3300	0.362	270	115	$ 1,368.00
2	B & G	NRF-36	4.5	16.4	3300	0.362	270	115	$ 1,368.00
3	B & G	NRF-36	15.0	16.4	3300	0.362	270	115	$ 1,368.00
4	B & G	NRF-36	5.5	16.4	3300	0.362	270	115	$ 1,368.00
5	B & G	NRF-36	9.0	16.4	3300	0.362	270	115	$ 1,368.00
6	B & G	NRF-36	9.0	16.4	3300	0.362	270	115	$ 1,368.00
7	B & G	NRF-36	12.0	16.4	3300	0.362	270	115	$ 1,368.00
8	B & G	NRF-25	3.5	16.4	2950	0.168	125	115	$ 724.00
9	B & G	NRF-25	1.4	16.4	2950	0.168	125	115	$ 724.00
10	B & G	NRF-36	6.0	16.4	3300	0.362	270	115	$ 1,368.00
11	B & G	NRF-36	6.0	16.4	3300	0.362	270	115	$ 1,368.00
12	B & G	NRF-25	1.5	16.4	2950	0.168	125	115	$ 724.00
13	B & G	NRF-25	1.8	16.4	2950	0.168	125	115	$ 724.00
14	B & G	NRF-36	5.5	16.4	3300	0.362	270	115	$ 1,368.00
15	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
16	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
17	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
18	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
19	B & G	NRF-36	7.5	16.4	3300	0.362	270	115	$ 1,368.00
20	B & G	NRF-25	1.5	16.4	2950	0.168	125	115	$ 724.00
21	B & G	NRF-36	5.5	16.4	3300	0.362	270	115	$ 1,368.00
22	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
23	B & G	NRF-36	12.0	16.4	3300	0.362	270	115	$ 1,368.00
24	B & G	NRF-36	11.0	16.4	3300	0.362	270	115	$ 1,368.00
25	B & G	NRF-25	3.5	16.4	2950	0.168	125	115	$ 724.00
26	B & G	NRF-36	4.1	16.4	3300	0.362	270	115	$ 1,368.00
27	B & G	NRF-25	2.6	16.4	2950	0.168	125	115	$ 724.00
28	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
29	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
30	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
31	B & G	NRF-25	4.0	16.4	2950	0.168	125	115	$ 724.00
32	B & G	NRF-36	11.0	16.4	3300	0.362	270	115	$ 1,368.00
33	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
34	B & G	NRF-36	6.8	16.4	3300	0.362	270	115	$ 1,368.00
35	B & G	NRF-36	8.3	16.4	3300	0.362	270	115	$ 1,368.00
36	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
37	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
38	B & G	NRF-36	6.0	16.4	3300	0.362	270	115	$ 1,368.00
39	B & G	NRF-25	1.5	16.4	2950	0.168	125	115	$ 724.00
40	B & G	NRF-25	2.8	16.4	2950	0.168	125	115	$ 724.00
41	B & G	NRF-36	6.0	16.4	3300	0.362	270	115	$ 1,368.00
42	B & G	NRF-36	4.1	16.4	3300	0.362	270	115	$ 1,368.00
						11.12	8295		$ 43,932.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

MODEL 2 - MONTHLY PUMP CONSUMPTION

AVERAGE DAY	COOLING DESIGN LOAD	HEATING DESIGN LOAD	JANUARY					FEBRUARY					MARCH					APRIL					MAY					JUNE				
			CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL
HOURS	TONS	MBH	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%
1	78.4	1003.1	4.8	6.1%	178.3	17.8%	23.9%	12.7	16.2%	136.0	13.6%	29.8%	17.0	21.7%	29.9	3.0%	24.7%	20.3	25.9%	7.0	0.7%	26.6%	26.4	33.7%	0.0	0.0%	33.7%	35.8	45.7%	0.0	0.0%	45.7%
2	78.4	1003.1	5.2	6.6%	182.7	18.2%	24.8%	12.6	16.1%	141.3	14.1%	30.2%	16.8	21.4%	32.6	3.2%	24.7%	19.9	25.4%	8.3	0.8%	26.2%	26.3	33.5%	0.1	0.0%	33.6%	35.2	44.9%	0.0	0.0%	44.9%
3	78.4	1003.1	5.9	7.5%	187.3	18.7%	26.2%	12.4	15.8%	146.3	14.6%	30.4%	16.6	21.2%	35.4	3.5%	24.7%	19.8	25.3%	10.3	1.0%	26.3%	25.9	33.0%	0.1	0.0%	33.0%	34.5	44.0%	0.0	0.0%	44.0%
4	78.4	1003.1	6.0	7.7%	189.6	18.9%	26.6%	12.3	15.7%	150.4	15.0%	30.7%	16.4	20.9%	37.5	3.7%	24.7%	19.8	25.3%	11.9	1.2%	26.4%	25.5	32.5%	0.2	0.0%	32.5%	34.0	43.4%	0.0	0.0%	43.4%
5	78.4	1003.1	6.0	7.7%	192.0	19.1%	26.8%	12.3	15.7%	151.8	15.1%	30.8%	16.5	21.0%	38.6	3.8%	24.9%	19.6	25.0%	12.6	1.3%	26.3%	25.3	32.3%	0.2	0.0%	32.3%	33.6	42.9%	0.0	0.0%	42.9%
6	78.4	1003.1	9.4	12.0%	191.0	19.0%	31.0%	12.2	15.6%	150.7	15.0%	30.6%	16.6	21.2%	37.9	3.8%	25.0%	19.6	25.0%	12.2	1.2%	26.2%	25.4	32.4%	0.2	0.0%	32.4%	34.1	43.5%	0.0	0.0%	43.5%
7	78.4	1003.1	9.7	12.4%	186.6	18.6%	31.0%	12.2	15.6%	146.7	14.6%	30.2%	16.8	21.4%	34.7	3.5%	24.9%	20.5	26.1%	9.8	1.0%	27.1%	27.1	34.6%	0.1	0.0%	34.6%	36.6	46.7%	0.0	0.0%	46.7%
8	78.4	1003.1	9.9	12.6%	179.0	17.8%	30.5%	12.5	15.9%	137.0	13.7%	29.6%	18.0	23.0%	28.0	2.8%	25.8%	22.7	29.0%	5.4	0.5%	29.5%	30.4	38.8%	0.0	0.0%	38.8%	41.1	52.4%	0.0	0.0%	52.4%
9	78.4	1003.1	10.2	13.0%	157.6	15.7%	28.7%	13.0	16.6%	116.9	11.7%	28.2%	20.3	25.9%	15.8	1.6%	27.5%	25.9	33.0%	0.0	0.0%	33.0%	35.1	44.8%	0.0	0.0%	44.8%	46.7	59.6%	0.0	0.0%	59.6%
10	78.4	1003.1	10.9	13.9%	134.3	13.4%	27.3%	14.3	18.2%	90.5	9.0%	27.3%	23.1	29.5%	6.3	0.6%	30.1%	29.5	37.6%	0.2	0.0%	37.6%	39.2	50.0%	0.0	0.0%	50.0%	51.8	66.1%	0.0	0.0%	66.1%
11	78.4	1003.1	12.1	15.4%	101.3	10.1%	25.5%	16.3	20.8%	61.0	6.1%	26.9%	25.8	32.9%	0.0	0.0%	32.9%	33.5	42.7%	0.0	0.0%	42.7%	43.0	54.8%	0.0	0.0%	54.8%	56.6	72.2%	0.0	0.0%	72.2%
12	78.4	1003.1	13.5	17.2%	75.7	7.5%	24.8%	20.0	25.5%	42.2	4.2%	29.7%	29.2	37.2%	0.0	0.0%	37.2%	36.6	46.7%	0.0	0.0%	46.7%	47.2	60.2%	0.0	0.0%	60.2%	59.8	76.3%	0.0	0.0%	76.3%
13	78.4	1003.1	16.4	20.9%	61.6	6.1%	27.1%	21.6	27.6%	28.7	2.9%	30.4%	32.0	40.8%	0.0	0.0%	40.8%	39.7	50.6%	0.0	0.0%	50.6%	50.8	64.8%	0.0	0.0%	64.8%	62.5	79.7%	0.0	0.0%	79.7%
14	78.4	1003.1	18.1	23.1%	52.0	5.2%	28.3%	22.7	29.0%	20.6	2.1%	31.0%	34.8	44.4%	0.2	0.0%	44.4%	41.8	53.3%	0.0	0.0%	53.3%	53.2	67.9%	0.0	0.0%	67.9%	64.5	82.3%	0.0	0.0%	82.3%
15	78.4	1003.1	19.7	25.1%	48.1	4.8%	29.9%	23.8	30.4%	17.5	1.7%	32.1%	36.5	46.6%	0.0	0.0%	46.6%	43.1	55.0%	0.0	0.0%	55.0%	54.6	69.6%	0.0	0.0%	69.6%	65.4	83.4%	0.0	0.0%	83.4%
16	78.4	1003.1	20.4	26.0%	48.7	4.9%	30.9%	24.2	30.9%	16.6	1.7%	32.5%	36.8	46.9%	0.0	0.0%	46.9%	44.7	57.0%	0.0	0.0%	57.0%	54.7	69.8%	0.0	0.0%	69.8%	65.3	83.3%	0.0	0.0%	83.3%
17	78.4	1003.1	19.7	25.1%	53.9	5.4%	30.5%	23.9	30.5%	20.1	2.0%	32.5%	35.8	45.7%	0.0	0.0%	45.7%	44.8	57.1%	0.0	0.0%	57.1%	53.7	68.5%	0.0	0.0%	68.5%	63.9	81.5%	0.0	0.0%	81.5%
18	78.4	1003.1	17.6	22.4%	65.6	6.5%	29.0%	21.9	27.9%	29.8	3.0%	30.9%	33.5	42.7%	0.1	0.0%	42.7%	42.5	54.2%	0.0	0.0%	54.2%	51.0	65.1%	0.0	0.0%	65.1%	61.1	77.9%	0.0	0.0%	77.9%
19	78.4	1003.1	15.5	19.8%	86.8	8.7%	28.4%	18.8	24.0%	39.4	3.9%	27.9%	29.4	37.5%	0.3	0.0%	37.5%	37.8	48.2%	0.0	0.0%	48.2%	47.0	59.9%	0.0	0.0%	59.9%	56.9	72.6%	0.0	0.0%	72.6%
20	78.4	1003.1	14.0	17.9%	108.9	10.9%	28.7%	16.3	20.8%	59.2	5.9%	26.7%	24.7	31.5%	0.6	0.1%	31.6%	32.1	40.9%	0.2	0.0%	41.0%	41.6	53.1%	0.0	0.0%	53.1%	51.3	65.4%	0.0	0.0%	65.4%
21	78.4	1003.1	13.0	16.5%	122.8	12.2%	28.8%	14.8	18.9%	76.6	7.6%	26.5%	21.6	27.6%	0.1	0.0%	27.6%	27.2	34.7%	0.3	0.0%	34.7%	36.6	46.7%	0.0	0.0%	46.7%	45.9	58.5%	0.0	0.0%	58.5%
22	78.4	1003.1	12.5	15.9%	134.1	13.4%	29.3%	13.9	17.7%	95.5	9.5%	27.3%	20.0	25.5%	0.2	0.0%	25.5%	24.4	31.1%	0.6	0.1%	31.2%	32.5	41.5%	0.0	0.0%	41.5%	41.8	53.3%	0.0	0.0%	53.3%
23	78.4	1003.1	12.0	15.3%	153.1	15.3%	30.6%	13.4	17.1%	105.8	10.5%	27.6%	18.9	24.1%	0.3	0.0%	24.1%	22.8	29.1%	0.6	0.1%	29.1%	30.1	38.4%	0.0	0.0%	38.4%	39.0	49.7%	0.0	0.0%	49.7%
24	78.4	1003.1	11.5	14.7%	160.1	16.0%	30.6%	13.0	16.6%	119.4	11.9%	28.5%	18.3	23.3%	0.5	0.0%	23.4%	21.7	27.7%	0.6	0.1%	27.7%	28.7	36.6%	0.0	0.0%	36.6%	37.3	47.6%	0.0	0.0%	47.6%

AVERAGE DAY	COOLING DESIGN LOAD	HEATING DESIGN LOAD	JULY					AUGUST					SEPTEMBER					OCTOBER					NOVEMBER					DECEMBER				
			CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL
HOURS	TONS	MBH	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%
1	78.4	1003.1	43.6	55.6%	0.0	0.0%	55.6%	41.1	52.4%	0.0	0.0%	52.4%	30.9	39.4%	0.0	0.0%	39.4%	23.7	30.2%	0.8	0.1%	30.3%	17.3	22.1%	0.1	0.0%	22.1%	15.6	19.9%	53.7	5.4%	25.3%
2	78.4	1003.1	42.5	54.2%	0.0	0.0%	54.2%	39.8	50.8%	0.0	0.0%	50.8%	29.4	37.5%	0.0	0.0%	37.5%	22.9	29.2%	0.6	0.1%	29.3%	17.1	21.8%	1.2	0.1%	21.9%	15.2	19.4%	59.7	6.0%	25.3%
3	78.4	1003.1	41.9	53.4%	0.0	0.0%	53.4%	39.0	49.7%	0.0	0.0%	49.7%	28.5	36.4%	0.1	0.0%	36.4%	22.1	28.2%	0.1	0.0%	28.2%	16.7	21.3%	19.1	1.9%	23.2%	15.0	19.1%	70.1	7.0%	26.1%
4	78.4	1003.1	41.5	52.9%	0.0	0.0%	52.9%	38.2	48.7%	0.0	0.0%	48.7%	27.8	35.5%	0.1	0.0%	35.5%	21.8	27.8%	0.6	0.1%	27.9%	16.5	21.0%	24.7	2.5%	23.5%	14.8	18.9%	76.2	7.6%	26.5%
5	78.4	1003.1	41.2	52.6%	0.0	0.0%	52.6%	38.0	48.5%	0.0	0.0%	48.5%	27.4	34.9%	0.1	0.0%	35.0%	21.4	27.3%	0.1	0.0%	27.3%	16.3	20.8%	32.1	3.2%	24.0%	14.6	18.6%	79.1	7.9%	26.5%
6	78.4	1003.1	41.4	52.8%	0.0	0.0%	52.8%	38.2	48.7%	0.0	0.0%	48.7%	27.5	35.1%	0.1	0.0%	35.1%	21.5	27.4%	0.6	0.1%	27.5%	16.4	20.9%	37.0	3.7%	24.6%	14.6	18.6%	79.1	7.9%	26.5%
7	78.4	1003.1	43.9	56.0%	0.0	0.0%	56.0%	39.8	50.8%	0.0	0.0%	50.8%	28.1	35.8%	0.0	0.0%	35.8%	21.8	27.8%	0.5	0.0%	27.9%	16.4	20.9%	35.2	3.5%	24.4%	14.7	18.8%	75.3	7.5%	26.3%
8	78.4	1003.1	48.4	61.7%	0.0	0.0%	61.7%	43.8	55.9%	0.0	0.0%	55.9%	30.8	39.3%	0.0	0.0%	39.3%	23.5	30.0%	0.4	0.0%	30.0%	16.8	21.4%	32.4	3.2%	24.7%	15.0	19.1%	67.5	6.7%	25.9%
9	78.4	1003.1	54.1	69.0%	0.0	0.0%	69.0%	49.6	63.3%	0.0	0.0%	63.3%	35.9	45.8%	0.0	0.0%	45.8%	26.7	34.1%	0.1	0.0%	34.1%	18.2	23.2%	22.9	2.3%	25.5%	15.9	20.3%	52.3	5.2%	25.5%
10	78.4	1003.1	59.0	75.3%	0.0	0.0%	75.3%	55.0	70.2%	0.0	0.0%	70.2%	42.5	54.2%	0.0	0.0%	54.2%	31.5	40.2%	0.1	0.0%	40.2%	20.4	26.0%	14.0	1.4%	27.4%	18.0	23.0%	34.0	3.4%	26.3%
11	78.4	1003.1	63.0	80.4%	0.0	0.0%	80.4%	60.2	76.8%	0.0	0.0%	76.8%	48.6	62.0%	0.0	0.0%	62.0%	36.7	46.8%	0.0	0.0%	46.8%	23.1	29.5%	5.8	0.6%	30.0%	20.6	26.3%	19.1	1.9%	28.2%
12	78.4	1003.1	66.7	85.1%	0.0	0.0%	85.1%	64.8	82.7%	0.0	0.0%	82.7%	53.5	68.2%	0.0	0.0%	68.2%	41.0	52.3%	0.0	0.0%	52.3%	26.3	33.5%	0.0	0.0%	33.5%	23.0	29.3%	7.4	0.7%	30.1%
13	78.4	1003.1	69.3	88.4%	0.0	0.0%	88.4%	68.1	86.9%	0.0	0.0%	86.9%	57.4	73.2%	0.0	0.0%	73.2%	45.1	57.5%	0.0	0.0%	57.5%	30.7	39.2%	0.0	0.0%	39.2%	25.4	32.4%	0.0	0.0%	32.4%
14	78.4	1003.1	71.2	90.8%	0.0	0.0%	90.8%	69.8	89.0%	0.0	0.0%	89.0%	59.9	76.4%	0.0	0.0%	76.4%	48.3	61.6%	0.0	0.0%	61.6%	32.9	42.0%	0.0	0.0%	42.0%	29.3	37.4%	0.0	0.0%	37.4%
15	78.4	1003.1	71.8	91.6%	0.0	0.0%	91.6%	70.4	89.8%	0.0	0.0%	89.8%	60.9	77.7%	0.0	0.0%	77.7%	49.8	63.5%	0.0	0.0%	63.5%	33.7	43.0%	0.0	0.0%	43.0%	30.9	39.4%	0.1	0.0%	39.4%
16	78.4	1003.1	71.5	91.2%	0.0	0.0%	91.2%	70.2	89.5%	0.0	0.0%	89.5%	60.4	77.0%	0.0	0.0%	77.0%	49.8	63.5%	0.0	0.0%	63.5%	33.4	42.6%	0.0	0.0%	42.6%	30.6	39.0%	0.0	0.0%	39.0%
17	78.4	1003.1	70.2	89.5%	0.0	0.0%	89.5%	68.7	87.6%	0.0	0.0%	87.6%	58.5	74.6%	0.0	0.0%	74.6%	47.9	61.1%	0.0	0.0%	61.1%	31.0	39.5%	0.0	0.0%	39.5%	28.6	36.5%	0.1	0.0%	36.5%
18	78.4	1003.1	67.5	86.1%	0.0	0.0%	86.1%	65.4	83.4%	0.0	0.0%	83.4%	54.8	69.9%	0.0	0.0%	69.9%	43.2	55.1%	0.0	0.0%	55.1%	27.4	34.9%	0.2	0.0%	35.0%	25.0	31.9%	0.4	0.0%	31.9%
19	78.4	1003.1	63.7	81.3%	0.0	0.0%	81.3%	60.9	77.7%	0.0	0.0%	77.7%	48.9	62.4%	0.0	0.0%	62.4%	37.6	48.0%	0.0	0.0%	48.0%	23.7	30.2%	0.5	0.0%	30.3%	21.4	27.3%	0.0	0.0%	27.3%
20	78.4	1003.1	59.3	75.6%	0.0	0.0%	75.6%	54.7	69.8%	0.0	0.0%	69.8%	43.5	55.5%	0.0	0.0%	55.5%	32.4	41.3%	0.0	0.0%	41.3%	21.2	27.0%	0.1	0.0%	27.1%	19.3	24.6%	7.2	0.7%	25.3%
21	78.4	1003.1	53.5	68.2%	0.0	0.0%	68.2%	49.9	63.6%	0.0	0.0%	63.6%	38.5	49.1%	0.0	0.0%	49.1%	29.2	37.2%	0.1	0.0%	37.3%	19.8	25.3%	0.1	0.0%	25.3%	18.0	23.0%	17.1	1.7%	24.7%
22	78.4	1003.1	49.2	62.8%	0.0	0.0%	62.8%	46.0	58.7%	0.0	0.0%	58.7%	35.2	44.9%	0.0	0.0%	44.9%	27.0	34.4%	0.2	0.0%	34.5%	18.8	24.0%	0.4	0.0%	24.0%	17.2	21.9%	29.0	2.9%	24.8%
23	78.4	1003.1	46.5	59.3%	0.0	0.0%	59.3%	43.2	55.1%	0.0	0.0%	55.1%	33.0	42.1%	0.0	0.0%	42.1%	25.3	32.3%	0.3	0.0%	32.3%	18.1	23.1%	8.5	0.8%	23.9%	16.4	20.9%	36.3	3.6%	24.5%
24	78.4	1003.1	44.7	57.0%	0.0	0.0%	57.0%	41.3	52.7%	0.0	0.0%	52.7%	31.0	39.5%	0.0	0.0%	39.5%	24.2	30.9%	0.6	0.1%	30.9%	17.5	22.3%	17.0	1.7%	24.0%	15.9	20.3%	41.0	4.1%	24.4%

GENERAL NOTES:

1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table G.32 Monthly Simultaneous Heating and Cooling Part-Load % Per Hour: Model 2

MODEL 2 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION		
	8.57	BHP
	6.39	KW

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.9%	0.09	29.8%	0.17	24.7%	0.10	26.6%	0.12	33.7%	0.24	45.7%	0.61
2	24.8%	0.10	30.2%	0.18	24.7%	0.10	26.2%	0.12	33.6%	0.24	44.9%	0.58
3	26.2%	0.11	30.4%	0.18	24.7%	0.10	26.3%	0.12	33.0%	0.23	44.0%	0.54
4	26.6%	0.12	30.7%	0.18	24.7%	0.10	26.4%	0.12	32.5%	0.22	43.4%	0.52
5	26.8%	0.12	30.8%	0.19	24.9%	0.10	26.3%	0.12	32.3%	0.22	42.9%	0.50
6	31.0%	0.19	30.6%	0.18	25.0%	0.10	26.2%	0.12	32.4%	0.22	43.5%	0.53
7	31.0%	0.19	30.2%	0.18	24.9%	0.10	27.1%	0.13	34.6%	0.26	46.7%	0.65
8	30.5%	0.18	29.6%	0.17	25.8%	0.11	29.5%	0.16	38.8%	0.37	52.4%	0.92
9	28.7%	0.15	28.2%	0.14	27.5%	0.13	33.0%	0.23	44.8%	0.57	59.6%	1.35
10	27.3%	0.13	27.3%	0.13	30.1%	0.17	37.6%	0.34	50.0%	0.80	66.1%	1.84
11	25.5%	0.11	26.9%	0.12	32.9%	0.23	42.7%	0.50	54.8%	1.05	72.2%	2.40
12	24.8%	0.10	29.7%	0.17	37.2%	0.33	46.7%	0.65	60.2%	1.39	76.3%	2.84
13	27.1%	0.13	30.4%	0.18	40.8%	0.43	50.6%	0.83	64.8%	1.74	79.7%	3.24
14	28.3%	0.14	31.0%	0.19	44.4%	0.56	53.3%	0.97	67.9%	2.00	82.3%	3.56
15	29.9%	0.17	32.1%	0.21	46.6%	0.64	55.0%	1.06	69.6%	2.16	83.4%	3.71
16	30.9%	0.19	32.5%	0.22	46.9%	0.66	57.0%	1.18	69.8%	2.17	83.3%	3.69
17	30.5%	0.18	32.5%	0.22	45.7%	0.61	57.1%	1.19	68.5%	2.05	81.5%	3.46
18	29.0%	0.16	30.9%	0.19	42.7%	0.50	54.2%	1.02	65.1%	1.76	77.9%	3.02
19	28.4%	0.15	27.9%	0.14	37.5%	0.34	48.2%	0.72	59.9%	1.38	72.6%	2.44
20	28.7%	0.15	26.7%	0.12	31.6%	0.20	41.0%	0.44	53.1%	0.95	65.4%	1.79
21	28.8%	0.15	26.5%	0.12	27.6%	0.13	34.7%	0.27	46.7%	0.65	58.5%	1.28
22	29.3%	0.16	27.3%	0.13	25.5%	0.11	31.2%	0.19	41.5%	0.46	53.3%	0.97
23	30.6%	0.18	27.6%	0.13	24.1%	0.09	29.1%	0.16	38.4%	0.36	49.7%	0.79
24	30.6%	0.18	28.5%	0.15	23.4%	0.08	27.7%	0.14	36.6%	0.31	47.6%	0.69
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		3.53		3.99		6.01		10.88		21.82		41.93

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	1.10	52.4%	0.92	39.4%	0.39	30.3%	0.18	22.1%	0.07	25.3%	0.10
2	54.2%	1.02	50.8%	0.84	37.5%	0.34	29.3%	0.16	21.9%	0.07	25.3%	0.10
3	53.4%	0.98	49.7%	0.79	36.4%	0.31	28.2%	0.14	23.2%	0.08	26.1%	0.11
4	52.9%	0.95	48.7%	0.74	35.5%	0.29	27.9%	0.14	23.5%	0.08	26.5%	0.12
5	52.6%	0.93	48.5%	0.73	35.0%	0.27	27.3%	0.13	24.0%	0.09	26.5%	0.12
6	52.8%	0.94	48.7%	0.74	35.1%	0.28	27.5%	0.13	24.6%	0.10	26.5%	0.12
7	56.0%	1.12	50.8%	0.84	35.8%	0.29	27.9%	0.14	24.4%	0.09	26.3%	0.12
8	61.7%	1.50	55.9%	1.11	39.3%	0.39	30.0%	0.17	24.7%	0.10	25.9%	0.11
9	69.0%	2.10	63.3%	1.62	45.8%	0.61	34.1%	0.25	25.5%	0.11	25.5%	0.11
10	75.3%	2.72	70.2%	2.21	54.2%	1.02	40.2%	0.41	27.4%	0.13	26.3%	0.12
11	80.4%	3.32	76.8%	2.89	62.0%	1.52	46.8%	0.66	30.0%	0.17	28.2%	0.14
12	85.1%	3.94	82.7%	3.61	68.2%	2.03	52.3%	0.91	33.5%	0.24	30.1%	0.17
13	88.4%	4.41	86.9%	4.19	73.2%	2.51	57.5%	1.22	39.2%	0.38	32.4%	0.22
14	90.8%	4.79	89.0%	4.51	76.4%	2.85	61.6%	1.49	42.0%	0.47	37.4%	0.33
15	91.6%	4.91	89.8%	4.63	77.7%	3.00	63.5%	1.64	43.0%	0.51	39.4%	0.39
16	91.2%	4.85	89.5%	4.59	77.0%	2.92	63.5%	1.64	42.6%	0.49	39.0%	0.38
17	89.5%	4.59	87.6%	4.30	74.6%	2.65	61.1%	1.46	39.5%	0.40	36.5%	0.31
18	86.1%	4.08	83.4%	3.71	69.9%	2.18	55.1%	1.07	35.0%	0.27	31.9%	0.21
19	81.3%	3.43	77.7%	3.00	62.4%	1.55	48.0%	0.70	30.3%	0.18	27.3%	0.13
20	75.6%	2.77	69.8%	2.17	55.5%	1.09	41.3%	0.45	27.1%	0.13	25.3%	0.10
21	68.2%	2.03	63.6%	1.65	49.1%	0.76	37.3%	0.33	25.3%	0.10	24.7%	0.10
22	62.8%	1.58	58.7%	1.29	44.9%	0.58	34.5%	0.26	24.0%	0.09	24.8%	0.10
23	59.3%	1.33	55.1%	1.07	42.1%	0.48	32.3%	0.22	23.9%	0.09	24.5%	0.09
24	57.0%	1.18	52.7%	0.93	39.5%	0.40	30.9%	0.19	24.0%	0.09	24.4%	0.09
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		60.55		53.06		28.70		14.10		4.52		3.90

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.33 Daily Pump Consumption (Primary): Model 2

Table G.34 Primary System Annual Utility Cost: Model 2

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	3.53	31	110	$ 0.09	$ 9.86
FEBRUARY	3.99	28	112	$ 0.09	$ 10.04
MARCH	6.01	31	186	$ 0.09	$ 16.77
APRIL	10.88	30	326	$ 0.09	$ 29.37
MAY	21.82	31	676	$ 0.09	$ 60.87
JUNE	41.93	30	1258	$ 0.09	$ 113.21
JULY	60.55	31	1877	$ 0.09	$ 168.94
AUGUST	53.06	31	1645	$ 0.09	$ 148.03
SEPTEMBER	28.70	30	861	$ 0.09	$ 77.49
OCTOBER	14.10	31	437	$ 0.09	$ 39.33
NOVEMBER	4.52	30	136	$ 0.09	$ 12.21
DECEMBER	3.90	31	121	$ 0.09	$ 10.88
ANNUAL UTILITY CONSUMPTION & COST			7744	KWH	$ 697.00

GENERAL NOTES:
1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 2 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY + SECONDARY PUMP CONSUMPTION		
	9.2	BHP
	6.86	KW

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.9%	0.09	29.8%	0.18	24.7%	0.10	26.6%	0.13	33.7%	0.26	45.7%	0.65
2	24.8%	0.11	30.2%	0.19	24.7%	0.10	26.2%	0.12	33.6%	0.26	44.9%	0.62
3	26.2%	0.12	30.4%	0.19	24.7%	0.10	26.3%	0.12	33.0%	0.25	44.0%	0.58
4	26.6%	0.13	30.7%	0.20	24.7%	0.10	26.4%	0.13	32.5%	0.24	43.4%	0.56
5	26.8%	0.13	30.8%	0.20	24.9%	0.11	26.3%	0.12	32.3%	0.23	42.9%	0.54
6	31.0%	0.20	30.6%	0.20	25.0%	0.11	26.2%	0.12	32.4%	0.23	43.5%	0.56
7	31.0%	0.20	30.2%	0.19	24.9%	0.11	27.1%	0.14	34.6%	0.28	46.7%	0.70
8	30.5%	0.19	29.6%	0.18	25.8%	0.12	29.5%	0.18	38.8%	0.40	52.4%	0.99
9	28.7%	0.16	28.2%	0.15	27.5%	0.14	33.0%	0.25	44.8%	0.62	59.6%	1.45
10	27.3%	0.14	27.3%	0.14	30.1%	0.19	37.6%	0.37	50.0%	0.86	66.1%	1.98
11	25.5%	0.11	26.9%	0.13	32.9%	0.24	42.7%	0.54	54.8%	1.13	72.2%	2.58
12	24.8%	0.10	29.7%	0.18	37.2%	0.35	46.7%	0.70	60.2%	1.50	76.3%	3.04
13	27.1%	0.14	30.4%	0.19	40.8%	0.47	50.6%	0.89	64.8%	1.87	79.7%	3.48
14	28.3%	0.16	31.0%	0.20	44.4%	0.60	53.3%	1.04	67.9%	2.14	82.3%	3.82
15	29.9%	0.18	32.1%	0.23	46.6%	0.69	55.0%	1.14	69.6%	2.32	83.4%	3.98
16	30.9%	0.20	32.5%	0.24	46.9%	0.71	57.0%	1.27	69.8%	2.33	83.3%	3.96
17	30.5%	0.19	32.5%	0.24	45.7%	0.65	57.1%	1.28	68.5%	2.20	81.5%	3.71
18	29.0%	0.17	30.9%	0.20	42.7%	0.54	54.2%	1.09	65.1%	1.89	77.9%	3.25
19	28.4%	0.16	27.9%	0.15	37.5%	0.36	48.2%	0.77	59.9%	1.48	72.6%	2.62
20	28.7%	0.16	26.7%	0.13	31.6%	0.22	41.0%	0.47	53.1%	1.02	65.4%	1.92
21	28.8%	0.16	26.5%	0.13	27.6%	0.14	34.7%	0.29	46.7%	0.70	58.5%	1.38
22	29.3%	0.17	27.3%	0.14	25.5%	0.11	31.2%	0.21	41.5%	0.49	53.3%	1.04
23	30.6%	0.20	27.6%	0.14	24.1%	0.10	29.1%	0.17	38.4%	0.39	49.7%	0.84
24	30.6%	0.20	28.5%	0.16	23.4%	0.09	27.7%	0.15	36.6%	0.34	47.6%	0.74
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		3.79		4.28		6.45		11.68		23.42		45.01

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	1.18	52.4%	0.99	39.4%	0.42	30.3%	0.19	22.1%	0.07	25.3%	0.11
2	54.2%	1.09	50.8%	0.90	37.5%	0.36	29.3%	0.17	21.9%	0.07	25.3%	0.11
3	53.4%	1.05	49.7%	0.84	36.4%	0.33	28.2%	0.15	23.2%	0.09	26.1%	0.12
4	52.9%	1.02	48.7%	0.79	35.5%	0.31	27.9%	0.15	23.5%	0.09	26.5%	0.13
5	52.6%	1.00	48.5%	0.78	35.0%	0.29	27.3%	0.14	24.0%	0.09	26.5%	0.13
6	52.8%	1.01	48.7%	0.79	35.1%	0.30	27.5%	0.14	24.6%	0.10	26.5%	0.13
7	56.0%	1.20	50.8%	0.90	35.8%	0.32	27.9%	0.15	24.4%	0.10	26.3%	0.12
8	61.7%	1.61	55.9%	1.20	39.3%	0.42	30.0%	0.19	24.7%	0.10	25.9%	0.12
9	69.0%	2.25	63.3%	1.74	45.8%	0.66	34.1%	0.27	25.5%	0.11	25.5%	0.11
10	75.3%	2.92	70.2%	2.37	54.2%	1.09	40.2%	0.45	27.4%	0.14	26.3%	0.13
11	80.4%	3.56	76.8%	3.11	62.0%	1.63	46.8%	0.70	30.0%	0.19	28.2%	0.15
12	85.1%	4.22	82.7%	3.87	68.2%	2.18	52.3%	0.98	33.5%	0.26	30.1%	0.19
13	88.4%	4.74	86.9%	4.50	73.2%	2.69	57.5%	1.31	39.2%	0.41	32.4%	0.23
14	90.8%	5.14	89.0%	4.84	76.4%	3.06	61.6%	1.60	42.0%	0.51	37.4%	0.36
15	91.6%	5.27	89.8%	4.97	77.7%	3.22	63.5%	1.76	43.0%	0.54	39.4%	0.42
16	91.2%	5.20	89.5%	4.93	77.0%	3.14	63.5%	1.76	42.6%	0.53	39.0%	0.41
17	89.5%	4.93	87.6%	4.62	74.6%	2.85	61.1%	1.56	39.5%	0.42	36.5%	0.33
18	86.1%	4.38	83.4%	3.98	69.9%	2.34	55.1%	1.15	35.0%	0.29	31.9%	0.22
19	81.3%	3.68	77.7%	3.22	62.4%	1.66	48.0%	0.76	30.3%	0.19	27.3%	0.14
20	75.6%	2.97	69.8%	2.33	55.5%	1.17	41.3%	0.48	27.1%	0.14	25.3%	0.11
21	68.2%	2.18	63.6%	1.77	49.1%	0.81	37.3%	0.35	25.3%	0.11	24.7%	0.10
22	62.8%	1.70	58.7%	1.39	44.9%	0.62	34.5%	0.28	24.0%	0.10	24.8%	0.11
23	59.3%	1.43	55.1%	1.15	42.1%	0.51	32.3%	0.23	23.9%	0.09	24.5%	0.10
24	57.0%	1.27	52.7%	1.00	39.5%	0.42	30.9%	0.20	24.0%	0.10	24.4%	0.10
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		65.01		56.96		30.81		15.13		4.85		4.19

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.35 Daily Pump Consumption (Primary/Secondary): Model 2

Table G.36 Primary/Secondary System Annual Utility Cost: Model 2

PRIMARY/SECONDARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	3.79	31	118	$ 0.09	$ 10.58
FEBRUARY	4.28	28	120	$ 0.09	$ 10.78
MARCH	6.45	31	200	$ 0.09	$ 18.01
APRIL	11.68	30	350	$ 0.09	$ 31.53
MAY	23.42	31	726	$ 0.09	$ 65.34
JUNE	45.01	30	1350	$ 0.09	$ 121.53
JULY	65.01	31	2015	$ 0.09	$ 181.36
AUGUST	56.96	31	1766	$ 0.09	$ 158.91
SEPTEMBER	30.81	30	924	$ 0.09	$ 83.18
OCTOBER	15.13	31	469	$ 0.09	$ 42.22
NOVEMBER	4.85	30	146	$ 0.09	$ 13.10
DECEMBER	4.19	31	130	$ 0.09	$ 11.68
ANNUAL UTILITY CONSUMPTION & COST			8314	KWH	$ 748.24

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 2 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS AND PRIMARY PUMP CONSUMPTION		
	10.98	BHP
	8.19	KW

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.9%	0.11	29.8%	0.22	24.7%	0.12	26.6%	0.15	33.7%	0.31	45.7%	0.78
2	24.8%	0.13	30.2%	0.22	24.7%	0.12	26.2%	0.15	33.6%	0.31	44.9%	0.74
3	26.2%	0.15	30.4%	0.23	24.7%	0.12	26.3%	0.15	33.0%	0.30	44.0%	0.70
4	26.6%	0.15	30.7%	0.24	24.7%	0.12	26.4%	0.15	32.5%	0.28	43.4%	0.67
5	26.8%	0.16	30.8%	0.24	24.9%	0.13	26.3%	0.15	32.3%	0.28	42.9%	0.64
6	31.0%	0.24	30.6%	0.23	25.0%	0.13	26.2%	0.15	32.4%	0.28	43.5%	0.67
7	31.0%	0.24	30.2%	0.23	24.9%	0.13	27.1%	0.16	34.6%	0.34	46.7%	0.83
8	30.5%	0.23	29.6%	0.21	25.8%	0.14	29.5%	0.21	38.8%	0.48	52.4%	1.18
9	28.7%	0.19	28.2%	0.18	27.5%	0.17	33.0%	0.30	44.8%	0.73	59.6%	1.73
10	27.3%	0.17	27.3%	0.17	30.1%	0.22	37.6%	0.44	50.0%	1.02	66.1%	2.36
11	25.5%	0.14	26.9%	0.16	32.9%	0.29	42.7%	0.64	54.8%	1.35	72.2%	3.08
12	24.8%	0.12	29.7%	0.21	37.2%	0.42	46.7%	0.83	60.2%	1.79	76.3%	3.63
13	27.1%	0.16	30.4%	0.23	40.8%	0.56	50.6%	1.06	64.8%	2.23	79.7%	4.15
14	28.3%	0.19	31.0%	0.24	44.4%	0.72	53.3%	1.24	67.9%	2.56	82.3%	4.56
15	29.9%	0.22	32.1%	0.27	46.6%	0.83	55.0%	1.36	69.6%	2.77	83.4%	4.75
16	30.9%	0.24	32.5%	0.28	46.9%	0.85	57.0%	1.52	69.8%	2.78	83.3%	4.73
17	30.5%	0.23	32.5%	0.28	45.7%	0.78	57.1%	1.53	68.5%	2.63	81.5%	4.43
18	29.0%	0.20	30.9%	0.24	42.7%	0.64	54.2%	1.30	65.1%	2.25	77.9%	3.88
19	28.4%	0.19	27.9%	0.18	37.5%	0.43	48.2%	0.92	59.9%	1.76	72.6%	3.13
20	28.7%	0.19	26.7%	0.16	31.6%	0.26	41.0%	0.56	53.1%	1.22	65.4%	2.29
21	28.8%	0.20	26.5%	0.15	27.6%	0.17	34.7%	0.34	46.7%	0.83	58.5%	1.64
22	29.3%	0.21	27.3%	0.17	25.5%	0.14	31.2%	0.25	41.5%	0.58	53.3%	1.24
23	30.6%	0.23	27.6%	0.17	24.1%	0.12	29.1%	0.20	38.4%	0.46	49.7%	1.01
24	30.6%	0.24	28.5%	0.19	23.4%	0.10	27.7%	0.17	36.6%	0.40	47.6%	0.88
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		4.53		5.11		7.70		13.94		27.95		53.72

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	1.41	52.4%	1.18	39.4%	0.50	30.3%	0.23	22.1%	0.09	25.3%	0.13
2	54.2%	1.30	50.8%	1.07	37.5%	0.43	29.3%	0.21	21.9%	0.09	25.3%	0.13
3	53.4%	1.25	49.7%	1.01	36.4%	0.39	28.2%	0.18	23.2%	0.10	26.1%	0.15
4	52.9%	1.21	48.7%	0.95	35.5%	0.37	27.9%	0.18	23.5%	0.11	26.5%	0.15
5	52.6%	1.19	48.5%	0.93	35.0%	0.35	27.3%	0.17	24.0%	0.11	26.5%	0.15
6	52.8%	1.21	48.7%	0.95	35.1%	0.35	27.5%	0.17	24.6%	0.12	26.5%	0.15
7	56.0%	1.44	50.8%	1.07	35.8%	0.38	27.9%	0.18	24.4%	0.12	26.3%	0.15
8	61.7%	1.93	55.9%	1.43	39.3%	0.50	30.0%	0.22	24.7%	0.12	25.9%	0.14
9	69.0%	2.69	63.3%	2.07	45.8%	0.79	34.1%	0.32	25.5%	0.14	25.5%	0.14
10	75.3%	3.49	70.2%	2.83	54.2%	1.30	40.2%	0.53	27.4%	0.17	26.3%	0.15
11	80.4%	4.25	76.8%	3.71	62.0%	1.95	46.8%	0.84	30.0%	0.22	28.2%	0.18
12	85.1%	5.04	82.7%	4.62	68.2%	2.60	52.3%	1.17	33.5%	0.31	30.1%	0.22
13	88.4%	5.65	86.9%	5.37	73.2%	3.21	57.5%	1.56	39.2%	0.49	32.4%	0.28
14	90.8%	6.13	89.0%	5.78	76.4%	3.65	61.6%	1.91	42.0%	0.61	37.4%	0.43
15	91.6%	6.29	89.8%	5.93	77.7%	3.84	63.5%	2.10	43.0%	0.65	39.4%	0.50
16	91.2%	6.21	89.5%	5.88	77.0%	3.74	63.5%	2.10	42.6%	0.63	39.0%	0.49
17	89.5%	5.88	87.6%	5.51	74.6%	3.40	61.1%	1.87	39.5%	0.51	36.5%	0.40
18	86.1%	5.23	83.4%	4.75	69.9%	2.80	55.1%	1.37	35.0%	0.35	31.9%	0.27
19	81.3%	4.39	77.7%	3.84	62.4%	1.99	48.0%	0.90	30.3%	0.23	27.3%	0.17
20	75.6%	3.54	69.8%	2.78	55.5%	1.40	41.3%	0.58	27.1%	0.16	25.3%	0.13
21	68.2%	2.60	63.6%	2.11	49.1%	0.97	37.3%	0.42	25.3%	0.13	24.7%	0.12
22	62.8%	2.02	58.7%	1.65	44.9%	0.74	34.5%	0.34	24.0%	0.11	24.8%	0.13
23	59.3%	1.71	55.1%	1.37	42.1%	0.61	32.3%	0.28	23.9%	0.11	24.5%	0.12
24	57.0%	1.52	52.7%	1.20	39.5%	0.51	30.9%	0.24	24.0%	0.11	24.4%	0.12
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		77.58		67.98		36.77		18.06		5.79		5.00

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.37 Daily Pump Consumption (Distributive w/ Primary): Model 2

Table G.38 Distributive w/ Primary System Annual Utility Cost: Model 2

DISTRIBUTIVE W/ PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	4.53	31	140	$ 0.09	$ 12.63
FEBRUARY	5.11	28	143	$ 0.09	$ 12.87
MARCH	7.70	31	239	$ 0.09	$ 21.49
APRIL	13.94	30	418	$ 0.09	$ 37.63
MAY	27.95	31	867	$ 0.09	$ 77.99
JUNE	53.72	30	1612	$ 0.09	$ 145.05
JULY	77.58	31	2405	$ 0.09	$ 216.45
AUGUST	67.98	31	2107	$ 0.09	$ 189.66
SEPTEMBER	36.77	30	1103	$ 0.09	$ 99.28
OCTOBER	18.06	31	560	$ 0.09	$ 50.39
NOVEMBER	5.79	30	174	$ 0.09	$ 15.64
DECEMBER	5.00	31	155	$ 0.09	$ 13.94
ANNUAL UTILITY CONSUMPTION & COST			9922	KWH	$ 893.01

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 2 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS CONSUMPTION		
	11.2	BHP
	8.35	KW

24-HOURS PER DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.9%	0.11	29.8%	0.22	24.7%	0.13	26.6%	0.16	33.7%	0.32	45.7%	0.80
2	24.8%	0.13	30.2%	0.23	24.7%	0.13	26.2%	0.15	33.6%	0.32	44.9%	0.76
3	26.2%	0.15	30.4%	0.23	24.7%	0.13	26.3%	0.15	33.0%	0.30	44.0%	0.71
4	26.6%	0.16	30.7%	0.24	24.7%	0.13	26.4%	0.15	32.5%	0.29	43.4%	0.68
5	26.8%	0.16	30.8%	0.24	24.9%	0.13	26.3%	0.15	32.3%	0.28	42.9%	0.66
6	31.0%	0.25	30.6%	0.24	25.0%	0.13	26.2%	0.15	32.4%	0.28	43.5%	0.69
7	31.0%	0.25	30.2%	0.23	24.9%	0.13	27.1%	0.17	34.6%	0.35	46.7%	0.85
8	30.5%	0.24	29.6%	0.22	25.8%	0.14	29.5%	0.21	38.8%	0.49	52.4%	1.20
9	28.7%	0.20	28.2%	0.19	27.5%	0.17	33.0%	0.30	44.8%	0.75	59.6%	1.77
10	27.3%	0.17	27.3%	0.17	30.1%	0.23	37.6%	0.45	50.0%	1.04	66.1%	2.41
11	25.5%	0.14	26.9%	0.16	32.9%	0.30	42.7%	0.65	54.8%	1.38	72.2%	3.14
12	24.8%	0.13	29.7%	0.22	37.2%	0.43	46.7%	0.85	60.2%	1.82	76.3%	3.71
13	27.1%	0.17	30.4%	0.23	40.8%	0.57	50.6%	1.08	64.8%	2.27	79.7%	4.23
14	28.3%	0.19	31.0%	0.25	44.4%	0.73	53.3%	1.27	67.9%	2.61	82.3%	4.65
15	29.9%	0.22	32.1%	0.28	46.6%	0.84	55.0%	1.39	69.6%	2.82	83.4%	4.85
16	30.9%	0.25	32.5%	0.29	46.9%	0.86	57.0%	1.55	69.8%	2.84	83.3%	4.83
17	30.5%	0.24	32.5%	0.29	45.7%	0.80	57.1%	1.56	68.5%	2.68	81.5%	4.52
18	29.0%	0.20	30.9%	0.25	42.7%	0.65	54.2%	1.33	65.1%	2.30	77.9%	3.95
19	28.4%	0.19	27.9%	0.18	37.5%	0.44	48.2%	0.94	59.9%	1.80	72.6%	3.19
20	28.7%	0.20	26.7%	0.16	31.6%	0.26	41.0%	0.57	53.1%	1.25	65.4%	2.34
21	28.8%	0.20	26.5%	0.16	27.6%	0.17	34.7%	0.35	46.7%	0.85	58.5%	1.68
22	29.3%	0.21	27.3%	0.17	25.5%	0.14	31.2%	0.25	41.5%	0.59	53.3%	1.27
23	30.6%	0.24	27.6%	0.18	24.1%	0.12	29.1%	0.21	38.4%	0.47	49.7%	1.03
24	30.6%	0.24	28.5%	0.19	23.4%	0.11	27.7%	0.18	36.6%	0.41	47.6%	0.90
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		4.62		5.21		7.86		14.22		28.51		54.80

24-HOURS PER DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	1.44	52.4%	1.20	39.4%	0.51	30.3%	0.23	22.1%	0.09	25.3%	0.13
2	54.2%	1.33	50.8%	1.09	37.5%	0.44	29.3%	0.21	21.9%	0.09	25.3%	0.14
3	53.4%	1.27	49.7%	1.03	36.4%	0.40	28.2%	0.19	23.2%	0.10	26.1%	0.15
4	52.9%	1.24	48.7%	0.97	35.5%	0.37	27.9%	0.18	23.5%	0.11	26.5%	0.15
5	52.6%	1.21	48.5%	0.95	35.0%	0.36	27.3%	0.17	24.0%	0.12	26.5%	0.16
6	52.8%	1.23	48.7%	0.97	35.1%	0.36	27.5%	0.17	24.6%	0.12	26.5%	0.16
7	56.0%	1.47	50.8%	1.09	35.8%	0.38	27.9%	0.18	24.4%	0.12	26.3%	0.15
8	61.7%	1.97	55.9%	1.46	39.3%	0.51	30.0%	0.23	24.7%	0.13	25.9%	0.14
9	69.0%	2.74	63.3%	2.11	45.8%	0.80	34.1%	0.33	25.5%	0.14	25.5%	0.14
10	75.3%	3.56	70.2%	2.88	54.2%	1.33	40.2%	0.54	27.4%	0.17	26.3%	0.15
11	80.4%	4.33	76.8%	3.78	62.0%	1.99	46.8%	0.86	30.0%	0.23	28.2%	0.19
12	85.1%	5.14	82.7%	4.72	68.2%	2.65	52.3%	1.19	33.5%	0.32	30.1%	0.23
13	88.4%	5.77	86.9%	5.47	73.2%	3.28	57.5%	1.59	39.2%	0.50	32.4%	0.28
14	90.8%	6.26	89.0%	5.89	76.4%	3.72	61.6%	1.95	42.0%	0.62	37.4%	0.44
15	91.6%	6.42	89.8%	6.05	77.7%	3.91	63.5%	2.14	43.0%	0.66	39.4%	0.51
16	91.2%	6.34	89.5%	6.00	77.0%	3.82	63.5%	2.14	42.6%	0.65	39.0%	0.50
17	89.5%	6.00	87.6%	5.62	74.6%	3.47	61.1%	1.90	39.5%	0.52	36.5%	0.41
18	86.1%	5.33	83.4%	4.85	69.9%	2.85	55.1%	1.40	35.0%	0.36	31.9%	0.27
19	81.3%	4.48	77.7%	3.91	62.4%	2.03	48.0%	0.92	30.3%	0.23	27.3%	0.17
20	75.6%	3.61	69.8%	2.84	55.5%	1.43	41.3%	0.59	27.1%	0.17	25.3%	0.14
21	68.2%	2.65	63.6%	2.15	49.1%	0.99	37.3%	0.43	25.3%	0.13	24.7%	0.13
22	62.8%	2.06	58.7%	1.69	44.9%	0.76	34.5%	0.34	24.0%	0.12	24.8%	0.13
23	59.3%	1.74	55.1%	1.40	42.1%	0.62	32.3%	0.28	23.9%	0.11	24.5%	0.12
24	57.0%	1.55	52.7%	1.22	39.5%	0.52	30.9%	0.25	24.0%	0.12	24.4%	0.12
AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)		79.14		69.34		37.51		18.42		5.91		5.10

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.39 Daily Pump Consumption (Distributive): Model 2

Table G.40 Distributive System Annual Utility Cost: Model 2

DISTRIBUTIVE SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	4.62	31	143	$ 0.09	$ 12.89
FEBRUARY	5.21	28	146	$ 0.09	$ 13.12
MARCH	7.86	31	244	$ 0.09	$ 21.92
APRIL	14.22	30	427	$ 0.09	$ 38.39
MAY	28.51	31	884	$ 0.09	$ 79.55
JUNE	54.80	30	1644	$ 0.09	$ 147.95
JULY	79.14	31	2453	$ 0.09	$ 220.79
AUGUST	69.34	31	2150	$ 0.09	$ 193.46
SEPTEMBER	37.51	30	1125	$ 0.09	$ 101.27
OCTOBER	18.42	31	571	$ 0.09	$ 51.40
NOVEMBER	5.91	30	177	$ 0.09	$ 15.95
DECEMBER	5.10	31	158	$ 0.09	$ 14.22
ANNUAL UTILITY CONSUMPTION & COST			10121	KWH	$ 910.90

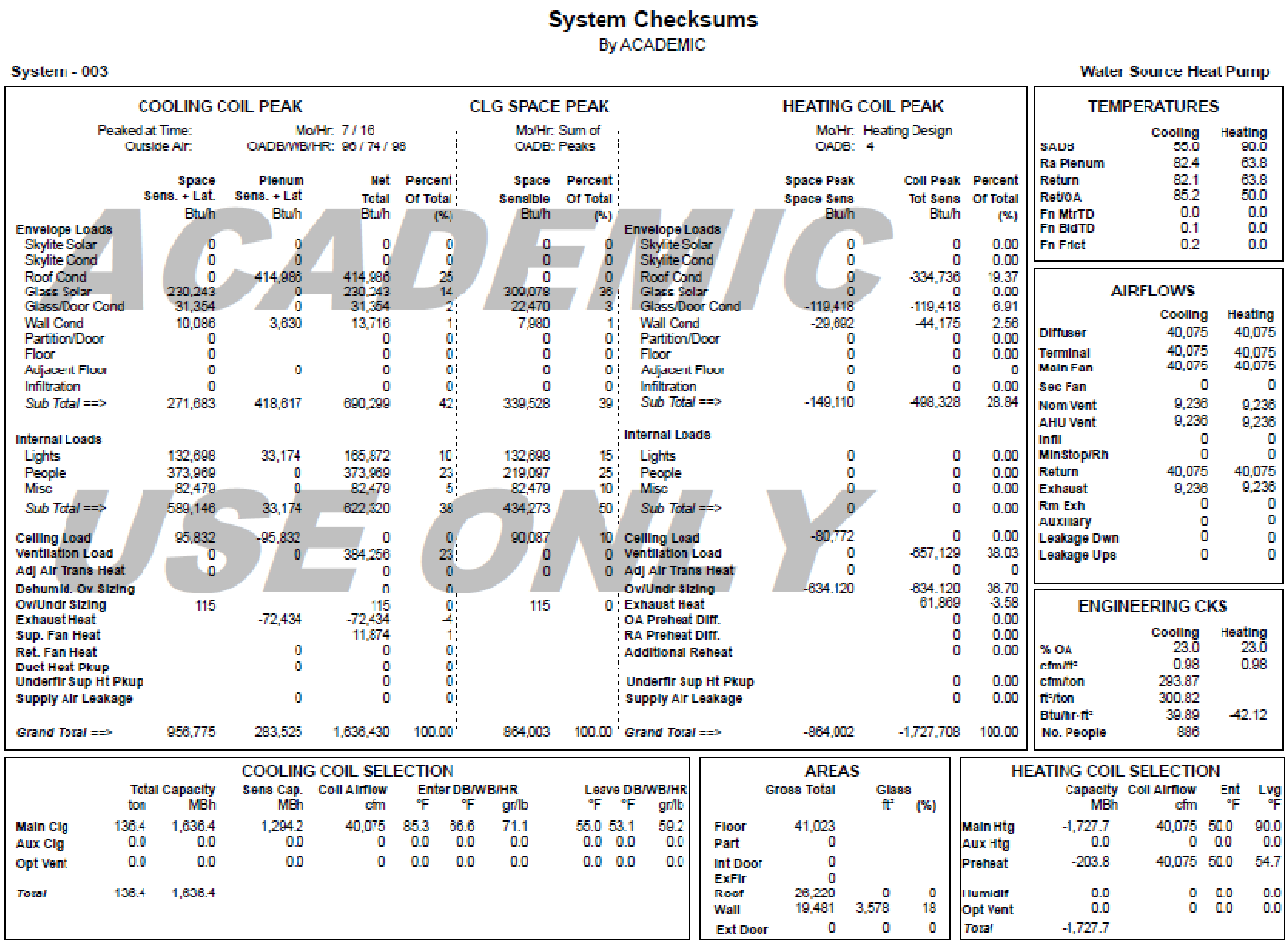
GENERAL NOTES:
1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 2 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 28,764.00	$ 2,754.00	$ 181,023.35	$ 37,393.20	$ 5,370.30	$ 102,485.22	$ 697.00	$ 55,103.56	$ 600.00	$ 676.00	$ 1,980.00	$ 32,109.18	$ 144.00	$ 11,384.38	$ 382,105.68
PRIMARY/SECONDARY	$ 38,658.00	$ 4,182.00	$ 246,051.16	$ 50,255.40	$ 8,154.90	$ 139,983.68	$ 748.24	$ 59,154.50	$ 1,200.00	$ 1,352.00	$ 3,080.00	$ 58,940.13	$ 216.00	$ 17,076.57	$ 521,206.04
DISTRIBUTIVE W/ PRIMARY	$ 51,502.86	$ 4,728.01	$ 322,961.48	$ 66,953.72	$ 9,219.61	$ 182,553.82	$ 893.01	$ 70,599.75	$ 600.00	$ 676.00	$ 1,980.00	$ 32,109.18	$ 1,029.60	$ 81,398.31	$ 689,622.54
DISTRIBUTIVE	$ 44,810.64	$ 2,742.37	$ 273,120.30	$ 58,253.83	$ 5,347.63	$ 152,424.59	$ 910.90	$ 72,014.10	$ -	$ -	$ -	$ -	$ 885.60	$ 70,013.93	$ 567,572.93

GENERAL NOTES:
1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table G.41 30-Year Life-Cycle Cost Analysis: Model 2



System Checksums
By ACADEMIC

System - 003 | Water Source Heat Pump

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 7 / 16; Outside Air: OADB/WB/HR: 96 / 74 / 98
CLG SPACE PEAK — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	414,986	414,986	25	0	0
Glass Solar	230,243	0	230,243	14	300,078	36
Glass/Door Cond	31,354	0	31,354	2	22,470	3
Wall Cond	10,086	3,630	13,716	1	7,980	1
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	271,683	418,617	690,299	42	339,528	39
Internal Loads						
Lights	132,698	33,174	165,872	10	132,698	15
People	373,969	0	373,969	23	219,097	25
Misc	82,479	0	82,479	5	82,479	10
Sub Total ==>	589,146	33,174	622,320	38	434,273	50
Ceiling Load	95,832	-95,832	0	0	90,087	10
Ventilation Load	0	0	384,256	23	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	115		115	0	115	0
Exhaust Heat		-72,434	-72,434	-4		
Sup. Fan Heat			11,874	1		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	956,775	283,525	1,636,430	100.00	864,003	100.00

HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-334,736	19.37
Glass Solar	0	0	0.00
Glass/Door Cond	-119,418	-119,418	6.91
Wall Cond	-29,692	-44,175	2.56
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-149,110	-498,328	28.84
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-80,772	0	0.00
Ventilation Load	0	-657,129	38.03
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-634,120	-634,120	36.70
Exhaust Heat		61,869	-3.58
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-864,002	-1,727,708	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	82.4	63.8
Return	82.1	63.8
Ret/OA	85.2	50.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	40,075	40,075
Terminal	40,075	40,075
Main Fan	40,075	40,075
Sec Fan	0	0
Nom Vent	9,236	9,236
AHU Vent	9,236	9,236
Infil	0	0
MinStop/Rh	0	0
Return	40,075	40,075
Exhaust	9,236	9,236
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	23.0	23.0
cfm/ft²	0.98	0.98
cfm/ton	293.87	
ft²/ton	300.82	
Btu/hr-ft²	39.89	-42.12
No. People	886	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	136.4	1,636.4	1,294.2	40,075	85.3	66.6	71.1	55.0	53.1	59.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	136.4	1,636.4								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	41,023		
Part	0		
Int Door	0		
ExFlr	0		
Roof	26,220	0	0
Wall	19,481	3,578	18
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-1,727.7	40,075	50.0	90.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-203.8	40,075	50.0	54.7
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-1,727.7			

Figure G.31 System Checksums: Model 3

SYSTEM SUMMARY
DESIGN COOLING CAPACITIES
By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

		Peak Plant Loads								Block Plant Loads								
Plant	System	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Peak Total ton	Time Of Peak mo/hr	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Block Total ton
GCHP		136.4	0.0	0.0	0.0	0.0	0.0	0.0	136.4	7/16	122.1	0.0	0.0	0.0	0.0	0.0	0.0	122.1
	System - 003	136.4	0.0	0.0	0.0	0.0	0.0	0.0	136.4	7/16	122.1	0.0	0.0	0.0	0.0	0.0	0.0	122.1
Building totals		136.4	0.0	0.0	0.0	0.0	0.0	0.0	136.4		122.1	0.0	0.0	0.0	0.0	0.0	0.0	122.1

Building peak load is 136.4 tons.

Building maximum block load of 122.1 tons occurs in July at hour 16 based on system simulation.

Figure G.32 Design Cooling Capacities: Model 3

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure G.33 Load/Airflow Summary (1 of 4): Model 3

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		224 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
	Zone - 009		Zn Peak	600	2.0	4,451	5,573	127			0	5,362	127	26.7	26.7
	Zone - 009		Zn Block	600	2.0	4,464	5,571	127			0	-6,669	127	26.7	26.7
		220 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		221 - Workroom	Rm Peak	100	0.0	881	1,057	38	2.27	0	0	1,311	38	15.9	15.9
		222 - Office	Rm Peak	225	1.1	7,699	8,435	274	7.29	0	0	-7,808	274	7.0	7.0
	Zone - 010		Zn Peak	425	1.1	10,224	11,473	349			0	-10,845	349	10.6	10.6
	Zone - 010		Zn Block	425	1.1	10,224	11,473	349			0	-11,936	349	10.6	10.6
		225 - Records	Rm Peak	175	0.0	2,172	2,471	42	1.45	0	0	-1,728	42	24.8	24.8
		226 - Breakroom	Rm Peak	100	2.5	1,974	2,690	46	2.78	0	0	-2,375	46	39.9	39.9
		227 - Storage	Rm Peak	100	0.0	1,217	1,531	17	1.04	0	0	-1,239	17	69.2	69.2
		228 - Electrical	Rm Peak	100	0.0	1,530	1,707	38	2.27	0	0	-1,311	38	15.9	15.9
		229 - Conference	Rm Peak	450	22.5	17,536	23,862	557	7.43	0	0	-22,848	557	25.0	25.0
	Zone - 011		Zn Peak	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
	Zone - 011		Zn Block	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
		214 - PS Office	Rm Peak	425	12.1	17,365	21,270	777	10.97	0	0	-24,383	777	11.1	11.1
	Zone - 012		Zn Peak	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
	Zone - 012		Zn Block	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
		103 - Elev Equip	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		104 - Storage	Rm Peak	150	0.0	978	1,497	34	1.37	0	0	-2,055	34	52.5	52.5
		108 - Quartermaster	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 013		Zn Peak	350	0.5	2,040	3,008	75			0	-4,015	75	43.5	43.5
	Zone - 013		Zn Block	350	0.5	2,045	3,007	75			0	-5,425	75	43.5	43.5
		105 - EOC	Rm Peak	1,250	83.3	38,434	62,341	1,194	5.73	0	0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Peak	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Block	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
		111 - CID	Rm Peak	880	4.4	5,432	7,902	204	1.39	0	0	-9,988	204	36.8	36.8
	Zone - 015		Zn Peak	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
	Zone - 015		Zn Block	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
		112 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		113 - Files	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		114 - Storage	Rm Peak	200	0.0	1,110	1,749	35	1.04	0	0	-2,478	35	69.2	69.2
	Zone - 016		Zn Peak	400	1.0	2,345	3,545	81			0	-4,748	81	50.7	50.7
	Zone - 016		Zn Block	400	1.0	2,345	3,545	81			0	-5,571	81	50.7	50.7
		121 - Armory	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		122 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		123 - Storage	Rm Peak	36	0.0	200	315	6	1.04	0	0	-446	6	69.2	69.2
	Zone - 017		Zn Peak	236	0.5	1,372	2,087	47			0	-2,820	47	53.1	53.1
	Zone - 017		Zn Block	236	0.5	1,372	2,087	47			0	-4,760	47	53.1	53.1
		115 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		116 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9

* This report does not display heating only systems .

Figure G.34 Load/Airflow Summary (2 of 4): Model 3

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		117 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
		118 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		119 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		120 - Patrol	Rm Peak	800	53.3	24,457	39,651	757	5.68	0	0	-48,864	757	59.2	59.2
	Zone - 018		Zn Peak	1,300	63.3	31,126	49,652	960			0	-60,431	960	56.9	56.9
	Zone - 018		Zn Block	1,300	63.3	31,115	49,641	960			0	-60,430	960	56.9	56.9
		124 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		125 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		126 - Warrant	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 019		Zn Peak	300	1.5	1,852	2,694	69			0	-3,405	69	36.8	36.8
	Zone - 019		Zn Block	300	1.5	1,852	2,694	69			0	-5,298	69	36.8	36.8
		127 - Lab	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		128 - Drugs	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
	Zone - 020		Zn Peak	200	0.0	1,110	1,749	35			0	-2,478	35	69.2	69.2
	Zone - 020		Zn Block	200	0.0	1,110	1,749	35			0	-4,474	35	69.2	69.2
		129 - Prop/Evid	Rm Peak	360	0.0	1,999	3,148	62	1.04	0	0	-4,460	62	69.2	69.2
		130 - Processing	Rm Peak	150	7.5	3,606	5,821	113	4.52	0	0	-7,181	113	57.8	57.8
	Zone - 021		Zn Peak	510	7.5	5,604	8,969	175			0	-11,641	175	61.8	61.8
	Zone - 021		Zn Block	510	7.5	5,604	8,968	175			0	-11,641	175	61.8	61.8
		131 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		132 - Cell	Rm Peak	180	4.5	2,555	4,055	83	2.78	0	0	-5,020	83	52.9	52.9
		133 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
	Zone - 022		Zn Peak	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
	Zone - 022		Zn Block	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
		134 - Jail	Rm Peak	175	0.0	972	1,530	30	1.04	0	0	-2,168	30	69.2	69.2
		135 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		136 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		137 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		138 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		139 - Holding	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		140 - Irtox	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		141 - Booking	Rm Peak	270	13.5	6,491	10,477	203	4.52	0	0	-12,926	203	57.8	57.8
	Zone - 023		Zn Peak	949	26.1	14,617	23,360	467			0	-29,150	467	56.1	56.1
	Zone - 023		Zn Block	949	26.1	14,617	23,360	467			0	-29,149	467	56.1	56.1
		142 - Mech	Rm Peak	150	0.0	1,176	1,452	49	1.41	0	0	-1,704	49	10.2	10.2
		143 - Storage	Rm Peak	150	0.0	940	1,424	31	1.23	0	0	-1,971	31	58.6	58.6
		146 - Sallyport	Rm Peak	900	0.0	17,172	20,087	481	3.21	0	0	-18,860	481	22.5	22.5
	Zone - 024		Zn Peak	1,200	0.0	19,287	22,963	561			0	-22,535	561	24.1	24.1
	Zone - 024		Zn Block	1,200	0.0	18,920	22,838	561			0	-22,622	561	24.1	24.1
		144 - Kitchen	Rm Peak	150	0.0	667	919	26	1.04	0	0	-1,238	26	34.6	34.6
		145 - Safety	Rm Peak	150	7.5	3,690	5,939	117	4.68	0	0	-7,276	117	55.8	55.8

* This report does not display heating only systems .

Figure G.35 Load/Airflow Summary (3 of 4): Model 3

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
	Zone - 025		Zn Peak	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
	Zone - 025		Zn Block	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
		110 - Corridor	Rm Peak	475	0.0	12,940	13,837	577	7.29	0	0	-15,659	577	4.9	4.9
		147 - Conference	Rm Peak	240	12.0	8,839	11,895	296	7.41	0	0	-12,162	296	25.1	25.1
	Zone - 026		Zn Peak	715	12.0	21,779	25,733	874			0	-27,821	874	11.8	11.8
	Zone - 026		Zn Block	715	12.0	21,017	25,322	874			0	-27,821	874	11.8	11.8
		148 - Office	Rm Peak	240	1.2	7,223	7,990	259	6.47	0	0	-7,551	259	7.9	7.9
		150 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		151 - Toilet	Rm Peak	100	0.0	1,418	1,418	38	2.27	0	0	-897	38	0.0	0.0
		152 - Office	Rm Peak	225	1.1	3,401	4,066	78	2.07	0	0	-3,165	78	24.6	24.6
	Zone - 027		Zn Peak	665	2.3	13,685	15,454	412			0	-13,338	412	12.5	12.5
	Zone - 027		Zn Block	665	2.3	13,622	15,439	412			0	-13,436	412	12.5	12.5
		109 - Corridor	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		110 - Corridor (Int)	Rm Peak	475	0.0	2,111	2,911	82	1.04	0	0	-3,919	82	34.6	34.6
		149 - Reception	Rm Peak	320	9.1	10,443	12,832	161	3.03	0	0	-8,308	161	40.2	40.2
		153 - Office	Rm Peak	225	1.1	2,875	3,498	52	1.39	0	0	-2,554	52	36.8	36.8
	Zone - 028		Zn Peak	1,120	10.3	15,873	19,854	313			0	-15,606	313	37.9	37.9
	Zone - 028		Zn Block	1,120	10.3	15,802	19,639	313			0	-15,606	313	37.9	37.9
		154 - Locker	Rm Peak	400	0.0	4,656	4,656	104	1.55	0	0	-2,458	104	0.0	0.0
		155 - Men	Rm Peak	400	0.0	3,963	3,963	69	1.04	0	0	-1,644	69	0.0	0.0
	Zone - 029		Zn Peak	800	0.0	8,619	8,619	173			0	-4,102	173	0.0	0.0
	Zone - 029		Zn Block	800	0.0	8,619	8,619	173			0	-7,754	173	0.0	0.0
		156 - Women	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		157 - Locker	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		158 - Toilet	Rm Peak	100	0.0	1,691	1,691	55	3.28	0	0	-1,298	55	0.0	0.0
		159 - Mech	Rm Peak	100	0.0	1,796	1,963	55	3.28	0	0	-1,712	55	11.0	11.0
	Zone - 030		Zn Peak	650	0.0	7,946	8,113	187			0	-4,860	187	3.2	3.2
	Zone - 030		Zn Block	650	0.0	7,777	7,962	187			0	-8,098	187	3.2	3.2
		160 - Workout	Rm Peak	575	2.9	48,899	51,906	2,044	21.33	0	0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Peak	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Block	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
		101 - Lobby (Ext)	Rm Peak	420	0.0	2,973	3,712	128	1.82	0	0	-4,763	128	19.8	19.8
		101 - Lobby (Int)	Rm Peak	154	0.0	684	944	27	1.04	0	0	-1,271	27	34.6	34.6
		106 - Breakroom	Rm Peak	100	2.5	1,309	2,034	46	2.78	0	0	-2,375	46	39.9	39.9
	Zone - 032		Zn Peak	674	2.5	4,966	6,691	201			0	-8,409	201	26.4	26.4
	Zone - 032		Zn Block	674	2.5	4,977	6,689	201			0	-8,409	201	26.4	26.4
System - 001			**Sys Peak**	**22,381**	**353.3**	**497,753**	**621,719**	**17,305**				**-672,528**	**17,305**	**22.0**	**22.0**
System - 001			**Sys Block**	**22,381**	**353.3**	**439,737**	**574,626**	**17,305**				**-672,612**	**17,305**	**22.0**	**22.0**

* This report does not display heating only systems .

Figure G.36 Load/Airflow Summary (4 of 4): Model 3

BUILDING COOL HEAT DEMAND

By ACADEMIC

January	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	6.2	5.4	-402,561	0.0	-509,208	0.0	-559,584	0.0	-559,731	0.0	-559,749	0.0
2	5.0	4.1	-422,826	0.0	-555,231	0.0	-582,155	0.0	-582,281	0.0	-582,298	0.0
3	4.2	3.3	-438,523	0.0	-594,903	0.0	-600,352	0.0	-600,464	0.0	-600,479	0.0
4	3.9	3.2	-451,266	0.0	-609,494	0.0	-611,471	0.0	-611,576	0.0	-611,592	0.0
5	4.3	3.5	-461,352	0.0	-612,699	0.0	-614,337	0.0	-614,435	0.0	-614,452	0.0
6	5.4	4.4	-465,418	0.0	-606,399	0.0	-607,761	0.0	-607,851	0.0	-607,867	0.0
7	7.1	6.2	-459,163	0.0	-592,124	0.0	-594,614	0.0	-594,685	0.0	-594,701	0.0
8	9.3	8.3	-445,679	0.0	-569,672	0.0	-571,673	0.0	-571,743	0.0	-571,759	0.0
9	11.8	10.8	-407,273	0.0	-527,608	0.0	-528,479	0.0	-528,552	0.0	-528,567	0.0
10	14.4	13.3	-332,140	0.0	-473,424	0.0	-474,177	0.0	-474,252	0.0	-474,269	0.0
11	16.9	15.4	-253,813	0.0	-412,421	0.0	-413,126	0.0	-413,197	0.0	-413,213	0.0
12	19.1	17.3	-177,540	0.0	-357,963	0.0	-358,607	0.0	-358,665	0.0	-358,678	0.0
13	20.8	18.6	-122,119	1.1	-317,488	0.0	-318,206	0.0	-318,267	0.0	-318,279	0.0
14	21.9	19.5	-78,496	1.2	-287,233	0.0	-287,558	0.0	-287,603	0.0	-287,615	0.0
15	22.3	19.6	-55,111	1.2	-265,192	0.0	-265,559	0.0	-265,604	0.0	-265,614	0.0
16	22.0	19.3	-39,549	1.5	-250,456	0.0	-250,777	0.0	-250,816	0.0	-250,826	0.0
17	21.2	18.7	-43,744	1.9	-250,859	0.0	-250,978	0.0	-251,016	0.0	-251,025	0.0
18	20.0	17.7	-61,560	1.8	-276,412	0.0	-276,479	0.0	-276,509	0.0	-276,516	0.0
19	18.3	16.4	-92,477	1.3	-316,561	0.0	-316,881	0.0	-316,910	0.0	-316,917	0.0
20	16.4	14.8	-130,436	0.9	-365,968	0.0	-366,090	0.0	-366,125	0.0	-366,132	0.0
21	14.2	13.0	-173,274	0.8	-417,901	0.0	-418,122	0.0	-418,149	0.0	-418,156	0.0
22	12.0	10.8	-246,341	0.7	-458,081	0.0	-458,311	0.0	-458,336	0.0	-458,342	0.0
23	9.9	8.8	-308,518	0.0	-494,812	0.0	-494,997	0.0	-495,020	0.0	-495,026	0.0
24	7.9	6.9	-349,338	0.0	-529,095	0.0	-529,260	0.0	-529,282	0.0	-529,287	0.0

February	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	17.2	16.3	-303,286	0.0	-220,821	0.0	-388,194	0.0	-388,310	0.0	-388,336	0.0
2	15.3	14.4	-325,098	0.0	-313,852	0.0	-415,307	0.0	-415,560	0.0	-415,584	0.0
3	13.7	12.7	-343,098	0.0	-359,863	0.0	-440,148	0.0	-440,373	0.0	-440,396	0.0
4	12.4	11.4	-356,672	0.7	-400,856	0.0	-461,573	0.0	-461,832	0.0	-461,854	0.0
5	11.3	10.5	-365,729	0.0	-444,190	0.0	-484,727	0.0	-484,927	0.0	-484,945	0.0
6	10.7	10.0	-367,587	0.0	-484,678	0.0	-502,466	0.0	-502,642	0.0	-502,659	0.0
7	10.5	9.9	-362,216	0.7	-507,974	0.0	-511,990	0.0	-512,147	0.0	-512,163	0.0
8	11.1	10.6	-342,213	0.8	-506,450	0.0	-508,615	0.0	-508,754	0.0	-508,768	0.0
9	12.8	12.2	-281,365	0.9	-470,078	0.0	-471,930	0.0	-472,053	0.0	-472,067	0.0
10	15.3	14.4	-210,432	1.1	-414,891	0.0	-416,450	0.0	-416,559	0.0	-416,572	0.0
11	18.5	16.9	-137,803	1.5	-353,126	0.0	-354,471	0.0	-354,569	0.0	-354,580	0.0
12	21.8	19.8	-83,381	1.9	-291,196	0.0	-292,057	0.0	-292,137	0.0	-292,147	0.0
13	25.0	22.6	-43,929	2.2	-242,754	0.8	-243,381	0.8	-243,443	0.8	-243,453	0.8
14	27.5	24.8	-20,325	3.2	-199,005	1.0	-201,064	1.0	-201,126	1.0	-201,135	1.0
15	29.2	26.3	-13,103	3.7	-163,260	1.3	-163,711	1.3	-163,759	1.3	-163,767	1.3
16	29.8	26.8	-11,894	4.5	-138,307	1.4	-138,704	1.4	-138,748	1.4	-138,756	1.4
17	29.6	26.8	-13,272	5.1	-121,645	1.4	-121,857	1.4	-121,886	1.4	-121,892	1.4
18	29.0	26.4	-17,343	5.6	-131,236	1.3	-131,627	1.3	-131,671	1.3	-131,679	1.3
19	28.0	25.7	-23,315	4.1	-153,706	1.2	-154,078	1.2	-154,149	1.2	-154,154	1.2
20	26.6	25.0	-34,826	2.6	-187,327	1.1	-187,742	1.1	-187,767	1.1	-187,772	1.1
21	25.0	23.5	-43,915	1.8	-236,898	0.9	-237,094	0.9	-236,786	0.9	-236,793	0.9
22	23.1	21.9	-58,600	1.2	-281,908	0.8	-281,839	0.8	-281,889	0.8	-281,896	0.8
23	21.2	20.1	-74,314	1.0	-318,963	0.7	-318,890	0.7	-318,932	0.7	-318,938	0.7
24	19.1	18.2	-102,203	0.9	-357,576	0.0	-357,624	0.0	-357,653	0.0	-357,658	0.0

Figure G.37 Building Cool Heat Demand (1 of 6): Model 3

BUILDING COOL HEAT DEMAND

By ACADEMIC

March	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.4	33.4	-21,155	2.8	0	2.5	-31,117	2.5	-31,407	2.5	-31,500	2.5
2	33.9	31.9	-30,772	3.7	0	2.2	-45,212	2.2	-45,493	2.2	-45,557	2.2
3	32.9	31.1	-43,572	3.6	0	2.0	-59,271	2.0	-59,681	2.0	-59,750	2.0
4	32.6	31.1	-51,220	3.5	0	2.0	-69,276	2.0	-69,987	2.0	-72,990	2.0
5	32.9	31.5	-50,201	3.5	-25,170	2.0	-84,002	2.0	-85,586	2.0	-85,245	2.0
6	33.9	32.5	-58,928	3.5	-51,936	2.1	-91,104	2.1	-98,183	2.1	-97,715	2.1
7	35.4	34.2	-60,128	4.2	-62,361	2.4	-96,393	2.4	-100,539	2.4	-102,200	2.4
8	37.4	30.1	-43,505	4.5	-63,370	2.7	-91,571	2.7	-101,140	2.7	-103,820	2.7
9	39.7	37.9	-26,453	5.7	-56,437	3.4	-76,384	3.4	-83,267	3.4	-85,844	3.4
10	42.1	39.6	-11,975	9.1	-45,919	5.0	-60,860	4.9	-61,595	4.9	-63,498	4.9
11	44.6	41.5	0	11.2	-32,782	6.3	-41,166	6.3	-41,636	6.3	-42,125	6.3
12	46.9	43.0	0	12.8	-16,879	7.0	-21,265	6.7	-21,463	6.7	-21,527	6.7
13	48.9	44.3	0	17.0	-2,147	7.7	-2,103	7.7	-2,103	7.7	-2,103	7.7
14	50.4	45.0	0	23.8	0	8.0	0	8.1	0	8.1	0	8.1
15	51.4	45.4	0	30.5	0	8.2	0	8.2	0	8.2	0	8.3
16	51.7	45.5	0	36.0	0	8.9	0	8.7	0	8.7	0	8.7
17	51.4	45.1	0	41.6	0	9.3	0	9.1	0	9.1	0	9.1
18	50.4	44.2	0	44.9	0	10.1	0	9.8	0	9.8	0	9.8
19	48.9	43.4	0	38.4	-1,028	10.2	-1,123	10.1	-1,102	10.1	-1,100	10.1
20	46.9	42.8	0	29.5	-1,785	8.5	-1,758	8.5	-1,757	8.5	-1,757	8.5
21	44.6	41.4	0	20.8	0	6.0	0	6.0	0	6.0	0	6.0
22	42.1	39.6	-1,912	13.8	0	4.7	0	4.7	0	4.7	0	4.7
23	39.7	37.4	-1,856	9.8	-1,357	3.4	-1,414	3.8	-1,413	3.8	-1,413	3.8
24	37.4	35.0	-3,808	7.5	-13,303	3.2	-13,811	2.9	-13,937	2.9	-13,980	2.9

April	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	48.1	46.0	0	9.1	-2,989	8.2	-3,143	8.3	-3,163	8.3	-3,165	8.3
2	45.9	44.2	0	9.4	-2,409	6.6	-2,465	6.7	-2,467	6.7	-2,467	6.7
3	44.1	42.4	0	9.1	0	5.2	0	5.2	0	5.2	0	5.2
4	42.5	40.9	0	8.7	0	4.6	0	4.2	0	4.2	0	4.2
5	41.3	39.8	-1,091	8.4	-1,206	4.3	-1,237	4.8	-1,242	4.8	-1,243	4.8
6	40.6	39.3	-1,191	8.4	0	4.0	0	3.6	0	3.6	0	3.6
7	40.4	30.1	0	0.6	0	3.8	0	3.8	0	3.8	0	3.8
8	41.1	39.7	0	12.6	0	5.0	0	5.0	0	5.0	0	5.0
9	43.0	40.8	0	18.3	0	5.7	0	6.2	0	6.2	0	6.2
10	45.9	42.4	0	25.5	-2,272	0.0	-2,310	0.1	-2,262	0.1	-2,262	0.1
11	49.6	44.5	0	33.1	0	10.6	0	10.7	0	10.7	0	10.7
12	53.4	47.5	0	38.1	0	14.6	0	14.8	0	14.8	0	14.8
13	57.0	50.1	0	47.1	0	10.5	0	10.6	0	10.6	0	10.6
14	60.0	52.3	0	53.2	0	22.2	0	22.5	0	22.5	0	22.5
15	61.9	53.7	0	59.7	0	25.6	0	25.8	0	25.8	0	25.8
16	62.0	53.9	0	62.7	0	28.4	0	28.4	0	28.5	0	28.5
17	62.3	53.9	0	65.2	0	32.3	0	32.5	0	32.5	0	32.6
18	61.6	53.4	0	62.4	0	33.2	0	33.3	0	33.3	0	33.3
19	60.5	52.6	0	56.1	0	30.5	0	30.7	0	30.7	0	30.7
20	58.9	52.7	0	46.7	0	26.5	0	26.6	0	26.6	0	26.6
21	57.0	52.5	0	37.4	0	22.0	0	22.2	0	22.2	0	22.2
22	54.9	51.5	0	28.8	0	17.3	0	17.4	0	17.4	0	17.4
23	52.6	50.0	0	21.8	0	13.2	0	13.3	0	13.3	0	13.3
24	50.3	48.0	0	17.4	-1,200	10.3	-1,210	10.4	-1,211	10.4	-1,211	10.4

Figure G.38 Building Cool Heat Demand (2 of 6): Model 3

BUILDING COOL HEAT DEMAND

By ACADEMIC

May	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	59.2	56.0	0	29.1	0	23.6	0	24.6	0	24.7	0	24.7
2	56.8	53.8	0	27.0	0	18.9	0	20.1	0	20.1	0	20.1
3	54.8	52.2	0	24.9	0	15.6	0	16.4	-1,110	16.5	-1,111	16.5
4	53.3	50.9	0	23.3	-1,308	13.4	0	13.9	0	13.9	0	13.9
5	52.3	50.2	0	22.3	0	11.7	0	12.2	0	12.2	0	12.2
6	52.0	50.3	0	22.5	-1,274	11.1	-1,430	11.5	-1,444	11.5	-1,446	11.5
7	52.5	50.8	0	26.2	-1,332	12.6	-1,545	13.1	-1,558	13.1	-1,560	13.1
8	53.8	51.6	0	32.8	1,116	16.7	1,203	16.2	1,306	16.3	1,307	16.3
9	55.9	52.4	0	42.1	0	20.2	0	21.2	0	21.2	0	21.2
10	58.5	53.8	0	52.2	0	26.4	0	27.7	0	27.7	0	27.7
11	61.6	55.1	0	59.5	0	32.1	0	33.4	0	33.4	0	33.4
12	64.7	56.6	0	66.1	0	37.9	0	39.0	0	39.0	0	39.0
13	67.8	58.2	0	71.5	0	43.0	0	43.9	0	43.9	0	44.0
14	70.4	59.6	0	77.4	0	48.0	0	48.9	0	48.9	0	48.9
15	72.5	61.1	0	82.4	0	54.0	0	54.7	0	54.7	0	54.7
16	73.8	62.4	0	85.6	0	59.0	0	59.7	0	59.7	0	59.7
17	74.3	62.8	0	86.0	0	61.2	0	61.8	0	61.9	0	61.9
18	74.0	62.6	0	82.8	0	59.9	0	60.3	0	60.4	0	60.4
19	73.0	62.1	0	76.1	0	56.0	0	56.4	0	56.4	0	56.4
20	71.5	62.0	0	66.6	0	51.2	0	51.5	0	51.5	0	51.5
21	69.5	63.0	0	57.2	0	47.4	0	47.6	0	47.6	0	47.6
22	67.1	61.9	0	48.3	0	41.2	0	41.4	0	41.4	0	41.4
23	64.5	59.9	0	41.1	0	34.8	0	34.9	0	34.9	0	34.9
24	61.8	58.0	0	35.9	0	29.4	0	29.5	0	29.5	0	29.5

June	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	68.3	64.8	0	49.8	0	45.4	0	46.6	0	46.7	0	46.7
2	66.4	63.3	0	46.1	0	41.4	0	42.0	0	42.0	0	42.0
3	64.8	62.3	0	43.6	0	36.4	0	38.1	0	38.1	0	38.1
4	63.6	61.5	0	41.8	0	33.8	0	35.5	0	35.6	0	35.6
5	62.9	61.0	0	40.6	0	32.1	0	33.4	0	33.4	0	33.4
6	62.6	60.8	0	41.5	0	31.5	0	32.5	0	32.5	0	32.5
7	63.1	61.4	0	47.5	0	34.6	0	35.5	0	35.6	0	35.6
8	64.5	61.6	0	56.0	0	39.3	0	40.3	0	40.3	0	40.4
9	66.8	62.3	0	66.6	0	45.2	0	46.1	0	46.2	0	46.2
10	69.0	63.9	0	77.1	0	54.1	0	54.9	0	54.8	0	54.9
11	72.7	66.0	0	85.9	0	62.3	0	63.0	0	63.1	0	63.0
12	75.8	67.7	0	92.2	0	70.0	0	70.6	0	70.7	0	70.6
13	78.7	69.7	0	97.5	0	77.8	0	78.3	0	78.4	0	78.4
14	80.0	71.1	0	102.7	0	83.9	0	84.3	0	84.3	0	84.3
15	82.3	71.7	0	106.7	0	89.3	0	89.6	0	89.7	0	89.7
16	82.8	72.0	0	109.3	0	92.5	0	92.8	0	92.9	0	92.9
17	82.6	71.4	0	108.8	0	92.4	0	92.8	0	92.9	0	92.9
18	81.8	71.1	0	105.3	0	90.2	0	90.6	0	90.6	0	90.6
19	80.6	70.5	0	98.3	0	85.3	0	85.6	0	85.6	0	85.6
20	79.0	70.3	0	88.7	0	79.3	0	79.5	0	79.5	0	79.5
21	77.1	70.2	0	79.2	0	73.0	0	73.1	0	73.2	0	73.2
22	75.0	69.6	0	68.8	0	66.5	0	66.5	0	66.6	0	66.6
23	72.7	68.0	0	60.6	0	58.5	0	58.5	0	58.6	0	58.6
24	70.5	66.8	0	55.0	0	53.0	0	53.1	0	53.1	0	53.1

Figure G.39 Building Cool Heat Demand (3 of 6): Model 3

BUILDING COOL HEAT DEMAND

By ACADEMIC

July	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	74.2	70.8	0	66.5	0	63.0	0	65.1	0	65.1	0	65.1
2	72.8	69.4	0	62.3	0	59.2	0	60.0	0	60.0	0	60.0
3	71.6	68.6	0	59.9	0	55.6	0	56.4	0	56.4	0	56.4
4	70.8	67.9	0	50.2	0	51.9	0	53.5	0	53.5	0	53.5
5	70.1	67.6	0	57.1	0	50.9	0	52.2	0	52.2	0	52.2
6	69.9	67.5	0	57.2	0	50.0	0	51.0	0	51.0	0	51.0
7	70.2	68.0	0	63.2	0	63.4	0	64.1	0	64.2	0	64.1
8	71.3	68.5	0	72.0	0	58.5	0	59.0	0	59.0	0	59.2
9	73.1	69.1	0	81.9	0	64.9	0	65.3	0	65.4	0	65.4
10	75.2	70.2	0	91.9	0	74.4	0	74.8	0	74.8	0	74.8
11	77.6	71.2	0	98.9	0	81.5	0	82.0	0	82.0	0	82.0
12	80.0	72.8	0	106.4	0	89.2	0	89.6	0	89.6	0	89.6
13	82.2	74.4	0	111.7	0	95.7	0	96.1	0	96.1	0	96.1
14	83.9	76.0	0	116.4	0	102.3	0	102.7	0	102.7	0	102.8
15	85.0	76.6	0	120.1	0	107.2	0	107.6	0	107.6	0	107.6
16	85.4	76.6	0	122.1	0	109.4	0	109.8	0	109.8	0	109.8
17	85.2	76.4	0	121.4	0	109.8	0	110.1	0	110.1	0	110.1
18	84.6	76.2	0	117.7	0	108.0	0	108.2	0	108.2	0	108.3
19	83.7	75.8	0	112.3	0	103.0	0	103.2	0	103.2	0	103.2
20	82.4	76.2	0	104.0	0	98.3	0	98.4	0	98.4	0	98.4
21	81.0	76.1	0	94.7	0	92.6	0	92.6	0	92.6	0	92.6
22	79.3	75.3	0	85.0	0	84.6	0	84.6	0	84.6	0	84.6
23	77.6	73.9	0	76.0	0	77.3	0	77.3	0	77.4	0	77.4
24	75.9	72.5	0	70.4	0	71.3	0	71.4	0	71.4	0	71.4

August	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	73.5	69.6	0	61.5	0	59.0	0	61.2	0	61.2	0	61.2
2	71.7	68.0	0	56.8	0	54.2	0	55.6	0	55.6	0	55.6
3	70.1	66.8	0	54.1	0	49.3	0	51.5	0	51.5	0	51.5
4	68.8	65.7	0	51.6	0	46.3	0	47.9	0	47.9	0	47.9
5	67.8	65.2	0	50.5	0	44.2	0	45.5	0	45.5	0	45.4
6	67.2	64.7	0	50.4	0	42.8	0	43.6	0	43.6	0	43.8
7	66.9	64.4	0	54.1	0	43.1	0	43.9	0	43.9	0	43.8
8	67.5	64.6	0	62.5	0	47.0	0	47.5	0	47.5	0	47.7
9	69.2	64.9	0	73.1	0	52.0	0	52.8	0	52.8	0	52.7
10	71.7	66.0	0	84.2	0	61.3	0	61.9	0	61.9	0	62.0
11	74.8	67.8	0	93.8	0	71.0	0	71.5	0	71.5	0	71.5
12	78.0	70.0	0	101.7	0	79.7	0	80.1	0	80.1	0	80.1
13	81.1	72.2	0	107.1	0	88.0	0	88.4	0	88.4	0	88.4
14	83.6	73.7	0	111.8	0	94.6	0	94.9	0	95.0	0	95.0
15	85.3	74.8	0	116.1	0	100.6	0	101.0	0	101.1	0	101.1
16	85.9	75.3	0	118.7	0	104.3	0	104.7	0	104.8	0	104.8
17	85.6	75.0	0	117.4	0	104.6	0	104.9	0	104.9	0	105.0
18	85.0	74.8	0	113.0	0	102.2	0	102.4	0	102.4	0	102.4
19	84.0	75.0	0	106.3	0	97.5	0	97.7	0	97.7	0	97.7
20	82.7	75.4	0	96.1	0	92.3	0	92.4	0	92.4	0	92.4
21	81.1	75.8	0	86.6	0	87.5	0	87.5	0	87.6	0	87.6
22	79.3	74.7	0	76.3	0	80.7	0	80.7	0	80.7	0	80.7
23	77.4	73.1	0	68.0	0	73.4	0	73.5	0	73.5	0	73.5
24	75.4	71.1	0	62.7	0	66.7	0	66.7	0	66.7	0	66.7

Figure G.40 Building Cool Heat Demand (4 of 6): Model 3

BUILDING COOL HEAT DEMAND

By ACADEMIC

September	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	62.0	58.8	0	37.8	0	29.1	0	31.6	0	31.6	0	31.6
2	59.5	56.4	0	33.3	0	24.3	0	26.2	0	26.2	0	26.2
3	57.3	54.7	0	30.5	0	20.6	0	21.8	0	21.9	0	21.9
4	56.7	53.3	0	28.2	-1,034	17.6	-1,079	18.5	-1,089	18.5	-1,090	18.5
5	54.7	52.7	0	27.0	0	15.3	0	16.2	0	16.2	0	16.2
6	54.4	52.4	0	26.9	0	14.4	0	14.9	0	14.9	0	14.9
7	56.0	53.1	0	27.8	0	14.5	0	15.0	0	15.0	0	15.0
8	57.0	54.8	0	33.8	0	18.2	0	19.1	0	19.1	0	19.1
9	60.0	56.2	0	43.9	0	24.3	0	25.3	0	25.3	0	25.3
10	63.7	57.6	0	55.8	0	32.1	0	33.2	0	33.2	0	33.2
11	67.9	59.7	0	68.1	0	42.5	0	43.7	0	43.7	0	43.7
12	72.1	61.7	0	75.8	0	50.6	0	51.4	0	51.5	0	51.5
13	76.0	64.1	0	82.4	0	60.3	0	60.3	0	60.3	0	60.3
14	78.9	65.7	0	88.7	0	67.3	0	68.0	0	68.0	0	68.0
15	80.8	66.9	0	94.1	0	73.2	0	73.8	0	73.8	0	73.8
16	81.5	67.1	0	96.9	0	76.7	0	77.1	0	77.1	0	77.2
17	81.1	67.1	0	96.0	0	76.0	0	77.3	0	77.3	0	77.3
18	80.1	67.3	0	89.9	0	74.1	0	74.3	0	74.4	0	74.4
19	78.5	68.0	0	80.0	0	70.0	0	70.2	0	70.3	0	70.3
20	76.4	69.9	0	70.7	0	68.3	0	68.4	0	68.5	0	68.5
21	73.8	68.7	0	60.1	0	60.8	0	60.0	0	60.0	0	61.0
22	70.9	66.5	0	51.3	0	52.7	0	52.7	0	52.8	0	52.8
23	67.9	64.2	0	44.8	0	45.3	0	45.4	0	45.4	0	45.4
24	64.9	61.3	0	39.0	0	37.9	0	37.9	0	37.9	0	37.9

October	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	46.2	40.6	0	19.4	-3,053	7.2	-2,318	7.0	-2,320	7.0	-2,320	7.0
2	44.9	39.9	0	17.0	-2,893	6.1	0	5.6	0	5.6	0	5.6
3	44.5	39.9	0	14.9	0	5.3	-1,963	5.8	-1,966	5.8	-1,966	5.8
4	44.9	40.5	0	13.7	-2,036	5.8	-2,072	5.4	-2,072	5.4	-2,072	5.4
5	46.2	41.5	0	12.8	-1,732	6.1	-1,820	6.1	-1,820	6.1	-1,820	6.1
6	48.3	43.8	0	12.8	-1,103	6.3	-1,143	6.8	-1,143	6.8	-1,143	6.8
7	51.0	46.5	0	13.5	0	7.7	0	7.7	0	7.7	0	7.7
8	54.2	49.8	0	17.4	0	9.4	0	9.4	0	9.4	0	9.4
9	57.6	52.1	0	24.2	0	12.0	0	12.1	0	12.1	0	12.1
10	61.0	53.5	0	33.1	0	15.7	0	15.8	0	15.8	0	15.8
11	64.1	55.0	0	43.1	0	21.7	0	21.8	0	21.8	0	21.8
12	66.9	56.1	0	50.7	0	27.2	0	27.2	0	27.1	0	27.1
13	68.9	57.1	0	57.2	0	32.4	0	32.4	0	32.4	0	32.4
14	70.3	57.3	0	62.9	0	36.5	0	36.4	0	36.4	0	36.4
15	70.7	57.2	0	68.6	0	40.0	0	40.2	0	40.2	0	40.2
16	70.3	56.4	0	71.7	0	41.5	0	41.8	0	41.8	0	41.8
17	68.9	55.3	0	70.5	0	40.3	0	40.5	0	40.5	0	40.5
18	66.9	53.9	0	63.8	0	36.5	0	36.6	0	36.6	0	36.6
19	64.1	52.7	0	55.0	0	31.6	0	31.5	0	31.5	0	31.5
20	61.0	52.0	0	45.3	0	26.2	0	26.1	0	26.1	0	26.1
21	57.6	49.8	0	36.6	0	20.6	0	20.6	0	20.6	0	20.6
22	54.2	47.5	0	30.4	0	15.5	0	15.5	0	15.5	0	15.5
23	51.0	44.9	0	25.6	-1,616	11.6	-1,608	11.7	-1,608	11.7	-1,607	11.7
24	48.3	42.6	0	21.8	-2,321	8.9	-2,331	8.9	-2,332	8.9	-2,332	8.9

Figure G.41 Building Cool Heat Demand (5 of 6): Model 3

BUILDING COOL HEAT DEMAND

By ACADEMIC

November	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.9	33.1	0	4.5	0	2.6	-56,298	2.6	-57,285	2.6	-57,720	2.6
2	33.9	31.2	-1,301	3.9	0	2.2	-77,653	2.2	-78,549	2.2	-78,859	2.2
3	32.3	29.8	0	3.6	0	1.9	-102,060	1.9	-104,856	1.9	-105,190	1.9
4	31.0	28.8	0	3.5	-21,328	1.7	-120,583	1.7	-128,314	1.7	-128,512	1.7
5	30.3	27.9	0	3.7	-66,312	1.6	-155,268	1.6	-163,146	1.6	-163,332	1.6
6	30.0	27.7	0	3.5	-84,224	1.6	-172,262	1.6	-182,015	1.6	-182,225	1.6
7	30.5	28.4	0	3.7	-83,035	1.6	-182,003	1.6	-189,145	1.6	-192,012	1.6
8	32.0	30.0	-14,980	5.0	-83,120	1.9	-174,327	1.9	-184,149	1.9	-184,403	1.9
9	34.3	32.0	-18,337	5.6	-98,640	2.2	-157,436	2.2	-167,098	2.2	-167,513	2.2
10	37.1	34.0	-12,375	8.2	-84,099	2.6	-126,556	2.6	-129,697	2.6	-129,930	2.6
11	40.3	36.2	0	9.9	-57,625	3.4	-62,446	3.4	-63,002	3.4	-63,215	3.4
12	43.5	38.3	0	11.7	-39,764	4.4	-48,248	4.3	-48,627	4.3	-48,731	4.3
13	46.4	40.1	0	16.7	-23,006	5.5	-26,947	5.5	-27,265	5.5	-27,356	5.5
14	48.6	41.4	0	22.5	0	5.9	-13,264	5.9	-13,625	5.9	-13,735	5.9
15	50.1	42.5	0	27.5	-1,060	7.3	-1,153	7.3	-1,153	7.3	-1,153	7.3
16	50.6	42.6	0	33.2	0	7.5	0	7.5	0	7.5	0	7.5
17	50.3	42.5	0	32.2	0	7.7	0	7.5	0	7.5	0	7.5
18	49.6	42.8	0	28.6	0	7.4	0	7.4	0	7.4	0	7.4
19	48.4	42.9	0	22.3	-1,117	6.8	-1,117	6.8	-1,117	6.8	-1,117	6.8
20	46.7	42.2	0	15.5	-1,821	6.2	-1,859	6.2	-1,850	6.2	-1,850	6.2
21	44.8	41.1	-2,444	11.1	-11,057	5.6	-11,935	5.6	-12,276	5.6	-12,388	5.6
22	42.6	39.3	-3,059	8.1	-12,379	4.5	-13,364	4.5	-13,625	4.5	-13,716	4.5
23	40.3	37.4	0	5.7	-28,641	3.5	-31,891	3.5	-32,403	3.5	-32,545	3.5
24	38.0	35.3	-2,194	5.5	-38,658	3.0	-42,458	3.0	-42,915	3.0	-43,020	3.0

December	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	23.5	20.5	-57,087	2.6	-43,221	0.8	-228,729	0.9	-230,488	0.9	-230,634	0.9
2	22.9	20.1	-75,089	2.3	-88,598	0.8	-267,844	0.8	-269,906	0.8	-270,273	0.8
3	23.2	20.5	-98,657	2.2	-120,249	0.8	-282,116	0.8	-283,502	0.8	-283,685	0.8
4	24.1	21.7	-113,194	2.0	-148,098	0.8	-292,489	0.8	-293,274	0.8	-293,369	0.8
5	25.5	23.2	-139,882	2.0	-168,573	0.9	-288,480	0.9	-288,897	0.9	-288,942	0.9
6	27.4	25.1	-153,031	2.0	-217,775	1.0	-278,443	1.0	-278,762	1.0	-278,803	1.0
7	29.7	27.4	-154,304	2.2	-225,201	1.2	-260,494	1.2	-261,117	1.2	-261,155	1.2
8	32.3	30.1	-145,485	2.5	-222,671	1.8	-241,784	1.8	-242,036	1.8	-242,069	1.8
9	34.9	32.8	-110,672	3.2	-196,396	2.2	-201,880	2.2	-202,087	2.2	-202,115	2.2
10	37.6	34.9	-64,563	4.3	-155,219	2.7	-157,376	2.7	-157,542	2.7	-157,563	2.7
11	40.1	30.4	-33,414	0.9	-107,014	3.1	-109,035	3.1	-109,071	3.1	-109,092	3.1
12	42.4	37.4	-14,230	8.3	-64,594	3.5	-65,063	3.5	-65,125	3.5	-65,138	3.5
13	44.3	38.1	0	9.5	-41,041	3.9	-41,404	3.8	-41,454	3.8	-41,466	3.8
14	45.7	38.4	0	10.5	-24,774	4.3	-25,047	4.1	-25,088	4.1	-25,099	4.1
15	46.6	38.6	0	12.0	-15,086	5.0	-15,374	4.9	-15,420	4.9	-15,432	4.9
16	46.9	38.6	0	14.8	0	5.5	0	4.6	0	4.6	0	4.6
17	46.3	38.2	0	18.6	0	5.1	-1,770	5.4	-1,770	5.4	-10,718	5.4
18	44.6	37.6	0	16.9	-13,330	5.5	-15,096	5.6	-15,158	5.6	-13,177	5.6
19	42.0	36.6	-1,058	13.1	-24,334	4.3	-24,189	4.3	-24,251	4.3	-24,412	4.3
20	38.6	34.1	-1,949	8.7	-42,131	3.4	-42,264	3.4	-42,333	3.4	-42,438	3.4
21	34.9	30.9	0	5.7	-61,398	2.4	-61,576	2.4	-61,631	2.4	-61,700	2.4
22	31.2	27.6	0	4.2	-84,605	1.8	-84,768	1.8	-84,813	1.8	-84,858	1.8
23	27.9	24.4	0	3.1	-139,790	1.3	-140,032	1.3	-140,089	1.3	-140,137	1.3
24	25.2	22.1	0	2.8	-194,128	1.0	-194,370	1.0	-194,410	1.0	-194,413	1.0

Figure G.42 Building Cool Heat Demand (6 of 6): Model 3

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - M6 - Durango Public Library

GCHP

	Year 1				
Month	Average Earth Temp. °F	Average Fluid Leaving Temp. °F	Average Fluid Entering Temp. °F	Minimum Fluid Entering Temp. °F	Maximum Fluid Entering Temp. °F
Jan	52.60	49.00	47.20	45.40	55.40
Feb	52.50	50.00	48.80	46.70	52.60
Mar	54.40	55.00	55.30	49.10	60.70
Apr	56.10	58.20	59.30	55.80	67.50
May	59.00	64.00	66.40	60.30	74.50
Jun	63.20	72.20	76.60	68.50	83.30
Jul	67.50	79.40	85.20	77.80	90.80
Aug	69.30	80.30	85.50	80.20	93.50
Sep	68.10	74.80	78.00	72.60	88.90
Oct	66.00	68.90	70.30	67.70	81.50
Nov	63.90	64.10	64.20	62.30	70.90
Dec	62.80	62.20	62.00	59.80	66.40
Annual	61.30	64.80	66.60	45.40	93.50

Figure G.43 Geothermal Earth Temperature Summary: Model 3

Table G.42 Heat Pump Selections (1 of 2): Model 3

MODEL 3 - HEAT PUMP SELECTIONS											
HEAT PUMP	**UNIT SIZE	UNIT AIR FLOW	COOLING					HEATING		GPM	WPD
			AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG LWT	HTG Q_T	HTG LWT		
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(ºF)	(MBH)	(ºF)		(FT)
1	030	950	795	2.3	24.1	27.3	80.0	-29.3	50.0	6.0	5.1
2A	042	1050	585	3.2	26.1	38.1	80.0	-40.6	50.0	11.0	7.4
2B	042	1050	585	3.2	26.1	38.1	80.0	-40.6	50.0	11.0	7.4
3A	042	1050	570	3.2	26.0	37.8	80.0	-39.8	50.0	8.3	4.4
3B	042	1050	570	3.2	26.0	37.8	81.0	-39.8	51.0	8.3	4.4
4	012	350	320	0.7	6.1	8.6	80.0	-12.1	50.0	2.6	3.5
5	042	1050	855	2.2	19.2	26.1	80.0	-37.1	50.0	5.5	1.6
6	048	1200	975	4.0	38.6	47.4	80.0	-43.0	50.0	9.0	5.3
7	048	1200	965	3.0	23.3	35.8	80.0	-48.6	50.0	6.0	2.1
8	042	1050	770	3.0	29.0	35.8	80.0	-33.8	50.0	8.3	4.4
9	036	940	845	2.2	20.8	26.0	80.0	-34.8	50.0	9.0	10.4
10	070	2100	1865	5.7	57.1	67.8	80.0	-68.3	50.0	12.4	8.8
11	009	225	200	0.3	2.8	4.0	80.0	-8.4	50.0	1.4	1.4
12	048	1600	1315	3.5	40.7	41.8	80.0	-40.1	50.0	6.0	2.1
13	048	1200	1000	3.1	24.2	37.2	80.0	-50.9	50.0	12.0	8.2
14	036	940	770	2.4	18.7	28.7	80.0	-39.2	50.0	6.8	6.5
15	060	1950	1630	4.3	39.3	51.7	80.0	-66.0	50.0	11.3	4.4
16	018	450	330	0.9	7.2	10.8	80.0	-14.4	50.0	2.8	0.5
17	018	450	410	0.9	8.2	10.6	80.0	-16.8	50.0	2.8	0.5
18	048	1200	1055	3.2	25.4	38.8	80.0	-53.3	50.0	9.0	5.3
19	042	1400	1145	2.7	27.0	31.9	80.0	-41.5	50.0	8.3	4.4
20	018	450	445	1.2	9.0	14.6	80.0	-18.2	50.0	4.1	2.8
21	060	1465	980	3.5	25.8	41.7	80.0	-57.7	50.0	11.3	4.4
22	060	1465	1370	4.8	47.0	58.1	80.0	-58.1	50.0	11.3	4.4
23	048	1200	1100	3.8	39.1	45.3	80.0	-40.4	50.0	6.0	2.1
24	030	950	525	2.4	23.6	29.3	80.0	-23.2	50.0	6.0	5.1
25	042	1050	755	3.0	31.1	35.8	80.0	-28.9	50.0	8.3	4.4
26	030	715	490	2.2	21.6	26.1	80.0	-22.1	50.0	6.0	5.1
27	060	1465	1450	4.5	39.3	53.6	80.0	-64.7	50.0	11.3	4.4
28	030	715	765	2.1	22.8	25.3	80.0	-26.2	50.0	6.0	5.1
29	070	1575	1910	4.7	48.9	56.2	80.0	-65.1	50.0	12.4	8.8
30	036	1250	700	2.9	28.9	34.7	80.0	-30.7	50.0	6.8	6.5
31	030	715	530	2.4	25.2	29.0	80.0	-20.4	50.0	6.0	5.1
32	009	225	145	0.7	7.3	8.8	80.0	-6.4	50.0	2.1	2.6
33	048	1200	730	3.8	37.3	45.8	80.0	-36.4	50.0	9.0	5.3
34	060	1465	1550	4.5	44.3	54.4	80.0	-59.8	50.0	15.0	8.3
35	024	850	835	1.9	20.9	22.5	80.0	-26.9	50.0	6.0	5.1
36	048	1200	665	3.5	34.1	42.0	80.0	-33.8	50.0	9.0	5.3
37	036	940	545	2.9	28.0	34.6	80.0	-27.9	50.0	9.0	10.4
38	060	1950	1460	4.7	40.7	56.0	80.0	-61.5	50.0	15.0	8.3
39	036	1250	700	2.6	23.4	31.6	80.0	-35.8	50.0	6.8	6.5

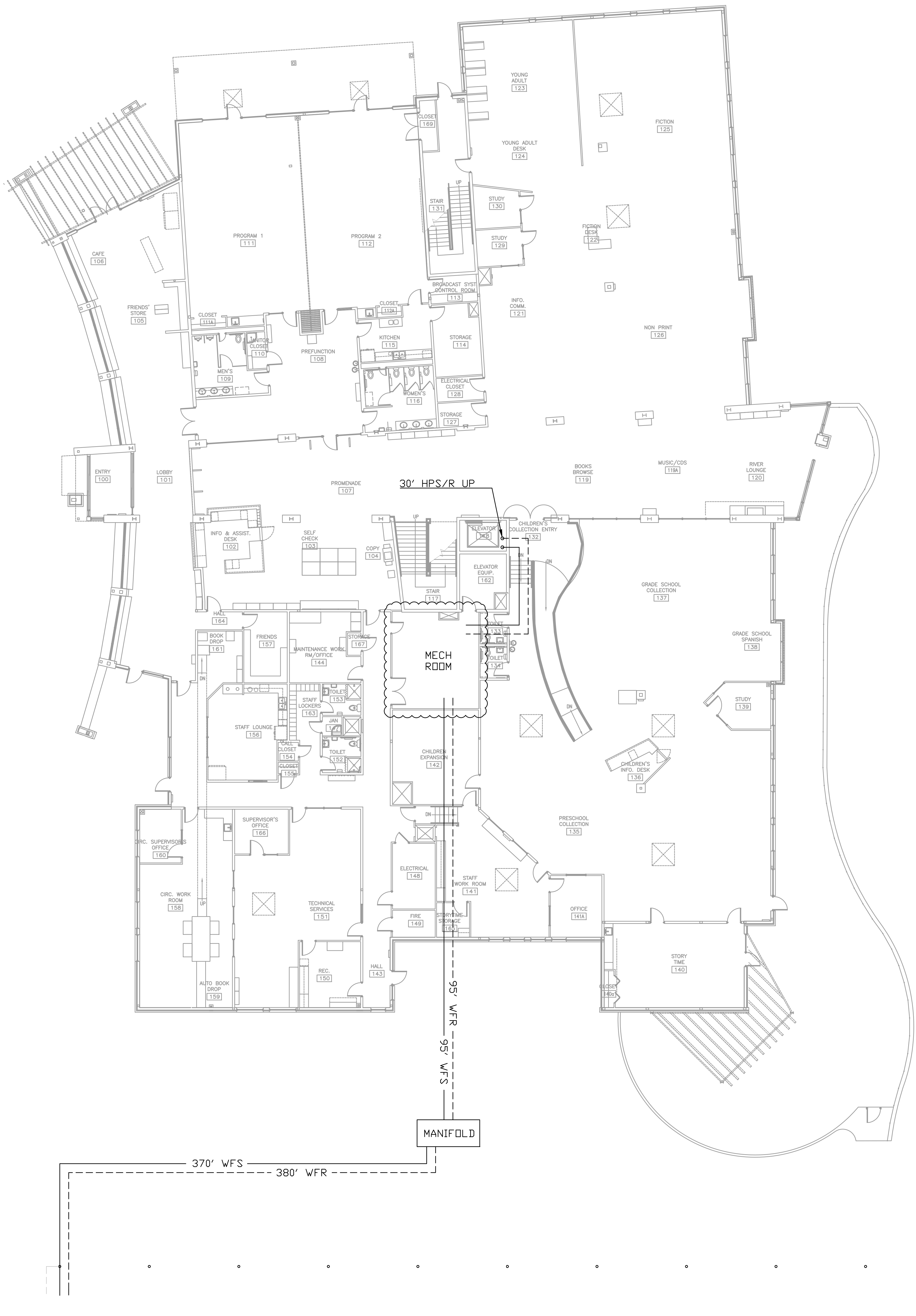
Table G.43 Heat Pump Selections (2 of 2): Model 3

MODEL 3 - HEAT PUMP SELECTIONS											
40	018	450	185	1.3	14.6	15.5	80.0	-6.7	50.0	2.8	0.5
41	036	940	910	2.7	28.3	32.4	80.0	-31.7	50.0	6.8	6.5
42	018	450	400	1.1	13.4	13.7	80.0	-11.9	50.0	2.8	0.5
43	036	940	540	2.7	27.8	32.2	80.0	-22.6	50.0	6.8	6.5
44	036	940	545	2.9	28.0	34.5	80.0	-27.8	50.0	6.8	6.5
45	024	640	690	1.6	17.2	19.3	80.0	-22.8	50.0	6.0	5.1
46	060	1465	1490	4.4	43.1	53.0	80.0	-57.6	50.0	11.3	4.4
47	009	225	105	0.7	8.3	8.9	80.0	-4.6	50.0	2.1	2.6
				136.4		1636.8		-1728.2		370.6	240.7

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

Figure G.44 Building Loop Piping Layout: Model 3



30' HPS/R UP
MECH ROOM
95' WFR
95' WFS
MANIFOLD
370' WFS
380' WFR
YOUNG ADULT 123
FICTION 125
YOUNG ADULT DESK 124
CLOSET 169
STAIR 131
STUDY 130
STUDY 129
FICTION DESK 122
PROGRAM 1 111
PROGRAM 2 112
CAFE 106
BROADCAST SYST CONTROL ROOM 113
INFO. COMM. 121
NON PRINT 126
FRIENDS' STORE 105
CLOSET 111A
CLOSET 112A
KITCHEN 115
STORAGE 114
JANITOR CLOSET 110
PREFUNCTION 108
MEN'S 109
WOMEN'S 116
ELECTRICAL CLOSET 128
STORAGE 127
ENTRY 100
LOBBY 101
PROMENADE 107
BOOKS BROWSE 119
MUSIC/CDS 119A
RIVER LOUNGE 120
INFO & ASSIST. DESK 102
SELF CHECK 103
COPY 104
STAIR 117
ELEVATOR 118
CHILDREN'S COLLECTION ENTRY 132
ELEVATOR EQUIP. 162
GRADE SCHOOL COLLECTION 137
GRADE SCHOOL SPANISH 138
HALL 164
BOOK DROP 161
FRIENDS 157
MAINTENANCE WORK RM/OFFICE 144
STORAGE 167
TOILET 133
TOILET 134
STAFF LOCKERS 163
TOILET 153
JAN
STAFF LOUNGE 156
CALL CLOSET 154
CLOSET 155
TOILET 152
CHILDREN EXPANSION 142
STUDY 139
CHILDREN'S INFO. DESK 136
PRESCHOOL COLLECTION 135
CIRC. SUPERVISOR'S OFFICE 160
SUPERVISOR'S OFFICE 166
CIRC. WORK ROOM 158
TECHNICAL SERVICES 151
ELECTRICAL 148
STAFF WORK ROOM 141
OFFICE 141A
FIRE 149
STORYTIME STORAGE 165
STORY TIME 140
REC. 150
HALL 143
AUTO BOOK DROP 159
CLOSET 140
UP
DN

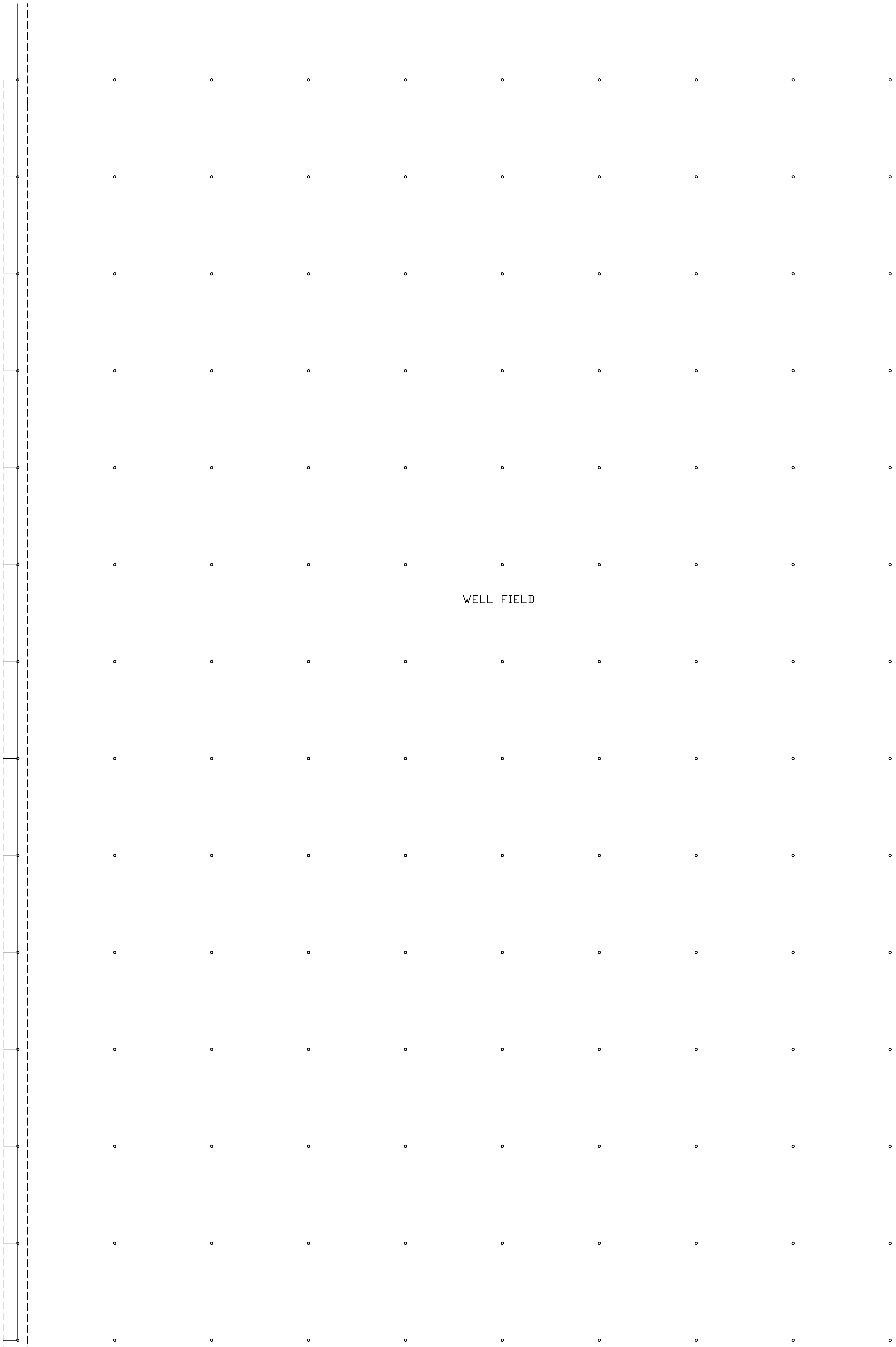


Figure G.45 Ground Loop Piping Layout: Model 3

MODEL	PRIMARY SYSTEM PUMP HEAD CALCULATIONS															PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.44 Primary Pump Head Calculations: All Models

Table G.45 Primary/Secondary Pump Head Calculations: All Models

PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS

PRIMARY LOOP

MODEL	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL: SUPPLY	DISTANCE TO WELL: RETURN	DISTANCE DOWN/UP WELL	TOTAL PRIMARY LOOP PIPE LENGTH	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD	TOTAL HEAT PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

SECONDARY LOOP

MODEL	DISTANCE TO HEAT PUMP: SUPPLY	DISTANCE TO HEAT PUMP: RETURN	TOTAL P/S LOOP PIPE LENGTH	P/S LENGTH W/ FITTINGS (TOTAL*1.5)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	SECONDARY LOOP PUMP HEAD
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	(FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS													PUMP HEAD	PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD		
		SUPPLY	RETURN		SUPPLY	RETURN									
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.46 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS																CIRCULATOR PUMP HEAD
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4		16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2		16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3		13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7		16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9		9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3		21.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM
		(%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table G.47 Distributive Circulator Pump Head Calculations: All Models

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.48 Primary Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.49 Primary/Secondary Pump Schedules: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.50 Distributive w/ Primary - Primary Pump Schedules: All Models

Table G.51 Distributive w/ Primary - Circulator Schedule (1 of 2): Model 3

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
2A	B & G	NRF-22	11.0	7.4	2940	0.123	92	115	$ 664.00
2B	B & G	NRF-22	11.0	7.4	2940	0.123	92	115	$ 664.00
3A	B & G	NRF-22	8.3	4.4	2940	0.123	92	115	$ 664.00
3B	B & G	NRF-22	8.3	4.4	2940	0.123	92	115	$ 664.00
4	B & G	NRF-9F/LW	2.6	3.5	2800	0.055	41	115	$ 449.00
5	B & G	NRF-9F/LW	5.5	1.6	2800	0.055	41	115	$ 449.00
6	B & G	NRF-22	9.0	5.3	2940	0.123	92	115	$ 664.00
7	B & G	NRF-9F/LW	6.0	2.1	2800	0.055	41	115	$ 449.00
8	B & G	NRF-22	8.3	4.4	2940	0.123	92	115	$ 664.00
9	B & G	NRF-22	9.0	10.4	2940	0.123	92	115	$ 664.00
10	B & G	NRF-22	12.4	8.8	2940	0.123	92	115	$ 664.00
11	B & G	NRF-9F/LW	1.4	1.4	2800	0.055	41	115	$ 449.00
12	B & G	NRF-9F/LW	6.0	2.1	2800	0.055	41	115	$ 449.00
13	B & G	NRF-22	12.0	8.2	2940	0.123	92	115	$ 664.00
14	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
15	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
16	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
17	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
18	B & G	NRF-22	9.0	5.3	2940	0.123	92	115	$ 664.00
19	B & G	NRF-22	8.3	4.4	2940	0.123	92	115	$ 664.00
20	B & G	NRF-9F/LW	4.1	2.8	2800	0.055	41	115	$ 449.00
21	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
22	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
23	B & G	NRF-9F/LW	6.0	2.1	2800	0.055	41	115	$ 449.00
24	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
25	B & G	NRF-22	8.3	4.4	2940	0.123	92	115	$ 664.00
26	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
27	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
28	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
29	B & G	NRF-22	12.4	8.8	2940	0.123	92	115	$ 664.00
30	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
31	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
32	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
33	B & G	NRF-22	9.0	5.3	2940	0.123	92	115	$ 664.00
34	B & G	NRF-22	15.0	8.3	2940	0.123	92	115	$ 664.00
35	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
36	B & G	NRF-22	9.0	5.3	2940	0.123	92	115	$ 664.00
37	B & G	NRF-22	9.0	10.4	2940	0.123	92	115	$ 664.00
38	B & G	NRF-22	15.0	8.3	2940	0.123	92	115	$ 664.00
39	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
40	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00

Table G.52 Distributive w/ Primary - Circulator Schedule (2 of 2): Model 3

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
41	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
42	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
43	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
44	B & G	NRF-22	6.8	6.5	2940	0.123	92	115	$ 664.00
45	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
46	B & G	NRF-22	11.3	4.4	2940	0.123	92	115	$ 664.00
47	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
						5.15	3845		$ 29,741.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table G.53 Distributive - Circulator Schedule (1 of 2): Model 3

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
2A	B & G	NRF-36	11.0	13.0	3300	0.362	270	115	$ 1,368.00
2B	B & G	NRF-36	11.0	13.0	3300	0.362	270	115	$ 1,368.00
3A	B & G	NRF-36	8.3	13.0	3300	0.362	270	115	$ 1,368.00
3B	B & G	NRF-36	8.3	13.0	3300	0.362	270	115	$ 1,368.00
4	B & G	NRF-25	2.6	13.0	2950	0.168	125	115	$ 724.00
5	B & G	NRF-25	5.5	13.0	2950	0.168	125	115	$ 724.00
6	B & G	NRF-36	9.0	13.0	3300	0.362	270	115	$ 1,368.00
7	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
8	B & G	NRF-36	8.3	13.0	3300	0.362	270	115	$ 1,368.00
9	B & G	NRF-36	9.0	13.0	3300	0.362	270	115	$ 1,368.00
10	B & G	NRF-36	12.4	13.0	3300	0.362	270	115	$ 1,368.00
11	B & G	NRF-22	1.4	13.0	2940	0.123	92	115	$ 664.00
12	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
13	B & G	NRF-36	12.0	13.0	3300	0.362	270	115	$ 1,368.00
14	B & G	NRF-25	6.8	13.0	2950	0.168	125	115	$ 724.00
15	B & G	NRF-36	11.3	13.0	3300	0.362	270	115	$ 1,368.00
16	B & G	NRF-25	2.8	13.0	2950	0.168	125	115	$ 724.00
17	B & G	NRF-25	2.8	13.0	2950	0.168	125	115	$ 724.00
18	B & G	NRF-36	9.0	13.0	3300	0.362	270	115	$ 1,368.00
19	B & G	NRF-36	8.3	13.0	3300	0.362	270	115	$ 1,368.00
20	B & G	NRF-25	4.1	13.0	2950	0.168	125	115	$ 724.00
21	B & G	NRF-36	11.3	13.0	3300	0.362	270	115	$ 1,368.00
22	B & G	NRF-36	11.3	13.0	3300	0.362	270	115	$ 1,368.00
23	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
24	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
25	B & G	NRF-36	8.3	13.0	3300	0.362	270	115	$ 1,368.00
26	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
27	B & G	NRF-36	11.3	13.0	3300	0.362	270	115	$ 1,368.00
28	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
29	B & G	NRF-36	12.4	13.0	3300	0.362	270	115	$ 1,368.00
30	B & G	NRF-25	6.8	13.0	2950	0.168	125	115	$ 724.00
31	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
32	B & G	NRF-22	2.1	13.0	2940	0.123	92	115	$ 664.00
33	B & G	NRF-36	9.0	13.0	3300	0.362	270	115	$ 1,368.00
34	B & G	NRF-36	15.0	13.0	3300	0.362	270	115	$ 1,368.00
35	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
36	B & G	NRF-36	9.0	13.0	3300	0.362	270	115	$ 1,368.00
37	B & G	NRF-36	9.0	13.0	3300	0.362	270	115	$ 1,368.00
38	B & G	NRF-36	15.0	13.0	3300	0.362	270	115	$ 1,368.00
39	B & G	NRF-25	6.8	13.0	2950	0.168	125	115	$ 724.00
40	B & G	NRF-25	2.8	13.0	2950	0.168	125	115	$ 724.00

Table G.54 Distributive - Circulator Schedule (2 of 2): Model 3

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
41	B & G	NRF-25	6.8	13.0	2950	0.168	125	115	$ 724.00
42	B & G	NRF-25	2.8	13.0	2950	0.168	125	115	$ 724.00
43	B & G	NRF-25	6.8	13.0	2950	0.168	125	115	$ 724.00
44	B & G	NRF-25	6.8	13.0	2950	0.168	125	115	$ 724.00
45	B & G	NRF-25	6.0	13.0	2950	0.168	125	115	$ 724.00
46	B & G	NRF-36	11.3	13.0	3300	0.362	270	115	$ 1,368.00
47	B & G	NRF-22	2.1	13.0	2940	0.123	92	115	$ 664.00
						12.55	9361		$ 50,108.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

MODEL 3 - MONTHLY PUMP CONSUMPTION

AVERAGE DAY HOURS	COOLING DESIGN LOAD TONS	HEATING DESIGN LOAD MBH	JANUARY CLG DESIGN TONS	JANUARY CLG %	JANUARY HTG DESIGN MBH	JANUARY HTG %	JANUARY TOTAL %	FEBRUARY CLG DESIGN TONS	FEBRUARY CLG %	FEBRUARY HTG DESIGN MBH	FEBRUARY HTG %	FEBRUARY TOTAL %	MARCH CLG DESIGN TONS	MARCH CLG %	MARCH HTG DESIGN MBH	MARCH HTG %	MARCH TOTAL %	APRIL CLG DESIGN TONS	APRIL CLG %	APRIL HTG DESIGN MBH	APRIL HTG %	APRIL TOTAL %	MAY CLG DESIGN TONS	MAY CLG %	MAY HTG DESIGN MBH	MAY HTG %	MAY TOTAL %	JUNE CLG DESIGN TONS	JUNE CLG %	JUNE HTG DESIGN MBH	JUNE HTG %	JUNE TOTAL %
1	136.4	1728.2	0.0	0.0%	402.6	23.3%	23.3%	0.0	0.0%	303.3	17.6%	17.6%	2.8	2.1%	21.2	1.2%	3.3%	9.1	6.7%	0.0	0.0%	6.7%	29.1	21.3%	0.0	0.0%	21.3%	49.8	36.5%	0.0	0.0%	36.5%
2	136.4	1728.2	0.0	0.0%	422.8	24.5%	24.5%	0.0	0.0%	325.0	18.8%	18.8%	3.7	2.7%	30.8	1.8%	4.5%	9.4	6.9%	0.0	0.0%	6.9%	27.0	19.8%	0.0	0.0%	19.8%	46.1	33.8%	0.0	0.0%	33.8%
3	136.4	1728.2	0.0	0.0%	438.5	25.4%	25.4%	0.0	0.0%	343.1	19.9%	19.9%	3.6	2.6%	43.6	2.5%	5.2%	9.1	6.7%	0.0	0.0%	6.7%	24.9	18.3%	0.0	0.0%	18.3%	43.6	32.0%	0.0	0.0%	32.0%
4	136.4	1728.2	0.0	0.0%	451.3	26.1%	26.1%	0.7	0.5%	356.7	20.6%	21.2%	3.5	2.6%	51.2	3.0%	5.5%	8.7	6.4%	0.0	0.0%	6.4%	23.3	17.1%	0.0	0.0%	17.1%	41.8	30.6%	0.0	0.0%	30.6%
5	136.4	1728.2	0.0	0.0%	461.4	26.7%	26.7%	0.0	0.0%	365.7	21.2%	21.2%	3.5	2.6%	56.3	3.3%	5.8%	8.4	6.2%	1.1	0.1%	6.2%	22.3	16.3%	0.0	0.0%	16.3%	40.6	29.8%	0.0	0.0%	29.8%
6	136.4	1728.2	0.0	0.0%	465.4	26.9%	26.9%	0.0	0.0%	367.6	21.3%	21.3%	3.5	2.6%	58.9	3.4%	6.0%	8.4	6.2%	1.2	0.1%	6.2%	22.5	16.5%	0.0	0.0%	16.5%	41.5	30.4%	0.0	0.0%	30.4%
7	136.4	1728.2	0.0	0.0%	459.2	26.6%	26.6%	0.7	0.5%	362.2	21.0%	21.5%	4.2	3.1%	60.1	3.5%	6.6%	9.5	7.0%	0.0	0.0%	7.0%	26.2	19.2%	0.0	0.0%	19.2%	47.5	34.8%	0.0	0.0%	34.8%
8	136.4	1728.2	0.0	0.0%	445.7	25.8%	25.8%	0.8	0.6%	342.2	19.8%	20.4%	4.5	3.3%	43.6	2.5%	5.8%	12.6	9.2%	0.0	0.0%	9.2%	32.8	24.0%	0.0	0.0%	24.0%	56.0	41.1%	0.0	0.0%	41.1%
9	136.4	1728.2	0.0	0.0%	407.3	23.6%	23.6%	0.9	0.7%	281.4	16.3%	16.9%	5.7	4.2%	26.5	1.5%	5.7%	18.3	13.4%	0.0	0.0%	13.4%	42.1	30.9%	0.0	0.0%	30.9%	66.6	48.8%	0.0	0.0%	48.8%
10	136.4	1728.2	0.0	0.0%	332.1	19.2%	19.2%	1.1	0.8%	210.4	12.2%	13.0%	9.1	6.7%	12.0	0.7%	7.4%	25.5	18.7%	0.0	0.0%	18.7%	52.2	38.3%	0.0	0.0%	38.3%	77.1	56.5%	0.0	0.0%	56.5%
11	136.4	1728.2	0.0	0.0%	253.8	14.7%	14.7%	1.5	1.1%	137.8	8.0%	9.1%	11.2	8.2%	0.0	0.0%	8.2%	33.1	24.3%	0.0	0.0%	24.3%	59.5	43.6%	0.0	0.0%	43.6%	85.9	63.0%	0.0	0.0%	63.0%
12	136.4	1728.2	0.0	0.0%	177.5	10.3%	10.3%	1.9	1.4%	83.4	4.8%	6.2%	12.8	9.4%	0.0	0.0%	9.4%	38.1	27.9%	0.0	0.0%	27.9%	66.1	48.5%	0.0	0.0%	48.5%	92.2	67.6%	0.0	0.0%	67.6%
13	136.4	1728.2	1.1	0.8%	122.1	7.1%	7.9%	2.2	1.6%	43.9	2.5%	4.2%	17.0	12.5%	0.0	0.0%	12.5%	47.1	34.5%	0.0	0.0%	34.5%	71.5	52.4%	0.0	0.0%	52.4%	97.5	71.5%	0.0	0.0%	71.5%
14	136.4	1728.2	1.2	0.9%	78.5	4.5%	5.4%	3.2	2.3%	20.3	1.2%	3.5%	23.8	17.4%	0.0	0.0%	17.4%	53.2	39.0%	0.0	0.0%	39.0%	77.4	56.7%	0.0	0.0%	56.7%	102.7	75.3%	0.0	0.0%	75.3%
15	136.4	1728.2	1.2	0.9%	55.1	3.2%	4.1%	3.7	2.7%	13.1	0.8%	3.5%	30.5	22.4%	0.0	0.0%	22.4%	59.7	43.8%	0.0	0.0%	43.8%	82.4	60.4%	0.0	0.0%	60.4%	106.7	78.2%	0.0	0.0%	78.2%
16	136.4	1728.2	1.5	1.1%	39.5	2.3%	3.4%	4.5	3.3%	11.9	0.7%	4.0%	36.0	26.4%	0.0	0.0%	26.4%	62.7	46.0%	0.0	0.0%	46.0%	85.6	62.8%	0.0	0.0%	62.8%	109.3	80.1%	0.0	0.0%	80.1%
17	136.4	1728.2	1.9	1.4%	43.7	2.5%	3.9%	5.1	3.7%	13.3	0.8%	4.5%	41.6	30.5%	0.0	0.0%	30.5%	65.2	47.8%	0.0	0.0%	47.8%	86.0	63.0%	0.0	0.0%	63.0%	108.8	79.8%	0.0	0.0%	79.8%
18	136.4	1728.2	1.8	1.3%	61.6	3.6%	4.9%	5.6	4.1%	17.3	1.0%	5.1%	44.9	32.9%	0.0	0.0%	32.9%	62.4	45.7%	0.0	0.0%	45.7%	82.8	60.7%	0.0	0.0%	60.7%	105.3	77.2%	0.0	0.0%	77.2%
19	136.4	1728.2	1.3	1.0%	92.5	5.4%	6.3%	4.1	3.0%	23.3	1.3%	4.4%	38.4	28.2%	0.0	0.0%	28.2%	56.1	41.1%	0.0	0.0%	41.1%	76.1	55.8%	0.0	0.0%	55.8%	98.3	72.1%	0.0	0.0%	72.1%
20	136.4	1728.2	0.9	0.7%	130.4	7.5%	8.2%	2.6	1.9%	34.8	2.0%	3.9%	29.5	21.6%	0.0	0.0%	21.6%	46.7	34.2%	0.0	0.0%	34.2%	66.6	48.8%	0.0	0.0%	48.8%	88.7	65.0%	0.0	0.0%	65.0%
21	136.4	1728.2	0.8	0.6%	173.3	10.0%	10.6%	1.8	1.3%	43.9	2.5%	3.9%	20.8	15.2%	0.0	0.0%	15.2%	37.4	27.4%	0.0	0.0%	27.4%	57.2	41.9%	0.0	0.0%	41.9%	79.2	58.1%	0.0	0.0%	58.1%
22	136.4	1728.2	0.7	0.5%	246.3	14.3%	14.8%	1.2	0.9%	58.6	3.4%	4.3%	13.8	10.1%	1.9	0.1%	10.2%	28.8	21.1%	0.0	0.0%	21.1%	48.3	35.4%	0.0	0.0%	35.4%	68.8	50.4%	0.0	0.0%	50.4%
23	136.4	1728.2	0.0	0.0%	308.5	17.9%	17.9%	1.0	0.7%	74.3	4.3%	5.0%	9.8	7.2%	1.9	0.1%	7.3%	21.8	16.0%	0.0	0.0%	16.0%	41.1	30.1%	0.0	0.0%	30.1%	60.6	44.4%	0.0	0.0%	44.4%
24	136.4	1728.2	0.0	0.0%	349.3	20.2%	20.2%	0.9	0.7%	102.2	5.9%	6.6%	7.5	5.5%	3.8	0.2%	5.7%	17.4	12.8%	0.0	0.0%	12.8%	35.9	26.3%	0.0	0.0%	26.3%	55.0	40.3%	0.0	0.0%	40.3%

AVERAGE DAY HOURS	COOLING DESIGN LOAD TONS	HEATING DESIGN LOAD MBH	JULY CLG DESIGN TONS	JULY CLG %	JULY HTG DESIGN MBH	JULY HTG %	JULY TOTAL %	AUGUST CLG DESIGN TONS	AUGUST CLG %	AUGUST HTG DESIGN MBH	AUGUST HTG %	AUGUST TOTAL %	SEPTEMBER CLG DESIGN TONS	SEPTEMBER CLG %	SEPTEMBER HTG DESIGN MBH	SEPTEMBER HTG %	SEPTEMBER TOTAL %	OCTOBER CLG DESIGN TONS	OCTOBER CLG %	OCTOBER HTG DESIGN MBH	OCTOBER HTG %	OCTOBER TOTAL %	NOVEMBER CLG DESIGN TONS	NOVEMBER CLG %	NOVEMBER HTG DESIGN MBH	NOVEMBER HTG %	NOVEMBER TOTAL %	DECEMBER CLG DESIGN TONS	DECEMBER CLG %	DECEMBER HTG DESIGN MBH	DECEMBER HTG %	DECEMBER TOTAL %
1	136.4	1728.2	66.5	48.8%	0.0	0.0%	48.8%	61.5	45.1%	0.0	0.0%	45.1%	37.8	27.7%	0.0	0.0%	27.7%	19.4	14.2%	0.0	0.0%	14.2%	4.5	3.3%	0.0	0.0%	3.3%	2.6	1.9%	57.1	3.3%	5.2%
2	136.4	1728.2	62.3	45.7%	0.0	0.0%	45.7%	56.8	41.6%	0.0	0.0%	41.6%	33.3	24.4%	0.0	0.0%	24.4%	17.0	12.5%	0.0	0.0%	12.5%	3.9	2.9%	1.3	0.1%	2.9%	2.3	1.7%	75.1	4.3%	6.0%
3	136.4	1728.2	59.9	43.9%	0.0	0.0%	43.9%	54.1	39.7%	0.0	0.0%	39.7%	30.5	22.4%	0.0	0.0%	22.4%	14.9	10.9%	0.0	0.0%	10.9%	3.6	2.6%	0.0	0.0%	2.6%	2.2	1.6%	98.7	5.7%	7.3%
4	136.4	1728.2	58.2	42.7%	0.0	0.0%	42.7%	51.6	37.8%	0.0	0.0%	37.8%	28.2	20.7%	0.0	0.0%	20.7%	13.7	10.0%	0.0	0.0%	10.0%	3.5	2.6%	0.0	0.0%	2.6%	2.0	1.5%	113.2	6.6%	8.0%
5	136.4	1728.2	57.1	41.9%	0.0	0.0%	41.9%	50.5	37.0%	0.0	0.0%	37.0%	27.0	19.8%	0.0	0.0%	19.8%	12.8	9.4%	0.0	0.0%	9.4%	3.7	2.7%	0.0	0.0%	2.7%	2.0	1.5%	139.9	8.1%	9.6%
6	136.4	1728.2	57.2	41.9%	0.0	0.0%	41.9%	50.4	37.0%	0.0	0.0%	37.0%	26.9	19.7%	0.0	0.0%	19.7%	12.8	9.4%	0.0	0.0%	9.4%	3.5	2.6%	0.0	0.0%	2.6%	2.0	1.5%	153.0	8.9%	10.3%
7	136.4	1728.2	63.2	46.3%	0.0	0.0%	46.3%	54.1	39.7%	0.0	0.0%	39.7%	27.8	20.4%	0.0	0.0%	20.4%	13.5	9.9%	0.0	0.0%	9.9%	3.7	2.7%	0.0	0.0%	2.7%	2.2	1.6%	154.3	8.9%	10.5%
8	136.4	1728.2	72.0	52.8%	0.0	0.0%	52.8%	62.5	45.8%	0.0	0.0%	45.8%	33.8	24.8%	0.0	0.0%	24.8%	17.4	12.8%	0.0	0.0%	12.8%	5.0	3.7%	15.0	0.9%	4.5%	2.5	1.8%	145.5	8.4%	10.3%
9	136.4	1728.2	81.9	60.0%	0.0	0.0%	60.0%	73.1	53.6%	0.0	0.0%	53.6%	43.9	32.2%	0.0	0.0%	32.2%	24.2	17.7%	0.0	0.0%	17.7%	5.6	4.1%	18.3	1.1%	5.2%	3.2	2.3%	110.7	6.4%	8.8%
10	136.4	1728.2	91.9	67.4%	0.0	0.0%	67.4%	84.2	61.7%	0.0	0.0%	61.7%	55.8	40.9%	0.0	0.0%	40.9%	33.1	24.3%	0.0	0.0%	24.3%	8.2	6.0%	12.4	0.7%	6.7%	4.3	3.2%	64.6	3.7%	6.9%
11	136.4	1728.2	98.9	72.5%	0.0	0.0%	72.5%	93.8	68.8%	0.0	0.0%	68.8%	68.1	49.9%	0.0	0.0%	49.9%	43.1	31.6%	0.0	0.0%	31.6%	9.9	7.3%	0.0	0.0%	7.3%	6.9	5.1%	33.4	1.9%	7.0%
12	136.4	1728.2	106.4	78.0%	0.0	0.0%	78.0%	101.7	74.6%	0.0	0.0%	74.6%	75.8	55.6%	0.0	0.0%	55.6%	50.7	37.2%	0.0	0.0%	37.2%	11.7	8.6%	0.0	0.0%	8.6%	8.3	6.1%	14.2	0.8%	6.9%
13	136.4	1728.2	111.7	81.9%	0.0	0.0%	81.9%	107.4	78.7%	0.0	0.0%	78.7%	82.4	60.4%	0.0	0.0%	60.4%	57.2	41.9%	0.0	0.0%	41.9%	16.7	12.2%	0.0	0.0%	12.2%	9.5	7.0%	0.0	0.0%	7.0%
14	136.4	1728.2	116.4	85.3%	0.0	0.0%	85.3%	111.8	82.0%	0.0	0.0%	82.0%	88.7	65.0%	0.0	0.0%	65.0%	62.9	46.1%	0.0	0.0%	46.1%	22.5	16.5%	0.0	0.0%	16.5%	10.5	7.7%	0.0	0.0%	7.7%
15	136.4	1728.2	120.1	88.0%	0.0	0.0%	88.0%	116.1	85.1%	0.0	0.0%	85.1%	94.1	69.0%	0.0	0.0%	69.0%	68.6	50.3%	0.0	0.0%	50.3%	27.5	20.2%	0.0	0.0%	20.2%	12.0	8.8%	0.0	0.0%	8.8%
16	136.4	1728.2	122.1	89.5%	0.0	0.0%	89.5%	118.7	87.0%	0.0	0.0%	87.0%	96.9	71.0%	0.0	0.0%	71.0%	71.7	52.6%	0.0	0.0%	52.6%	33.2	24.3%	0.0	0.0%	24.3%	14.8	10.9%	0.0	0.0%	10.9%
17	136.4	1728.2	121.4	89.0%	0.0	0.0%	89.0%	117.4	86.1%	0.0	0.0%	86.1%	95.9	70.3%	0.0	0.0%	70.3%	70.5	51.7%	0.0	0.0%	51.7%	32.2	23.6%	0.0	0.0%	23.6%	18.6	13.6%	0.0	0.0%	13.6%
18	136.4	1728.2	117.7	86.3%	0.0	0.0%	86.3%	113.0	82.8%	0.0	0.0%	82.8%	89.9	65.9%	0.0	0.0%	65.9%	63.8	46.8%	0.0	0.0%	46.8%	28.6	21.0%	0.0	0.0%	21.0%	16.9	12.4%	0.0	0.0%	12.4%
19	136.4	1728.2	112.3	82.3%	0.0	0.0%	82.3%	106.3	77.9%	0.0	0.0%	77.9%	80.0	58.7%	0.0	0.0%	58.7%	55.0	40.3%	0.0	0.0%	40.3%	22.3	16.3%	0.0	0.0%	16.3%	13.1	9.6%	1.1	0.1%	9.7%
20	136.4	1728.2	104.0	76.2%	0.0	0.0%	76.2%	96.1	70.5%	0.0	0.0%	70.5%	70.7	51.8%	0.0	0.0%	51.8%	45.3	33.2%	0.0	0.0%	33.2%	15.5	11.4%	0.0	0.0%	11.4%	8.7	6.4%	1.9	0.1%	6.5%
21	136.4	1728.2	94.7	69.4%	0.0	0.0%	69.4%	86.6	63.5%	0.0	0.0%	63.5%	60.1	44.1%	0.0	0.0%	44.1%	36.6	26.8%	0.0	0.0%	26.8%	11.1	8.1%	2.4	0.1%	8.3%	5.7	4.2%	0.0	0.0%	4.2%
22	136.4	1728.2	85.0	62.3%	0.0	0.0%	62.3%	76.3	55.9%	0.0	0.0%	55.9%	51.3	37.6%	0.0	0.0%	37.6%	30.4	22.3%	0.0	0.0%	22.3%	8.1	5.9%	3.1	0.2%	6.1%	4.2	3.1%	0.0	0.0%	3.1%
23	136.4	1728.2	76.0	55.7%	0.0	0.0%	55.7%	68.0	49.9%	0.0	0.0%	49.9%	44.8	32.8%	0.0	0.0%	32.8%	25.6	18.8%	0.0	0.0%	18.8%	5.7	4.2%	0.0	0.0%	4.2%	3.1	2.3%	0.0	0.0%	2.3%
24	136.4	1728.2	70.4	51.6%	0.0	0.0%	51.6%	62.7	46.0%	0.0	0.0%	46.0%	39.0	28.6%	0.0	0.0%	28.6%	21.8	16.0%	0.0	0.0%	16.0%	5.5	4.0%	2.2	0.1%	4.2%	2.8	2.1%	0.0	0.0%	2.1%

GENERAL NOTES:

1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table G.55 Monthly Simultaneous Heating and Cooling Part-Load % Per Hour: Model 3

MODEL 3 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION		
	13.13	BHP
	9.79	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.3%	0.12	20.0%	0.08	20.0%	0.08	20.0%	0.08	21.3%	0.10	36.5%	0.48
2	24.5%	0.14	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	33.8%	0.38
3	25.4%	0.16	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	32.0%	0.32
4	26.1%	0.17	21.2%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.6%	0.28
5	26.7%	0.19	21.2%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08	29.8%	0.26
6	26.9%	0.19	21.3%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.4%	0.28
7	26.6%	0.18	21.5%	0.10	20.0%	0.08	20.0%	0.08	20.0%	0.08	34.8%	0.41
8	25.8%	0.17	20.4%	0.08	20.0%	0.08	20.0%	0.08	24.0%	0.14	41.1%	0.68
9	23.6%	0.13	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.9%	0.29	48.8%	1.14
10	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	38.3%	0.55	56.5%	1.77
11	20.0%	0.08	20.0%	0.08	20.0%	0.08	24.3%	0.14	43.6%	0.81	63.0%	2.45
12	20.0%	0.08	20.0%	0.08	20.0%	0.08	27.9%	0.21	48.5%	1.11	67.6%	3.02
13	20.0%	0.08	20.0%	0.08	20.0%	0.08	34.5%	0.40	52.4%	1.41	71.5%	3.58
14	20.0%	0.08	20.0%	0.08	20.0%	0.08	39.0%	0.58	56.7%	1.79	75.3%	4.18
15	20.0%	0.08	20.0%	0.08	22.4%	0.11	43.8%	0.82	60.4%	2.16	78.2%	4.69
16	20.0%	0.08	20.0%	0.08	26.4%	0.18	46.0%	0.95	62.8%	2.42	80.1%	5.04
17	20.0%	0.08	20.0%	0.08	30.5%	0.28	47.8%	1.07	63.0%	2.45	79.8%	4.97
18	20.0%	0.08	20.0%	0.08	32.9%	0.35	45.7%	0.94	60.7%	2.19	77.2%	4.50
19	20.0%	0.08	20.0%	0.08	28.2%	0.22	41.1%	0.68	55.8%	1.70	72.1%	3.66
20	20.0%	0.08	20.0%	0.08	21.6%	0.10	34.2%	0.39	48.8%	1.14	65.0%	2.69
21	20.0%	0.08	20.0%	0.08	20.0%	0.08	27.4%	0.20	41.9%	0.72	58.1%	1.92
22	20.0%	0.08	20.0%	0.08	20.0%	0.08	21.1%	0.09	35.4%	0.43	50.4%	1.26
23	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.1%	0.27	44.4%	0.86
24	20.2%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	26.3%	0.18	40.3%	0.64
AVG, DAILY CONSUMPTION PER MONTH (KW)		2.64		1.95		2.64		7.42		20.33		49.44

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	1.13	45.1%	0.90	27.7%	0.21	20.0%	0.08	20.0%	0.08	20.0%	0.08
2	45.7%	0.93	41.6%	0.71	24.4%	0.14	20.0%	0.08	20.0%	0.08	20.0%	0.08
3	43.9%	0.83	39.7%	0.61	22.4%	0.11	20.0%	0.08	20.0%	0.08	20.0%	0.08
4	42.7%	0.76	37.8%	0.53	20.7%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08
5	41.9%	0.72	37.0%	0.50	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08
6	41.9%	0.72	37.0%	0.49	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08
7	46.3%	0.97	39.7%	0.61	20.4%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08
8	52.8%	1.44	45.8%	0.94	24.8%	0.15	20.0%	0.08	20.0%	0.08	20.0%	0.08
9	60.0%	2.12	53.6%	1.51	32.2%	0.33	20.0%	0.08	20.0%	0.08	20.0%	0.08
10	67.4%	2.99	61.7%	2.30	40.9%	0.67	24.3%	0.14	20.0%	0.08	20.0%	0.08
11	72.5%	3.73	68.8%	3.18	49.9%	1.22	31.6%	0.31	20.0%	0.08	20.0%	0.08
12	78.0%	4.65	74.6%	4.06	55.6%	1.68	37.2%	0.50	20.0%	0.08	20.0%	0.08
13	81.9%	5.38	78.7%	4.78	60.4%	2.16	41.9%	0.72	20.0%	0.08	20.0%	0.08
14	85.3%	6.08	82.0%	5.39	65.0%	2.69	46.1%	0.96	20.0%	0.08	20.0%	0.08
15	88.0%	6.68	85.1%	6.04	69.0%	3.21	50.3%	1.25	20.2%	0.08	20.0%	0.08
16	89.5%	7.02	87.0%	6.45	71.0%	3.51	52.6%	1.42	24.3%	0.14	20.0%	0.08
17	89.0%	6.90	86.1%	6.24	70.3%	3.40	51.7%	1.35	23.6%	0.13	20.0%	0.08
18	86.3%	6.29	82.8%	5.57	65.9%	2.80	46.8%	1.00	21.0%	0.09	20.0%	0.08
19	82.3%	5.46	77.9%	4.63	58.7%	1.98	40.3%	0.64	20.0%	0.08	20.0%	0.08
20	76.2%	4.34	70.5%	3.42	51.8%	1.36	33.2%	0.36	20.0%	0.08	20.0%	0.08
21	69.4%	3.28	63.5%	2.51	44.1%	0.84	26.8%	0.19	20.0%	0.08	20.0%	0.08
22	62.3%	2.37	55.9%	1.71	37.6%	0.52	22.3%	0.11	20.0%	0.08	20.0%	0.08
23	55.7%	1.69	49.9%	1.21	32.8%	0.35	20.0%	0.08	20.0%	0.08	20.0%	0.08
24	51.6%	1.35	46.0%	0.95	28.6%	0.23	20.0%	0.08	20.0%	0.08	20.0%	0.08
AVG, DAILY CONSUMPTION PER MONTH (KW)		77.86		65.26		27.89		9.82		2.01		1.88

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.56 Daily Pump Consumption (Primary): Model 3

Table G.57 Primary System Annual Utility Cost: Model 3

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	2.64	31	82	$ 0.09	$ 7.36
FEBRUARY	1.95	28	55	$ 0.09	$ 4.91
MARCH	2.64	31	82	$ 0.09	$ 7.38
APRIL	7.42	30	223	$ 0.09	$ 20.05
MAY	20.33	31	630	$ 0.09	$ 56.72
JUNE	49.44	30	1483	$ 0.09	$ 133.50
JULY	77.86	31	2414	$ 0.09	$ 217.22
AUGUST	65.26	31	2023	$ 0.09	$ 182.06
SEPTEMBER	27.89	30	837	$ 0.09	$ 75.29
OCTOBER	9.82	31	304	$ 0.09	$ 27.38
NOVEMBER	2.01	30	60	$ 0.09	$ 5.42
DECEMBER	1.88	31	58	$ 0.09	$ 5.24
ANNUAL UTILITY CONSUMPTION & COST			8250	KWH	$ 742.53

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 3 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY + SECONDARY PUMP CONSUMPTION		
	13.91	BHP
	10.37	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.3%	0.13	20.0%	0.08	20.0%	0.08	20.0%	0.08	21.3%	0.10	36.5%	0.50
2	24.5%	0.15	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	33.8%	0.40
3	25.4%	0.17	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	32.0%	0.34
4	26.1%	0.18	21.2%	0.10	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.6%	0.30
5	26.7%	0.20	21.2%	0.10	20.0%	0.08	20.0%	0.08	20.0%	0.08	29.8%	0.27
6	26.9%	0.20	21.3%	0.10	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.4%	0.29
7	26.6%	0.19	21.5%	0.10	20.0%	0.08	20.0%	0.08	20.0%	0.08	34.8%	0.44
8	25.8%	0.18	20.4%	0.09	20.0%	0.08	20.0%	0.08	24.0%	0.14	41.1%	0.72
9	23.6%	0.14	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.9%	0.30	48.8%	1.21
10	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	38.3%	0.58	56.5%	1.87
11	20.0%	0.08	20.0%	0.08	20.0%	0.08	24.3%	0.15	43.6%	0.86	63.0%	2.59
12	20.0%	0.08	20.0%	0.08	20.0%	0.08	27.9%	0.23	48.5%	1.18	67.6%	3.20
13	20.0%	0.08	20.0%	0.08	20.0%	0.08	34.5%	0.43	52.4%	1.49	71.5%	3.79
14	20.0%	0.08	20.0%	0.08	20.0%	0.08	39.0%	0.62	56.7%	1.90	75.3%	4.43
15	20.0%	0.08	20.0%	0.08	22.4%	0.12	43.8%	0.87	60.4%	2.29	78.2%	4.97
16	20.0%	0.08	20.0%	0.08	26.4%	0.19	46.0%	1.01	62.8%	2.56	80.1%	5.34
17	20.0%	0.08	20.0%	0.08	30.5%	0.29	47.8%	1.13	63.0%	2.60	79.8%	5.26
18	20.0%	0.08	20.0%	0.08	32.9%	0.37	45.7%	0.99	60.7%	2.32	77.2%	4.77
19	20.0%	0.08	20.0%	0.08	28.2%	0.23	41.1%	0.72	55.8%	1.80	72.1%	3.88
20	20.0%	0.08	20.0%	0.08	21.6%	0.10	34.2%	0.42	48.8%	1.21	65.0%	2.85
21	20.0%	0.08	20.0%	0.08	20.0%	0.08	27.4%	0.21	41.9%	0.76	58.1%	2.03
22	20.0%	0.08	20.0%	0.08	20.0%	0.08	21.1%	0.10	35.4%	0.46	50.4%	1.33
23	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08	30.1%	0.28	44.4%	0.91
24	20.2%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08	26.3%	0.19	40.3%	0.68
AVG, DAILY CONSUMPTION PER MONTH (KW)		2.79		2.06		2.80		7.87		21.54		52.38

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	1.20	45.1%	0.95	27.7%	0.22	20.0%	0.08	20.0%	0.08	20.0%	0.08
2	45.7%	0.99	41.6%	0.75	24.4%	0.15	20.0%	0.08	20.0%	0.08	20.0%	0.08
3	43.9%	0.88	39.7%	0.65	22.4%	0.12	20.0%	0.08	20.0%	0.08	20.0%	0.08
4	42.7%	0.81	37.8%	0.56	20.7%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08
5	41.9%	0.76	37.0%	0.53	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08
6	41.9%	0.76	37.0%	0.52	20.0%	0.08	20.0%	0.08	20.0%	0.08	20.0%	0.08
7	46.3%	1.03	39.7%	0.65	20.4%	0.09	20.0%	0.08	20.0%	0.08	20.0%	0.08
8	52.8%	1.53	45.8%	1.00	24.8%	0.16	20.0%	0.08	20.0%	0.08	20.0%	0.08
9	60.0%	2.25	53.6%	1.60	32.2%	0.35	20.0%	0.08	20.0%	0.08	20.0%	0.08
10	67.4%	3.17	61.7%	2.44	40.9%	0.71	24.3%	0.15	20.0%	0.08	20.0%	0.08
11	72.5%	3.95	68.8%	3.37	49.9%	1.29	31.6%	0.33	20.0%	0.08	20.0%	0.08
12	78.0%	4.92	74.6%	4.30	55.6%	1.78	37.2%	0.53	20.0%	0.08	20.0%	0.08
13	81.9%	5.70	78.7%	5.06	60.4%	2.29	41.9%	0.76	20.0%	0.08	20.0%	0.08
14	85.3%	6.45	82.0%	5.71	65.0%	2.85	46.1%	1.02	20.0%	0.08	20.0%	0.08
15	88.0%	7.08	85.1%	6.40	69.0%	3.41	50.3%	1.32	20.2%	0.09	20.0%	0.08
16	89.5%	7.44	87.0%	6.84	71.0%	3.72	52.6%	1.51	24.3%	0.15	20.0%	0.08
17	89.0%	7.31	86.1%	6.61	70.3%	3.60	51.7%	1.43	23.6%	0.14	20.0%	0.08
18	86.3%	6.66	82.8%	5.90	65.9%	2.97	46.8%	1.06	21.0%	0.10	20.0%	0.08
19	82.3%	5.79	77.9%	4.91	58.7%	2.09	40.3%	0.68	20.0%	0.08	20.0%	0.08
20	76.2%	4.60	70.5%	3.63	51.8%	1.44	33.2%	0.38	20.0%	0.08	20.0%	0.08
21	69.4%	3.47	63.5%	2.65	44.1%	0.89	26.8%	0.20	20.0%	0.08	20.0%	0.08
22	62.3%	2.51	55.9%	1.82	37.6%	0.55	22.3%	0.11	20.0%	0.08	20.0%	0.08
23	55.7%	1.79	49.9%	1.29	32.8%	0.37	20.0%	0.08	20.0%	0.08	20.0%	0.08
24	51.6%	1.43	46.0%	1.01	28.6%	0.24	20.0%	0.08	20.0%	0.08	20.0%	0.08
AVG, DAILY CONSUMPTION PER MONTH (KW)		82.48		69.13		29.54		10.40		2.13		1.99

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.58 Daily Pump Consumption (Primary/Secondary): Model 3

Table G.59 Primary/Secondary System Annual Utility Cost: Model 3

PRIMARY/SECONDARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	2.79	31	87	$ 0.09	$ 7.79
FEBRUARY	2.06	28	58	$ 0.09	$ 5.20
MARCH	2.80	31	87	$ 0.09	$ 7.81
APRIL	7.87	30	236	$ 0.09	$ 21.24
MAY	21.54	31	668	$ 0.09	$ 60.09
JUNE	52.38	30	1571	$ 0.09	$ 141.43
JULY	82.48	31	2557	$ 0.09	$ 230.13
AUGUST	69.13	31	2143	$ 0.09	$ 192.88
SEPTEMBER	29.54	30	886	$ 0.09	$ 79.77
OCTOBER	10.40	31	322	$ 0.09	$ 29.01
NOVEMBER	2.13	30	64	$ 0.09	$ 5.74
DECEMBER	1.99	31	62	$ 0.09	$ 5.56
ANNUAL UTILITY CONSUMPTION & COST			8740	KWH	$ 786.64

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 3 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS AND PRIMARY PUMP CONSUMPTION	
16.96	**BHP**
12.65	**KW**

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.3%	0.16	20.0%	0.10	20.0%	0.10	20.0%	0.10	21.3%	0.12	36.5%	0.62
2	24.5%	0.19	20.0%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10	33.8%	0.49
3	25.4%	0.21	20.0%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10	32.0%	0.41
4	26.1%	0.23	21.2%	0.12	20.0%	0.10	20.0%	0.10	20.0%	0.10	30.6%	0.36
5	26.7%	0.24	21.2%	0.12	20.0%	0.10	20.0%	0.10	20.0%	0.10	29.8%	0.33
6	26.9%	0.25	21.3%	0.12	20.0%	0.10	20.0%	0.10	20.0%	0.10	30.4%	0.36
7	26.6%	0.24	21.5%	0.13	20.0%	0.10	20.0%	0.10	20.0%	0.10	34.8%	0.53
8	25.8%	0.22	20.4%	0.11	20.0%	0.10	20.0%	0.10	24.0%	0.18	41.1%	0.88
9	23.6%	0.17	20.0%	0.10	20.0%	0.10	20.0%	0.10	30.9%	0.37	48.8%	1.47
10	20.0%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10	38.3%	0.71	56.5%	2.28
11	20.0%	0.10	20.0%	0.10	20.0%	0.10	24.3%	0.18	43.6%	1.05	63.0%	3.16
12	20.0%	0.10	20.0%	0.10	20.0%	0.10	27.9%	0.28	48.5%	1.44	67.6%	3.91
13	20.0%	0.10	20.0%	0.10	20.0%	0.10	34.5%	0.52	52.4%	1.82	71.5%	4.62
14	20.0%	0.10	20.0%	0.10	20.0%	0.10	39.0%	0.75	56.7%	2.31	75.3%	5.40
15	20.0%	0.10	20.0%	0.10	22.4%	0.14	43.8%	1.06	60.4%	2.79	78.2%	6.05
16	20.0%	0.10	20.0%	0.10	26.4%	0.23	46.0%	1.23	62.8%	3.13	80.1%	6.51
17	20.0%	0.10	20.0%	0.10	30.5%	0.36	47.8%	1.38	63.0%	3.17	79.8%	6.42
18	20.0%	0.10	20.0%	0.10	32.9%	0.45	45.7%	1.21	60.7%	2.83	77.2%	5.82
19	20.0%	0.10	20.0%	0.10	28.2%	0.28	41.1%	0.88	55.8%	2.20	72.1%	4.73
20	20.0%	0.10	20.0%	0.10	21.6%	0.13	34.2%	0.51	48.8%	1.47	65.0%	3.48
21	20.0%	0.10	20.0%	0.10	20.0%	0.10	27.4%	0.26	41.9%	0.93	58.1%	2.48
22	20.0%	0.10	20.0%	0.10	20.0%	0.10	21.1%	0.12	35.4%	0.56	50.4%	1.62
23	20.0%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10	30.1%	0.35	44.4%	1.11
24	20.2%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10	26.3%	0.23	40.3%	0.83
AVG, DAILY CONSUMPTION PER MONTH (KW)		3.41		2.52		3.42		9.59		26.26		63.87

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	1.47	45.1%	1.16	27.7%	0.27	20.0%	0.10	20.0%	0.10	20.0%	0.10
2	45.7%	1.21	41.6%	0.91	24.4%	0.18	20.0%	0.10	20.0%	0.10	20.0%	0.10
3	43.9%	1.07	39.7%	0.79	22.4%	0.14	20.0%	0.10	20.0%	0.10	20.0%	0.10
4	42.7%	0.98	37.8%	0.68	20.7%	0.11	20.0%	0.10	20.0%	0.10	20.0%	0.10
5	41.9%	0.93	37.0%	0.64	20.0%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10
6	41.9%	0.93	37.0%	0.64	20.0%	0.10	20.0%	0.10	20.0%	0.10	20.0%	0.10
7	46.3%	1.26	39.7%	0.79	20.4%	0.11	20.0%	0.10	20.0%	0.10	20.0%	0.10
8	52.8%	1.86	45.8%	1.22	24.8%	0.19	20.0%	0.10	20.0%	0.10	20.0%	0.10
9	60.0%	2.74	53.6%	1.95	32.2%	0.42	20.0%	0.10	20.0%	0.10	20.0%	0.10
10	67.4%	3.87	61.7%	2.97	40.9%	0.87	24.3%	0.18	20.0%	0.10	20.0%	0.10
11	72.5%	4.82	68.8%	4.11	49.9%	1.57	31.6%	0.40	20.0%	0.10	20.0%	0.10
12	78.0%	6.00	74.6%	5.24	55.6%	2.17	37.2%	0.65	20.0%	0.10	20.0%	0.10
13	81.9%	6.95	78.7%	6.17	60.4%	2.79	41.9%	0.93	20.0%	0.10	20.0%	0.10
14	85.3%	7.86	82.0%	6.96	65.0%	3.48	46.1%	1.24	20.0%	0.10	20.0%	0.10
15	88.0%	8.63	85.1%	7.80	69.0%	4.15	50.3%	1.61	20.2%	0.10	20.0%	0.10
16	89.5%	9.07	87.0%	8.33	71.0%	4.53	52.6%	1.84	24.3%	0.18	20.0%	0.10
17	89.0%	8.92	86.1%	8.06	70.3%	4.40	51.7%	1.75	23.6%	0.17	20.0%	0.10
18	86.3%	8.13	82.8%	7.19	65.9%	3.62	46.8%	1.29	21.0%	0.12	20.0%	0.10
19	82.3%	7.06	77.9%	5.99	58.7%	2.55	40.3%	0.83	20.0%	0.10	20.0%	0.10
20	76.2%	5.61	70.5%	4.42	51.8%	1.76	33.2%	0.46	20.0%	0.10	20.0%	0.10
21	69.4%	4.23	63.5%	3.24	44.1%	1.08	26.8%	0.24	20.0%	0.10	20.0%	0.10
22	62.3%	3.06	55.9%	2.21	37.6%	0.67	22.3%	0.14	20.0%	0.10	20.0%	0.10
23	55.7%	2.19	49.9%	1.57	32.8%	0.45	20.0%	0.10	20.0%	0.10	20.0%	0.10
24	51.6%	1.74	46.0%	1.23	28.6%	0.30	20.0%	0.10	20.0%	0.10	20.0%	0.10
AVG, DAILY CONSUMPTION (KW)		100.57		84.29		36.02		12.68		2.59		2.43

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.60 Daily Pump Consumption (Distributive w/ Primary): Model 3

Table G.61 Distributive w/ Primary System Annual Utility Cost: Model 3

DISTRIBUTIVE W/ PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	3.41	31	106	$ 0.09	$ 9.50
FEBRUARY	2.52	28	70	$ 0.09	$ 6.34
MARCH	3.42	31	106	$ 0.09	$ 9.53
APRIL	9.59	30	288	$ 0.09	$ 25.89
MAY	26.26	31	814	$ 0.09	$ 73.27
JUNE	63.87	30	1916	$ 0.09	$ 172.44
JULY	100.57	31	3118	$ 0.09	$ 280.59
AUGUST	84.29	31	2613	$ 0.09	$ 235.17
SEPTEMBER	36.02	30	1081	$ 0.09	$ 97.26
OCTOBER	12.68	31	393	$ 0.09	$ 35.37
NOVEMBER	2.59	30	78	$ 0.09	$ 7.00
DECEMBER	2.43	31	75	$ 0.09	$ 6.77
ANNUAL UTILITY CONSUMPTION & COST			10657	KWH	$ 959.13

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 3 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS CONSUMPTION		
	12.55	BHP
	9.36	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	23.3%	0.12	20.0%	0.07	20.0%	0.07	20.0%	0.07	21.3%	0.09	36.5%	0.46
2	24.5%	0.14	20.0%	0.07	20.0%	0.07	20.0%	0.07	20.0%	0.07	33.8%	0.36
3	25.4%	0.15	20.0%	0.07	20.0%	0.07	20.0%	0.07	20.0%	0.07	32.0%	0.31
4	26.1%	0.17	21.2%	0.09	20.0%	0.07	20.0%	0.07	20.0%	0.07	30.6%	0.27
5	26.7%	0.18	21.2%	0.09	20.0%	0.07	20.0%	0.07	20.0%	0.07	29.8%	0.25
6	26.9%	0.18	21.3%	0.09	20.0%	0.07	20.0%	0.07	20.0%	0.07	30.4%	0.26
7	26.6%	0.18	21.5%	0.09	20.0%	0.07	20.0%	0.07	20.0%	0.07	34.8%	0.40
8	25.8%	0.16	20.4%	0.08	20.0%	0.07	20.0%	0.07	24.0%	0.13	41.1%	0.65
9	23.6%	0.12	20.0%	0.07	20.0%	0.07	20.0%	0.07	30.9%	0.28	48.8%	1.09
10	20.0%	0.07	20.0%	0.07	20.0%	0.07	20.0%	0.07	38.3%	0.52	56.5%	1.69
11	20.0%	0.07	20.0%	0.07	20.0%	0.07	24.3%	0.13	43.6%	0.78	63.0%	2.34
12	20.0%	0.07	20.0%	0.07	20.0%	0.07	27.9%	0.20	48.5%	1.07	67.6%	2.89
13	20.0%	0.07	20.0%	0.07	20.0%	0.07	34.5%	0.39	52.4%	1.35	71.5%	3.42
14	20.0%	0.07	20.0%	0.07	20.0%	0.07	39.0%	0.56	56.7%	1.71	75.3%	3.99
15	20.0%	0.07	20.0%	0.07	22.4%	0.10	43.8%	0.78	60.4%	2.06	78.2%	4.48
16	20.0%	0.07	20.0%	0.07	26.4%	0.17	46.0%	0.91	62.8%	2.31	80.1%	4.82
17	20.0%	0.07	20.0%	0.07	30.5%	0.27	47.8%	1.02	63.0%	2.35	79.8%	4.75
18	20.0%	0.07	20.0%	0.07	32.9%	0.33	45.7%	0.90	60.7%	2.09	77.2%	4.31
19	20.0%	0.07	20.0%	0.07	28.2%	0.21	41.1%	0.65	55.8%	1.63	72.1%	3.50
20	20.0%	0.07	20.0%	0.07	21.6%	0.09	34.2%	0.38	48.8%	1.09	65.0%	2.57
21	20.0%	0.07	20.0%	0.07	20.0%	0.07	27.4%	0.19	41.9%	0.69	58.1%	1.83
22	20.0%	0.07	20.0%	0.07	20.0%	0.07	21.1%	0.09	35.4%	0.42	50.4%	1.20
23	20.0%	0.07	20.0%	0.07	20.0%	0.07	20.0%	0.07	30.1%	0.26	44.4%	0.82
24	20.2%	0.08	20.0%	0.07	20.0%	0.07	20.0%	0.07	26.3%	0.17	40.3%	0.61
AVG, DAILY CONSUMPTION PER MONTH (KW)		2.52		1.86		2.53		7.10		19.43		47.26

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	1.08	45.1%	0.86	27.7%	0.20	20.0%	0.07	20.0%	0.07	20.0%	0.07
2	45.7%	0.89	41.6%	0.68	24.4%	0.14	20.0%	0.07	20.0%	0.07	20.0%	0.07
3	43.9%	0.79	39.7%	0.58	22.4%	0.10	20.0%	0.07	20.0%	0.07	20.0%	0.07
4	42.7%	0.73	37.8%	0.51	20.7%	0.08	20.0%	0.07	20.0%	0.07	20.0%	0.07
5	41.9%	0.69	37.0%	0.47	20.0%	0.07	20.0%	0.07	20.0%	0.07	20.0%	0.07
6	41.9%	0.69	37.0%	0.47	20.0%	0.07	20.0%	0.07	20.0%	0.07	20.0%	0.07
7	46.3%	0.93	39.7%	0.58	20.4%	0.08	20.0%	0.07	20.0%	0.07	20.0%	0.07
8	52.8%	1.38	45.8%	0.90	24.8%	0.14	20.0%	0.07	20.0%	0.07	20.0%	0.07
9	60.0%	2.03	53.6%	1.44	32.2%	0.31	20.0%	0.07	20.0%	0.07	20.0%	0.07
10	67.4%	2.86	61.7%	2.20	40.9%	0.64	24.3%	0.13	20.0%	0.07	20.0%	0.07
11	72.5%	3.57	68.8%	3.04	49.9%	1.16	31.6%	0.30	20.0%	0.07	20.0%	0.07
12	78.0%	4.44	74.6%	3.88	55.6%	1.61	37.2%	0.48	20.0%	0.07	20.0%	0.07
13	81.9%	5.14	78.7%	4.57	60.4%	2.06	41.9%	0.69	20.0%	0.07	20.0%	0.07
14	85.3%	5.82	82.0%	5.15	65.0%	2.57	46.1%	0.92	20.0%	0.07	20.0%	0.07
15	88.0%	6.39	85.1%	5.77	69.0%	3.07	50.3%	1.19	20.2%	0.08	20.0%	0.07
16	89.5%	6.71	87.0%	6.17	71.0%	3.36	52.6%	1.36	24.3%	0.13	20.0%	0.07
17	89.0%	6.60	86.1%	5.97	70.3%	3.25	51.7%	1.29	23.6%	0.12	20.0%	0.07
18	86.3%	6.01	82.8%	5.32	65.9%	2.68	46.8%	0.96	21.0%	0.09	20.0%	0.07
19	82.3%	5.22	77.9%	4.43	58.7%	1.89	40.3%	0.61	20.0%	0.07	20.0%	0.07
20	76.2%	4.15	70.5%	3.27	51.8%	1.30	33.2%	0.34	20.0%	0.07	20.0%	0.07
21	69.4%	3.13	63.5%	2.40	44.1%	0.80	26.8%	0.18	20.0%	0.07	20.0%	0.07
22	62.3%	2.26	55.9%	1.64	37.6%	0.50	22.3%	0.10	20.0%	0.07	20.0%	0.07
23	55.7%	1.62	49.9%	1.16	32.8%	0.33	20.0%	0.07	20.0%	0.07	20.0%	0.07
24	51.6%	1.29	46.0%	0.91	28.6%	0.22	20.0%	0.07	20.0%	0.07	20.0%	0.07
AVG, DAILY CONSUMPTION (KW)		74.42		62.37		26.65		9.38		1.92		1.80

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.62 Daily Pump Consumption (Distributive): Model 3

Table G.63 Distributive System Annual Utility Cost: Model 3

DISTRIBUTIVE SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	2.52	31	78	$ 0.09	$ 7.03
FEBRUARY	1.86	28	52	$ 0.09	$ 4.69
MARCH	2.53	31	78	$ 0.09	$ 7.05
APRIL	7.10	30	213	$ 0.09	$ 19.16
MAY	19.43	31	602	$ 0.09	$ 54.22
JUNE	47.26	30	1418	$ 0.09	$ 127.60
JULY	74.42	31	2307	$ 0.09	$ 207.63
AUGUST	62.37	31	1934	$ 0.09	$ 174.02
SEPTEMBER	26.65	30	800	$ 0.09	$ 71.97
OCTOBER	9.38	31	291	$ 0.09	$ 26.17
NOVEMBER	1.92	30	58	$ 0.09	$ 5.18
DECEMBER	1.80	31	56	$ 0.09	$ 5.01
ANNUAL UTILITY CONSUMPTION & COST			7886	KWH	$ 709.73

GENERAL NOTES:
1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 3 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 29,835.00	$ 3,376.20	$ 190,748.23	$ 38,785.50	$ 6,583.59	$ 108,729.66	$ 742.53	$ 58,703.08	$ 600.00	$ 676.00	$ 2,180.00	$ 33,308.77	$ 144.00	$ 11,384.38	$ 402,874.13
PRIMARY/SECONDARY	$ 49,623.00	$ 5,457.00	$ 316,351.49	$ 64,509.90	$ 10,641.15	$ 180,103.86	$ 786.64	$ 62,190.33	$ 1,200.00	$ 1,352.00	$ 3,380.00	$ 60,739.52	$ 216.00	$ 17,076.57	$ 636,461.78
DISTRIBUTIVE W/ PRIMARY	$ 61,700.82	$ 5,664.06	$ 386,909.59	$ 80,211.07	$ 11,044.92	$ 218,700.27	$ 959.13	$ 75,827.08	$ 600.00	$ 676.00	$ 2,180.00	$ 33,308.77	$ 1,159.20	$ 91,644.25	$ 806,389.97
DISTRIBUTIVE	$ 51,110.16	$ 3,127.93	$ 311,516.00	$ 66,443.21	$ 6,099.47	$ 173,852.74	$ 709.73	$ 56,109.97	$ -	$ -	$ -	$ -	$ 1,015.20	$ 80,259.87	$ 621,738.58

GENERAL NOTES:

1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. 100% REDUNDANCY WAS ASSUMED FOR ALL PRIMARY AND SECONDARY PUMPING CONFIGURATIONS
13. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table G.64 30-Year Life-Cycle Cost Analysis: Model 3

System Checksums

By ACADEMIC

System - 004 — Water Source Heat Pump

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 7 / 16; Outside Air: OADB/WB/HR: 96 / 74 / 98

CLG SPACE PEAK — Mo/Hr: Sum of; OADB: Peaks

	Cooling Coil Peak: Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	CLG Space Peak: Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	98,455	98,455	13	0	0
Glass Solar	135,193	0	135,193	18	165,452	41
Glass/Door Cond	11,874	0	11,874	2	3,323	2
Wall Cond	11,342	10,484	21,826	3	11,209	3
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	158,409	108,939	267,348	36	182,984	45
Internal Loads						
Lights	30,354	9,088	45,442	0	30,354	9
People	205,876	0	205,876	28	107,652	27
Misc	56,924	0	56,924	8	53,924	14
Sub Total ==>	299,153	9,088	308,241	41	200,929	50
Ceiling Load	20,241	-20,241	0	0	19,884	5
Ventilation Load	0	0	185,563	25	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-23,366	-23,366	-3		
Sup. Fan Heat			5,550	1		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	477,804	74,420	743,336	100.00	403,797	100.00

HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-83,152	10.44
Glass Solar	0	0	0.00
Glass/Door Cond	-45,150	-45,150	5.67
Wall Cond	-13,527	-25,599	3.21
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-58,677	-153,901	19.31
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-16,607	0	0.00
Ventilation Load	0	-334,146	41.93
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-328,513	-328,513	41.23
Exhaust Heat		19,714	-2.47
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-403,797	-796,845	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	79.8	66.1
Return	79.4	66.1
Ret/OA	83.5	50.5
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	18,729	18,729
Terminal	18,729	18,729
Main Fan	18,729	18,729
Sec Fan	0	0
Nom Vent	4,697	4,697
AHU Vent	4,697	4,697
Infil	0	0
MinStop/Rh	0	0
Return	18,729	18,729
Exhaust	4,697	4,697
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	25.1	25.1
cfm/ft²	1.39	1.39
cfm/ton	302.36	
ft²/ton	217.29	
Btu/hr·ft²	55.23	-59.20
No. People	409	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	61.9	743.3	560.0	18,729	83.5	66.0	71.1	55.0	52.8	58.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	61.9	743.3								

AREAS

	Gross Total	Glass ft²	(%)
Floor	13,460		
Part	0		
Int Door	0		
ExFlr	0		
Roof	6,270	0	0
Wall	5,137	1,563	30
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-796.9	18,729	50.5	90.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-84.7	18,729	50.5	54.7
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-796.9			

Figure G.46 System Checksums: Model 4

SYSTEM SUMMARY

DESIGN COOLING CAPACITIES

By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

		Peak Plant Loads								Block Plant Loads								
						Stg 1	Stg 2			Time					Stg 1	Stg 2		
		Main	Aux	Opt Vent	Misc	Desic	Desic	Base	Peak	Of	Main	Aux	Opt Vent	Misc	Desic	Desic	Base	Block
		Coil	Coil	Coil	Load	Cond	Cond	Utility	Total	Peak	Coil	Coil	Coil	Load	Cond	Cond	Utility	Total
Plant	System	ton	ton	ton	ton	ton	ton	ton	ton	mo/hr	ton	ton	ton	ton	ton	ton	ton	ton
GCHP		61.9	0.0	0.0	0.0	0.0	0.0	0.0	61.9	7/16	55.5	0.0	0.0	0.0	0.0	0.0	0.0	55.5
	System - 004	61.9	0.0	0.0	0.0	0.0	0.0	0.0	61.9	7/16	55.5	0.0	0.0	0.0	0.0	0.0	0.0	55.5
Building totals		61.9	0.0	0.0	0.0	0.0	0.0	0.0	61.9		55.5	0.0	0.0	0.0	0.0	0.0	0.0	55.5

Building peak load is 61.9 tons.

Building maximum block load of 55.5 tons occurs in July at hour 16 based on system simulation.

Figure G.47 Design Cooling Capacities: Model 4

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure G.48 Load/Airflow Summary (1 of 4): Model 4

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		224 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
	Zone 009		Zn Peak	600	2.0	4,451	5,573	127			0	5,362	127	26.7	26.7
	Zone - 009		Zn Block	600	2.0	4,464	5,571	127			0	-6,669	127	26.7	26.7
		220 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		221 Workroom	Rm Peak	100	0.0	881	1,057	38	2.27	0	0	1,311	38	15.9	15.9
		222 - Office	Rm Peak	225	1.1	7,699	8,435	274	7.29	0	0	-7,808	274	7.0	7.0
	Zone - 010		Zn Peak	425	1.1	10,224	11,473	349			0	-10,845	349	10.6	10.6
	Zone - 010		Zn Block	425	1.1	10,224	11,473	349			0	-11,936	349	10.6	10.6
		225 - Records	Rm Peak	175	0.0	2,172	2,471	42	1.45	0	0	-1,728	42	24.8	24.8
		226 - Breakroom	Rm Peak	100	2.5	1,974	2,690	46	2.78	0	0	-2,375	46	39.9	39.9
		227 - Storage	Rm Peak	100	0.0	1,217	1,531	17	1.04	0	0	-1,239	17	69.2	69.2
		228 - Electrical	Rm Peak	100	0.0	1,530	1,707	38	2.27	0	0	-1,311	38	15.9	15.9
		229 - Conference	Rm Peak	450	22.5	17,536	23,862	557	7.43	0	0	-22,848	557	25.0	25.0
	Zone - 011		Zn Peak	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
	Zone - 011		Zn Block	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
		214 - PS Office	Rm Peak	425	12.1	17,365	21,270	777	10.97	0	0	-24,383	777	11.1	11.1
	Zone - 012		Zn Peak	425	12.1	17,365	21,270	777			0	-24,303	777	11.1	11.1
	Zone - 012		Zn Block	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
		103 - Elev Equip	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		104 - Storage	Rm Peak	150	0.0	978	1,497	34	1.37	0	0	-2,055	34	52.5	52.5
		108 - Quartermaster	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 013		Zn Peak	350	0.5	2,040	3,008	75			0	-4,015	75	43.5	43.5
	Zone - 013		Zn Block	350	0.5	2,045	3,007	75			0	-5,425	75	43.5	43.5
		105 - EOC	Rm Peak	1,250	83.3	38,434	52,341	1,194	5.73	0	0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Peak	1,250	83.3	38,434	52,341	1,194			0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Block	1,250	83.3	38,434	52,341	1,194			0	-76,602	1,194	58.6	58.6
		111 - CID	Rm Peak	880	4.4	5,432	7,902	204	1.39	0	0	-9,988	204	36.8	36.8
	Zone - 015		Zn Peak	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
	Zone - 015		Zn Block	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
		112 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		113 - Files	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		114 - Storage	Rm Peak	200	0.0	1,110	1,749	35	1.04	0	0	-2,478	35	69.2	69.2
	Zone - 016		Zn Peak	400	1.0	2,345	3,545	81			0	-4,748	81	50.7	50.7
	Zone - 016		Zn Block	400	1.0	2,345	3,545	81			0	-5,571	81	50.7	50.7
		121 - Armory	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		122 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		123 - Storage	Rm Peak	36	0.0	200	315	6	1.04	0	0	-446	6	69.2	69.2
	Zone - 017		Zn Peak	236	0.5	1,372	2,087	47			0	-2,820	47	53.1	53.1
	Zone - 017		Zn Block	236	0.5	1,372	2,087	47			0	-4,760	47	53.1	53.1
		115 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		116 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9

* This report does not display heating only systems .

Figure G.49 Load/Airflow Summary (2 of 4): Model 4

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		117 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
		118 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		119 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		120 - Patrol	Rm Peak	800	53.3	24,457	39,651	757	5.68	0	0	-48,864	757	59.2	59.2
	Zone - 018		Zn Peak	1,300	63.3	31,126	49,652	960			0	-60,431	960	56.9	56.9
	Zone - 018		Zn Block	1,300	63.3	31,115	49,641	960			0	-60,430	960	56.9	56.9
		124 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		125 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		126 - Warrant	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 019		Zn Peak	300	1.5	1,852	2,694	69			0	-3,405	69	36.8	36.8
	Zone - 019		Zn Block	300	1.5	1,852	2,694	69			0	-5,298	69	36.8	36.8
		127 - Lab	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		128 - Drugs	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
	Zone - 020		Zn Peak	200	0.0	1,110	1,749	35			0	-2,478	35	69.2	69.2
	Zone - 020		Zn Block	200	0.0	1,110	1,749	35			0	-4,474	35	69.2	69.2
		129 - Prop/Evid	Rm Peak	360	0.0	1,999	3,148	62	1.04	0	0	-4,460	62	69.2	69.2
		130 - Processing	Rm Peak	150	7.5	3,606	5,821	113	4.52	0	0	-7,181	113	57.8	57.8
	Zone - 021		Zn Peak	510	7.5	5,604	8,969	175			0	-11,641	175	61.8	61.8
	Zone - 021		Zn Block	510	7.5	5,604	8,968	175			0	-11,641	175	61.8	61.8
		131 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		132 - Cell	Rm Peak	180	4.5	2,555	4,055	83	2.78	0	0	-5,020	83	52.9	52.9
		133 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
	Zone - 022		Zn Peak	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
	Zone - 022		Zn Block	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
		134 - Jail	Rm Peak	175	0.0	972	1,530	30	1.04	0	0	-2,168	30	69.2	69.2
		135 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		136 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		137 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		138 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		139 - Holding	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		140 - Irtox	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		141 - Booking	Rm Peak	270	13.5	6,491	10,477	203	4.52	0	0	-12,926	203	57.8	57.8
	Zone - 023		Zn Peak	949	26.1	14,617	23,360	467			0	-29,150	467	56.1	56.1
	Zone - 023		Zn Block	949	26.1	14,617	23,360	467			0	-29,149	467	56.1	56.1
		142 - Mech	Rm Peak	150	0.0	1,176	1,452	49	1.41	0	0	-1,704	49	10.2	10.2
		143 - Storage	Rm Peak	150	0.0	940	1,424	31	1.23	0	0	-1,971	31	58.6	58.6
		146 - Sallyport	Rm Peak	900	0.0	17,172	20,087	481	3.21	0	0	-18,860	481	22.5	22.5
	Zone - 024		Zn Peak	1,200	0.0	19,287	22,963	561			0	-22,535	561	24.1	24.1
	Zone - 024		Zn Block	1,200	0.0	18,920	22,838	561			0	-22,622	561	24.1	24.1
		144 - Kitchen	Rm Peak	150	0.0	667	919	26	1.04	0	0	-1,238	26	34.6	34.6
		145 - Safety	Rm Peak	150	7.5	3,690	5,939	117	4.68	0	0	-7,276	117	55.8	55.8

* This report does not display heating only systems .

Figure G.50 Load/Airflow Summary (3 of 4): Model 4

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
	Zone - 025		Zn Peak	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
	Zone - 025		Zn Block	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
		110 - Corridor	Rm Peak	475	0.0	12,940	13,837	577	7.29	0	0	-15,659	577	4.9	4.9
		147 - Conference	Rm Peak	240	12.0	8,839	11,895	296	7.41	0	0	-12,162	296	25.1	25.1
	Zone - 026		Zn Peak	715	12.0	21,779	25,733	874			0	-27,821	874	11.8	11.8
	Zone - 026		Zn Block	715	12.0	21,017	25,322	874			0	-27,821	874	11.8	11.8
		148 - Office	Rm Peak	240	1.2	7,223	7,990	259	6.47	0	0	-7,551	259	7.9	7.9
		150 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		151 - Toilet	Rm Peak	100	0.0	1,418	1,418	38	2.27	0	0	-897	38	0.0	0.0
		152 - Office	Rm Peak	225	1.1	3,401	4,066	78	2.07	0	0	-3,165	78	24.6	24.6
	Zone - 027		Zn Peak	665	2.3	13,685	15,454	412			0	-13,338	412	12.5	12.5
	Zone - 027		Zn Block	665	2.3	13,622	15,439	412			0	-13,436	412	12.5	12.5
		109 - Corridor	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		110 - Corridor (Int)	Rm Peak	475	0.0	2,111	2,911	82	1.04	0	0	-3,919	82	34.6	34.6
		149 - Reception	Rm Peak	320	9.1	10,443	12,832	161	3.03	0	0	-8,308	161	40.2	40.2
		153 - Office	Rm Peak	225	1.1	2,875	3,498	52	1.39	0	0	-2,554	52	36.8	36.8
	Zone - 028		Zn Peak	1,120	10.3	15,873	19,854	313			0	-15,606	313	37.9	37.9
	Zone - 028		Zn Block	1,120	10.3	15,802	19,639	313			0	-15,606	313	37.9	37.9
		154 - Locker	Rm Peak	400	0.0	4,656	4,656	104	1.55	0	0	-2,458	104	0.0	0.0
		155 - Men	Rm Peak	400	0.0	3,963	3,963	69	1.04	0	0	-1,644	69	0.0	0.0
	Zone - 029		Zn Peak	800	0.0	8,619	8,619	173			0	-4,102	173	0.0	0.0
	Zone - 029		Zn Block	800	0.0	8,619	8,619	173			0	-7,754	173	0.0	0.0
		156 - Women	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		157 - Locker	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		158 - Toilet	Rm Peak	100	0.0	1,691	1,691	55	3.28	0	0	-1,298	55	0.0	0.0
		159 - Mech	Rm Peak	100	0.0	1,796	1,963	55	3.28	0	0	-1,712	55	11.0	11.0
	Zone - 030		Zn Peak	650	0.0	7,946	8,113	187			0	-4,860	187	3.2	3.2
	Zone - 030		Zn Block	650	0.0	7,777	7,962	187			0	-8,098	187	3.2	3.2
		160 - Workout	Rm Peak	575	2.9	48,899	51,906	2,044	21.33	0	0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Peak	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Block	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
		101 - Lobby (Ext)	Rm Peak	420	0.0	2,973	3,712	128	1.82	0	0	-4,763	128	19.8	19.8
		101 - Lobby (Int)	Rm Peak	154	0.0	684	944	27	1.04	0	0	-1,271	27	34.6	34.6
		106 - Breakroom	Rm Peak	100	2.5	1,309	2,034	46	2.78	0	0	-2,375	46	39.9	39.9
	Zone - 032		Zn Peak	674	2.5	4,966	6,691	201			0	-8,409	201	26.4	26.4
	Zone - 032		Zn Block	674	2.5	4,977	6,689	201			0	-8,409	201	26.4	26.4
System - 001			**Sys Peak**	**22,381**	**353.3**	**497,753**	**621,719**	**17,305**				**-672,528**	**17,305**	**22.0**	**22.0**
System - 001			**Sys Block**	**22,381**	**353.3**	**439,737**	**574,626**	**17,305**				**-672,612**	**17,305**	**22.0**	**22.0**

* This report does not display heating only systems .

Figure G.51 Load/Airflow Summary (4 of 4): Model 4

BUILDING COOL HEAT DEMAND

By ACADEMIC

January	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	6.2	5.4	-178,301	0.0	-230,791	0.9	-240,219	1.0	-240,210	1.0	-240,209	1.0
2	5.0	4.1	-186,418	0.0	-243,242	0.9	-249,692	0.9	-249,687	0.9	-249,686	0.9
3	4.2	3.3	-192,334	0.4	-250,143	0.9	-250,978	0.9	-250,971	0.9	-250,970	0.9
4	3.9	3.2	-196,831	0.5	-260,703	0.9	-261,512	0.9	-261,505	0.9	-261,504	0.9
5	4.3	3.5	-199,379	0.6	-261,069	0.9	-261,269	0.9	-261,262	0.9	-261,261	0.9
6	5.4	4.4	-198,941	0.7	-256,545	0.9	-256,487	0.9	-256,480	0.9	-256,479	0.9
7	7.1	6.2	-194,379	0.8	-247,924	0.9	-247,868	1.0	-247,861	1.0	-247,860	1.0
8	9.3	8.3	-186,069	1.0	-235,532	1.0	-235,478	1.0	-235,472	1.0	-235,471	1.0
9	11.8	10.8	-154,047	1.0	-210,538	1.0	-210,479	1.0	-210,473	1.0	-210,473	1.0
10	14.4	13.3	-104,552	1.0	-176,368	1.0	-176,314	1.0	-176,309	1.0	-176,307	1.0
11	16.9	15.4	-60,260	1.2	-139,267	1.0	-139,190	1.0	-139,182	1.0	-139,181	1.0
12	19.1	17.3	-37,695	1.6	-112,326	1.0	-112,288	1.0	-112,294	1.0	-112,284	1.0
13	20.8	18.6	-24,322	1.5	-95,695	1.1	-95,656	1.1	-95,651	1.1	-95,650	1.1
14	21.9	19.5	-15,147	3.6	-83,638	1.1	-83,594	1.1	-83,590	1.1	-83,589	1.1
15	22.3	19.6	-9,504	4.7	-73,900	1.2	-73,873	1.2	-73,870	1.2	-73,870	1.2
16	22.0	19.3	-8,701	4.8	-70,565	1.3	-70,540	1.3	-70,537	1.3	-70,537	1.3
17	21.2	18.7	-10,877	4.4	-80,857	1.3	-80,835	1.3	-80,833	1.3	-80,833	1.3
18	20.0	17.7	-15,083	1.7	-110,155	1.2	-110,135	1.2	-110,133	1.2	-110,133	1.2
19	18.3	16.4	-25,103	1.2	-141,385	1.1	-141,367	1.1	-141,365	1.1	-141,365	1.1
20	16.4	14.8	-55,119	1.2	-165,154	1.0	-165,138	1.0	-165,136	1.0	-165,136	1.0
21	14.2	13.0	-111,235	1.1	-182,158	1.0	-182,143	1.0	-182,142	1.0	-182,141	1.0
22	12.0	10.8	-141,207	1.1	-198,184	1.0	-198,171	1.0	-198,169	1.0	-198,169	1.0
23	9.9	8.8	-154,115	1.0	-213,371	1.0	-213,359	1.0	-213,357	1.0	-213,357	1.0
24	7.9	6.9	-163,599	1.0	-227,645	1.0	-227,634	1.0	-227,633	1.0	-227,633	1.0

February	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	17.2	10.3	-130,220	1.1	-152,703	1.1	-102,493	1.1	-102,485	1.1	-102,484	1.1
2	15.3	14.4	-138,429	1.1	-168,011	1.0	-176,688	1.0	-176,681	1.0	-176,680	1.0
3	13.7	12.7	-145,367	1.1	-182,412	1.0	-189,876	1.0	-189,870	1.0	-189,869	1.0
4	12.4	11.4	-150,603	1.1	-193,241	1.0	-199,871	1.0	-199,865	1.0	-199,865	1.0
5	11.3	10.5	-153,370	1.1	-202,813	1.0	-208,308	1.0	-208,303	1.0	-208,303	1.0
6	10.7	10.0	-152,622	1.1	-209,698	1.0	-213,953	1.0	-213,948	1.0	-213,948	1.0
7	10.5	9.9	-148,153	1.1	-216,744	1.0	-217,015	1.0	-217,010	1.0	-217,010	1.0
8	11.1	10.6	-135,778	1.2	-213,416	1.0	-213,472	1.0	-213,469	1.0	-213,468	1.0
9	12.8	12.2	-96,622	1.2	-190,468	1.0	-190,426	1.0	-190,423	1.0	-190,423	1.0
10	15.3	14.4	-55,422	1.4	-156,482	1.0	-156,439	1.0	-156,435	1.0	-156,435	1.0
11	18.5	16.9	-23,287	2.3	-119,237	1.1	-119,199	1.1	-119,196	1.1	-119,196	1.1
12	21.8	19.8	-11,054	3.3	-89,360	1.1	-89,328	1.1	-89,326	1.1	-89,326	1.1
13	25.0	22.6	-4,958	4.6	-65,196	1.2	-65,168	1.2	-65,166	1.2	-65,166	1.2
14	27.5	24.8	0	6.2	-47,403	1.3	-47,382	1.3	-47,380	1.3	-47,380	1.3
15	29.2	26.3	0	7.3	-34,613	1.4	-34,590	1.4	-34,588	1.4	-34,588	1.4
16	29.8	26.8	0	8.7	-28,640	1.5	-28,619	1.5	-28,618	1.5	-28,618	1.5
17	29.6	26.8	0	9.1	-29,453	1.6	-29,440	1.6	-29,438	1.6	-29,438	1.6
18	29.0	26.4	0	6.2	-36,385	1.5	-36,368	1.5	-36,367	1.5	-36,366	1.5
19	28.0	25.7	0	3.0	-53,540	1.4	-53,531	1.4	-53,530	1.4	-53,529	1.4
20	26.6	25.0	-6,233	1.6	-85,265	1.3	-85,252	1.3	-85,251	1.3	-85,250	1.3
21	25.0	23.5	-15,670	1.5	-107,372	1.2	-107,360	1.2	-107,359	1.2	-107,359	1.2
22	23.1	21.9	-65,446	1.3	-121,365	1.2	-121,355	1.2	-121,354	1.2	-121,354	1.2
23	21.2	20.1	-100,282	1.2	-134,891	1.1	-134,882	1.1	-134,881	1.1	-134,881	1.1
24	19.1	18.2	-113,456	1.2	-149,979	1.1	-149,971	1.1	-149,970	1.1	-149,970	1.1

Figure G.52 Building Cool Heat Demand (1 of 6): Model 4

BUILDING COOL HEAT DEMAND

By ACADEMIC

March	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.4	33.4	-12,270	1.6	0	1.6	-26,879	1.6	-26,879	1.6	-26,879	1.6
2	33.0	31.0	16,647	1.6	-4,640	1.6	-44,807	1.6	-44,807	1.6	-44,807	1.5
3	32.9	31.1	-20,082	1.8	-37,096	1.5	-51,644	1.5	-51,654	1.5	-51,655	1.5
4	32.6	31.1	-22,747	1.9	-51,367	1.4	-62,769	1.4	-62,768	1.4	-62,768	1.4
5	32.9	31.5	-24,315	2.0	-59,788	1.4	-64,252	1.4	-64,251	1.4	-64,251	1.4
6	33.9	32.5	-24,384	2.2	-59,806	1.4	-62,110	1.4	-62,110	1.4	-62,110	1.4
7	35.4	34.2	-22,871	2.5	-56,061	1.5	-56,855	1.5	-57,627	1.5	-57,629	1.5
8	37.4	36.1	-10,436	2.8	-39,975	1.5	-41,581	1.5	-41,688	1.5	-41,688	1.5
9	39.7	37.9	0	3.9	-23,177	1.7	-24,872	1.7	-24,875	1.7	-24,875	1.7
10	42.1	39.6	0	7.8	-11,439	1.9	-12,691	1.9	-12,694	1.9	-12,694	1.9
11	44.6	41.5	0	10.7	0	2.7	-4,641	2.7	-4,643	2.7	-4,643	2.7
12	46.9	43.0	0	13.7	0	4.4	0	4.4	0	4.4	0	4.4
13	48.9	44.3	0	18.0	0	6.0	0	6.0	0	6.0	0	6.0
14	50.4	45.0	0	20.0	0	7.7	0	7.7	0	7.7	0	7.7
15	51.4	45.4	0	21.6	0	8.8	0	8.8	0	8.8	0	8.8
16	51.7	45.6	0	22.0	0	0.7	0	0.7	0	0.7	0	0.7
17	51.4	45.1	0	23.1	0	9.6	0	9.6	0	9.6	0	9.6
18	50.4	44.2	0	20.4	0	8.7	0	8.7	0	8.7	0	8.7
19	48.9	43.4	0	15.2	0	6.2	0	6.2	0	6.2	0	6.2
20	46.9	42.8	0	10.2	0	4.1	0	4.1	0	4.1	0	4.1
21	44.6	41.4	0	6.8	0	3.2	0	3.2	0	3.2	0	3.2
22	42.1	39.6	0	5.0	0	2.6	0	2.6	0	2.6	0	2.6
23	39.7	37.4	0	4.1	0	2.0	0	2.0	0	2.0	0	2.0
24	37.4	36.0	0	3.5	-5,537	1.8	-5,515	1.8	-5,514	1.8	-5,514	1.8

April	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	48.1	46.0	0	4.7	0	4.2	0	4.2	0	4.2	0	4.2
2	45.9	44.2	0	5.0	0	3.5	0	3.4	0	3.4	0	3.4
3	44.1	42.4	0	4.9	0	2.9	0	2.9	0	2.9	0	2.9
4	42.5	40.9	0	4.8	0	2.5	0	2.5	0	2.5	0	2.5
5	41.3	39.8	0	4.7	0	2.2	0	2.2	0	2.2	0	2.2
6	40.6	39.3	0	4.7	-7,108	2.0	-9,907	2.0	-9,957	2.0	-9,972	2.0
7	40.4	39.1	0	5.1	-15,410	2.0	-16,205	2.0	-16,249	2.0	-16,263	2.0
8	41.1	39.7	0	6.0	-14,487	2.1	-14,640	2.1	-14,681	2.1	-14,695	2.1
9	43.0	40.8	0	10.7	-9,675	2.6	-9,820	2.6	-9,859	2.6	-9,872	2.6
10	45.9	42.4	0	14.5	0	3.9	0	3.9	0	3.9	0	3.9
11	49.6	44.5	0	18.6	0	6.5	0	6.5	0	6.5	0	6.5
12	53.4	47.5	0	21.4	0	8.4	0	8.4	0	8.4	0	8.4
13	57.0	50.1	0	23.4	0	9.8	0	9.8	0	9.8	0	9.8
14	60.0	52.3	0	25.7	0	14.3	0	14.4	0	14.4	0	14.4
15	61.9	53.7	0	28.2	0	16.8	0	16.9	0	16.9	0	16.9
16	62.6	53.9	0	29.5	0	17.6	0	17.7	0	17.7	0	17.7
17	02.3	53.9	0	29.3	0	17.5	0	17.5	0	17.5	0	17.5
18	61.6	53.4	0	27.1	0	16.6	0	16.6	0	16.6	0	16.6
19	60.5	52.6	0	22.4	0	14.4	0	14.4	0	14.4	0	14.4
20	58.9	52.7	0	17.4	0	11.8	0	11.8	0	11.8	0	11.8
21	57.0	52.5	0	13.3	0	9.7	0	9.7	0	9.7	0	9.7
22	54.9	51.5	0	10.6	0	7.9	0	7.9	0	7.9	0	7.9
23	52.6	50.0	0	8.6	0	6.3	0	6.3	0	6.3	0	6.3
24	50.3	40.0	0	7.2	0	5.2	0	5.2	0	5.2	0	5.2

Figure G.53 Building Cool Heat Demand (2 of 6): Model 4

BUILDING COOL HEAT DEMAND

By ACADEMIC

May	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	59.2	56.0	0	12.8	0	11.1	0	12.1	0	12.2	0	12.2
2	56.8	53.8	0	12.1	0	9.4	0	9.9	0	9.9	0	9.9
3	54.8	52.2	0	11.3	0	7.8	0	8.1	0	8.1	0	8.1
4	53.3	50.9	0	10.8	0	6.6	0	6.7	0	6.7	0	6.7
5	52.3	50.2	0	10.5	0	6.1	0	6.1	0	6.1	0	6.1
6	52.0	50.3	0	10.7	0	5.9	0	5.9	0	5.9	0	5.9
7	52.5	50.8	0	12.3	0	6.0	0	6.1	0	6.1	0	6.1
8	53.8	51.6	0	16.4	0	8.1	0	8.2	0	8.2	0	8.2
9	55.9	52.4	0	21.0	0	10.8	0	10.9	0	10.9	0	10.9
10	58.5	53.8	0	24.2	0	14.0	0	14.1	0	14.1	0	14.1
11	61.0	55.1	0	27.1	0	10.0	0	10.8	0	10.8	0	10.8
12	64.7	56.6	0	30.2	0	19.2	0	19.3	0	19.4	0	19.4
13	67.8	58.2	0	32.5	0	21.4	0	21.4	0	21.4	0	21.4
14	70.4	60.6	0	34.7	0	23.8	0	23.0	0	23.0	0	23.0
15	72.5	61.1	0	37.1	0	27.3	0	27.3	0	27.3	0	27.3
16	73.8	62.4	0	38.6	0	29.1	0	29.2	0	29.2	0	29.2
17	74.3	62.8	0	38.3	0	29.4	0	29.4	0	29.4	0	29.4
18	74.0	62.6	0	35.9	0	28.3	0	28.3	0	28.3	0	28.3
19	73.0	62.1	0	31.5	0	26.2	0	26.2	0	26.2	0	26.2
20	71.5	62.0	0	25.9	0	23.2	0	23.2	0	23.2	0	23.2
21	69.5	63.0	0	21.6	0	21.3	0	21.4	0	21.4	0	21.4
22	67.1	61.9	0	18.3	0	19.2	0	19.2	0	19.2	0	19.2
23	64.5	59.9	0	16.1	0	16.8	0	16.8	0	16.8	0	16.8
24	61.8	58.0	0	14.6	0	14.4	0	14.5	0	14.5	0	14.5

June	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	68.3	64.8	0	22.2	0	21.6	0	22.8	0	22.9	0	22.9
2	66.4	63.3	0	21.0	0	20.0	0	20.7	0	20.7	0	20.7
3	64.0	62.3	0	20.1	0	10.7	0	10.9	0	10.9	0	10.9
4	63.6	61.5	0	19.5	0	17.5	0	17.6	0	17.6	0	17.6
5	62.9	61.0	0	19.1	0	16.6	0	16.7	0	16.7	0	16.7
6	62.6	60.8	0	19.7	0	16.3	0	16.4	0	16.4	0	16.4
7	63.1	61.4	0	22.8	0	17.9	0	18.0	0	18.0	0	18.0
8	64.5	61.6	0	26.8	0	20.4	0	20.4	0	20.4	0	20.4
9	66.8	62.3	0	31.2	0	23.0	0	23.0	0	23.0	0	23.0
10	69.6	63.9	0	34.6	0	26.3	0	26.4	0	26.5	0	26.5
11	72.7	66.0	0	38.3	0	30.1	0	30.2	0	30.2	0	30.2
12	75.8	67.7	0	41.2	0	33.8	0	33.8	0	33.8	0	33.8
13	78.7	69.7	0	43.7	0	37.0	0	37.1	0	37.1	0	37.1
14	80.9	71.1	0	46.1	0	40.1	0	40.2	0	40.2	0	40.2
15	82.3	71.7	0	48.1	0	43.0	0	43.0	0	43.0	0	43.0
16	82.8	72.0	0	49.5	0	43.9	0	44.0	0	44.0	0	44.0
17	82.6	71.4	0	48.6	0	43.0	0	43.1	0	43.1	0	43.1
18	81.8	71.1	0	46.2	0	41.7	0	41.7	0	41.7	0	41.7
19	80.6	70.6	0	41.7	0	30.4	0	30.4	0	30.4	0	30.4
20	79.0	70.3	0	35.7	0	35.7	0	35.8	0	35.8	0	35.8
21	77.1	70.2	0	30.6	0	32.7	0	32.8	0	32.8	0	32.8
22	75.0	69.6	0	27.1	0	30.7	0	30.7	0	30.7	0	30.7
23	72.7	68.0	0	24.8	0	27.9	0	27.9	0	27.9	0	27.9
24	70.5	66.8	0	23.5	0	25.7	0	25.7	0	25.8	0	25.8

Figure G.54 Building Cool Heat Demand (3 of 6): Model 4

BUILDING COOL HEAT DEMAND

By ACADEMIC

July	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	74.2	70.3	0	30.2	0	30.8	0	31.8	0	31.8	0	31.8
2	72.8	69.4	0	28.6	0	29.0	0	29.5	0	29.5	0	29.5
3	71.6	68.3	0	27.8	0	27.7	0	27.8	0	27.8	0	27.8
4	70.6	67.9	0	27.3	0	26.5	0	26.6	0	26.6	0	26.6
5	70.1	67.3	0	26.9	0	25.9	0	26.0	0	26.0	0	26.0
6	69.9	67.5	0	27.2	0	25.5	0	25.5	0	25.5	0	25.5
7	70.2	68.0	0	30.1	0	27.1	0	27.1	0	27.1	0	27.1
8	71.3	68.5	0	34.4	0	28.5	0	29.4	0	29.5	0	29.5
9	73.1	69.1	0	39.0	0	32.3	0	32.3	0	32.4	0	32.4
10	75.2	70.2	0	42.0	0	36.0	0	36.0	0	36.0	0	36.0
11	77.6	71.2	0	46.3	0	30.2	0	30.2	0	30.2	0	30.2
12	80.0	72.3	0	48.2	0	42.9	0	42.8	0	42.8	0	42.8
13	82.2	74.4	0	50.4	0	45.7	0	45.8	0	45.8	0	45.8
14	83.9	76.0	0	52.8	0	48.7	0	48.8	0	48.8	0	48.8
15	85.0	76.3	0	54.8	0	51.3	0	51.4	0	51.4	0	51.4
16	85.4	76.3	0	55.5	0	51.5	0	51.6	0	51.6	0	51.6
17	85.2	76.4	0	54.5	0	50.9	0	50.9	0	50.9	0	50.9
18	84.6	76.2	0	52.6	0	49.7	0	49.7	0	49.8	0	49.8
19	83.7	75.3	0	48.8	0	47.6	0	47.6	0	47.6	0	47.6
20	82.4	76.2	0	42.9	0	44.5	0	44.6	0	44.6	0	44.6
21	81.0	76.1	0	37.9	0	41.9	0	42.0	0	42.0	0	42.0
22	79.3	75.3	0	34.8	0	39.6	0	39.6	0	39.6	0	39.6
23	77.6	73.9	0	32.7	0	37.1	0	37.1	0	37.1	0	37.1
24	75.9	72.5	0	31.2	0	34.7	0	34.7	0	34.7	0	34.7

August	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	73.5	69.3	0	27.6	0	28.7	0	30.0	0	30.0	0	30.0
2	71.7	68.0	0	25.6	0	26.7	0	27.3	0	27.4	0	27.4
3	70.1	66.3	0	24.6	0	25.2	0	25.4	0	25.4	0	25.4
4	68.8	65.7	0	23.7	0	23.5	0	23.6	0	23.6	0	23.6
5	67.0	65.2	0	23.5	0	22.4	0	22.5	0	22.5	0	22.5
6	67.2	64.7	0	23.7	0	21.8	0	21.8	0	21.8	0	21.8
7	66.9	64.4	0	25.6	0	21.9	0	21.9	0	21.9	0	21.9
8	67.5	64.3	0	29.9	0	23.7	0	23.7	0	23.7	0	23.7
9	69.2	64.9	0	35.1	0	26.2	0	26.3	0	26.3	0	26.3
10	71.7	66.0	0	39.4	0	30.2	0	30.3	0	30.3	0	30.3
11	74.8	67.3	0	43.6	0	34.6	0	34.7	0	34.7	0	34.7
12	78.0	70.0	0	47.4	0	30.4	0	30.4	0	30.4	0	30.4
13	81.1	72.2	0	50.0	0	43.1	0	43.1	0	43.1	0	43.1
14	83.6	73.7	0	52.1	0	46.4	0	46.5	0	46.5	0	46.5
15	85.3	74.3	0	54.1	0	49.5	0	49.6	0	49.6	0	49.6
16	85.9	75.3	0	54.9	0	50.4	0	50.4	0	50.4	0	50.4
17	85.6	75.0	0	53.3	0	49.2	0	49.2	0	49.2	0	49.2
18	85.0	74.3	0	50.3	0	47.3	0	47.3	0	47.3	0	47.3
19	84.0	76.0	0	44.6	0	44.7	0	44.7	0	44.7	0	44.7
20	82.7	75.4	0	38.6	0	42.0	0	42.0	0	42.1	0	42.1
21	81.1	75.3	0	34.6	0	40.6	0	40.6	0	40.6	0	40.6
22	79.3	74.7	0	31.6	0	38.5	0	38.5	0	38.5	0	38.5
23	77.4	73.1	0	29.4	0	35.8	0	35.8	0	35.8	0	35.8
24	75.4	71.1	0	27.6	0	32.7	0	32.7	0	32.7	0	32.7

Figure G.55 Building Cool Heat Demand (4 of 6): Model 4

BUILDING COOL HEAT DEMAND

By ACADEMIC

September	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	62.0	58.6	0	16.7	0	14.2	0	15.4	0	15.4	0	15.4
2	59.5	56.4	0	14.7	0	12.0	0	12.7	0	12.7	0	12.7
3	57.3	54.7	0	13.6	0	10.2	0	10.6	0	10.6	0	10.6
4	55.7	53.3	0	12.7	0	8.8	0	8.9	0	8.9	0	9.0
5	54.7	52.7	0	12.3	0	7.8	0	7.9	0	7.8	0	7.9
6	54.4	52.4	0	12.4	0	7.3	0	7.4	0	7.4	0	7.4
7	55.0	53.1	0	13.1	0	7.5	0	7.6	0	7.6	0	7.6
8	57.0	54.8	0	16.4	0	9.9	0	10.1	0	10.1	0	10.1
9	60.0	56.2	0	22.0	0	14.0	0	14.1	0	14.1	0	14.1
10	63.7	57.6	0	28.6	0	18.7	0	18.8	0	18.8	0	18.8
11	67.9	59.7	0	33.5	0	23.6	0	23.7	0	23.7	0	23.7
12	72.1	61.7	0	37.6	0	28.0	0	28.1	0	28.1	0	28.1
13	76.0	64.1	0	40.8	0	32.7	0	32.8	0	32.8	0	32.8
14	78.9	65.7	0	43.3	0	35.4	0	35.5	0	35.5	0	35.5
15	80.8	66.9	0	45.7	0	37.5	0	37.6	0	37.6	0	37.6
16	81.5	67.1	0	46.1	0	37.8	0	37.8	0	37.8	0	37.8
17	81.1	67.1	0	44.0	0	36.8	0	36.8	0	36.8	0	36.8
18	80.1	67.3	0	38.6	0	34.4	0	34.5	0	34.5	0	34.5
19	78.5	68.0	0	31.9	0	31.6	0	31.6	0	31.6	0	31.6
20	76.4	69.9	0	27.2	0	30.9	0	31.0	0	31.0	0	31.0
21	73.8	68.7	0	23.5	0	28.5	0	28.6	0	28.6	0	28.6
22	70.9	66.5	0	20.8	0	25.6	0	25.6	0	25.6	0	25.6
23	67.9	64.2	0	18.6	0	22.2	0	22.2	0	22.2	0	22.2
24	64.9	61.3	0	16.7	0	10.5	0	10.5	0	10.5	0	10.5

October	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	46.2	40.6	0	8.7	0	3.5	0	3.5	0	3.5	0	3.5
2	44.9	39.9	0	7.8	0	3.1	0	3.1	0	3.1	0	3.1
3	44.5	39.9	0	7.1	0	3.0	0	2.9	0	2.9	0	2.9
4	44.9	40.5	0	6.5	0	3.0	0	3.0	0	3.0	0	3.0
5	46.2	41.5	0	6.3	0	3.2	0	3.2	0	3.2	0	3.2
6	48.3	43.8	0	6.4	0	3.7	0	3.7	0	3.7	0	3.7
7	51.0	46.5	0	6.9	0	4.3	-4,045	4.3	-4,084	4.3	-4,098	4.3
8	54.2	49.6	0	9.0	0	5.5	0	5.5	0	5.5	0	5.5
9	57.6	52.1	0	13.1	0	6.9	0	6.9	0	6.9	0	6.9
10	61.0	53.5	0	19.1	0	9.5	0	9.4	0	9.4	0	9.4
11	64.1	55.0	0	23.9	0	15.1	0	15.1	0	15.1	0	15.1
12	66.9	56.1	0	27.2	0	18.7	0	18.8	0	18.8	0	18.8
13	68.0	57.1	0	30.0	0	20.6	0	20.6	0	20.6	0	20.6
14	70.3	57.3	0	32.4	0	21.7	0	21.7	0	21.7	0	21.7
15	70.7	57.2	0	34.7	0	22.5	0	22.5	0	22.5	0	22.5
16	70.3	56.4	0	34.9	0	22.2	0	22.3	0	22.3	0	22.3
17	68.9	55.3	0	32.5	0	20.4	0	20.4	0	20.4	0	20.4
18	66.9	53.9	0	26.8	0	17.1	0	17.1	0	17.1	0	17.1
19	64.1	52.7	0	21.3	0	13.8	0	13.8	0	13.8	0	13.8
20	61.0	52.0	0	17.3	0	11.2	0	11.2	0	11.2	0	11.2
21	57.6	49.8	0	14.7	0	9.1	0	9.1	0	9.1	0	9.1
22	54.2	47.5	0	12.5	0	7.0	0	7.0	0	7.0	0	7.0
23	51.0	44.9	0	10.9	0	5.3	0	5.3	0	5.3	0	5.3
24	48.3	42.6	0	0.7	0	4.3	0	4.3	0	4.3	0	4.3

Figure G.56 Building Cool Heat Demand (5 of 6): Model 4

BUILDING COOL HEAT DEMAND

By ACADEMIC

November	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.9	33.1	0	2.5	0	1.6	-33,304	1.6	-33,300	1.6	-33,299	1.6
2	33.9	31.2	0	2.3	-21,096	1.5	-45,153	1.5	-45,149	1.5	-45,149	1.5
3	32.3	29.8	0	2.1	-47,470	1.4	-55,039	1.4	-55,048	1.4	-55,048	1.4
4	31.0	28.8	-8,313	1.9	-58,287	1.4	-68,789	1.4	-68,786	1.3	-68,785	1.3
5	30.3	27.9	-24,413	1.9	-73,600	1.3	-76,010	1.3	-76,007	1.3	-76,007	1.3
6	30.0	27.7	-29,790	1.9	-79,757	1.3	-81,590	1.3	-81,613	1.3	-81,623	1.3
7	30.5	28.4	-28,086	2.1	-78,795	1.3	-81,946	1.3	-81,964	1.3	-81,965	1.3
8	32.0	30.0	-23,712	2.4	-73,331	1.4	-75,158	1.4	-75,161	1.4	-75,162	1.4
9	34.3	32.0	-6,091	2.9	-48,189	1.4	-49,589	1.4	-49,591	1.4	-49,592	1.4
10	37.1	34.0	0	4.5	-22,368	1.5	-23,540	1.5	-23,543	1.5	-23,543	1.5
11	40.3	36.2	0	8.4	-10,275	1.6	-10,819	1.6	-10,821	1.6	-10,822	1.6
12	43.5	38.3	0	13.4	-5,626	2.1	-5,629	2.1	-5,631	2.1	-5,632	2.1
13	46.4	40.1	0	17.0	-4,101	3.2	-4,091	3.2	-4,089	3.2	-4,089	3.2
14	48.6	41.4	0	19.2	0	5.4	0	5.4	0	5.4	0	5.4
15	50.1	42.5	0	20.6	0	6.9	0	6.9	0	6.9	0	6.9
16	50.6	42.6	0	20.4	0	8.3	0	8.3	0	8.3	0	8.3
17	50.3	42.5	0	17.5	0	7.3	0	7.3	0	7.3	0	7.3
18	49.6	42.8	0	12.9	0	5.3	0	5.2	0	5.2	0	5.2
19	48.4	42.9	0	8.6	0	3.9	0	3.9	0	3.9	0	3.9
20	46.7	42.2	0	5.8	0	3.5	0	3.5	0	3.5	0	3.5
21	44.8	41.1	0	4.6	-4,688	3.0	-4,682	3.0	-4,681	3.0	-4,681	3.0
22	42.6	39.3	0	3.8	-5,504	2.5	-5,497	2.5	-5,497	2.5	-5,497	2.5
23	40.3	37.4	0	3.2	-6,261	2.1	-6,255	2.1	-6,255	2.1	-6,255	2.1
24	38.0	35.3	0	2.8	-11,182	1.8	-11,177	1.8	-11,176	1.8	-11,176	1.8

December	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	23.5	20.5	-34,438	1.6	-69,266	1.2	-115,477	1.2	-115,470	1.2	-115,470	1.2
2	22.9	20.1	-44,487	1.5	-113,724	1.2	-122,366	1.2	-122,360	1.2	-122,360	1.2
3	23.2	20.5	-50,566	1.5	-120,225	1.2	-125,462	1.2	-125,457	1.2	-125,456	1.2
4	24.1	21.7	-62,323	1.4	-119,269	1.2	-123,801	1.2	-123,796	1.2	-123,796	1.2
5	25.5	23.2	-64,462	1.4	-114,663	1.2	-117,987	1.2	-117,983	1.2	-117,983	1.2
6	27.4	25.1	-65,546	1.4	-108,539	1.3	-108,654	1.3	-108,651	1.3	-108,650	1.3
7	29.7	27.4	-61,921	1.4	-96,088	1.3	-97,042	1.3	-97,038	1.3	-97,038	1.3
8	32.3	30.1	-54,199	1.5	-82,134	1.4	-83,159	1.4	-83,156	1.4	-83,156	1.4
9	34.9	32.8	-27,563	1.6	-58,716	1.4	-59,162	1.4	-59,160	1.4	-59,159	1.4
10	37.6	34.9	-7,666	1.8	-30,949	1.5	-30,917	1.5	-30,914	1.5	-30,919	1.5
11	40.1	36.4	-4,940	3.6	-14,103	1.5	-14,074	1.5	-14,090	1.5	-14,113	1.5
12	42.4	37.4	0	9.2	-7,063	1.7	-7,037	1.7	-7,046	1.7	-7,046	1.7
13	44.3	38.1	0	12.6	-4,944	2.5	-4,921	2.5	-4,919	2.5	-4,919	2.5
14	45.7	38.4	0	15.3	0	3.8	0	3.8	0	3.8	0	3.8
15	46.6	38.6	0	16.8	0	5.4	0	5.3	0	5.3	0	5.3
16	46.9	38.6	0	17.5	0	5.5	0	5.5	0	5.5	0	5.5
17	46.3	38.2	0	14.5	0	5.2	0	5.2	0	5.2	0	5.2
18	44.6	37.6	0	9.7	0	3.2	0	3.2	0	3.2	0	3.2
19	42.0	36.6	0	5.5	-4,224	2.4	-4,212	2.4	-4,211	2.4	-4,211	2.4
20	38.6	34.1	0	3.7	-5,775	1.9	-5,764	1.9	-5,763	1.9	-5,763	1.9
21	34.9	30.9	0	2.8	-7,101	1.6	-7,091	1.6	-7,091	1.6	-7,090	1.6
22	31.2	27.6	0	2.2	-31,502	1.4	-31,493	1.4	-31,492	1.4	-31,492	1.4
23	27.9	24.4	0	1.8	-74,493	1.3	-74,485	1.3	-74,484	1.3	-74,484	1.3
24	25.2	22.1	-8,181	1.7	-100,012	1.2	-100,004	1.2	-100,004	1.2	-100,004	1.2

Figure G.57 Building Cool Heat Demand (6 of 6): Model 4

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - Graland Academy

GCHP

	Year 1				
Month	Average Earth Temp. °F	Average Fluid Leaving Temp. °F	Average Fluid Entering Temp. °F	Minimum Fluid Entering Temp. °F	Maximum Fluid Entering Temp. °F
Jan	53.20	50.30	48.90	46.90	55.60
Feb	53.20	51.30	50.40	48.20	56.00
Mar	55.00	55.90	56.40	50.60	63.10
Apr	56.70	59.10	60.30	56.90	68.30
May	59.60	65.00	67.50	61.20	74.70
Jun	64.00	73.50	78.10	69.60	83.50
Jul	68.50	81.10	87.20	79.10	92.20
Aug	70.60	82.20	87.90	82.60	94.70
Sep	69.40	76.70	80.30	74.40	90.90
Oct	67.30	70.80	72.40	69.10	83.90
Nov	65.10	65.60	65.80	63.90	74.50
Dec	64.10	63.90	63.70	61.80	70.90
Annual	62.20	66.30	68.20	46.90	94.70

Figure G.58 Geothermal Earth Temperature Summary: Model 4

Table G.65 Heat Pump Selections: Model 4

MODEL 4 - HEAT PUMP SELECTIONS												
HEAT PUMP	**UNIT SIZE	UNIT AIR FLOW	COOLING					HEATING		GPM	WPD
			AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG LWT	HTG Q_T	HTG LWT		
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(ºF)	(MBH)	(ºF)		(FT)
1	006	240	320	0.4	4.8	4.8	85.0	-8.2	50.0	1.0	0.5
2	006	180	130	0.3	2.5	3.0	85.0	-4.5	50.0	1.0	0.5
3	NOT USED										
4	006	240	220	0.4	4.4	4.5	85.0	-6.0	50.0	1.0	0.5
5	006	180	180	0.4	3.8	4.9	85.0	-7.2	50.0	1.0	0.5
6	060	1465	1310	4.2	34.9	49.9	85.0	-63.9	50.0	15.0	8.2
7	070	2100	1670	4.8	42.2	57.7	85.0	-73.1	50.0	12.4	8.7
8	009	300	275	0.7	6.1	8.0	85.0	-10.7	50.0	2.1	2.5
9	048	1200	965	3.9	29.5	47.3	85.0	-59.3	50.0	9.0	5.2
10	048	1200	830	3.4	25.3	40.6	85.0	-50.9	50.0	9.0	5.2
11	024	640	685	1.7	16.0	20.1	85.0	-23.6	50.0	4.0	2.3
12	NOT USED										
13	018	450	410	1.2	14.3	14.3	85.0	-10.6	50.0	2.8	0.5
14	024	640	420	1.7	17.3	20.2	85.0	-15.9	50.0	4.0	2.3
15	012	350	250	1.0	11.7	11.9	85.0	-6.9	50.0	2.6	3.4
16	024	640	510	1.8	18.9	22.0	85.0	-18.8	50.0	4.0	2.3
17	030	715	495	2.4	23.9	28.6	85.0	-21.4	50.0	8.0	8.0
18	018	450	195	1.3	13.2	15.2	85.0	-9.0	50.0	2.8	0.5
19	018	450	300	1.4	13.8	16.7	85.0	-13.0	50.0	2.8	0.5
20A	060	1465	1295	4.2	38.3	50.2	85.0	-50.6	50.0	7.5	0.5
20B	060	1465	1295	4.2	38.3	50.2	85.0	-50.6	51.0	7.5	0.5
21	070	2100	1080	6.1	49.7	73.7	85.0	-71.3	50.0	12.4	8.7
22A	048	1200	1170	3.7	30.4	43.5	85.0	-47.4	50.0	9.0	5.2
22B	048	1200	1170	3.7	30.4	43.5	85.0	-47.4	50.0	9.0	5.2
23A	048	1600	1335	3.9	35.2	46.1	85.0	-51.7	50.0	9.0	5.2
23B	048	1600	1335	3.9	35.2	46.1	85.0	-51.7	50.0	9.0	5.2
24	024	850	885	1.7	20.2	20.5	85.0	-23.3	50.0	6.0	5.0
				61.9		743.3		-796.9		151.9	87.1

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

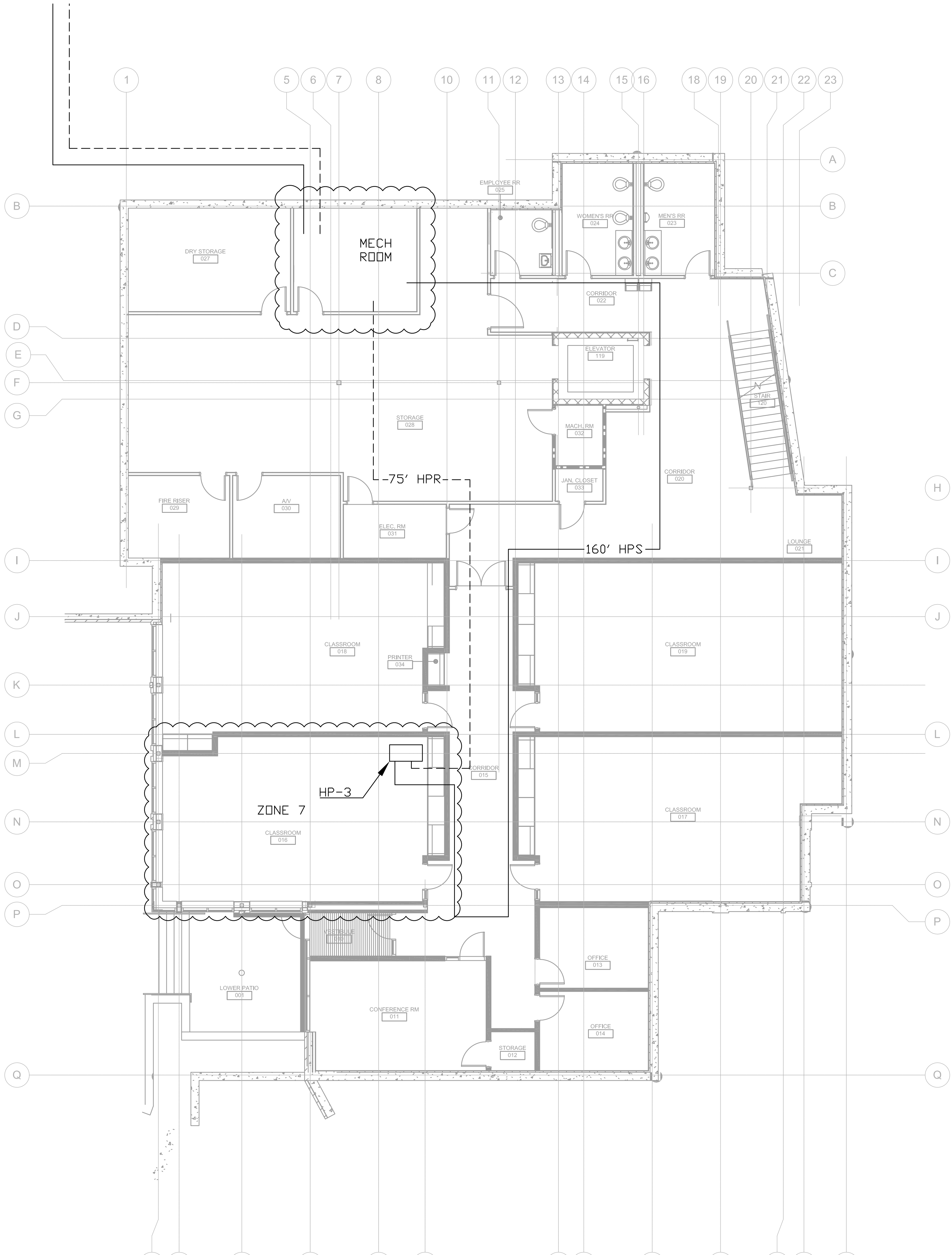


Figure G.59 Building Loop Piping Layout: Model 4

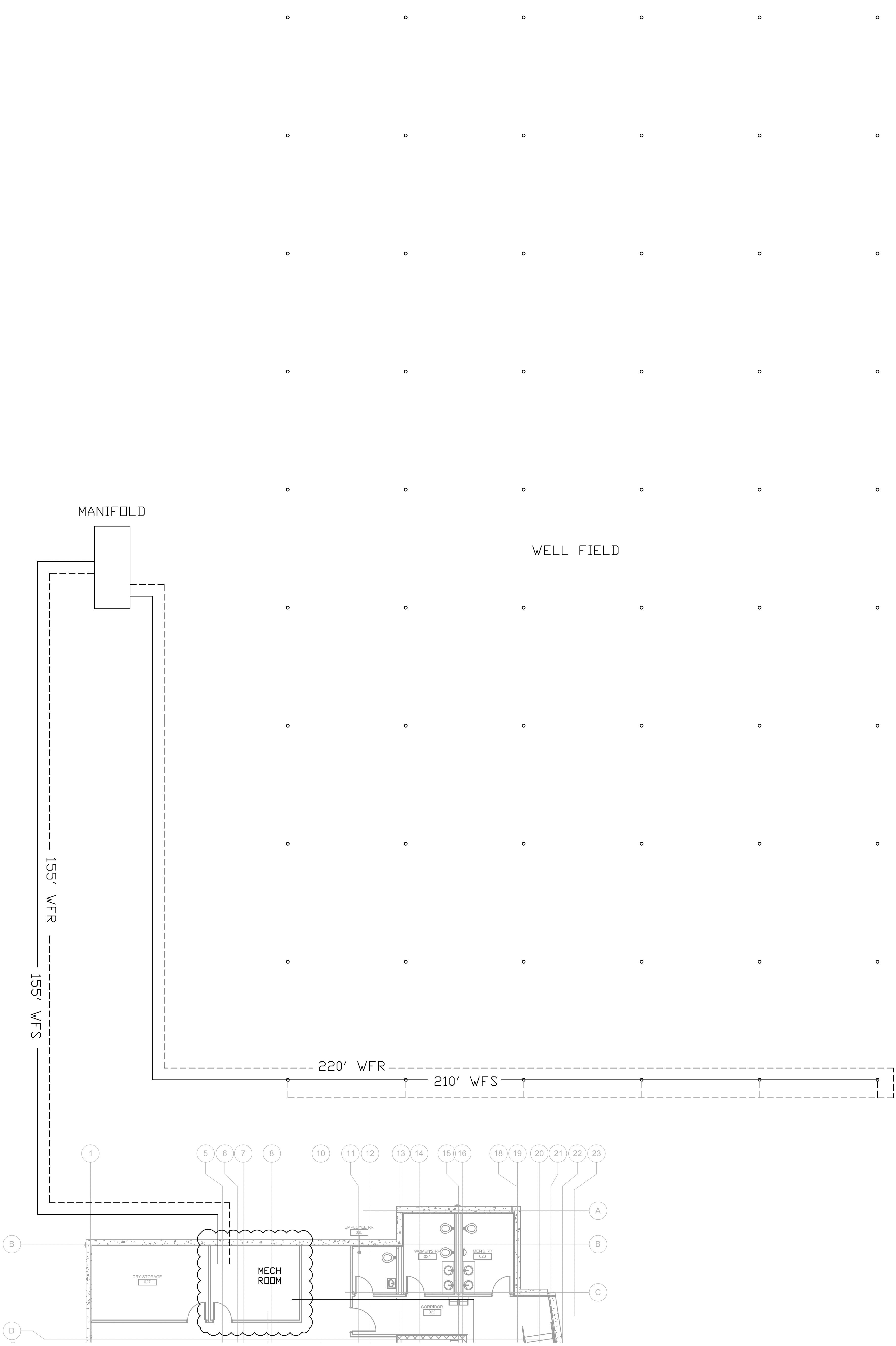


Figure G.60 Ground Loop Piping Layout: Model 4

MODEL	PRIMARY SYSTEM PUMP HEAD CALCULATIONS															PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.66 Primary Pump Head Calculations: All Models

Table G.67 Primary/Secondary Pump Head Calculations: All Models

MODEL	PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS — PRIMARY LOOP										
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL: SUPPLY	DISTANCE TO WELL: RETURN	DISTANCE DOWN/UP WELL	TOTAL PRIMARY LOOP PIPE LENGTH	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD	TOTAL HEAT PUMP GPM
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

MODEL	SECONDARY LOOP										
	DISTANCE TO HEAT PUMP: SUPPLY	DISTANCE TO HEAT PUMP: RETURN	TOTAL P/S LOOP PIPE LENGTH	P/S LENGTH W/ FITTINGS (TOTAL*1.5)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	SECONDARY LOOP PUMP HEAD
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	(FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS													PUMP HEAD	PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD		
		SUPPLY	RETURN		SUPPLY	RETURN									
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.68 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS															CIRCULATOR PUMP HEAD
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD	
		SUPPLY	RETURN		SUPPLY	RETURN										
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4	16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2	16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3	13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7	16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9	9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3	21.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM (%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table G.69 Distributive Circulator Pump Head Calculations: All Models

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.70 Primary Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.71 Primary/Secondary Pump Schedules: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY	BARE COST
			(FT)					(%)	($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.72 Distributive w/ Primary - Primary Pump Schedules: All Models

Table G.73 Distributive w/ Primary - Circulator Schedule: Model 4

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
2	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
4	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
5	B & G	NRF-9F/LW	1.0	0.5	2800	0.055	41	115	$ 449.00
6	B & G	NRF-22	15.0	8.2	2940	0.123	92	115	$ 664.00
7	B & G	NRF-22	12.4	8.7	2940	0.123	92	115	$ 664.00
8	B & G	NRF-9F/LW	2.1	2.5	2800	0.055	41	115	$ 449.00
9	B & G	NRF-22	9.0	5.2	2940	0.123	92	115	$ 664.00
10	B & G	NRF-22	9.0	5.2	2940	0.123	92	115	$ 664.00
11	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
13	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
14	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
15	B & G	NRF-9F/LW	2.6	3.4	2800	0.055	41	115	$ 449.00
16	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
17	B & G	NRF-22	8.0	8.0	2940	0.123	92	115	$ 664.00
18	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
19	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
20A	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
20B	B & G	NRF-9F/LW	7.5	0.5	2800	0.055	41	115	$ 449.00
21	B & G	NRF-22	12.4	8.7	2940	0.123	92	115	$ 664.00
22A	B & G	NRF-22	9.0	5.2	2940	0.123	92	115	$ 664.00
22B	B & G	NRF-22	9.0	5.2	2940	0.123	92	115	$ 664.00
23A	B & G	NRF-22	9.0	5.2	2940	0.123	92	115	$ 664.00
23B	B & G	NRF-22	9.0	5.2	2940	0.123	92	115	$ 664.00
24	B & G	NRF-22	6.0	5.0	2940	0.123	92	115	$ 664.00
						2.126	1586		$ 13,590.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table G.74 Distributive - Circulator Schedule: Model 4

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-25	1.0	16.7	2950	0.168	125	115	$ 724.00
2	B & G	NRF-25	1.0	16.7	2950	0.168	125	115	$ 724.00
4	B & G	NRF-25	1.0	16.7	2950	0.168	125	115	$ 724.00
5	B & G	NRF-25	1.0	16.7	2950	0.168	125	115	$ 724.00
6	B & G	NRF-36	15.0	16.7	3300	0.362	270	115	$ 1,368.00
7	B & G	NRF-36	12.4	16.7	3300	0.362	270	115	$ 1,368.00
8	B & G	NRF-25	2.1	16.7	2950	0.168	125	115	$ 724.00
9	B & G	NRF-36	9.0	16.7	3300	0.362	270	115	$ 1,368.00
10	B & G	NRF-36	9.0	16.7	3300	0.362	270	115	$ 1,368.00
11	B & G	NRF-25	4.0	16.7	2950	0.168	125	115	$ 724.00
13	B & G	NRF-25	2.8	16.7	2950	0.168	125	115	$ 724.00
14	B & G	NRF-25	4.0	16.7	2950	0.168	125	115	$ 724.00
15	B & G	NRF-25	2.6	16.7	2950	0.168	125	115	$ 724.00
16	B & G	NRF-25	4.0	16.7	2950	0.168	125	115	$ 724.00
17	B & G	NRF-36	8.0	16.7	3300	0.362	270	115	$ 1,368.00
18	B & G	NRF-25	2.8	16.7	2950	0.168	125	115	$ 724.00
19	B & G	NRF-25	2.8	16.7	2950	0.168	125	115	$ 724.00
20A	B & G	NRF-36	7.5	16.7	3300	0.362	270	115	$ 1,368.00
20B	B & G	NRF-36	7.5	16.7	3300	0.362	270	115	$ 1,368.00
21	B & G	NRF-36	12.4	16.7	3300	0.362	270	115	$ 1,368.00
22A	B & G	NRF-36	9.0	16.7	3300	0.362	270	115	$ 1,368.00
22B	B & G	NRF-36	9.0	16.7	3300	0.362	270	115	$ 1,368.00
23A	B & G	NRF-36	9.0	16.7	3300	0.362	270	115	$ 1,368.00
23B	B & G	NRF-36	9.0	16.7	3300	0.362	270	115	$ 1,368.00
24	B & G	NRF-36	6.0	16.7	3300	0.362	270	115	$ 1,368.00
						6.716	5010		$ 26,472.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

MODEL 4 - MONTHLY PUMP CONSUMPTION

AVERAGE DAY HOURS	COOLING DESIGN LOAD TONS	HEATING DESIGN MBH	JANUARY CLG DESIGN TONS	JANUARY CLG %	JANUARY HTG DESIGN MBH	JANUARY HTG %	JANUARY TOTAL %	FEBRUARY CLG DESIGN TONS	FEBRUARY CLG %	FEBRUARY HTG DESIGN MBH	FEBRUARY HTG %	FEBRUARY TOTAL %	MARCH CLG DESIGN TONS	MARCH CLG %	MARCH HTG DESIGN MBH	MARCH HTG %	MARCH TOTAL %	APRIL CLG DESIGN TONS	APRIL CLG %	APRIL HTG DESIGN MBH	APRIL HTG %	APRIL TOTAL %	MAY CLG DESIGN TONS	MAY CLG %	MAY HTG DESIGN MBH	MAY HTG %	MAY TOTAL %	JUNE CLG DESIGN TONS	JUNE CLG %	JUNE HTG DESIGN MBH	JUNE HTG %	JUNE TOTAL %
1	61.9	796.9	0.0	0.0%	178.3	22.4%	22.4%	1.1	1.8%	130.2	16.3%	18.1%	1.6	2.6%	12.3	1.5%	4.1%	4.7	7.6%	0.0	0.0%	7.6%	12.6	20.4%	0.0	0.0%	20.4%	22.2	35.9%	0.0	0.0%	35.9%
2	61.9	796.9	0.0	0.0%	186.4	23.4%	23.4%	1.1	1.8%	138.4	17.4%	19.1%	1.6	2.6%	16.5	2.1%	4.7%	5.0	8.1%	0.0	0.0%	8.1%	12.1	19.5%	0.0	0.0%	19.5%	21.0	33.9%	0.0	0.0%	33.9%
3	61.9	796.6	0.4	0.6%	192.3	24.1%	24.8%	1.1	1.8%	145.4	18.3%	20.0%	1.8	2.9%	20.1	2.5%	5.4%	4.9	7.9%	0.0	0.0%	7.9%	11.3	18.3%	0.0	0.0%	18.3%	20.1	32.5%	0.0	0.0%	32.5%
4	61.9	796.3	0.5	0.8%	196.8	24.7%	25.5%	1.1	1.8%	150.6	18.9%	20.7%	1.9	3.1%	22.7	2.9%	5.9%	4.8	7.8%	0.0	0.0%	7.8%	10.8	17.4%	0.0	0.0%	17.4%	19.5	31.5%	0.0	0.0%	31.5%
5	61.9	796.0	0.6	1.0%	199.4	25.1%	26.0%	1.1	1.8%	153.4	19.3%	21.0%	2.0	3.2%	24.3	3.1%	6.3%	4.7	7.6%	0.0	0.0%	7.6%	10.5	17.0%	0.0	0.0%	17.0%	19.1	30.9%	0.0	0.0%	30.9%
6	61.9	796.3	0.7	1.1%	198.9	25.0%	26.1%	1.1	1.8%	152.6	19.2%	20.9%	2.2	3.6%	24.4	3.1%	6.6%	4.7	7.6%	7.1	0.9%	8.5%	10.7	17.3%	0.0	0.0%	17.3%	19.7	31.8%	0.0	0.0%	31.8%
7	61.9	796.6	0.8	1.3%	194.4	24.4%	25.7%	1.1	1.8%	148.2	18.6%	20.4%	2.5	4.0%	22.9	2.9%	6.9%	5.1	8.2%	15.4	1.9%	10.2%	12.3	19.9%	0.0	0.0%	19.9%	22.8	36.8%	0.0	0.0%	36.8%
8	61.9	796.9	1.0	1.6%	186.1	23.4%	25.0%	1.2	1.9%	135.8	17.0%	19.0%	2.8	4.5%	10.4	1.3%	5.8%	6.0	9.7%	14.5	1.8%	11.5%	16.4	26.5%	0.0	0.0%	26.5%	26.8	43.3%	0.0	0.0%	43.3%
9	61.9	796.12	1.0	1.6%	154.0	19.3%	21.0%	1.2	1.9%	96.6	12.1%	14.1%	3.9	6.3%	0.0	0.0%	6.3%	10.7	17.3%	9.7	1.2%	18.5%	21.0	33.9%	0.0	0.0%	33.9%	31.2	50.4%	0.0	0.0%	50.4%
10	61.9	796.15	1.0	1.6%	104.6	13.1%	14.8%	1.4	2.3%	55.4	7.0%	9.2%	7.8	12.6%	0.0	0.0%	12.6%	14.5	23.4%	0.0	0.0%	23.4%	24.2	39.1%	0.0	0.0%	39.1%	34.6	55.9%	0.0	0.0%	55.9%
11	61.9	796.18	1.2	1.9%	60.3	7.6%	9.5%	2.3	3.7%	26.3	3.3%	7.0%	10.7	17.3%	0.0	0.0%	17.3%	18.6	30.0%	0.0	0.0%	30.0%	27.1	43.8%	0.0	0.0%	43.8%	38.3	61.9%	0.0	0.0%	61.9%
12	61.9	796.21	1.6	2.6%	37.7	4.7%	7.3%	3.3	5.3%	11.1	1.4%	6.7%	13.7	22.1%	0.0	0.0%	22.1%	21.4	34.6%	0.0	0.0%	34.6%	30.2	48.8%	0.0	0.0%	48.8%	41.2	66.6%	0.0	0.0%	66.6%
13	61.9	796.24	1.5	2.4%	24.3	3.1%	5.5%	4.8	7.8%	5.0	0.6%	8.4%	18.0	29.1%	0.0	0.0%	29.1%	23.4	37.8%	0.0	0.0%	37.8%	32.5	52.5%	0.0	0.0%	52.5%	43.7	70.6%	0.0	0.0%	70.6%
14	61.9	796.27	3.6	5.8%	15.1	1.9%	7.7%	6.2	10.0%	0.0	0.0%	10.0%	20.0	32.3%	0.0	0.0%	32.3%	25.7	41.5%	0.0	0.0%	41.5%	34.7	56.1%	0.0	0.0%	56.1%	46.1	74.5%	0.0	0.0%	74.5%
15	61.9	796.30	4.7	7.6%	9.5	1.2%	8.8%	7.3	11.8%	0.0	0.0%	11.8%	21.6	34.9%	0.0	0.0%	34.9%	28.2	45.6%	0.0	0.0%	45.6%	37.1	59.9%	0.0	0.0%	59.9%	48.1	77.7%	0.0	0.0%	77.7%
16	61.9	796.33	4.8	7.8%	8.7	1.1%	8.8%	8.7	14.1%	0.0	0.0%	14.1%	22.9	37.0%	0.0	0.0%	37.0%	29.5	47.7%	0.0	0.0%	47.7%	38.6	62.4%	0.0	0.0%	62.4%	49.5	80.0%	0.0	0.0%	80.0%
17	61.9	796.36	4.4	7.1%	10.9	1.4%	8.5%	9.1	14.7%	0.0	0.0%	14.7%	23.1	37.3%	0.0	0.0%	37.3%	29.3	47.3%	0.0	0.0%	47.3%	38.3	61.9%	0.0	0.0%	61.9%	48.6	78.5%	0.0	0.0%	78.5%
18	61.9	796.39	1.7	2.7%	15.1	1.9%	4.6%	6.2	10.0%	0.0	0.0%	10.0%	20.5	33.1%	0.0	0.0%	33.1%	27.1	43.8%	0.0	0.0%	43.8%	35.9	58.0%	0.0	0.0%	58.0%	46.2	74.6%	0.0	0.0%	74.6%
19	61.9	796.42	1.2	1.9%	25.1	3.2%	5.1%	3.0	4.8%	0.0	0.0%	4.8%	15.2	24.6%	0.0	0.0%	24.6%	22.4	36.2%	0.0	0.0%	36.2%	31.5	50.9%	0.0	0.0%	50.9%	41.7	67.4%	0.0	0.0%	67.4%
20	61.9	796.45	1.2	1.9%	55.1	6.9%	8.9%	1.8	2.9%	6.2	0.8%	3.7%	10.2	16.5%	0.0	0.0%	16.5%	17.4	28.1%	0.0	0.0%	28.1%	25.9	41.8%	0.0	0.0%	41.8%	35.7	57.7%	0.0	0.0%	57.7%
21	61.9	796.48	1.1	1.8%	111.2	14.0%	15.7%	1.5	2.4%	15.7	2.0%	4.4%	6.8	11.0%	0.0	0.0%	11.0%	13.3	21.5%	0.0	0.0%	21.5%	21.6	34.9%	0.0	0.0%	34.9%	30.6	49.4%	0.0	0.0%	49.4%
22	61.9	796.51	1.1	1.8%	141.2	17.7%	19.5%	1.3	2.1%	65.4	8.2%	10.3%	5.0	8.1%	0.0	0.0%	8.1%	10.6	17.1%	0.0	0.0%	17.1%	18.3	29.6%	0.0	0.0%	29.6%	27.1	43.8%	0.0	0.0%	43.8%
23	61.9	796.54	1.0	1.6%	154.1	19.3%	21.0%	1.2	1.9%	100.3	12.6%	14.5%	4.1	6.6%	0.0	0.0%	6.6%	8.6	13.9%	0.0	0.0%	13.9%	16.1	26.0%	0.0	0.0%	26.0%	24.8	40.1%	0.0	0.0%	40.1%
24	61.9	796.54	1.0	1.6%	163.6	20.5%	22.2%	1.2	1.9%	113.5	14.2%	16.2%	3.5	5.7%	0.0	0.0%	5.7%	7.2	11.6%	0.0	0.0%	11.6%	14.6	23.6%	0.0	0.0%	23.6%	23.5	38.0%	0.0	0.0%	38.0%

AVERAGE DAY HOURS	COOLING DESIGN LOAD TONS	HEATING DESIGN MBH	JULY CLG DESIGN TONS	JULY CLG %	JULY HTG DESIGN MBH	JULY HTG %	JULY TOTAL %	AUGUST CLG DESIGN TONS	AUGUST CLG %	AUGUST HTG DESIGN MBH	AUGUST HTG %	AUGUST TOTAL %	SEPTEMBER CLG DESIGN TONS	SEPTEMBER CLG %	SEPTEMBER HTG DESIGN MBH	SEPTEMBER HTG %	SEPTEMBER TOTAL %	OCTOBER CLG DESIGN TONS	OCTOBER CLG %	OCTOBER HTG DESIGN MBH	OCTOBER HTG %	OCTOBER TOTAL %	NOVEMBER CLG DESIGN TONS	NOVEMBER CLG %	NOVEMBER HTG DESIGN MBH	NOVEMBER HTG %	NOVEMBER TOTAL %	DECEMBER CLG DESIGN TONS	DECEMBER CLG %	DECEMBER HTG DESIGN MBH	DECEMBER HTG %	DECEMBER TOTAL %
1	61.9	796.9	30.2	48.8%	0.0	0.0%	48.8%	27.6	44.6%	0.0	0.0%	44.6%	16.7	27.0%	0.0	0.0%	27.0%	8.7	14.1%	0.0	0.0%	14.1%	2.5	4.0%	0.0	0.0%	4.0%	1.6	2.6%	34.4	4.3%	6.9%
2	61.9	796.9	28.6	46.2%	0.0	0.0%	46.2%	25.6	41.4%	0.0	0.0%	41.4%	14.7	23.7%	0.0	0.0%	23.7%	7.8	12.6%	0.0	0.0%	12.6%	2.3	3.7%	0.0	0.0%	3.7%	1.5	2.4%	44.5	5.6%	8.0%
3	61.9	796.6	27.8	44.9%	0.0	0.0%	44.9%	24.6	39.7%	0.0	0.0%	39.7%	13.6	22.0%	0.0	0.0%	22.0%	7.1	11.5%	0.0	0.0%	11.5%	2.1	3.4%	0.0	0.0%	3.4%	1.5	2.4%	50.6	6.4%	8.8%
4	61.9	796.3	27.3	44.1%	0.0	0.0%	44.1%	23.7	38.3%	0.0	0.0%	38.3%	12.7	20.5%	0.0	0.0%	20.5%	6.5	10.5%	0.0	0.0%	10.5%	1.9	3.1%	8.3	1.0%	4.1%	1.4	2.3%	62.3	7.8%	10.1%
5	61.9	796.0	26.9	43.5%	0.0	0.0%	43.5%	23.5	38.0%	0.0	0.0%	38.0%	12.3	19.9%	0.0	0.0%	19.9%	6.3	10.2%	0.0	0.0%	10.2%	1.9	3.1%	24.4	3.1%	6.1%	1.4	2.3%	64.5	8.1%	10.4%
6	61.9	796.3	27.2	43.9%	0.0	0.0%	43.9%	23.7	38.3%	0.0	0.0%	38.3%	12.4	20.0%	0.0	0.0%	20.0%	6.4	10.3%	0.0	0.0%	10.3%	1.9	3.1%	29.8	3.7%	6.8%	1.4	2.3%	65.5	8.2%	10.5%
7	61.9	796.6	30.1	48.6%	0.0	0.0%	48.6%	25.6	41.4%	0.0	0.0%	41.4%	13.1	21.2%	0.0	0.0%	21.2%	6.9	11.1%	0.0	0.0%	11.1%	2.1	3.4%	28.1	3.5%	6.9%	1.4	2.3%	61.9	7.8%	10.0%
8	61.9	796.9	34.4	55.6%	0.0	0.0%	55.6%	29.9	48.3%	0.0	0.0%	48.3%	16.4	26.5%	0.0	0.0%	26.5%	9.0	14.5%	0.0	0.0%	14.5%	2.4	3.9%	23.7	3.0%	6.9%	1.5	2.4%	54.2	6.8%	9.2%
9	61.9	796.12	39.0	63.0%	0.0	0.0%	63.0%	35.1	56.7%	0.0	0.0%	56.7%	22.0	35.5%	0.0	0.0%	35.5%	13.1	21.2%	0.0	0.0%	21.2%	2.9	4.7%	6.1	0.8%	5.5%	1.6	2.6%	27.6	3.5%	6.1%
10	61.9	796.15	42.0	67.9%	0.0	0.0%	67.9%	39.4	63.7%	0.0	0.0%	63.7%	28.6	46.2%	0.0	0.0%	46.2%	19.1	30.9%	0.0	0.0%	30.9%	4.5	7.3%	0.0	0.0%	7.3%	1.8	2.9%	7.7	1.0%	3.9%
11	61.9	796.18	45.3	73.2%	0.0	0.0%	73.2%	43.6	70.4%	0.0	0.0%	70.4%	33.5	54.1%	0.0	0.0%	54.1%	23.9	38.6%	0.0	0.0%	38.6%	8.4	13.6%	0.0	0.0%	13.6%	3.6	5.8%	4.9	0.6%	6.4%
12	61.9	796.21	48.2	77.9%	0.0	0.0%	77.9%	47.4	76.6%	0.0	0.0%	76.6%	37.6	60.7%	0.0	0.0%	60.7%	27.2	43.9%	0.0	0.0%	43.9%	13.4	21.6%	0.0	0.0%	21.6%	9.2	14.9%	0.0	0.0%	14.9%
13	61.9	796.24	50.4	81.4%	0.0	0.0%	81.4%	50.0	80.8%	0.0	0.0%	80.8%	40.8	65.9%	0.0	0.0%	65.9%	30.0	48.5%	0.0	0.0%	48.5%	17.0	27.5%	0.0	0.0%	27.5%	12.6	20.4%	0.0	0.0%	20.4%
14	61.9	796.27	52.8	85.3%	0.0	0.0%	85.3%	52.1	84.2%	0.0	0.0%	84.2%	43.3	70.0%	0.0	0.0%	70.0%	32.4	52.3%	0.0	0.0%	52.3%	19.2	31.0%	0.0	0.0%	31.0%	15.3	24.7%	0.0	0.0%	24.7%
15	61.9	796.30	54.8	88.5%	0.0	0.0%	88.5%	54.1	87.4%	0.0	0.0%	87.4%	45.7	73.8%	0.0	0.0%	73.8%	34.7	56.1%	0.0	0.0%	56.1%	20.6	33.3%	0.0	0.0%	33.3%	16.8	27.1%	0.0	0.0%	27.1%
16	61.9	796.33	55.5	89.7%	0.0	0.0%	89.7%	54.9	88.7%	0.0	0.0%	88.7%	46.1	74.5%	0.0	0.0%	74.5%	34.9	56.4%	0.0	0.0%	56.4%	20.4	33.0%	0.0	0.0%	33.0%	17.5	28.3%	0.0	0.0%	28.3%
17	61.9	796.36	54.5	88.0%	0.0	0.0%	88.0%	53.3	86.1%	0.0	0.0%	86.1%	44.0	71.1%	0.0	0.0%	71.1%	32.5	52.5%	0.0	0.0%	52.5%	17.5	28.3%	0.0	0.0%	28.3%	14.5	23.4%	0.0	0.0%	23.4%
18	61.9	796.39	52.6	85.0%	0.0	0.0%	85.0%	50.3	81.3%	0.0	0.0%	81.3%	38.6	62.4%	0.0	0.0%	62.4%	26.8	43.3%	0.0	0.0%	43.3%	12.9	20.8%	0.0	0.0%	20.8%	9.7	15.7%	0.0	0.0%	15.7%
19	61.9	796.42	48.8	78.8%	0.0	0.0%	78.8%	44.6	72.1%	0.0	0.0%	72.1%	31.9	51.5%	0.0	0.0%	51.5%	21.3	34.4%	0.0	0.0%	34.4%	8.6	13.9%	0.0	0.0%	13.9%	5.5	8.9%	0.0	0.0%	8.9%
20	61.9	796.45	42.9	69.3%	0.0	0.0%	69.3%	38.6	62.4%	0.0	0.0%	62.4%	27.2	43.9%	0.0	0.0%	43.9%	17.3	27.9%	0.0	0.0%	27.9%	5.8	9.4%	0.0	0.0%	9.4%	3.7	6.0%	0.0	0.0%	6.0%
21	61.9	796.48	37.9	61.2%	0.0	0.0%	61.2%	34.6	55.9%	0.0	0.0%	55.9%	23.5	38.0%	0.0	0.0%	38.0%	14.7	23.7%	0.0	0.0%	23.7%	4.6	7.4%	0.0	0.0%	7.4%	2.8	4.5%	0.0	0.0%	4.5%
22	61.9	796.51	34.8	56.2%	0.0	0.0%	56.2%	31.6	51.1%	0.0	0.0%	51.1%	20.8	33.6%	0.0	0.0%	33.6%	12.5	20.2%	0.0	0.0%	20.2%	3.8	6.1%	0.0	0.0%	6.1%	2.2	3.6%	0.0	0.0%	3.6%
23	61.9	796.54	32.7	52.8%	0.0	0.0%	52.8%	29.4	47.5%	0.0	0.0%	47.5%	18.6	30.0%	0.0	0.0%	30.0%	10.9	17.6%	0.0	0.0%	17.6%	3.2	5.2%	0.0	0.0%	5.2%	1.8	2.9%	0.0	0.0%	2.9%
24	61.9	796.54	31.2	50.4%	0.0	0.0%	50.4%	27.6	44.6%	0.0	0.0%	44.6%	16.7	27.0%	0.0	0.0%	27.0%	9.7	15.7%	0.0	0.0%	15.7%	2.8	4.5%	0.0	0.0%	4.5%	1.7	2.7%	8.2	1.0%	3.8%

GENERAL NOTES:

1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table G.75 Monthly Simultaneous Heating and Cooling Part-Load % Per Hour: Model 4

MODEL 4 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION		
	4.97	BHP
	3.71	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	22.4%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.4%	0.03	35.9%	0.17
2	23.4%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	33.9%	0.14
3	24.8%	0.06	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	32.5%	0.13
4	25.5%	0.06	21.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.5%	0.12
5	26.0%	0.07	21.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	30.9%	0.11
6	26.1%	0.07	21.3%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.8%	0.12
7	25.7%	0.06	21.5%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	36.8%	0.19
8	25.0%	0.06	20.4%	0.03	20.0%	0.03	20.0%	0.03	26.5%	0.07	43.3%	0.30
9	21.0%	0.03	20.0%	0.03	20.0%	0.03	18.5%	0.02	33.9%	0.14	50.4%	0.47
10	20.0%	0.03	20.0%	0.03	20.0%	0.03	23.4%	0.05	39.1%	0.22	55.9%	0.65
11	20.0%	0.03	20.0%	0.03	20.0%	0.03	30.0%	0.10	43.8%	0.31	61.9%	0.88
12	20.0%	0.03	20.0%	0.03	20.0%	0.03	34.6%	0.15	48.8%	0.43	66.6%	1.09
13	20.0%	0.03	20.0%	0.03	20.0%	0.03	37.8%	0.20	52.5%	0.54	70.6%	1.30
14	20.0%	0.03	20.0%	0.03	20.0%	0.03	41.5%	0.27	56.1%	0.65	74.5%	1.53
15	20.0%	0.03	20.0%	0.03	22.4%	0.04	45.6%	0.35	59.9%	0.80	77.7%	1.74
16	20.0%	0.03	20.0%	0.03	26.4%	0.07	47.7%	0.40	62.4%	0.90	80.0%	1.90
17	20.0%	0.03	20.0%	0.03	30.5%	0.11	47.3%	0.39	61.9%	0.88	78.5%	1.79
18	20.0%	0.03	20.0%	0.03	32.9%	0.13	43.8%	0.31	58.0%	0.72	74.6%	1.54
19	20.0%	0.03	20.0%	0.03	28.2%	0.08	36.2%	0.18	50.9%	0.49	67.4%	1.13
20	20.0%	0.03	20.0%	0.03	21.6%	0.04	28.1%	0.08	41.8%	0.27	57.7%	0.71
21	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.5%	0.04	34.9%	0.16	49.4%	0.45
22	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.6%	0.10	43.8%	0.31
23	21.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.0%	0.07	40.1%	0.24
24	22.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	23.6%	0.05	38.0%	0.20
AVG, DAILY CONSUMPTION PER MONTH (KW)		0.95		0.74		1.00		2.87		7.00		17.21

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	0.43	44.6%	0.33	27.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
2	46.2%	0.37	41.4%	0.26	23.7%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03
3	44.9%	0.34	39.7%	0.23	22.0%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
4	44.1%	0.32	38.3%	0.21	20.5%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
5	43.5%	0.30	38.0%	0.20	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
6	43.9%	0.31	38.3%	0.21	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
7	48.6%	0.43	41.4%	0.26	21.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
8	55.6%	0.64	48.3%	0.42	26.5%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
9	63.0%	0.93	56.7%	0.68	35.5%	0.17	21.2%	0.04	20.0%	0.03	20.0%	0.03
10	67.9%	1.16	63.7%	0.96	46.2%	0.37	30.9%	0.11	20.0%	0.03	20.0%	0.03
11	73.2%	1.45	70.4%	1.30	54.1%	0.59	38.6%	0.21	20.0%	0.03	20.0%	0.03
12	77.9%	1.75	76.6%	1.66	60.7%	0.83	43.9%	0.31	21.6%	0.04	20.0%	0.03
13	81.4%	2.00	80.8%	1.95	65.9%	1.06	48.5%	0.42	27.5%	0.08	20.4%	0.03
14	85.3%	2.30	84.2%	2.21	70.0%	1.27	52.3%	0.53	31.0%	0.11	24.7%	0.06
15	88.5%	2.57	87.4%	2.47	73.8%	1.49	56.1%	0.65	33.3%	0.14	27.1%	0.07
16	89.7%	2.67	88.7%	2.59	74.5%	1.53	56.4%	0.66	33.0%	0.13	28.3%	0.08
17	88.0%	2.53	86.1%	2.37	71.1%	1.33	52.5%	0.54	28.3%	0.08	23.4%	0.05
18	85.0%	2.27	81.3%	1.99	62.4%	0.90	43.3%	0.30	20.8%	0.03	20.0%	0.03
19	78.8%	1.82	72.1%	1.39	51.5%	0.51	34.4%	0.15	20.0%	0.03	20.0%	0.03
20	69.3%	1.23	62.4%	0.90	43.9%	0.31	27.9%	0.08	20.0%	0.03	20.0%	0.03
21	61.2%	0.85	55.9%	0.65	38.0%	0.20	23.7%	0.05	20.0%	0.03	20.0%	0.03
22	56.2%	0.66	51.1%	0.49	33.6%	0.14	20.2%	0.03	20.0%	0.03	20.0%	0.03
23	52.8%	0.55	47.5%	0.40	30.0%	0.10	20.0%	0.03	20.0%	0.03	20.0%	0.03
24	50.4%	0.47	44.6%	0.33	27.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
AVG, DAILY CONSUMPTION PER MONTH (KW)		28.34		24.44		11.23		4.39		1.12		0.86

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.76 Daily Pump Consumption (Primary): Model 4

Table G.77 Primary System Annual Utility Cost: Model 4

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	0.95	31	30	$ 0.09	$ 2.66
FEBRUARY	0.74	28	21	$ 0.09	$ 1.86
MARCH	1.00	31	31	$ 0.09	$ 2.79
APRIL	2.87	30	86	$ 0.09	$ 7.74
MAY	7.00	31	217	$ 0.09	$ 19.53
JUNE	17.21	30	516	$ 0.09	$ 46.48
JULY	28.34	31	879	$ 0.09	$ 79.08
AUGUST	24.44	31	758	$ 0.09	$ 68.19
SEPTEMBER	11.23	30	337	$ 0.09	$ 30.31
OCTOBER	4.39	31	136	$ 0.09	$ 12.24
NOVEMBER	1.12	30	33	$ 0.09	$ 3.01
DECEMBER	0.86	31	27	$ 0.09	$ 2.39
ANNUAL UTILITY CONSUMPTION & COST			3070	KWH	$ 276.28

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 4 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY + SECONDARY PUMP CONSUMPTION		
	5.25	BHP
	3.91	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	22.4%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.4%	0.03	35.9%	0.18
2	23.4%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	33.9%	0.15
3	24.8%	0.06	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	32.5%	0.13
4	25.5%	0.07	21.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.5%	0.12
5	26.0%	0.07	21.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	30.9%	0.12
6	26.1%	0.07	21.3%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	31.8%	0.13
7	25.7%	0.07	21.5%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	36.8%	0.20
8	25.0%	0.06	20.4%	0.03	20.0%	0.03	20.0%	0.03	26.5%	0.07	43.3%	0.32
9	21.0%	0.04	20.0%	0.03	20.0%	0.03	18.5%	0.02	33.9%	0.15	50.4%	0.50
10	20.0%	0.03	20.0%	0.03	20.0%	0.03	23.4%	0.05	39.1%	0.23	55.9%	0.68
11	20.0%	0.03	20.0%	0.03	20.0%	0.03	30.0%	0.11	43.8%	0.33	61.9%	0.93
12	20.0%	0.03	20.0%	0.03	20.0%	0.03	34.6%	0.16	48.8%	0.45	66.6%	1.15
13	20.0%	0.03	20.0%	0.03	20.0%	0.03	37.8%	0.21	52.5%	0.57	70.6%	1.38
14	20.0%	0.03	20.0%	0.03	20.0%	0.03	41.5%	0.28	56.1%	0.69	74.5%	1.62
15	20.0%	0.03	20.0%	0.03	22.4%	0.04	45.6%	0.37	59.9%	0.84	77.7%	1.84
16	20.0%	0.03	20.0%	0.03	26.4%	0.07	47.7%	0.42	62.4%	0.95	80.0%	2.00
17	20.0%	0.03	20.0%	0.03	30.5%	0.11	47.3%	0.42	61.9%	0.93	78.5%	1.89
18	20.0%	0.03	20.0%	0.03	32.9%	0.14	43.8%	0.33	58.0%	0.76	74.6%	1.63
19	20.0%	0.03	20.0%	0.03	28.2%	0.09	36.2%	0.19	50.9%	0.52	67.4%	1.20
20	20.0%	0.03	20.0%	0.03	21.6%	0.04	28.1%	0.09	41.8%	0.29	57.7%	0.75
21	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.5%	0.04	34.9%	0.17	49.4%	0.47
22	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03	29.6%	0.10	43.8%	0.33
23	21.0%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	26.0%	0.07	40.1%	0.25
24	22.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03	23.6%	0.05	38.0%	0.21
AVG, DAILY CONSUMPTION PER MONTH (KW)		1.01		0.78		1.06		3.03		7.39		18.18

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	0.45	44.6%	0.35	27.0%	0.08	20.0%	0.03	20.0%	0.03	20.0%	0.03
2	46.2%	0.39	41.4%	0.28	23.7%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03
3	44.9%	0.35	39.7%	0.25	22.0%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
4	44.1%	0.34	38.3%	0.22	20.5%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
5	43.5%	0.32	38.0%	0.21	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
6	43.9%	0.33	38.3%	0.22	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
7	48.6%	0.45	41.4%	0.28	21.2%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
8	55.6%	0.67	48.3%	0.44	26.5%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
9	63.0%	0.98	56.7%	0.71	35.5%	0.18	21.2%	0.04	20.0%	0.03	20.0%	0.03
10	67.9%	1.22	63.7%	1.01	46.2%	0.39	30.9%	0.12	20.0%	0.03	20.0%	0.03
11	73.2%	1.53	70.4%	1.37	54.1%	0.62	38.6%	0.23	20.0%	0.03	20.0%	0.03
12	77.9%	1.85	76.6%	1.76	60.7%	0.88	43.9%	0.33	21.6%	0.04	20.0%	0.03
13	81.4%	2.11	80.8%	2.06	65.9%	1.12	48.5%	0.45	27.5%	0.08	20.4%	0.03
14	85.3%	2.43	84.2%	2.33	70.0%	1.34	52.3%	0.56	31.0%	0.12	24.7%	0.06
15	88.5%	2.72	87.4%	2.61	73.8%	1.58	56.1%	0.69	33.3%	0.14	27.1%	0.08
16	89.7%	2.82	88.7%	2.73	74.5%	1.62	56.4%	0.70	33.0%	0.14	28.3%	0.09
17	88.0%	2.67	86.1%	2.50	71.1%	1.41	52.5%	0.57	28.3%	0.09	23.4%	0.05
18	85.0%	2.40	81.3%	2.10	62.4%	0.95	43.3%	0.32	20.8%	0.04	20.0%	0.03
19	78.8%	1.92	72.1%	1.46	51.5%	0.54	34.4%	0.16	20.0%	0.03	20.0%	0.03
20	69.3%	1.30	62.4%	0.95	43.9%	0.33	27.9%	0.09	20.0%	0.03	20.0%	0.03
21	61.2%	0.90	55.9%	0.68	38.0%	0.21	23.7%	0.05	20.0%	0.03	20.0%	0.03
22	56.2%	0.70	51.1%	0.52	33.6%	0.15	20.2%	0.03	20.0%	0.03	20.0%	0.03
23	52.8%	0.58	47.5%	0.42	30.0%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03
24	50.4%	0.50	44.6%	0.35	27.0%	0.08	20.0%	0.03	20.0%	0.03	20.0%	0.03
AVG, DAILY CONSUMPTION PER MONTH (KW)		29.94		25.82		11.86		4.64		1.18		0.90

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.78 Daily Pump Consumption (Primary/Secondary): Model 4

Table G.79 Primary/Secondary System Annual Utility Cost: Model 4

PRIMARY/SECONDARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.01	31	31	$ 0.09	$ 2.81
FEBRUARY	0.78	28	22	$ 0.09	$ 1.96
MARCH	1.06	31	33	$ 0.09	$ 2.95
APRIL	3.03	30	91	$ 0.09	$ 8.18
MAY	7.39	31	229	$ 0.09	$ 20.63
JUNE	18.18	30	545	$ 0.09	$ 49.09
JULY	29.94	31	928	$ 0.09	$ 83.54
AUGUST	25.82	31	800	$ 0.09	$ 72.03
SEPTEMBER	11.86	30	356	$ 0.09	$ 32.02
OCTOBER	4.64	31	144	$ 0.09	$ 12.93
NOVEMBER	1.18	30	35	$ 0.09	$ 3.18
DECEMBER	0.90	31	28	$ 0.09	$ 2.52
ANNUAL UTILITY CONSUMPTION & COST			3243	KWH	$ 291.85

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 4 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS AND PRIMARY PUMP CONSUMPTION		
	6.70	**BHP**
	5.00	**KW**

AVERAGE DAY	JANUARY PART-LOAD % EACH HOUR	JANUARY PART-LOAD CONSUMPTION PER HOUR	FEBRUARY PART-LOAD % EACH HOUR	FEBRUARY PART-LOAD CONSUMPTION PER HOUR	MARCH PART-LOAD % EACH HOUR	MARCH PART-LOAD CONSUMPTION PER HOUR	APRIL PART-LOAD % EACH HOUR	APRIL PART-LOAD CONSUMPTION PER HOUR	MAY PART-LOAD % EACH HOUR	MAY PART-LOAD CONSUMPTION PER HOUR	JUNE PART-LOAD % EACH HOUR	JUNE PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	22.4%	0.06	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.4%	0.04	35.9%	0.23
2	23.4%	0.06	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04	33.9%	0.20
3	24.8%	0.08	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04	32.5%	0.17
4	25.5%	0.08	21.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	31.5%	0.16
5	26.0%	0.09	21.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	30.9%	0.15
6	26.1%	0.09	21.3%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	31.8%	0.16
7	25.7%	0.08	21.5%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	36.8%	0.25
8	25.0%	0.08	20.4%	0.04	20.0%	0.04	20.0%	0.04	26.5%	0.09	43.3%	0.41
9	21.0%	0.05	20.0%	0.04	20.0%	0.04	18.5%	0.03	33.9%	0.20	50.4%	0.64
10	20.0%	0.04	20.0%	0.04	20.0%	0.04	23.4%	0.06	39.1%	0.30	55.9%	0.87
11	20.0%	0.04	20.0%	0.04	20.0%	0.04	30.0%	0.14	43.8%	0.42	61.9%	1.18
12	20.0%	0.04	20.0%	0.04	20.0%	0.04	34.6%	0.21	48.8%	0.58	66.6%	1.47
13	20.0%	0.04	20.0%	0.04	20.0%	0.04	37.8%	0.27	52.5%	0.72	70.6%	1.76
14	20.0%	0.04	20.0%	0.04	20.0%	0.04	41.5%	0.36	56.1%	0.88	74.5%	2.06
15	20.0%	0.04	20.0%	0.04	22.4%	0.06	45.6%	0.47	59.9%	1.08	77.7%	2.34
16	20.0%	0.04	20.0%	0.04	26.4%	0.09	47.7%	0.54	62.4%	1.21	80.0%	2.55
17	20.0%	0.04	20.0%	0.04	30.5%	0.14	47.3%	0.53	61.9%	1.18	78.5%	2.42
18	20.0%	0.04	20.0%	0.04	32.9%	0.18	43.8%	0.42	58.0%	0.97	74.6%	2.08
19	20.0%	0.04	20.0%	0.04	28.2%	0.11	36.2%	0.24	50.9%	0.66	67.4%	1.53
20	20.0%	0.04	20.0%	0.04	21.6%	0.05	28.1%	0.11	41.8%	0.37	57.7%	0.96
21	20.0%	0.04	20.0%	0.04	20.0%	0.04	21.5%	0.05	34.9%	0.21	49.4%	0.60
22	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04	29.6%	0.13	43.8%	0.42
23	21.0%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	26.0%	0.09	40.1%	0.32
24	22.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	23.6%	0.07	38.0%	0.27
AVG, DAILY CONSUMPTION PER MONTH (KW)		1.28		0.99		1.35		3.86		9.44		23.20

AVERAGE DAY	JULY PART-LOAD % EACH HOUR	JULY PART-LOAD CONSUMPTION PER HOUR	AUGUST PART-LOAD % EACH HOUR	AUGUST PART-LOAD CONSUMPTION PER HOUR	SEPTEMBER PART-LOAD % EACH HOUR	SEPTEMBER PART-LOAD CONSUMPTION PER HOUR	OCTOBER PART-LOAD % EACH HOUR	OCTOBER PART-LOAD CONSUMPTION PER HOUR	NOVEMBER PART-LOAD % EACH HOUR	NOVEMBER PART-LOAD CONSUMPTION PER HOUR	DECEMBER PART-LOAD % EACH HOUR	DECEMBER PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	0.58	44.6%	0.44	27.0%	0.10	20.0%	0.04	20.0%	0.04	20.0%	0.04
2	46.2%	0.49	41.4%	0.35	23.7%	0.07	20.0%	0.04	20.0%	0.04	20.0%	0.04
3	44.9%	0.45	39.7%	0.31	22.0%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
4	44.1%	0.43	38.3%	0.28	20.5%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
5	43.5%	0.41	38.0%	0.27	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
6	43.9%	0.42	38.3%	0.28	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
7	48.6%	0.57	41.4%	0.35	21.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
8	55.6%	0.86	48.3%	0.56	26.5%	0.09	20.0%	0.04	20.0%	0.04	20.0%	0.04
9	63.0%	1.25	56.7%	0.91	35.5%	0.22	21.2%	0.05	20.0%	0.04	20.0%	0.04
10	67.9%	1.56	63.7%	1.29	46.2%	0.49	30.9%	0.15	20.0%	0.04	20.0%	0.04
11	73.2%	1.96	70.4%	1.75	54.1%	0.79	38.6%	0.29	20.0%	0.04	20.0%	0.04
12	77.9%	2.36	76.6%	2.24	60.7%	1.12	43.9%	0.42	21.6%	0.05	20.0%	0.04
13	81.4%	2.70	80.8%	2.63	65.9%	1.43	48.5%	0.57	27.5%	0.10	20.4%	0.04
14	85.3%	3.10	84.2%	2.98	70.0%	1.71	52.3%	0.72	31.0%	0.15	24.7%	0.08
15	88.5%	3.47	87.4%	3.34	73.8%	2.01	56.1%	0.88	33.3%	0.18	27.1%	0.10
16	89.7%	3.60	88.7%	3.49	74.5%	2.06	56.4%	0.90	33.0%	0.18	28.3%	0.11
17	88.0%	3.41	86.1%	3.19	71.1%	1.79	52.5%	0.72	28.3%	0.11	23.4%	0.06
18	85.0%	3.07	81.3%	2.68	62.4%	1.21	43.3%	0.41	20.8%	0.05	20.0%	0.04
19	78.8%	2.45	72.1%	1.87	51.5%	0.68	34.4%	0.20	20.0%	0.04	20.0%	0.04
20	69.3%	1.66	62.4%	1.21	43.9%	0.42	27.9%	0.11	20.0%	0.04	20.0%	0.04
21	61.2%	1.15	55.9%	0.87	38.0%	0.27	23.7%	0.07	20.0%	0.04	20.0%	0.04
22	56.2%	0.89	51.1%	0.66	33.6%	0.19	20.2%	0.04	20.0%	0.04	20.0%	0.04
23	52.8%	0.74	47.5%	0.54	30.0%	0.14	20.0%	0.04	20.0%	0.04	20.0%	0.04
24	50.4%	0.64	44.6%	0.44	27.0%	0.10	20.0%	0.04	20.0%	0.04	20.0%	0.04
AVG, DAILY CONSUMPTION (KW)		38.21		32.95		15.14		5.92		1.50		1.15

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.80 Daily Pump Consumption (Distributive w/ Primary): Model 4

Table G.81 Distributive w/ Primary System Annual Utility Cost: Model 4

DISTRIBUTIVE W/ PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.28	31	40	$ 0.09	$ 3.58
FEBRUARY	0.99	28	28	$ 0.09	$ 2.50
MARCH	1.35	31	42	$ 0.09	$ 3.76
APRIL	3.86	30	116	$ 0.09	$ 10.43
MAY	9.44	31	293	$ 0.09	$ 26.33
JUNE	23.20	30	696	$ 0.09	$ 62.65
JULY	38.21	31	1185	$ 0.09	$ 106.61
AUGUST	32.95	31	1021	$ 0.09	$ 91.93
SEPTEMBER	15.14	30	454	$ 0.09	$ 40.87
OCTOBER	5.92	31	183	$ 0.09	$ 16.50
NOVEMBER	1.50	30	45	$ 0.09	$ 4.06
DECEMBER	1.15	31	36	$ 0.09	$ 3.22
ANNUAL UTILITY CONSUMPTION & COST			4138	KWH	$ 372.45

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 4 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS CONSUMPTION		
	6.72	BHP
	5.01	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	22.4%	0.06	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.4%	0.04	35.9%	0.23
2	23.4%	0.06	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04	33.9%	0.20
3	24.8%	0.08	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04	32.5%	0.17
4	25.5%	0.08	21.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	31.5%	0.16
5	26.0%	0.09	21.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	30.9%	0.15
6	26.1%	0.09	21.3%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	31.8%	0.16
7	25.7%	0.09	21.5%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	36.8%	0.25
8	25.0%	0.08	20.4%	0.04	20.0%	0.04	20.0%	0.04	26.5%	0.09	43.3%	0.41
9	21.0%	0.05	20.0%	0.04	20.0%	0.04	18.5%	0.03	33.9%	0.20	50.4%	0.64
10	20.0%	0.04	20.0%	0.04	20.0%	0.04	23.4%	0.06	39.1%	0.30	55.9%	0.88
11	20.0%	0.04	20.0%	0.04	20.0%	0.04	30.0%	0.14	43.8%	0.42	61.9%	1.19
12	20.0%	0.04	20.0%	0.04	20.0%	0.04	34.6%	0.21	48.8%	0.58	66.6%	1.48
13	20.0%	0.04	20.0%	0.04	20.0%	0.04	37.8%	0.27	52.5%	0.73	70.6%	1.76
14	20.0%	0.04	20.0%	0.04	20.0%	0.04	41.5%	0.36	56.1%	0.88	74.5%	2.07
15	20.0%	0.04	20.0%	0.04	22.4%	0.06	45.6%	0.47	59.9%	1.08	77.7%	2.35
16	20.0%	0.04	20.0%	0.04	26.4%	0.09	47.7%	0.54	62.4%	1.22	80.0%	2.56
17	20.0%	0.04	20.0%	0.04	30.5%	0.14	47.3%	0.53	61.9%	1.19	78.5%	2.43
18	20.0%	0.04	20.0%	0.04	32.9%	0.18	43.8%	0.42	58.0%	0.98	74.6%	2.08
19	20.0%	0.04	20.0%	0.04	28.2%	0.11	36.2%	0.24	50.9%	0.66	67.4%	1.53
20	20.0%	0.04	20.0%	0.04	21.6%	0.05	28.1%	0.11	41.8%	0.37	57.7%	0.96
21	20.0%	0.04	20.0%	0.04	20.0%	0.04	21.5%	0.05	34.9%	0.21	49.4%	0.61
22	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04	29.6%	0.13	43.8%	0.42
23	21.0%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	26.0%	0.09	40.1%	0.32
24	22.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04	23.6%	0.07	38.0%	0.27
AVG, DAILY CONSUMPTION PER MONTH (KW)		1.29		1.00		1.35		3.88		9.46		23.27

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	48.8%	0.58	44.6%	0.44	27.0%	0.10	20.0%	0.04	20.0%	0.04	20.0%	0.04
2	46.2%	0.49	41.4%	0.35	23.7%	0.07	20.0%	0.04	20.0%	0.04	20.0%	0.04
3	44.9%	0.45	39.7%	0.31	22.0%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
4	44.1%	0.43	38.3%	0.28	20.5%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
5	43.5%	0.41	38.0%	0.27	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
6	43.9%	0.43	38.3%	0.28	20.0%	0.04	20.0%	0.04	20.0%	0.04	20.0%	0.04
7	48.6%	0.58	41.4%	0.35	21.2%	0.05	20.0%	0.04	20.0%	0.04	20.0%	0.04
8	55.6%	0.86	48.3%	0.56	26.5%	0.09	20.0%	0.04	20.0%	0.04	20.0%	0.04
9	63.0%	1.25	56.7%	0.91	35.5%	0.22	21.2%	0.05	20.0%	0.04	20.0%	0.04
10	67.9%	1.57	63.7%	1.29	46.2%	0.49	30.9%	0.15	20.0%	0.04	20.0%	0.04
11	73.2%	1.96	70.4%	1.75	54.1%	0.79	38.6%	0.29	20.0%	0.04	20.0%	0.04
12	77.9%	2.37	76.6%	2.25	60.7%	1.12	43.9%	0.43	21.6%	0.05	20.0%	0.04
13	81.4%	2.70	80.8%	2.64	65.9%	1.43	48.5%	0.57	27.5%	0.10	20.4%	0.04
14	85.3%	3.11	84.2%	2.99	70.0%	1.72	52.3%	0.72	31.0%	0.15	24.7%	0.08
15	88.5%	3.48	87.4%	3.35	73.8%	2.02	56.1%	0.88	33.3%	0.18	27.1%	0.10
16	89.7%	3.61	88.7%	3.50	74.5%	2.07	56.4%	0.90	33.0%	0.18	28.3%	0.11
17	88.0%	3.42	86.1%	3.20	71.1%	1.80	52.5%	0.73	28.3%	0.11	23.4%	0.06
18	85.0%	3.07	81.3%	2.69	62.4%	1.22	43.3%	0.41	20.8%	0.05	20.0%	0.04
19	78.8%	2.46	72.1%	1.87	51.5%	0.69	34.4%	0.20	20.0%	0.04	20.0%	0.04
20	69.3%	1.67	62.4%	1.22	43.9%	0.43	27.9%	0.11	20.0%	0.04	20.0%	0.04
21	61.2%	1.15	55.9%	0.88	38.0%	0.27	23.7%	0.07	20.0%	0.04	20.0%	0.04
22	56.2%	0.89	51.1%	0.67	33.6%	0.19	20.2%	0.04	20.0%	0.04	20.0%	0.04
23	52.8%	0.74	47.5%	0.54	30.0%	0.14	20.0%	0.04	20.0%	0.04	20.0%	0.04
24	50.4%	0.64	44.6%	0.44	27.0%	0.10	20.0%	0.04	20.0%	0.04	20.0%	0.04
AVG, DAILY CONSUMPTION (KW)		38.32		33.05		15.18		5.93		1.51		1.16

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.82 Daily Pump Consumption (Distributive): Model 4

Table G.83 Distributive System Annual Utility Cost: Model 4

DISTRIBUTIVE SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.29	31	40	$ 0.09	$ 3.59
FEBRUARY	1.00	28	28	$ 0.09	$ 2.51
MARCH	1.35	31	42	$ 0.09	$ 3.78
APRIL	3.88	30	116	$ 0.09	$ 10.47
MAY	9.46	31	293	$ 0.09	$ 26.40
JUNE	23.27	30	698	$ 0.09	$ 62.84
JULY	38.32	31	1188	$ 0.09	$ 106.93
AUGUST	33.05	31	1024	$ 0.09	$ 92.20
SEPTEMBER	15.18	30	455	$ 0.09	$ 40.99
OCTOBER	5.93	31	184	$ 0.09	$ 16.55
NOVEMBER	1.51	30	45	$ 0.09	$ 4.07
DECEMBER	1.16	31	36	$ 0.09	$ 3.23
ANNUAL UTILITY CONSUMPTION & COST			4151	KWH	$ 373.56

GENERAL NOTES:
1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 4 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 22,389.00	$ 2,274.60	$ 141,655.17	$ 29,105.70	$ 4,435.47	$ 80,383.37	$ 276.28	$ 21,842.20	$ 600.00	$ 676.00	$ 1,880.00	$ 31,509.38	$ 144.00	$ 11,384.38	$ 286,774.49
PRIMARY/SECONDARY	$ 32,028.00	$ 3,519.00	$ 204,163.88	$ 41,636.40	$ 6,862.05	$ 116,229.36	$ 291.85	$ 23,073.13	$ 1,200.00	$ 1,352.00	$ 2,580.00	$ 55,941.14	$ 216.00	$ 17,076.57	$ 416,484.08
DISTRIBUTIVE W/ PRIMARY	$ 24,942.06	$ 2,289.65	$ 156,405.06	$ 32,424.68	$ 4,464.81	$ 88,407.80	$ 372.45	$ 29,445.22	$ 600.00	$ 676.00	$ 1,780.00	$ 30,909.58	$ 619.20	$ 48,952.83	$ 354,120.49
DISTRIBUTIVE	$ 28,886.40	$ 1,767.86	$ 176,062.49	$ 37,552.32	$ 3,447.33	$ 98,258.06	$ 373.56	$ 29,532.98	$ -	$ -	$ -	$ -	$ 475.20	$ 37,568.45	$ 341,421.98

GENERAL NOTES:

1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. 100% REDUNDANCY WAS ASSUMED FOR ALL PRIMARY AND SECONDARY PUMPING CONFIGURATIONS
13. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table G.84 30-Year Life-Cycle Cost Analysis: Model 4

System Checksums
By ACADEMIC

System 005 — Water Source Heat Pump

COOLING COIL PEAK / CLG SPACE PEAK

Cooling coil peak — Peaked at Time: Mo/Hr: 7 / 16; Outside Air: OADB/WB/HR: 96 / 74 / 98

Clg space peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	72,806	72,806	3	0	0
Glass Solar	466,338	0	466,338	18	505,609	28
Glass/Door Cond	114,961	0	114,961	5	90,304	5
Wall Cond	27,721	41,414	69,135	3	27,606	2
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	608,919	114,221	723,140	28	632,519	35
Internal Loads						
Lights	251,391	0	251,391	10	251,391	14
People	459,000	0	459,000	18	229,500	13
Misc	680,389	0	680,389	27	680,389	37
Sub Total ==>	1,390,780	0	1,390,780	55	1,161,280	64
Ceiling Load	20,471	-20,471	0	0	21,727	1
Ventilation Load	0	0	420,844	17	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-9,104	-9,104	0		
Sup. Fan Heat			24,952	1		
Ret. Fan Heat		1	1	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	2,020,171	84,556	2,550,522	100.00	1,815,526	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-111,572	4.52
Glass Solar	0	0	0.00
Glass/Door Cond	-188,602	-188,602	10.80
Wall Cond	-38,814	-92,903	3.77
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-527,315	-692,977	28.09
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-33,882	0	0.00
Ventilation Load	0	-716,839	29.05
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-1,072,775	-1,072,775	43.48
Exhaust Heat		15,304	-0.62
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-1,633,972	-2,467,287	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	75.9	70.6
Return	75.9	70.6
Ret/OA	78.2	62.8
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	84,210	84,210
Terminal	84,210	84,210
Main Fan	84,210	84,210
Sec Fan	0	0
Nom Vent	9,779	9,779
AHU Vent	9,779	9,779
Infil	0	0
MinStop/Rh	0	0
Return	84,210	84,210
Exhaust	9,779	9,779
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	11.6	11.6
cfm/ft²	1.14	1.14
cfm/ton	396.20	
ft²/ton	346.55	
Btu/hr·ft²	34.63	-33.50
No. People	918	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	212.5	2,550.5	2,105.1	84,210	78.3	63.2	65.4	55.0	52.7	57.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	212.5	2,550.5								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	73,657		
Part	0		
Int Door	0		
ExFlr	0		
Roof	36,353	0	0
Wall	33,162	16,164	49
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-2,467.3	84,210	62.8	90.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-2,467.3			

Figure G.61 System Checksums: Model 5

SYSTEM SUMMARY

DESIGN COOLING CAPACITIES

By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

Plant	System	Peak Plant Loads: Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Peak Total ton	Block Plant Loads: Time Of Peak mo/hr	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Block Total ton
GSHP		212.5	0.0	0.0	0.0	0.0	0.0	0.0	212.5	7/16	203.9	0.0	0.0	0.0	0.0	0.0	0.0	203.9
	System 005	212.5	0.0	0.0	0.0	0.0	0.0	0.0	212.5	7/16	203.9	0.0	0.0	0.0	0.0	0.0	0.0	203.9
Building totals		212.5	0.0	0.0	0.0	0.0	0.0	0.0	212.5		203.9	0.0	0.0	0.0	0.0	0.0	0.0	203.9

Building peak load is 212.5 tons.

Building maximum block load of 203.9 tons occurs in July at hour 16 based on system simulation.

Figure G.62 Design Cooling Capacities: Model 5

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure G.63 Load/Airflow Summary (1 of 4): Model 5

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		224 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
	Zone - 009		Zn Peak	600	2.0	4,451	5,573	127			0	5,362	127	26.7	26.7
	Zone - 009		Zn Block	600	2.0	4,464	5,571	127			0	-6,669	127	26.7	26.7
		220 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		221 - Workroom	Rm Peak	100	0.0	881	1,057	38	2.27	0	0	1,311	38	15.9	15.9
		222 - Office	Rm Peak	225	1.1	7,699	8,435	274	7.29	0	0	-7,808	274	7.0	7.0
	Zone - 010		Zn Peak	425	1.1	10,224	11,473	349			0	-10,845	349	10.6	10.6
	Zone - 010		Zn Block	425	1.1	10,224	11,473	349			0	-11,936	349	10.6	10.6
		225 - Records	Rm Peak	175	0.0	2,172	2,471	42	1.45	0	0	-1,728	42	24.8	24.8
		226 - Breakroom	Rm Peak	100	2.5	1,974	2,690	46	2.78	0	0	-2,375	46	39.9	39.9
		227 - Storage	Rm Peak	100	0.0	1,217	1,531	17	1.04	0	0	-1,239	17	69.2	69.2
		228 - Electrical	Rm Peak	100	0.0	1,530	1,707	38	2.27	0	0	-1,311	38	15.9	15.9
		229 - Conference	Rm Peak	450	22.5	17,536	23,862	557	7.43	0	0	-22,848	557	25.0	25.0
	Zone - 011		Zn Peak	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
	Zone - 011		Zn Block	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
		214 - PS Office	Rm Peak	425	12.1	17,365	21,270	777	10.97	0	0	-24,383	777	11.1	11.1
	Zone - 012		Zn Peak	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
	Zone - 012		Zn Block	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
		103 - Elev Equip	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		104 - Storage	Rm Peak	150	0.0	978	1,497	34	1.37	0	0	-2,055	34	52.5	52.5
		108 - Quartermaster	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 013		Zn Peak	350	0.5	2,040	3,008	75			0	-4,015	75	43.5	43.5
	Zone - 013		Zn Block	350	0.5	2,045	3,007	75			0	-5,425	75	43.5	43.5
		105 - EOC	Rm Peak	1,250	83.3	38,434	62,341	1,194	5.73	0	0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Peak	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Block	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
		111 - CID	Rm Peak	880	4.4	5,432	7,902	204	1.39	0	0	-9,988	204	36.8	36.8
	Zone - 015		Zn Peak	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
	Zone - 015		Zn Block	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
		112 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		113 - Files	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		114 - Storage	Rm Peak	200	0.0	1,110	1,749	35	1.04	0	0	-2,478	35	69.2	69.2
	Zone - 016		Zn Peak	400	1.0	2,345	3,545	81			0	-4,748	81	50.7	50.7
	Zone - 016		Zn Block	400	1.0	2,345	3,545	81			0	-5,571	81	50.7	50.7
		121 - Armory	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		122 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		123 - Storage	Rm Peak	36	0.0	200	315	6	1.04	0	0	-446	6	69.2	69.2
	Zone - 017		Zn Peak	236	0.5	1,372	2,087	47			0	-2,820	47	53.1	53.1
	Zone - 017		Zn Block	236	0.5	1,372	2,087	47			0	-4,760	47	53.1	53.1
		115 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		116 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9

* This report does not display heating only systems .

Figure G.64 Load/Airflow Summary (2 of 4): Model 5

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		117 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
		118 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		119 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		120 - Patrol	Rm Peak	800	53.3	24,457	39,651	757	5.68	0	0	-48,864	757	59.2	59.2
	Zone - 018		Zn Peak	1,300	63.3	31,126	49,652	960			0	-60,431	960	56.9	56.9
	Zone - 018		Zn Block	1,300	63.3	31,115	49,641	960			0	-60,430	960	56.9	56.9
		124 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		125 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		126 - Warrant	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 019		Zn Peak	300	1.5	1,852	2,694	69			0	-3,405	69	36.8	36.8
	Zone - 019		Zn Block	300	1.5	1,852	2,694	69			0	-5,298	69	36.8	36.8
		127 - Lab	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		128 - Drugs	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
	Zone - 020		Zn Peak	200	0.0	1,110	1,749	35			0	-2,478	35	69.2	69.2
	Zone - 020		Zn Block	200	0.0	1,110	1,749	35			0	-4,474	35	69.2	69.2
		129 - Prop/Evid	Rm Peak	360	0.0	1,999	3,148	62	1.04	0	0	-4,460	62	69.2	69.2
		130 - Processing	Rm Peak	150	7.5	3,606	5,821	113	4.52	0	0	-7,181	113	57.8	57.8
	Zone - 021		Zn Peak	510	7.5	5,604	8,969	175			0	-11,641	175	61.8	61.8
	Zone - 021		Zn Block	510	7.5	5,604	8,968	175			0	-11,641	175	61.8	61.8
		131 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		132 - Cell	Rm Peak	180	4.5	2,555	4,055	83	2.78	0	0	-5,020	83	52.9	52.9
		133 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
	Zone - 022		Zn Peak	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
	Zone - 022		Zn Block	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
		134 - Jail	Rm Peak	175	0.0	972	1,530	30	1.04	0	0	-2,168	30	69.2	69.2
		135 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		136 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		137 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		138 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		139 - Holding	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		140 - Irtox	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		141 - Booking	Rm Peak	270	13.5	6,491	10,477	203	4.52	0	0	-12,926	203	57.8	57.8
	Zone - 023		Zn Peak	949	26.1	14,617	23,360	467			0	-29,150	467	56.1	56.1
	Zone - 023		Zn Block	949	26.1	14,617	23,360	467			0	-29,149	467	56.1	56.1
		142 - Mech	Rm Peak	150	0.0	1,176	1,452	49	1.41	0	0	-1,704	49	10.2	10.2
		143 - Storage	Rm Peak	150	0.0	940	1,424	31	1.23	0	0	-1,971	31	58.6	58.6
		146 - Sallyport	Rm Peak	900	0.0	17,172	20,087	481	3.21	0	0	-18,860	481	22.5	22.5
	Zone - 024		Zn Peak	1,200	0.0	19,287	22,963	561			0	-22,535	561	24.1	24.1
	Zone - 024		Zn Block	1,200	0.0	18,920	22,838	561			0	-22,622	561	24.1	24.1
		144 - Kitchen	Rm Peak	150	0.0	667	919	26	1.04	0	0	-1,238	26	34.6	34.6
		145 - Safety	Rm Peak	150	7.5	3,690	5,939	117	4.68	0	0	-7,276	117	55.8	55.8

* This report does not display heating only systems .

Figure G.65 Load/Airflow Summary (3 of 4): Model 5

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
	Zone - 025		Zn Peak	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
	Zone - 025		Zn Block	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
		110 - Corridor	Rm Peak	475	0.0	12,940	13,837	577	7.29	0	0	-15,659	577	4.9	4.9
		147 - Conference	Rm Peak	240	12.0	8,839	11,895	296	7.41	0	0	-12,162	296	25.1	25.1
	Zone - 026		Zn Peak	715	12.0	21,779	25,733	874			0	-27,821	874	11.8	11.8
	Zone - 026		Zn Block	715	12.0	21,017	25,322	874			0	-27,821	874	11.8	11.8
		148 - Office	Rm Peak	240	1.2	7,223	7,990	259	6.47	0	0	-7,551	259	7.9	7.9
		150 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		151 - Toilet	Rm Peak	100	0.0	1,418	1,418	38	2.27	0	0	-897	38	0.0	0.0
		152 - Office	Rm Peak	225	1.1	3,401	4,066	78	2.07	0	0	-3,165	78	24.6	24.6
	Zone - 027		Zn Peak	665	2.3	13,685	15,454	412			0	-13,338	412	12.5	12.5
	Zone - 027		Zn Block	665	2.3	13,622	15,439	412			0	-13,436	412	12.5	12.5
		109 - Corridor	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		110 - Corridor (Int)	Rm Peak	475	0.0	2,111	2,911	82	1.04	0	0	-3,919	82	34.6	34.6
		149 - Reception	Rm Peak	320	9.1	10,443	12,832	161	3.03	0	0	-8,308	161	40.2	40.2
		153 - Office	Rm Peak	225	1.1	2,875	3,498	52	1.39	0	0	-2,554	52	36.8	36.8
	Zone - 028		Zn Peak	1,120	10.3	15,873	19,854	313			0	-15,606	313	37.9	37.9
	Zone - 028		Zn Block	1,120	10.3	15,802	19,639	313			0	-15,606	313	37.9	37.9
		154 - Locker	Rm Peak	400	0.0	4,656	4,656	104	1.55	0	0	-2,458	104	0.0	0.0
		155 - Men	Rm Peak	400	0.0	3,963	3,963	69	1.04	0	0	-1,644	69	0.0	0.0
	Zone - 029		Zn Peak	800	0.0	8,619	8,619	173			0	-4,102	173	0.0	0.0
	Zone - 029		Zn Block	800	0.0	8,619	8,619	173			0	-7,754	173	0.0	0.0
		156 - Women	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		157 - Locker	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		158 - Toilet	Rm Peak	100	0.0	1,691	1,691	55	3.28	0	0	-1,298	55	0.0	0.0
		159 - Mech	Rm Peak	100	0.0	1,796	1,963	55	3.28	0	0	-1,712	55	11.0	11.0
	Zone - 030		Zn Peak	650	0.0	7,946	8,113	187			0	-4,860	187	3.2	3.2
	Zone - 030		Zn Block	650	0.0	7,777	7,962	187			0	-8,098	187	3.2	3.2
		160 - Workout	Rm Peak	575	2.9	48,899	51,906	2,044	21.33	0	0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Peak	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Block	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
		101 - Lobby (Ext)	Rm Peak	420	0.0	2,973	3,712	128	1.82	0	0	-4,763	128	19.8	19.8
		101 - Lobby (Int)	Rm Peak	154	0.0	684	944	27	1.04	0	0	-1,271	27	34.6	34.6
		106 - Breakroom	Rm Peak	100	2.5	1,309	2,034	46	2.78	0	0	-2,375	46	39.9	39.9
	Zone - 032		Zn Peak	674	2.5	4,966	6,691	201			0	-8,409	201	26.4	26.4
	Zone - 032		Zn Block	674	2.5	4,977	6,689	201			0	-8,409	201	26.4	26.4
System - 001			**Sys Peak**	**22,381**	**353.3**	**497,753**	**621,719**	**17,305**				**-672,528**	**17,305**	**22.0**	**22.0**
System - 001			**Sys Block**	**22,381**	**353.3**	**439,737**	**574,626**	**17,305**				**-672,612**	**17,305**	**22.0**	**22.0**

* This report does not display heating only systems .

Figure G.66 Load/Airflow Summary (4 of 4): Model 5

BUILDING COOL HEAT DEMAND

By ACADEMIC

January Hour	Typical Weather (°F) OADB	CAWB	Design Htg (Btuh)	Design Clg (Tons)	Weekday Htg (Btuh)	Weekday Clg (Tons)	Saturday Htg (Btuh)	Saturday Clg (Tons)	Sunday Htg (Btuh)	Sunday Clg (Tons)	Monday Htg (Btuh)	Monday Clg (Tons)
1	6.2	5.4	-187,788	3.0	-230,869	19.1	-324,746	19.0	-324,746	18.9	-324,746	18.9
2	5.0	4.1	-206,708	13.4	-270,292	18.2	-344,920	18.1	-344,920	18.1	-344,920	18.1
3	4.2	3.3	-223,053	16.1	-324,409	17.6	-361,193	17.5	-361,193	17.5	-361,193	17.4
4	3.9	3.2	-236,516	15.9	-360,348	17.3	-369,911	17.2	-369,911	17.2	-369,911	17.1
5	4.3	3.5	-246,075	15.8	-366,201	17.4	-372,994	17.3	-372,994	17.2	-372,994	17.2
6	5.4	4.4	-249,923	16.0	-364,067	17.8	-366,562	17.7	-366,562	17.6	-366,562	17.6
7	7.1	6.2	-246,106	18.4	-354,732	18.6	-354,732	18.5	-354,732	18.4	-354,732	18.4
8	9.3	8.3	-235,285	19.5	-334,808	19.7	-334,808	19.6	-334,808	19.5	-334,808	19.5
9	11.8	10.8	-160,028	21.6	-281,867	21.3	-281,867	21.2	-281,867	21.2	-281,867	21.2
10	14.4	13.3	-95,949	24.1	-222,216	23.2	-222,216	23.1	-222,216	23.1	-222,216	23.1
11	16.9	15.4	-63,316	29.0	-173,268	25.0	-173,268	24.9	-173,268	24.9	-173,268	24.8
12	19.1	17.3	-40,024	36.1	-145,162	26.5	-145,162	26.4	-145,162	26.4	-145,162	26.4
13	20.8	18.6	-25,901	39.5	-128,795	27.7	-128,795	27.6	-128,795	27.6	-128,795	27.6
14	21.0	10.6	17,606	42.4	111,741	28.8	111,741	28.8	111,741	28.7	111,741	28.7
15	22.3	19.6	0	44.4	-90,062	29.5	-90,062	29.5	-90,062	29.4	-90,062	29.4
16	22.0	19.3	0	47.0	-79,982	29.9	-79,982	29.8	-79,982	29.8	-79,982	29.8
17	21.2	18.7	0	47.0	-83,774	29.3	-83,774	29.2	-83,774	29.2	-83,774	29.1
18	20.0	17.7	-17,457	41.3	-103,609	27.8	-103,609	27.8	-103,609	27.7	-103,609	27.7
19	18.3	16.4	-27,808	36.7	-128,545	26.6	-128,545	26.6	-128,545	26.5	-128,545	26.5
20	16.4	14.8	-40,814	32.9	-164,123	25.4	-164,123	25.3	-164,123	25.3	-164,123	25.3
21	14.2	13.0	-54,050	30.4	-204,057	24.0	-204,057	24.0	-204,057	23.9	-204,057	23.9
22	12.0	10.8	-63,371	28.7	-236,254	22.7	-236,254	22.6	-236,254	22.6	-236,254	22.6
23	9.9	8.8	-79,264	27.5	-265,302	21.4	-265,302	21.3	-265,302	21.3	-265,302	21.3
24	7.9	6.9	-108,964	26.5	-294,876	20.1	-294,876	20.0	-294,876	20.0	-294,876	20.0

February Hour	Typical Weather (°F) OADB	CAWB	Design Htg (Btuh)	Design Clg (Tons)	Weekday Htg (Btuh)	Weekday Clg (Tons)	Saturday Htg (Btuh)	Saturday Clg (Tons)	Sunday Htg (Btuh)	Sunday Clg (Tons)	Monday Htg (Btuh)	Monday Clg (Tons)
1	17.2	16.3	-84,019	30.4	-66,903	26.1	-140,125	26.0	-140,125	26.1	-140,125	26.1
2	15.3	14.4	-102,772	29.5	-107,410	24.8	-183,932	24.8	-183,932	24.8	-183,932	24.8
3	13.7	12.7	-122,254	28.8	-156,259	23.7	-214,712	23.7	-214,712	23.7	-214,712	23.7
4	12.4	11.4	-138,287	28.2	-180,369	22.8	-246,089	22.9	-246,089	22.9	-246,089	22.9
5	11.3	10.5	-150,026	27.8	-200,222	22.0	-268,016	22.1	-268,016	22.1	-268,016	22.1
6	10.7	10.0	-154,940	27.8	-215,791	21.5	-280,706	21.6	-280,706	21.6	-280,706	21.6
7	10.5	9.9	-152,999	28.1	-253,855	21.3	-288,745	21.3	-288,745	21.3	-288,745	21.3
8	11.1	10.6	-130,118	29.0	-274,550	21.5	-281,230	21.6	-281,230	21.6	-281,230	21.6
9	12.8	12.2	-63,917	31.3	-222,075	22.9	-224,783	22.9	-224,783	22.9	-224,783	22.9
10	15.3	14.4	-30,126	34.6	-168,283	24.7	-168,283	24.7	-168,283	24.7	-168,283	24.7
11	18.5	16.9	-12,621	41.0	-125,464	26.7	-125,464	26.8	-125,464	26.8	-125,464	26.8
12	21.8	19.8	0	45.3	-96,893	28.8	-96,893	28.8	-96,893	28.8	-96,893	28.8
13	25.0	22.6	0	48.9	-75,264	30.8	-75,264	30.9	-75,264	30.9	-75,264	30.9
14	27.5	24.8	0	53.3	-52,050	32.8	-52,050	32.8	-52,050	32.8	-52,050	32.8
15	29.2	26.3	0	58.1	-34,289	34.6	-34,289	34.7	-34,289	34.7	-34,289	34.7
16	29.8	26.8	0	61.5	-26,057	35.6	-26,057	35.6	-26,057	35.6	-26,057	35.6
17	29.6	26.8	0	63.1	-22,571	36.1	-22,571	36.1	-22,571	36.1	-22,571	36.1
18	29.0	26.4	0	59.8	-24,322	36.5	-24,322	36.6	-24,322	36.6	-24,322	36.6
19	28.0	25.7	0	51.7	-33,107	34.5	-33,107	34.5	-33,107	34.5	-33,107	34.5
20	26.6	25.0	0	44.9	-42,834	32.7	-42,834	32.7	-42,834	32.7	-42,834	32.7
21	25.0	23.5	0	39.9	-54,996	31.3	-54,996	31.3	-54,996	31.3	-54,996	31.3
22	23.1	21.9	0	35.9	-68,974	30.0	-68,974	30.0	-68,974	30.0	-68,974	30.0
23	21.2	20.1	-18,562	33.3	-88,600	28.7	-88,600	28.7	-88,600	28.7	-88,600	28.7
24	19.1	18.2	-29,118	31.7	-114,519	27.3	-114,519	27.3	-114,519	27.3	-114,519	27.3

Figure G.67 Building Cool Heat Demand (1 of 6): Model 5

BUILDING COOL HEAT DEMAND

By ACADEMIC

March	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.4	33.4	0	45.9	0	42.3	0	42.5	0	42.6	0	42.6
2	33.9	31.9	0	47.5	0	40.0	0	40.1	0	40.2	0	40.2
3	32.9	31.1	0	47.7	0	38.3	0	38.4	0	38.5	0	38.5
4	32.6	31.1	0	47.5	0	37.6	-14,369	37.6	-14,369	37.7	-14,369	37.7
5	32.9	31.5	0	48.0	-21,272	37.4	-22,247	37.5	-22,247	37.5	-22,247	37.5
6	33.9	32.5	0	48.2	-23,287	38.0	-23,614	38.0	-23,614	38.0	-23,614	38.0
7	35.4	34.2	0	49.0	-22,455	39.0	-22,467	39.0	-22,467	39.1	-22,467	39.1
8	37.4	36.1	0	55.7	0	42.1	0	42.2	0	42.2	0	42.2
9	39.7	37.9	0	66.4	0	47.1	0	47.1	0	47.2	0	47.2
10	42.1	39.6	0	77.3	0	51.8	0	51.9	0	52.0	0	52.0
11	44.6	41.5	0	86.0	0	57.5	0	57.7	0	57.8	0	57.8
12	46.9	43.0	0	92.2	0	62.5	0	62.7	0	62.8	0	62.8
13	48.9	44.3	0	96.0	0	67.3	0	67.5	0	67.6	0	67.6
14	50.4	45.0	0	100.3	0	70.7	0	70.9	0	71.0	0	71.0
15	51.4	45.4	0	105.0	0	73.6	0	73.9	0	74.0	0	74.0
16	51.7	45.5	0	108.5	0	76.0	0	76.4	0	76.5	0	76.5
17	51.4	45.1	0	109.3	0	77.0	0	77.4	0	77.5	0	77.5
18	50.4	44.2	0	105.2	0	75.0	0	75.3	0	75.4	0	75.4
19	48.9	43.4	0	94.1	0	69.1	0	69.4	0	69.4	0	69.5
20	46.9	42.8	0	85.6	0	64.2	0	64.4	0	64.5	0	64.5
21	44.6	41.4	0	78.5	0	59.3	0	59.5	0	59.5	0	59.5
22	42.1	39.6	0	72.7	0	54.3	0	54.5	0	54.5	0	54.5
23	39.7	37.4	0	67.7	0	49.8	0	49.9	0	50.0	0	50.0
24	37.4	35.0	0	63.9	0	45.7	0	45.8	0	45.8	0	45.8

April	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	48.1	46.0	0	75.9	0	64.5	0	66.2	0	66.3	0	66.3
2	45.9	44.2	0	73.2	0	60.3	0	61.6	0	61.7	0	61.7
3	44.1	42.4	0	70.5	0	56.7	0	57.8	0	57.8	0	57.8
4	42.5	40.9	0	68.3	0	53.4	0	54.2	0	54.3	0	54.3
5	41.3	39.8	0	66.7	0	51.0	0	51.7	0	51.7	0	51.7
6	40.6	39.3	0	66.1	0	49.4	0	49.9	0	49.9	0	49.9
7	40.4	39.1	0	71.3	0	50.4	0	50.8	0	50.9	0	50.9
8	41.1	39.7	0	80.6	0	53.9	0	54.5	0	54.5	0	54.5
9	43.0	40.8	0	90.9	0	59.2	0	59.7	0	59.7	0	59.8
10	45.9	42.4	0	100.2	0	66.1	0	66.8	0	67.0	0	67.0
11	49.6	44.5	0	107.6	0	73.3	0	74.2	0	74.4	0	74.4
12	53.4	47.5	0	112.8	0	79.5	0	80.4	0	80.6	0	80.6
13	57.0	50.1	0	116.6	0	85.9	0	86.9	0	87.1	0	87.2
14	60.0	52.3	0	121.7	0	92.9	0	94.1	0	94.4	0	94.4
15	61.9	53.7	0	127.2	0	98.3	0	99.6	0	99.9	0	99.9
16	62.0	53.9	0	130.9	0	100.7	0	102.1	0	102.4	0	102.4
17	62.3	53.9	0	132.0	0	102.2	0	103.7	0	103.9	0	103.9
18	61.6	53.4	0	128.2	0	101.0	0	102.3	0	102.4	0	102.5
19	60.5	52.6	0	116.6	0	96.5	0	97.3	0	97.4	0	97.4
20	58.9	52.7	0	105.8	0	91.0	0	91.5	0	91.6	0	91.6
21	57.0	52.5	0	97.9	0	86.3	0	86.8	0	86.8	0	86.8
22	54.9	51.5	0	91.1	0	81.4	0	81.8	0	81.8	0	81.8
23	52.6	50.0	0	85.5	0	76.3	0	76.6	0	76.6	0	76.6
24	50.3	48.0	0	81.0	0	71.1	0	71.3	0	71.4	0	71.4

Figure G.68 Building Cool Heat Demand (2 of 6): Model 5

BUILDING COOL HEAT DEMAND

By ACADEMIC

May	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	59.2	56.0	0	103.6	0	89.8	0	93.7	0	93.8	0	93.8
2	56.8	53.8	0	98.9	0	84.5	0	87.3	0	87.4	0	87.4
3	54.8	52.2	0	95.3	0	79.9	0	82.1	0	82.2	0	82.2
4	53.3	50.9	0	92.2	0	75.9	0	77.9	0	77.9	0	77.9
5	52.3	50.2	0	90.5	0	73.5	0	75.1	0	75.1	0	75.1
6	52.0	50.3	0	90.6	0	72.7	0	74.1	0	74.1	0	74.1
7	52.5	50.8	0	100.2	0	76.9	0	78.7	0	78.8	0	78.8
8	53.8	51.6	0	112.5	0	82.8	0	85.2	0	85.2	0	85.2
9	55.9	52.4	0	123.2	0	88.9	0	91.2	0	91.2	0	91.3
10	58.5	53.8	0	131.9	0	98.0	0	100.3	0	100.3	0	100.3
11	61.6	55.1	0	138.1	0	104.6	0	106.7	0	106.7	0	106.7
12	64.7	56.6	0	142.7	0	109.3	0	111.2	0	111.3	0	111.3
13	67.8	58.2	0	146.3	0	114.2	0	115.9	0	116.0	0	116.0
14	70.4	59.6	0	151.2	0	121.0	0	122.5	0	122.5	0	122.6
15	72.5	61.1	0	156.9	0	126.7	0	131.1	0	131.1	0	131.1
16	73.8	62.4	0	160.4	0	133.1	0	134.1	0	134.1	0	134.1
17	74.3	62.8	0	160.6	0	135.8	0	136.5	0	136.5	0	136.5
18	74.0	62.6	0	156.3	0	135.5	0	136.0	0	136.0	0	136.1
19	73.0	62.1	0	146.3	0	130.9	0	131.3	0	131.3	0	131.3
20	71.5	62.0	0	132.0	0	123.5	0	123.7	0	123.8	0	123.8
21	69.5	63.0	0	123.5	0	119.7	0	120.0	0	120.0	0	120.1
22	67.1	61.9	0	115.9	0	113.7	0	113.9	0	114.0	0	114.0
23	64.5	59.9	0	109.7	0	106.8	0	107.0	0	107.0	0	107.1
24	61.8	58.0	0	105.0	0	100.1	0	100.2	0	100.2	0	100.3

June	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	68.3	64.8	0	132.8	0	114.9	0	121.7	0	121.7	0	121.7
2	66.4	63.3	0	127.2	0	110.9	0	116.0	0	116.1	0	116.1
3	64.8	62.3	0	123.2	0	107.5	0	111.3	0	111.4	0	111.4
4	63.6	61.5	0	120.1	0	104.8	0	107.9	0	107.9	0	107.9
5	62.9	61.0	0	117.9	0	102.9	0	105.3	0	105.3	0	105.3
6	62.6	60.0	0	119.7	0	102.0	0	104.0	0	104.0	0	104.0
7	63.1	61.4	0	131.6	0	109.3	0	111.0	0	111.1	0	111.1
8	64.5	61.6	0	143.0	0	116.0	0	117.9	0	117.9	0	117.9
9	66.8	62.3	0	152.5	0	122.3	0	123.9	0	123.9	0	123.9
10	69.6	63.9	0	159.9	0	133.0	0	134.4	0	134.4	0	134.4
11	72.7	66.0	0	167.6	0	141.5	0	142.6	0	142.7	0	142.7
12	75.8	67.7	0	172.2	0	147.4	0	148.3	0	148.3	0	148.3
13	78.7	69.7	0	176.1	0	153.8	0	154.6	0	154.6	0	154.6
14	80.9	71.1	0	181.0	0	161.1	0	161.7	0	161.7	0	161.8
15	82.3	71.7	0	185.7	0	168.0	0	168.6	0	168.7	0	168.7
16	82.8	72.0	0	188.8	0	169.4	0	169.9	0	170.0	0	170.0
17	82.6	71.4	0	187.7	0	169.3	0	169.8	0	169.8	0	169.8
18	81.8	71.1	0	183.6	0	168.1	0	168.4	0	168.5	0	168.5
19	80.6	70.5	0	175.6	0	163.3	0	163.6	0	163.6	0	163.6
20	79.0	70.3	0	159.9	0	154.3	0	154.5	0	154.5	0	154.5
21	77.1	70.2	0	149.7	0	148.1	0	148.2	0	148.2	0	148.2
22	75.0	69.6	0	141.9	0	142.6	0	142.7	0	142.7	0	142.7
23	72.7	68.0	0	135.5	0	135.1	0	135.1	0	135.2	0	135.2
24	70.5	66.8	0	131.0	0	129.0	0	129.1	0	129.1	0	129.1

Figure G.69 Building Cool Heat Demand (3 of 6): Model 5

BUILDING COOL HEAT DEMAND

By ACADEMIC

July	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	74.2	70.8	0	153.6	0	135.4	0	144.0	0	144.0	0	144.0
2	72.8	69.4	0	147.3	0	131.9	0	138.2	0	138.2	0	138.2
3	71.6	68.6	0	143.3	0	129.3	0	133.7	0	133.8	0	133.8
4	70.6	67.9	0	140.5	0	126.9	0	130.0	0	130.1	0	130.1
5	70.1	67.6	0	138.4	0	125.8	0	128.2	0	128.2	0	128.2
6	69.9	67.5	0	138.0	0	125.0	0	126.8	0	126.8	0	126.8
7	70.2	68.0	0	149.6	0	131.6	0	133.1	0	133.1	0	133.1
8	71.3	68.5	0	162.2	0	139.2	0	140.3	0	140.3	0	140.3
9	73.1	69.1	0	170.5	0	146.3	0	147.1	0	147.1	0	147.1
10	75.2	70.2	0	176.5	0	156.3	0	157.2	0	157.3	0	157.3
11	77.6	71.2	0	182.0	0	162.8	0	163.6	0	163.6	0	163.6
12	80.0	72.8	0	188.0	0	168.2	0	168.9	0	168.9	0	168.9
13	82.2	74.4	0	192.6	0	173.3	0	173.9	0	173.9	0	173.9
14	83.9	76.0	0	197.4	0	180.7	0	181.1	0	181.1	0	181.1
15	85.0	76.6	0	201.9	0	186.8	0	187.1	0	187.1	0	187.1
16	85.4	76.6	0	203.9	0	187.2	0	187.5	0	187.5	0	187.5
17	85.2	76.4	0	201.2	0	187.8	0	188.0	0	188.0	0	188.0
18	84.6	76.2	0	196.8	0	187.0	0	187.2	0	187.2	0	187.2
19	83.7	75.8	0	191.6	0	182.3	0	182.4	0	182.4	0	182.4
20	82.4	76.2	0	179.7	0	174.3	0	174.3	0	174.4	0	174.4
21	81.0	76.1	0	160.3	0	160.2	0	160.3	0	160.3	0	160.3
22	79.3	75.3	0	161.7	0	163.7	0	163.8	0	163.8	0	163.8
23	77.6	73.9	0	155.2	0	157.2	0	157.3	0	157.3	0	157.3
24	75.9	72.5	0	150.7	0	150.9	0	150.9	0	150.9	0	150.9

August	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	73.5	69.6	0	146.3	0	131.0	0	139.1	0	139.2	0	139.2
2	71.7	69.0	0	139.6	0	126.7	0	132.5	0	132.6	0	132.6
3	70.1	66.8	0	135.4	0	123.1	0	127.2	0	127.2	0	127.2
4	68.8	65.7	0	131.5	0	119.7	0	122.6	0	122.6	0	122.6
5	67.8	65.2	0	129.7	0	117.2	0	119.5	0	119.5	0	119.5
6	67.2	64.7	0	129.2	0	115.6	0	117.3	0	117.3	0	117.3
7	66.9	64.4	0	136.3	0	117.8	0	119.2	0	119.2	0	119.2
8	67.5	64.6	0	150.1	0	124.6	0	126.1	0	126.1	0	126.1
9	69.2	64.9	0	162.0	0	131.1	0	132.4	0	132.4	0	132.4
10	71.7	66.0	0	170.3	0	142.6	0	143.7	0	143.7	0	143.7
11	74.8	67.8	0	177.9	0	152.1	0	152.9	0	152.9	0	152.9
12	78.0	70.0	0	185.1	0	159.5	0	160.2	0	160.2	0	160.2
13	81.1	72.2	0	189.4	0	166.7	0	167.3	0	167.3	0	167.3
14	83.6	73.7	0	193.9	0	174.8	0	175.3	0	175.3	0	175.3
15	85.3	74.8	0	199.3	0	183.1	0	183.6	0	183.6	0	183.6
16	85.9	75.3	0	202.1	0	185.3	0	185.7	0	185.7	0	185.7
17	85.6	75.0	0	198.4	0	184.6	0	185.0	0	185.0	0	185.0
18	85.0	74.8	0	192.6	0	182.2	0	182.4	0	182.4	0	182.4
19	84.0	75.0	0	183.2	0	170.0	0	170.2	0	170.2	0	170.2
20	82.7	75.4	0	169.2	0	170.0	0	170.1	0	170.1	0	170.1
21	81.1	75.8	0	160.8	0	166.3	0	166.4	0	166.4	0	166.4
22	79.3	74.7	0	152.8	0	160.3	0	160.3	0	160.4	0	160.4
23	77.4	73.1	0	146.2	0	163.1	0	163.2	0	163.2	0	163.2
24	75.4	71.1	0	141.0	0	145.6	0	145.7	0	145.7	0	145.7

Figure G.70 Building Cool Heat Demand (4 of 6): Model 5

BUILDING COOL HEAT DEMAND

By ACADEMIC

September	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	62.0	58.8	0	113.2	0	97.7	0	102.8	0	102.8	0	102.8
2	59.5	56.4	0	107.0	0	91.7	0	95.7	0	95.7	0	95.7
3	57.3	54.7	0	102.6	0	86.8	0	89.9	0	89.9	0	89.9
4	55.7	53.3	0	99.8	0	82.0	0	85.3	0	85.3	0	85.3
5	54.7	52.7	0	96.7	0	80.3	0	82.2	0	82.3	0	82.3
6	54.4	52.4	0	96.1	0	78.9	0	80.5	0	80.5	0	80.5
7	55.0	53.1	0	97.8	0	79.5	0	81.0	0	81.0	0	81.0
8	57.0	54.8	0	111.9	0	88.3	0	90.3	0	90.3	0	90.3
9	60.0	56.2	0	127.7	0	98.4	0	100.5	0	100.5	0	100.5
10	63.7	57.6	0	140.5	0	107.8	0	109.6	0	109.7	0	109.7
11	67.9	59.7	0	150.9	0	120.4	0	122.2	0	122.2	0	122.2
12	72.1	61.7	0	157.5	0	129.0	0	130.5	0	130.6	0	130.6
13	75.9	64.1	0	162.8	0	138.0	0	139.1	0	139.2	0	139.2
14	78.9	65.7	0	169.4	0	146.3	0	147.2	0	147.2	0	147.3
15	80.8	66.9	0	176.0	0	152.0	0	152.7	0	152.8	0	152.8
16	81.5	67.1	0	178.6	0	154.7	0	155.2	0	155.3	0	155.3
17	81.1	67.1	0	176.1	0	154.8	0	155.2	0	155.3	0	155.3
18	80.1	67.3	0	164.7	0	150.2	0	150.5	0	150.6	0	150.6
19	78.5	68.0	0	149.4	0	143.8	0	144.0	0	144.1	0	144.1
20	76.4	69.9	0	140.2	0	142.5	0	142.7	0	142.7	0	142.7
21	73.8	68.7	0	130.9	0	135.9	0	136.0	0	136.1	0	136.1
22	70.9	66.5	0	122.8	0	127.8	0	127.9	0	127.9	0	127.9
23	67.9	64.2	0	116.5	0	119.4	0	119.5	0	119.5	0	119.5
24	64.9	61.3	0	111.0	0	110.6	0	110.6	0	110.6	0	110.6

October	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	46.2	40.6	0	84.9	0	59.6	0	60.2	0	60.3	0	60.3
2	44.9	39.9	0	80.6	0	56.8	0	57.3	0	57.3	0	57.3
3	44.5	39.9	0	77.3	0	55.4	0	55.7	0	55.8	0	55.8
4	44.9	40.5	0	74.6	0	54.9	0	55.2	0	55.2	0	55.2
5	46.2	41.5	0	72.8	0	55.9	0	56.2	0	56.2	0	56.2
6	48.3	43.8	0	72.4	0	58.3	0	58.6	0	58.7	0	58.7
7	51.0	46.5	0	73.3	0	61.7	0	62.1	0	62.1	0	62.1
8	54.2	49.8	0	81.6	0	69.6	0	70.1	0	70.2	0	70.2
9	57.6	52.1	0	94.7	0	78.8	0	79.5	0	79.6	0	79.6
10	61.0	53.5	0	107.3	0	86.9	0	88.0	0	88.1	0	88.1
11	64.1	55.0	0	117.7	0	94.3	0	95.7	0	95.9	0	95.9
12	66.9	56.1	0	124.6	0	99.8	0	101.3	0	101.5	0	101.5
13	68.9	57.1	0	130.4	0	104.1	0	105.6	0	105.7	0	105.8
14	70.3	57.3	0	136.9	0	108.4	0	109.8	0	109.9	0	109.9
15	70.7	57.2	0	143.2	0	111.7	0	113.2	0	113.3	0	113.3
16	70.3	56.4	0	145.4	0	112.6	0	113.8	0	114.0	0	114.0
17	68.9	55.3	0	141.0	0	110.1	0	111.0	0	111.1	0	111.1
18	66.9	53.9	0	126.6	0	102.0	0	102.5	0	102.5	0	102.5
19	64.1	52.7	0	116.6	0	95.3	0	95.6	0	95.6	0	95.6
20	61.0	52.0	0	108.2	0	89.6	0	89.8	0	89.8	0	89.8
21	57.0	49.8	0	101.0	0	82.7	0	82.9	0	82.9	0	82.9
22	54.2	47.5	0	94.8	0	76.3	0	76.4	0	76.4	0	76.4
23	51.0	44.9	0	89.6	0	70.1	0	70.2	0	70.2	0	70.2
24	48.3	42.6	0	85.4	0	64.7	0	64.7	0	64.7	0	64.7

Figure G.71 Building Cool Heat Demand (5 of 6): Model 5

BUILDING COOL HEAT DEMAND

By ACADEMIC

November	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.9	33.1	0	53.4	0	41.1	0	41.3	0	41.3	0	41.3
2	33.9	31.2	0	50.9	0	38.6	0	38.8	0	38.8	0	38.8
3	32.3	29.8	0	48.7	0	36.8	0	36.9	0	36.9	0	36.9
4	31.0	28.8	0	47.1	-15,873	35.5	-22,574	35.6	-22,574	35.6	-22,574	35.6
5	30.3	27.9	0	46.1	-29,391	34.8	-30,447	34.9	-30,447	34.9	-30,447	34.9
6	30.0	27.7	0	45.8	-33,973	34.4	-34,052	34.5	-34,052	34.5	-34,052	34.5
7	30.5	28.4	0	46.6	-34,512	34.6	-34,512	34.7	-34,512	34.7	-34,512	34.7
8	32.0	30.0	0	48.5	-32,175	35.5	-32,175	35.5	-32,175	35.5	-32,175	35.5
9	34.3	32.0	0	57.0	-18,327	37.6	-18,327	37.7	-18,704	37.7	-18,972	37.7
10	37.1	34.0	0	67.3	0	41.3	0	41.4	0	41.4	0	41.4
11	40.3	36.2	0	76.6	0	46.5	0	46.5	0	46.5	0	46.5
12	43.5	38.3	0	82.9	0	51.8	0	51.8	0	51.8	0	51.8
13	46.4	40.1	0	88.2	0	56.3	0	56.4	0	56.4	0	56.4
14	48.6	41.4	0	93.6	0	60.9	0	60.9	0	60.9	0	60.9
15	50.1	42.5	0	98.7	0	65.5	0	65.5	0	65.5	0	65.5
16	50.6	42.6	0	100.1	0	68.7	0	68.7	0	68.7	0	68.7
17	50.3	42.5	0	94.6	0	67.4	0	67.4	0	67.4	0	67.4
18	49.6	42.8	0	86.4	0	64.5	0	64.4	0	64.4	0	64.4
19	48.4	42.9	0	79.1	0	61.5	0	61.5	0	61.5	0	61.5
20	46.7	42.2	0	72.5	0	58.3	0	58.3	0	58.3	0	58.3
21	44.8	41.1	0	67.1	0	55.0	0	55.0	0	55.0	0	55.0
22	42.6	39.3	0	62.3	0	51.3	0	51.3	0	51.3	0	51.3
23	40.3	37.4	0	58.5	0	47.8	0	47.8	0	47.8	0	47.8
24	38.0	35.3	0	55.3	0	44.4	0	44.4	0	44.4	0	44.4

December	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	23.5	20.5	0	42.7	0	30.6	-48,236	30.6	-48,564	30.6	-48,564	30.6
2	22.9	20.1	0	40.5	-32,858	30.0	-56,503	30.0	-56,564	30.0	-56,564	30.0
3	23.2	20.5	0	38.8	-50,149	29.9	-64,339	30.0	-64,396	30.0	-34,396	30.0
4	24.1	21.7	-14,110	37.6	-54,748	30.2	-80,456	30.2	-81,513	30.2	-31,513	30.2
5	25.5	23.2	-20,466	36.9	-65,242	30.8	-87,280	30.8	-87,962	30.8	-37,962	30.8
6	27.4	25.1	-23,801	36.8	-67,998	31.7	-80,714	31.7	-83,035	31.7	-33,035	31.7
7	29.7	27.4	-23,888	37.5	-01,911	33.0	-72,979	33.0	-72,979	33.0	-72,979	33.0
8	32.3	30.1	-20,644	39.1	-52,921	34.6	-59,127	34.6	-59,127	34.6	-59,127	34.6
9	34.9	32.8	0	44.1	-31,493	36.9	-33,080	36.9	-33,080	36.9	-33,080	36.9
10	37.6	34.9	0	52.8	-15,491	39.1	-15,704	39.2	-15,704	39.2	-15,704	39.2
11	40.1	36.4	0	62.8	0	41.8	0	41.8	0	41.8	0	41.8
12	42.4	37.4	0	70.8	0	45.6	0	45.7	0	45.7	0	45.7
13	44.3	38.1	0	77.4	0	49.4	0	49.1	0	49.1	0	49.1
14	45.7	38.4	0	83.1	0	53.3	0	53.1	0	53.1	0	53.1
15	46.6	38.6	0	88.1	0	56.7	0	56.4	0	56.4	0	56.4
16	46.9	38.6	0	89.6	0	59.4	0	59.2	0	59.2	0	59.2
17	46.3	38.2	0	84.5	0	58.1	0	57.9	0	57.9	0	57.9
18	44.6	37.6	0	76.6	0	55.1	0	54.8	0	54.8	0	54.8
19	42.0	36.6	0	69.1	0	50.9	0	50.8	0	50.8	0	50.8
20	38.6	34.1	0	62.3	0	46.0	0	46.0	0	46.0	0	46.0
21	34.9	30.9	0	56.6	0	41.0	0	41.0	0	41.0	0	41.0
22	31.2	27.6	0	51.7	0	36.6	0	36.6	0	36.6	0	36.6
23	27.9	24.4	0	47.9	-14,074	33.6	-14,074	33.6	-14,074	33.6	-14,074	33.6
24	25.2	22.1	0	44.9	-31,187	31.8	-31,460	31.8	-31,460	31.8	-31,460	31.8

Figure G.72 Building Cool Heat Demand (6 of 6): Model 5

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - VMware - CSF

GSHP

	Year 1				
Month	Average Earth Temp. °F	Average Fluid Leaving Temp. °F	Average Fluid Entering Temp. °F	Minimum Fluid Entering Temp. °F	Maximum Fluid Entering Temp. °F
Jan	56.10	57.00	57.40	55.90	61.10
Feb	57.10	59.10	60.00	57.60	64.40
Mar	60.00	65.10	67.50	60.90	72.60
Apr	62.80	69.90	73.30	68.40	79.00
May	66.50	76.50	81.30	75.20	86.50
Jun	71.10	84.40	90.90	83.80	95.00
Jul	75.20	90.20	97.50	93.30	101.70
Aug	77.00	90.40	96.90	92.60	104.00
Sep	77.30	88.20	93.50	89.50	101.50
Oct	76.50	84.40	88.30	85.10	96.70
Nov	74.80	79.40	81.70	79.80	89.20
Dec	74.20	78.00	79.90	78.30	86.10
Annual	69.10	76.90	80.70	55.90	104.00

Figure G.73 Geothermal Earth Temperature Summary: Model 5

Table G.85 Heat Pump Selections (1 of 3): Model 5

MODEL 5 - HEAT PUMP SELECTIONS												
HEAT PUMP	**UNIT SIZE	UNIT AIR FLOW	COOLING					HEATING		GPM	WPD
			AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG LWT	HTG Q_T	HTG LWT		
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(ºF)	(MBH)	(ºF)		(FT)
1	018	450	665	1.5	15.9	17.7	90.0	-16.8	55.0	4.1	2.5
2	018	600	510	1.2	12.9	14.7	90.0	-13.5	55.0	4.1	2.5
3	018	600	550	1.3	13.9	15.8	90.0	-14.4	55.0	4.1	2.5
4	024	850	945	2.0	22.1	24.2	90.0	-24.0	55.0	6.0	4.9
5	042	1400	1145	2.9	30.5	35.1	90.0	-32.9	55.0	8.3	4.2
6	042	1400	1085	3.1	29.9	37.4	90.0	-34.5	55.0	8.3	4.2
7	036	1250	1065	2.5	26.9	30.5	90.0	-28.0	55.0	6.8	6.0
8	036	1250	1020	2.5	25.8	29.4	90.0	-27.0	55.0	6.8	6.0
9	036	1250	880	2.7	25.3	32.7	90.0	-35.7	55.0	6.8	6.0
10	060	1465	1595	4.2	40.9	50.0	90.0	-46.1	55.0	11.3	4.2
11	042	1400	1085	3.1	29.9	37.4	90.0	-34.5	55.0	8.3	4.2
12	018	450	555	1.3	14.1	16.0	90.0	-14.6	55.0	4.1	2.5
13	018	450	535	1.3	13.5	16.0	90.0	-14.7	55.0	4.1	2.5
14	018	450	570	1.4	14.5	16.3	90.0	-14.9	55.0	4.1	2.5
15	042	1400	1150	2.9	30.6	35.2	90.0	-33.0	55.0	8.3	4.2
16	024	640	700	1.7	17.4	20.0	90.0	-18.9	55.0	6.0	4.9
17	060	1950	2010	4.9	49.3	58.9	90.0	-57.7	55.0	11.3	4.2
18	009	300	230	0.7	6.5	8.9	90.0	-8.2	55.0	2.1	2.5
19	012	350	290	1.0	8.2	12.0	90.0	-10.9	55.0	2.6	3.3
20	024	640	510	1.7	14.5	20.8	90.0	-18.9	55.0	6.0	4.9
21	018	600	425	1.5	12.2	18.1	90.0	-16.4	55.0	4.1	2.5
22	024	850	900	1.9	21.7	23.0	90.0	-22.6	55.0	6.0	4.9
23	018	600	440	1.4	12.4	17.3	90.0	-15.7	55.0	4.1	2.5
24	NOT USED										
25	048	1600	1710	3.8	41.0	45.7	90.0	-44.0	55.0	9.0	5.1
26	012	350	360	1.1	10.0	12.9	90.0	-11.9	55.0	2.6	3.3
27	NOT USED										
28	018	450	460	1.4	13.1	17.3	90.0	-15.9	55.0	4.1	2.5
29	018	600	420	1.5	12.1	18.0	90.0	-16.3	55.0	4.1	2.5
30	024	850	830	1.9	21.3	22.5	90.0	-21.1	55.0	6.0	4.9
31	024	640	510	1.7	14.5	20.8	90.0	-18.9	55.0	6.0	4.9
32	012	350	290	1.0	8.4	12.2	90.0	-11.1	55.0	2.6	3.3
33	009	225	180	0.6	5.1	7.4	90.0	-6.7	55.0	2.1	2.5
34	060	1950	1690	4.7	45.8	56.3	90.0	-51.8	55.0	11.3	4.2
35	060	1950	1865	4.5	46.1	54.2	90.0	-49.2	55.0	11.3	4.2
36	030	950	965	2.1	22.9	25.0	90.0	-24.4	55.0	6.0	4.9
37	018	450	610	1.4	14.7	16.6	90.0	-15.7	55.0	4.1	2.5
38	018	450	465	1.1	11.3	13.1	90.0	-12.5	55.0	2.8	0.5
39	018	600	500	1.2	12.2	14.0	90.0	-13.4	55.0	2.8	0.5

Table G.86 Heat Pump Selections (2 of 3): Model 5

MODEL 5 - HEAT PUMP SELECTIONS											
40	036	1250	1110	2.8	28.2	33.7	90.0	-32.2	55.0	6.8	6.0
41	042	1400	1085	3.1	29.9	37.4	90.0	-34.5	55.0	8.3	4.2
42	024	850	770	2.0	19.1	24.3	90.0	-22.5	55.0	6.0	4.9
43	024	850	760	2.0	18.4	24.3	90.0	-23.1	55.0	6.0	4.9
44	042	1400	905	3.2	26.9	38.6	90.0	-40.6	55.0	8.3	4.2
45	030	950	920	2.2	22.5	26.0	90.0	-24.9	55.0	6.0	4.9
46	030	950	960	2.3	23.5	27.0	90.0	-25.8	55.0	6.0	4.9
47	042	1400	1085	3.1	29.9	37.4	90.0	-34.5	55.0	8.3	4.2
48	036	1250	1105	2.8	28.1	33.6	90.0	-32.0	55.0	6.8	6.0
49	018	600	500	1.2	12.0	14.2	90.0	-13.5	55.0	4.1	2.5
50	018	450	465	1.1	11.3	13.1	90.0	-12.5	55.0	2.8	0.5
51	018	600	515	1.2	12.7	14.6	90.0	-13.7	55.0	2.8	0.5
52	024	850	725	1.8	18.2	21.2	90.0	-19.4	55.0	6.0	4.9
53	030	950	1075	2.2	25.2	26.3	90.0	-25.6	55.0	8.0	7.9
54	042	1400	1355	2.8	32.0	33.1	90.0	-31.7	55.0	8.3	4.2
55	024	850	790	1.6	18.0	19.5	90.0	-19.3	55.0	6.0	4.9
56	036	1250	1240	2.8	29.1	33.7	90.0	-34.9	55.0	6.8	6.0
57	042	1400	1270	2.9	30.8	34.4	90.0	-32.3	55.0	8.3	4.2
58	018	600	530	1.4	13.0	16.6	90.0	-16.8	55.0	4.1	2.5
59	036	1250	1235	2.8	29.5	33.2	90.0	-31.4	55.0	6.8	6.0
60A	042	1400	1030	3.3	28.0	39.3	90.0	-41.9	55.0	8.3	4.2
60B	042	1400	1030	3.3	28.0	39.3	90.0	-41.9	55.0	8.3	4.2
61	060	1950	1875	4.6	45.4	54.7	90.0	-51.9	55.0	11.3	4.2
62	018	600	530	1.4	13.0	16.6	90.0	-16.8	55.0	4.1	2.5
63	042	1400	1275	2.9	30.7	34.4	90.0	-32.4	55.0	8.3	4.2
64	036	1250	1240	2.8	29.1	33.7	90.0	-34.9	55.0	6.8	6.0
65	024	640	675	1.5	16.4	18.3	90.0	-17.0	55.0	6.0	4.9
66	024	850	835	1.9	19.3	22.3	90.0	-21.8	55.0	6.0	4.9
67	060	1950	2245	4.9	49.5	59.2	90.0	-62.6	55.0	11.3	4.2
68	012	350	270	0.9	7.2	10.4	90.0	-10.1	55.0	2.6	3.3
69	012	350	290	1.0	7.7	11.5	90.0	-11.0	55.0	2.6	3.3
70	024	640	510	1.6	13.4	19.7	90.0	-18.9	55.0	6.0	4.9
71	018	450	425	1.4	11.4	17.3	90.0	-16.5	55.0	4.1	2.5
72	024	640	655	1.5	15.4	17.5	90.0	-18.7	55.0	6.0	4.9
73	018	450	440	1.4	11.3	16.3	90.0	-15.7	55.0	2.8	0.5
74	NOT USED										
75	048	1600	1560	3.4	36.1	40.4	90.0	-39.8	55.0	9.0	5.1
76	012	350	360	1.0	8.9	11.9	90.0	-11.9	55.0	2.6	3.3
77	NOT USED										
78	009	225	220	0.7	5.6	7.8	90.0	-7.6	55.0	2.1	2.5

Table G.87 Heat Pump Selections (3 of 3): Model 5

MODEL 5 - HEAT PUMP SELECTIONS											
79	024	640	655	1.5	15.4	17.5	90.0	-18.7	55.0	6.0	4.9
80	018	450	420	1.4	11.3	17.2	90.0	-16.4	55.0	4.1	0.5
81	024	640	510	1.6	13.4	19.7	90.0	-18.9	55.0	6.0	4.9
82	009	225	200	0.7	5.5	8.4	90.0	-7.9	55.0	2.1	2.5
83	012	350	290	1.0	7.7	11.6	90.0	-11.1	55.0	2.6	3.3
84	060	1950	1875	4.7	46.0	56.9	90.0	-56.9	55.0	11.3	4.2
85	048	1600	1490	3.5	36.4	43.2	90.0	-40.3	55.0	9.0	5.1
86	036	1250	1195	2.5	27.4	29.5	90.0	-29.2	55.0	6.8	6.0
87	036	1250	1190	2.7	27.7	32.5	90.0	-33.9	55.0	6.8	6.0
88	024	850	735	1.6	17.1	19.1	90.0	-18.2	55.0	6.0	4.9
89	036	1250	1140	2.6	27.3	30.9	90.0	-29.6	55.0	6.8	6.0
90	018	600	530	1.4	13.0	16.6	90.0	-16.8	55.0	4.1	2.5
91	060	1950	1775	4.5	43.0	53.6	90.0	-51.4	55.0	11.3	4.2
92A	042	1400	1030	3.3	28.0	39.3	90.0	-41.9	55.0	8.3	4.2
92B	042	1400	1030	3.3	28.0	39.3	90.0	-41.9	55.0	8.3	4.2
93	036	1250	1110	2.5	26.4	30.0	90.0	-28.8	55.0	6.8	6.0
94	018	600	530	1.4	13.0	16.6	90.0	-16.8	55.0	4.1	2.5
95	036	1250	1135	2.6	27.2	30.8	90.0	-29.5	55.0	6.8	6.0
96	036	1250	1145	2.6	27.4	31.0	90.0	-29.7	55.0	6.8	6.0
97	036	1250	1180	2.7	27.5	32.3	90.0	-33.7	55.0	6.8	6.0
98	024	850	860	2.0	20.5	23.5	90.0	-22.2	55.0	6.0	4.9
99	018	600	595	1.4	14.6	16.4	90.0	-15.3	55.0	4.1	2.5
				212.7		2551.9		-2468.5		588.1	389.6

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

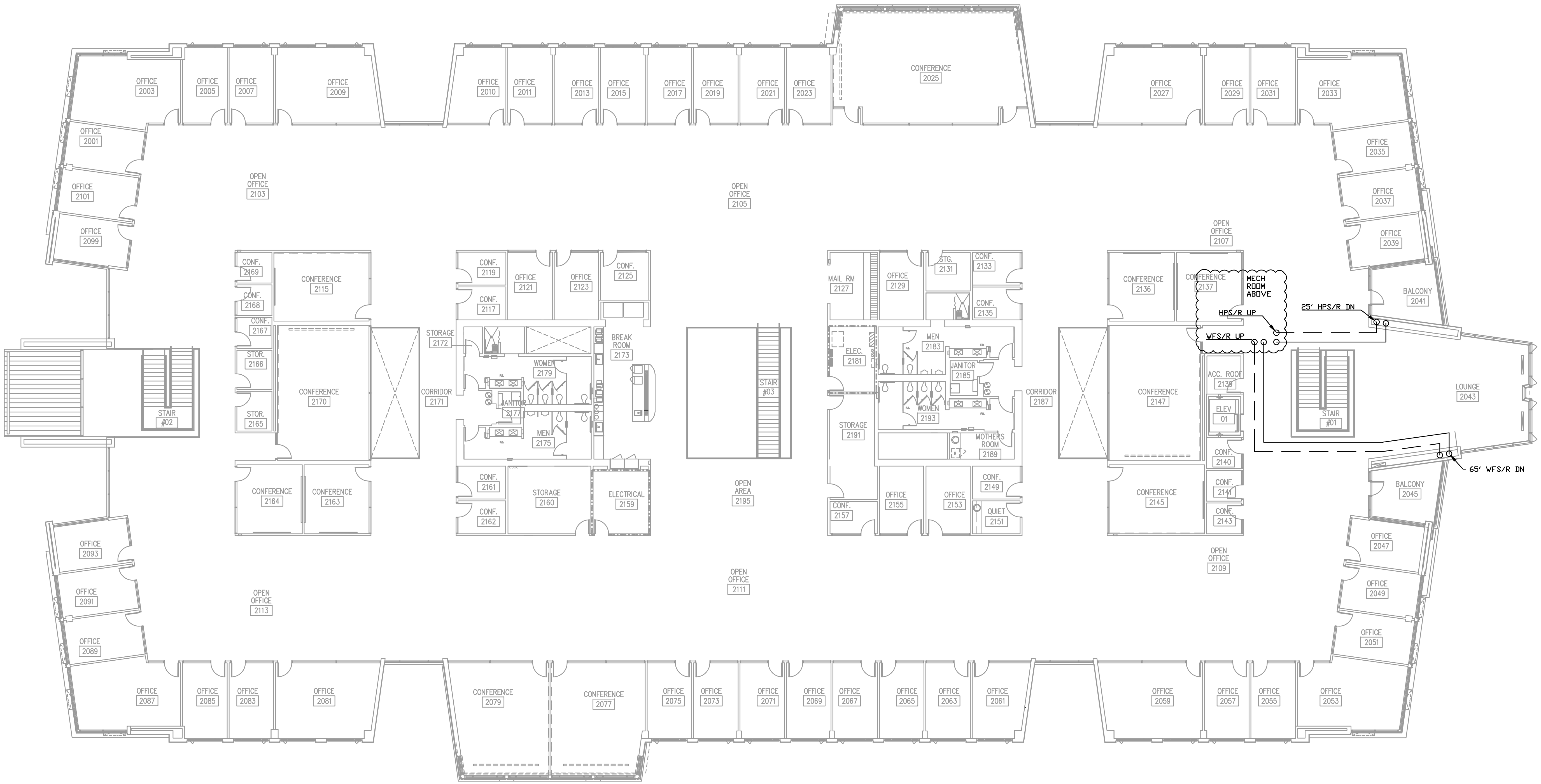
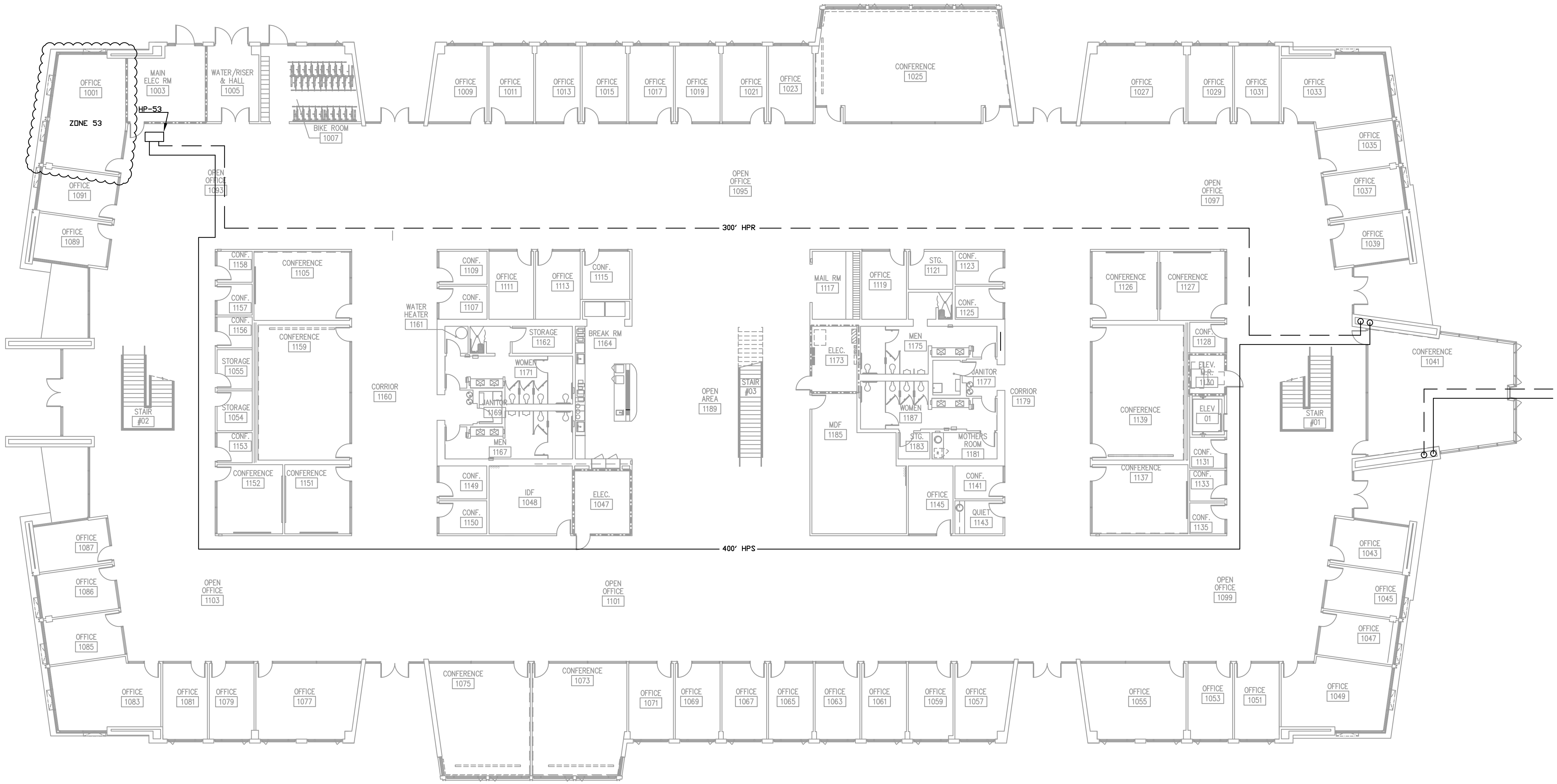


Figure G.74 Building Loop Piping Layout: Model 5


OFFICE 1001
ZONE 53
HP-53
MAIN ELEC RM 1003
WATER/RISER & HALL 1005
BIKE ROOM 1007
OFFICE 1009
OFFICE 1011
OFFICE 1013
OFFICE 1015
OFFICE 1017
OFFICE 1019
OFFICE 1021
OFFICE 1023
CONFERENCE 1025
OFFICE 1027
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CONFERENCE 1041
OFFICE 1043
OFFICE 1045
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CONFERENCE 1073
CONFERENCE 1075
OFFICE 1077
OFFICE 1079
OFFICE 1081
OFFICE 1083
OFFICE 1085
OFFICE 1086
OFFICE 1087
OFFICE 1089
OFFICE 1091
OPEN OFFICE 1093
OPEN OFFICE 1095
OPEN OFFICE 1097
OPEN OFFICE 1099
OPEN OFFICE 1101
OPEN OFFICE 1103
300' HPR
400' HPS
CONF. 1158
CONFERENCE 1105
CONF. 1157
CONF. 1156
CONFERENCE 1159
STORAGE 1055
STORAGE 1054
CONF. 1153
CONFERENCE 1152
CONFERENCE 1151
CORRIDOR 1160
WATER HEATER 1161
CONF. 1109
CONF. 1107
OFFICE 1111
OFFICE 1113
CONF. 1115
STORAGE 1162
BREAK RM 1164
WOMEN 1171
JANITOR 1169
MEN 1167
CONF. 1149
CONF. 1150
IDF 1048
ELEC. 1047
OPEN AREA 1189
STAIR #03
MAIL RM 1117
OFFICE 1119
STG. 1121
CONF. 1123
CONF. 1125
ELEC. 1173
MEN 1175
JANITOR 1177
WOMEN 1187
MDF 1185
STG. 1183
MOTHERS ROOM 1181
OFFICE 1145
CONF. 1141
QUIET 1143
CORRIDOR 1179
CONFERENCE 1126
CONFERENCE 1127
CONF. 1128
ELEV. M.R. 1130
ELEV 01
CONFERENCE 1139
CONF. 1131
CONF. 1133
CONFERENCE 1137
CONF. 1135
STAIR #02
STAIR #01

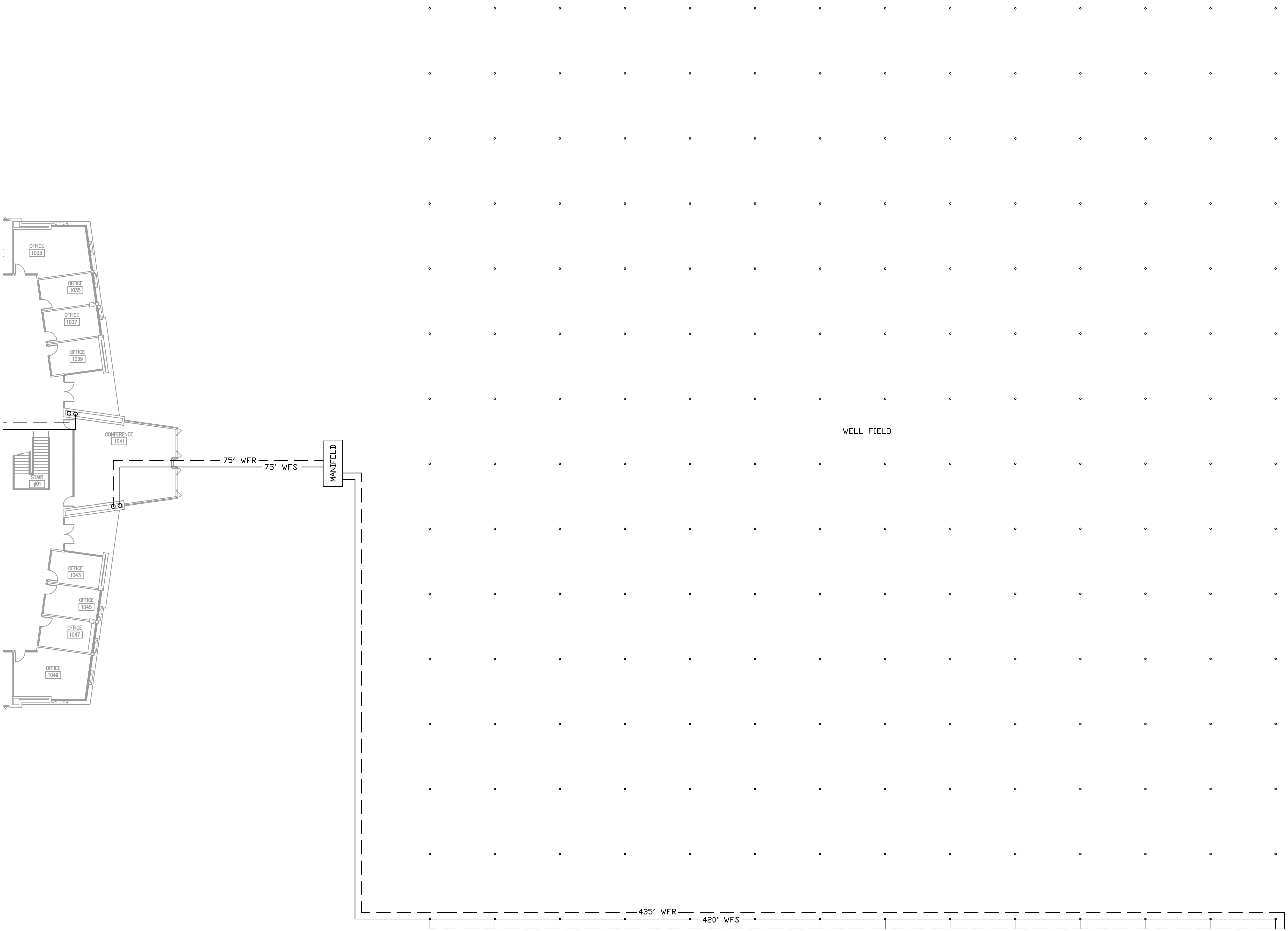

Figure G.75 Ground Loop Piping Layout: Model 5

MODEL	PRIMARY SYSTEM PUMP HEAD CALCULATIONS															PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.88 Primary Pump Head Calculations: All Models

Table G.89 Primary/Secondary Pump Head Calculations: All Models

PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS

PRIMARY LOOP

MODEL	SUPPLY/ RETURN TO MANIFOLD (FT)	DISTANCE TO WELL: SUPPLY (FT)	DISTANCE TO WELL: RETURN (FT)	DISTANCE DOWN/UP WELL (FT)	TOTAL PRIMARY LOOP PIPE LENGTH (FT)	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5) (FT)	MANIFOLD PD (EQUIV. LENGTH) (FT)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH) (FT)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD (FT OF HD)	TOTAL HEAT PUMP GPM
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

SECONDARY LOOP

MODEL	DISTANCE TO HEAT PUMP: SUPPLY (FT)	DISTANCE TO HEAT PUMP: RETURN (FT)	TOTAL P/S LOOP PIPE LENGTH (FT)	P/S LENGTH W/ FITTINGS (TOTAL*1.5) (FT)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH) (FT)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH) (FT)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP (FT OF HD)	AIR SEPARATOR PD (FT OF HD)	WORSE CASE HEAT PUMP WPD (FT OF HD)	SECONDARY LOOP PUMP HEAD (FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS													PUMP HEAD	PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD		
		SUPPLY	RETURN		SUPPLY	RETURN									
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.90 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD	CIRCULATOR PUMP HEAD
		SUPPLY	RETURN		SUPPLY	RETURN										
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4	16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2	16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3	13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7	16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9	9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3	21.7

DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS

GENERAL NOTES:
1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM
		(%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table G.91 Distributive Circulator Pump Head Calculations: All Models

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.92 Primary Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.93 Primary/Secondary Pump Schedules: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.94 Distributive w/ Primary - Primary Pump Schedules: All Models

Table G.95 Distributive w/ Primary - Circulator Schedule (1 of 3): Model 5

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
2	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
3	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
4	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
5	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
6	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
7	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
8	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
9	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
10	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
11	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
12	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
13	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
14	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
15	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
16	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
17	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
18	B & G	NRF-9F/LW	2.1	2.5	2800	0.055	41	115	$ 449.00
19	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
20	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
21	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
22	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
23	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
25	B & G	NRF-22	9.0	5.1	2940	0.123	92	115	$ 664.00
26	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
28	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
29	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
30	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
31	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
32	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
33	B & G	NRF-9F/LW	2.1	2.5	2800	0.055	41	115	$ 449.00
34	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
35	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
36	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
37	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
38	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
39	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
40	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
41	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
42	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
43	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
44	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
45	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
46	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
47	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
48	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
49	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00

Table G.96 Distributive w/ Primary - Circulator Schedule (2 of 3): Model 5

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
50	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
51	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
52	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
53	B & G	NRF-22	8.0	7.9	2940	0.123	92	115	$ 664.00
54	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
55	B & G	NRF-22	6.0	4.9	2940	0.123	92	115	$ 664.00
56	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
57	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
58	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
59	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
60A	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
60B	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
61	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
62	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
63	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
64	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
65	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
66	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
67	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
68	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
69	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
70	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
71	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
72	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
73	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
75	B & G	NRF-22	9.0	5.1	2940	0.123	92	115	$ 664.00
76	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
78	B & G	NRF-9F/LW	2.1	2.5	2800	0.055	41	115	$ 449.00
79	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
80	B & G	NRF-9F/LW	4.1	0.5	2800	0.055	41	115	$ 449.00
81	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
82	B & G	NRF-9F/LW	2.1	2.5	2800	0.055	41	115	$ 449.00
83	B & G	NRF-9F/LW	2.6	3.3	2800	0.055	41	115	$ 449.00
84	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
85	B & G	NRF-22	9.0	5.1	2940	0.123	92	115	$ 664.00
86	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
87	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
88	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
89	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
90	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
91	B & G	NRF-22	11.3	4.2	2940	0.123	92	115	$ 664.00
92A	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
92B	B & G	NRF-22	8.3	4.2	2940	0.123	92	115	$ 664.00
93	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
94	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
95	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00

Table G.97 Distributive w/ Primary - Circulator Schedule (3 of 3): Model 5

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
96	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
97	B & G	NRF-22	6.8	6.0	2940	0.123	92	115	$ 664.00
98	B & G	NRF-9F/LW	6.0	4.9	2800	0.055	41	115	$ 449.00
99	B & G	NRF-9F/LW	4.1	2.5	2800	0.055	41	115	$ 449.00
						8.20	6119		$52,583.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table G.98 Distributive - Circulator Schedule (1 of 3): Model 5

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
2	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
3	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
4	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
5	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
6	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
7	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
8	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
9	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
10	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
11	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
12	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
13	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
14	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
15	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
16	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
17	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
18	B & G	NRF-22	2.1	9.8	2940	0.123	92	115	$ 664.00
19	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
20	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
21	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
22	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
23	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
25	B & G	NRF-25	9.0	9.8	2950	0.168	125	115	$ 724.00
26	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
28	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
29	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
30	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
31	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
32	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
33	B & G	NRF-22	2.1	9.8	2940	0.123	92	115	$ 664.00
34	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
35	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
36	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
37	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
38	B & G	NRF-22	2.8	9.8	2940	0.123	92	115	$ 664.00
39	B & G	NRF-22	2.8	9.8	2940	0.123	92	115	$ 664.00
40	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
41	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
42	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
43	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
44	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
45	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
46	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
47	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
48	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
49	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00

Table G.99 Distributive - Circulator Schedule (2 of 3): Model 5

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
50	B & G	NRF-22	2.8	9.8	2940	0.123	92	115	$ 664.00
51	B & G	NRF-22	2.8	9.8	2940	0.123	92	115	$ 664.00
52	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
53	B & G	NRF-25	8.0	9.8	2950	0.168	125	115	$ 724.00
54	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
55	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
56	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
57	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
58	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
59	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
60A	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
60B	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
61	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
62	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
63	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
64	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
65	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
66	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
67	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
68	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
69	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
70	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
71	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
72	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
73	B & G	NRF-22	2.8	9.8	2940	0.123	92	115	$ 664.00
75	B & G	NRF-25	9.0	9.8	2950	0.168	125	115	$ 724.00
76	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
78	B & G	NRF-22	2.1	9.8	2940	0.123	92	115	$ 664.00
79	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
80	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
81	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
82	B & G	NRF-22	2.1	9.8	2940	0.123	92	115	$ 664.00
83	B & G	NRF-22	2.6	9.8	2940	0.123	92	115	$ 664.00
84	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
85	B & G	NRF-25	9.0	9.8	2950	0.168	125	115	$ 724.00
86	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
87	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
88	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
89	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
90	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
91	B & G	NRF-25	11.3	9.8	2950	0.168	125	115	$ 724.00
92A	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
92B	B & G	NRF-25	8.3	9.8	2950	0.168	125	115	$ 724.00
93	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
94	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
95	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00

Table G.100 Distributive - Circulator Schedule (3 of 3): Model 5

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
96	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
97	B & G	NRF-22	6.8	9.8	2940	0.123	92	115	$ 664.00
98	B & G	NRF-22	6.0	9.8	2940	0.123	92	115	$ 664.00
99	B & G	NRF-22	4.1	9.8	2940	0.123	92	115	$ 664.00
						13.11	9782		$65,968.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

MODEL 5 - MONTHLY PUMP CONSUMPTION

AVERAGE DAY	COOLING DESIGN LOAD	HEATING DESIGN LOAD	JANUARY					FEBRUARY					MARCH					APRIL					MAY					JUNE				
			CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL
			DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%	
HOURS	TONS	MBH	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%
1	212.7	2468.5	3.0	1.4%	187.8	7.6%	9.0%	30.4	14.3%	84.0	3.4%	17.7%	45.9	21.6%	0.0	0.0%	21.6%	75.9	35.7%	0.0	0.0%	35.7%	103.6	48.7%	0.0	0.0%	48.7%	132.8	62.4%	0.0	0.0%	62.4%
2	212.7	2468.5	13.4	6.3%	206.7	8.4%	14.7%	29.5	13.9%	102.8	4.2%	18.0%	47.5	22.3%	0.0	0.0%	22.3%	73.2	34.4%	0.0	0.0%	34.4%	98.9	46.5%	0.0	0.0%	46.5%	127.2	59.8%	0.0	0.0%	59.8%
3	212.7	2468.5	16.1	7.6%	223.1	9.0%	16.6%	28.8	13.5%	122.3	5.0%	18.5%	47.7	22.4%	0.0	0.0%	22.4%	70.5	33.1%	0.0	0.0%	33.1%	95.3	44.8%	0.0	0.0%	44.8%	123.2	57.9%	0.0	0.0%	57.9%
4	212.7	2468.5	15.9	7.5%	236.5	9.6%	17.1%	28.2	13.3%	138.3	5.6%	18.9%	47.5	22.3%	0.0	0.0%	22.3%	68.3	32.1%	0.0	0.0%	32.1%	92.2	43.3%	0.0	0.0%	43.3%	120.1	56.5%	0.0	0.0%	56.5%
5	212.7	2468.5	15.8	7.4%	246.1	10.0%	17.4%	27.8	13.1%	150.0	6.1%	19.1%	48.0	22.6%	0.0	0.0%	22.6%	66.7	31.4%	0.0	0.0%	31.4%	90.5	42.5%	0.0	0.0%	42.5%	117.9	55.4%	0.0	0.0%	55.4%
6	212.7	2468.5	16.0	7.5%	249.9	10.1%	17.6%	27.8	13.1%	154.9	6.3%	19.3%	48.2	22.7%	0.0	0.0%	22.7%	66.1	31.1%	0.0	0.0%	31.1%	90.6	42.6%	0.0	0.0%	42.6%	119.7	56.3%	0.0	0.0%	56.3%
7	212.7	2468.5	16.4	7.7%	246.1	10.0%	17.7%	28.1	13.2%	152.9	6.2%	19.4%	49.0	23.0%	0.0	0.0%	23.0%	71.3	33.5%	0.0	0.0%	33.5%	100.2	47.1%	0.0	0.0%	47.1%	131.6	61.9%	0.0	0.0%	61.9%
8	212.7	2468.5	19.5	9.2%	235.3	9.5%	18.7%	29.0	13.6%	130.1	5.3%	18.9%	55.7	26.2%	0.0	0.0%	26.2%	80.6	37.9%	0.0	0.0%	37.9%	112.5	52.9%	0.0	0.0%	52.9%	143.0	67.2%	0.0	0.0%	67.2%
9	212.7	2468.5	21.6	10.2%	160.0	6.5%	16.6%	31.3	14.7%	63.9	2.6%	17.3%	66.4	31.2%	0.0	0.0%	31.2%	90.3	42.5%	0.0	0.0%	42.5%	123.2	57.9%	0.0	0.0%	57.9%	152.5	71.7%	0.0	0.0%	71.7%
10	212.7	2468.5	24.1	11.3%	95.9	3.9%	15.2%	34.6	16.3%	30.1	1.2%	17.5%	77.3	36.3%	0.0	0.0%	36.3%	100.2	47.1%	0.0	0.0%	47.1%	131.9	62.0%	0.0	0.0%	62.0%	159.9	75.2%	0.0	0.0%	75.2%
11	212.7	2468.5	29.0	13.6%	63.3	2.6%	16.2%	41.0	19.3%	12.6	0.5%	19.8%	86.0	40.4%	0.0	0.0%	40.4%	107.6	50.6%	0.0	0.0%	50.6%	138.1	64.9%	0.0	0.0%	64.9%	167.6	78.8%	0.0	0.0%	78.8%
12	212.7	2468.5	36.1	17.0%	40.0	1.6%	18.6%	45.3	21.3%	0.0	0.0%	21.3%	92.2	43.3%	0.0	0.0%	43.3%	112.8	53.0%	0.0	0.0%	53.0%	142.7	67.1%	0.0	0.0%	67.1%	172.2	81.0%	0.0	0.0%	81.0%
13	212.7	2468.5	39.5	18.6%	25.9	1.0%	19.6%	48.9	23.0%	0.0	0.0%	23.0%	96.0	45.1%	0.0	0.0%	45.1%	116.6	54.8%	0.0	0.0%	54.8%	146.3	68.8%	0.0	0.0%	68.8%	176.1	82.8%	0.0	0.0%	82.8%
14	212.7	2468.5	42.4	19.9%	17.6	0.7%	20.6%	53.3	25.1%	0.0	0.0%	25.1%	100.3	47.2%	0.0	0.0%	47.2%	121.7	57.2%	0.0	0.0%	57.2%	151.2	71.1%	0.0	0.0%	71.1%	181.0	85.1%	0.0	0.0%	85.1%
15	212.7	2468.5	44.4	20.9%	0.0	0.0%	20.9%	58.1	27.3%	0.0	0.0%	27.3%	105.0	49.4%	0.0	0.0%	49.4%	127.2	59.8%	0.0	0.0%	59.8%	156.9	73.8%	0.0	0.0%	73.8%	185.7	87.3%	0.0	0.0%	87.3%
16	212.7	2468.5	47.0	22.1%	0.0	0.0%	22.1%	61.5	28.9%	0.0	0.0%	28.9%	108.5	51.0%	0.0	0.0%	51.0%	130.9	61.5%	0.0	0.0%	61.5%	160.4	75.4%	0.0	0.0%	75.4%	188.8	88.8%	0.0	0.0%	88.8%
17	212.7	2468.5	47.0	22.1%	0.0	0.0%	22.1%	53.1	25.0%	0.0	0.0%	25.0%	109.3	51.4%	0.0	0.0%	51.4%	132.0	62.1%	0.0	0.0%	62.1%	160.6	75.5%	0.0	0.0%	75.5%	187.7	88.2%	0.0	0.0%	88.2%
18	212.7	2468.5	41.3	19.4%	17.5	0.7%	20.1%	59.8	28.1%	0.0	0.0%	28.1%	105.2	49.5%	0.0	0.0%	49.5%	128.2	60.3%	0.0	0.0%	60.3%	156.3	73.5%	0.0	0.0%	73.5%	183.6	86.3%	0.0	0.0%	86.3%
19	212.7	2468.5	36.7	17.3%	27.8	1.1%	18.4%	51.7	24.3%	0.0	0.0%	24.3%	94.1	44.2%	0.0	0.0%	44.2%	116.6	54.8%	0.0	0.0%	54.8%	146.3	68.8%	0.0	0.0%	68.8%	175.6	82.6%	0.0	0.0%	82.6%
20	212.7	2468.5	32.9	15.5%	40.8	1.7%	17.1%	44.9	21.1%	0.0	0.0%	21.1%	85.6	40.2%	0.0	0.0%	40.2%	105.8	49.7%	0.0	0.0%	49.7%	132.0	62.1%	0.0	0.0%	62.1%	159.9	75.2%	0.0	0.0%	75.2%
21	212.7	2468.5	30.4	14.3%	54.1	2.2%	16.5%	39.8	18.7%	0.0	0.0%	18.7%	78.5	36.9%	0.0	0.0%	36.9%	97.9	46.0%	0.0	0.0%	46.0%	123.5	58.1%	0.0	0.0%	58.1%	149.7	70.4%	0.0	0.0%	70.4%
22	212.7	2468.5	28.7	13.5%	63.4	2.6%	16.1%	35.9	16.9%	0.0	0.0%	16.9%	72.7	34.2%	0.0	0.0%	34.2%	91.1	42.8%	0.0	0.0%	42.8%	115.9	54.5%	0.0	0.0%	54.5%	141.9	66.7%	0.0	0.0%	66.7%
23	212.7	2468.5	27.5	12.9%	79.3	3.2%	16.1%	33.3	15.7%	18.6	0.8%	16.4%	67.7	31.8%	0.0	0.0%	31.8%	85.5	40.2%	0.0	0.0%	40.2%	109.7	51.6%	0.0	0.0%	51.6%	135.5	63.7%	0.0	0.0%	63.7%
24	212.7	2468.5	26.5	12.5%	109.0	4.4%	16.9%	31.7	14.9%	29.1	1.2%	16.1%	63.9	30.0%	0.0	0.0%	30.0%	81.0	38.1%	0.0	0.0%	38.1%	105.0	49.4%	0.0	0.0%	49.4%	131.0	61.6%	0.0	0.0%	61.6%
AVERAGE DAY	COOLING DESIGN LOAD	HEATING DESIGN LOAD	JULY					AUGUST					SEPTEMBER					OCTOBER					NOVEMBER					DECEMBER				
			CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL
			DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%		DESIGN	%	DESIGN	%	
HOURS	TONS	MBH	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%	TONS		MBH		%
1	212.7	2468.5	153.6	72.2%	0.0	0.0%	72.2%	146.3	68.8%	0.0	0.0%	68.8%	113.2	53.2%	0.0	0.0%	53.2%	84.9	39.9%	0.0	0.0%	39.9%	53.4	25.1%	0.0	0.0%	25.1%	42.7	20.1%	0.0	0.0%	20.1%
2	212.7	2468.5	147.3	69.3%	0.0	0.0%	69.3%	139.6	65.6%	0.0	0.0%	65.6%	107.0	50.3%	0.0	0.0%	50.3%	80.6	37.9%	0.0	0.0%	37.9%	50.9	23.9%	0.0	0.0%	23.9%	40.5	19.0%	0.0	0.0%	19.0%
3	212.7	2468.5	143.3	67.4%	0.0	0.0%	67.4%	135.4	63.7%	0.0	0.0%	63.7%	102.6	48.2%	0.0	0.0%	48.2%	77.3	36.3%	0.0	0.0%	36.3%	48.7	22.9%	0.0	0.0%	22.9%	38.8	18.2%	0.0	0.0%	18.2%
4	212.7	2468.5	140.5	66.1%	0.0	0.0%	66.1%	131.5	61.8%	0.0	0.0%	61.8%	98.8	46.5%	0.0	0.0%	46.5%	74.6	35.1%	0.0	0.0%	35.1%	47.1	22.1%	0.0	0.0%	22.1%	37.6	17.7%	0.0	0.0%	17.7%
5	212.7	2468.5	138.4	65.1%	0.0	0.0%	65.1%	129.7	61.0%	0.0	0.0%	61.0%	96.7	45.5%	0.0	0.0%	45.5%	72.8	34.2%	0.0	0.0%	34.2%	46.1	21.7%	0.0	0.0%	21.7%	36.9	17.3%	0.0	0.0%	17.3%
6	212.7	2468.5	138.0	64.9%	0.0	0.0%	64.9%	129.2	60.7%	0.0	0.0%	60.7%	96.1	45.2%	0.0	0.0%	45.2%	72.4	34.0%	0.0	0.0%	34.0%	45.8	21.5%	0.0	0.0%	21.5%	36.8	17.3%	0.0	0.0%	17.3%
7	212.7	2468.5	149.6	70.3%	0.0	0.0%	70.3%	136.3	64.1%	0.0	0.0%	64.1%	97.8	46.0%	0.0	0.0%	46.0%	73.3	34.5%	0.0	0.0%	34.5%	46.6	21.9%	0.0	0.0%	21.9%	37.5	17.6%	0.0	0.0%	17.6%
8	212.7	2468.5	162.2	76.3%	0.0	0.0%	76.3%	150.1	70.6%	0.0	0.0%	70.6%	111.9	52.6%	0.0	0.0%	52.6%	81.6	38.4%	0.0	0.0%	38.4%	48.5	22.8%	0.0	0.0%	22.8%	39.1	18.4%	0.0	0.0%	18.4%
9	212.7	2468.5	170.5	80.2%	0.0	0.0%	80.2%	162.0	76.2%	0.0	0.0%	76.2%	127.7	60.0%	0.0	0.0%	60.0%	94.7	44.5%	0.0	0.0%	44.5%	57.0	26.8%	0.0	0.0%	26.8%	44.1	20.7%	0.0	0.0%	20.7%
10	212.7	2468.5	176.5	83.0%	0.0	0.0%	83.0%	170.3	80.1%	0.0	0.0%	80.1%	140.5	66.1%	0.0	0.0%	66.1%	107.3	50.4%	0.0	0.0%	50.4%	67.3	31.6%	0.0	0.0%	31.6%	52.8	24.8%	0.0	0.0%	24.8%
11	212.7	2468.5	182.0	85.6%	0.0	0.0%	85.6%	177.9	83.6%	0.0	0.0%	83.6%	150.9	70.9%	0.0	0.0%	70.9%	117.7	55.3%	0.0	0.0%	55.3%	76.6	36.0%	0.0	0.0%	36.0%	62.8	29.5%	0.0	0.0%	29.5%
12	212.7	2468.5	188.0	88.4%	0.0	0.0%	88.4%	185.1	87.0%	0.0	0.0%	87.0%	157.5	74.0%	0.0	0.0%	74.0%	124.6	58.6%	0.0	0.0%	58.6%	82.9	39.0%	0.0	0.0%	39.0%	70.8	33.3%	0.0	0.0%	33.3%
13	212.7	2468.5	192.6	90.6%	0.0	0.0%	90.6%	189.4	89.0%	0.0	0.0%	89.0%	162.8	76.5%	0.0	0.0%	76.5%	130.4	61.3%	0.0	0.0%	61.3%	88.2	41.5%	0.0	0.0%	41.5%	77.4	36.4%	0.0	0.0%	36.4%
14	212.7	2468.5	197.4	92.8%	0.0	0.0%	92.8%	193.9	91.2%	0.0	0.0%	91.2%	169.4	79.6%	0.0	0.0%	79.6%	136.9	64.4%	0.0	0.0%	64.4%	93.6	44.0%	0.0	0.0%	44.0%	83.1	39.1%	0.0	0.0%	39.1%
15	212.7	2468.5	201.9	94.9%	0.0	0.0%	94.9%	199.3	93.7%	0.0	0.0%	93.7%	176.0	82.7%	0.0	0.0%	82.7%	143.2	67.3%	0.0	0.0%	67.3%	98.7	46.4%	0.0	0.0%	46.4%	88.1	41.4%	0.0	0.0%	41.4%
16	212.7	2468.5	203.9	95.9%	0.0	0.0%	95.9%	202.1	95.0%	0.0	0.0%	95.0%	178.6	84.0%	0.0	0.0%	84.0%	145.4	68.4%	0.0	0.0%	68.4%	100.1	47.1%	0.0	0.0%	47.1%	89.6	42.1%	0.0	0.0%	42.1%
17	212.7	2468.5	201.2	94.6%	0.0	0.0%	94.6%	192.4	90.5%	0.0	0.0%	90.5%	176.1	82.8%	0.0	0.0%	82.8%	141.0	66.3%	0.0	0.0%	66.3%	94.6	44.5%	0.0	0.0%	44.5%	84.5	39.7%	0.0	0.0%	39.7%
18	212.7	2468.5	196.8	92.5%	0.0	0.0%	92.5%	192.6	90.6%	0.0	0.0%	90.6%	164.7	77.4%	0.0	0.0%	77.4%	126.6	59.5%	0.0	0.0%	59.5%	86.4	40.6%	0.0	0.0%	40.6%	76.6	36.0%	0.0	0.0%	36.0%
19	212.7	2468.5	191.6	90.1%	0.0	0.0%	90.1%	183.2	86.1%	0.0	0.0%	86.1%	149.4	70.2%	0.0	0.0%	70.2%	116.6	54.8%	0.0	0.0%	54.8%	79.1	37.2%	0.0	0.0%	37.2%	69.1	32.5%	0.0	0.0%	32.5%
20	212.7	2468.5	179.7	84.5%	0.0	0.0%	84.5%	169.2	79.5%	0.0	0.0%	79.5%	140.2	65.9%	0.0	0.0%	65.9%	108.2	50.9%	0.0	0.0%	50.9%	72.5	34.1%	0.0	0.0%	34.1%	62.3	29.3%	0.0	0.0%	29.3%
21	212.7	2468.5	169.3	79.6%	0.0	0.0%	79.6%	160.8	75.6%	0.0	0.0%	75.6%	130.9	61.5%	0.0	0.0%	61.5%	101.0	47.5%	0.0	0.0%	47.5%	67.1	31.5%	0.0	0.0%	31.5%	56.6	26.6%	0.0	0.0%	26.6%
22	212.7	2468.5	161.7	76.0%	0.0	0.0%	76.0%	152.8	71.8%	0.0	0.0%	71.8%	122.8	57.7%	0.0	0.0%	57.7%	94.8	44.6%	0.0	0.0%	44.6%	62.3	29.3%	0.0	0.0%	29.3%	51.7	24.3%	0.0	0.0%	24.3%
23	212.7	2468.5	155.2	73.0%	0.0	0.0%	73.0%	146.2	68.7%	0.0	0.0%	68.7%	116.5	54.8%	0.0	0.0%	54.8%	89.6	42.1%	0.0	0.0%	42.1%	58.5	27.5%	0.0	0.0%	27.5%	47.9	22.5%	0.0	0.0%	22.5%
24	212.7	2468.5	150.7	70.9%	0.0	0.0%	70.9%	141.0	66.3%	0.0	0.0%	66.3%	111.0	52.2%	0.0	0.0%	52.2%	85.4	40.2%	0.0	0.0%	40.2%	55.3	26.0%	0.0	0.0%	26.0%	44.9	21.1%	0.0	0.0%	21.1%

GENERAL NOTES:

1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table G.101 Monthly Simultaneous Heating and Cooling Part-Load % Per Hour: Model 5

MODEL 5 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION	24.34	BHP
	18.15	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	20.0%	0.15	20.0%	0.15	21.6%	0.18	35.7%	0.82	48.7%	2.10	62.4%	4.42
2	20.0%	0.15	20.0%	0.15	22.3%	0.20	34.4%	0.74	46.5%	1.82	59.8%	3.88
3	20.0%	0.15	20.0%	0.15	22.4%	0.20	33.1%	0.66	44.8%	1.63	57.9%	3.53
4	20.0%	0.15	20.0%	0.15	22.3%	0.20	32.1%	0.60	43.3%	1.48	56.5%	3.27
5	20.0%	0.15	20.0%	0.15	22.6%	0.21	31.4%	0.56	42.5%	1.40	55.4%	3.09
6	20.0%	0.15	20.0%	0.15	22.7%	0.21	31.1%	0.54	42.6%	1.40	56.3%	3.23
7	20.0%	0.15	20.0%	0.15	23.0%	0.22	33.5%	0.68	47.1%	1.90	61.9%	4.30
8	20.0%	0.15	20.0%	0.15	26.2%	0.33	37.9%	0.99	52.9%	2.69	67.2%	5.52
9	20.0%	0.15	20.0%	0.15	31.2%	0.55	42.5%	1.39	57.9%	3.53	71.7%	6.69
10	20.0%	0.15	20.0%	0.15	36.3%	0.87	47.1%	1.90	62.0%	4.33	75.2%	7.71
11	20.0%	0.15	20.0%	0.15	40.4%	1.20	50.6%	2.35	64.9%	4.97	78.8%	8.88
12	20.0%	0.15	21.3%	0.18	43.3%	1.48	53.0%	2.71	67.1%	5.48	81.0%	9.63
13	20.0%	0.15	23.0%	0.22	45.1%	1.67	54.8%	2.99	68.8%	5.91	82.8%	10.30
14	20.6%	0.16	25.1%	0.29	47.2%	1.90	57.2%	3.40	71.1%	6.52	85.1%	11.18
15	20.9%	0.17	27.3%	0.37	49.4%	2.18	59.8%	3.88	73.8%	7.29	87.3%	12.08
16	22.1%	0.20	28.9%	0.44	51.0%	2.41	61.5%	4.23	75.4%	7.78	88.8%	12.69
17	22.1%	0.20	25.0%	0.28	51.4%	2.46	62.1%	4.34	75.5%	7.81	88.2%	12.47
18	20.1%	0.15	28.1%	0.40	49.5%	2.20	60.3%	3.97	73.5%	7.20	86.3%	11.67
19	20.0%	0.15	24.3%	0.26	44.2%	1.57	54.8%	2.99	68.8%	5.91	82.6%	10.21
20	20.0%	0.15	21.1%	0.17	40.2%	1.18	49.7%	2.23	62.1%	4.34	75.2%	7.71
21	20.0%	0.15	20.0%	0.15	36.9%	0.91	46.0%	1.77	58.1%	3.55	70.4%	6.33
22	20.0%	0.15	20.0%	0.15	34.2%	0.72	42.8%	1.43	54.5%	2.94	66.7%	5.39
23	20.0%	0.15	20.0%	0.15	31.8%	0.59	40.2%	1.18	51.6%	2.49	63.7%	4.69
24	20.0%	0.15	20.0%	0.15	30.0%	0.49	38.1%	1.00	49.4%	2.18	61.6%	4.24
AVG, DAILY CONSUMPTION PER MONTH (KW)		3.62		4.79		24.15		47.36		96.64		173.12

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	72.2%	6.84	68.8%	5.91	53.2%	2.74	39.9%	1.15	25.1%	0.29	20.1%	0.15
2	69.3%	6.03	65.6%	5.13	50.3%	2.31	37.9%	0.99	23.9%	0.25	20.0%	0.15
3	67.4%	5.55	63.7%	4.68	48.2%	2.04	36.3%	0.87	22.9%	0.22	20.0%	0.15
4	66.1%	5.23	61.8%	4.29	46.5%	1.82	35.1%	0.78	22.1%	0.20	20.0%	0.15
5	65.1%	5.00	61.0%	4.12	45.5%	1.71	34.2%	0.73	21.7%	0.18	20.0%	0.15
6	64.9%	4.96	60.7%	4.07	45.2%	1.67	34.0%	0.72	21.5%	0.18	20.0%	0.15
7	70.3%	6.32	64.1%	4.78	46.0%	1.76	34.5%	0.74	21.9%	0.19	20.0%	0.15
8	76.3%	8.05	70.6%	6.38	52.6%	2.64	38.4%	1.02	22.8%	0.22	20.0%	0.15
9	80.2%	9.35	76.2%	8.02	60.0%	3.93	44.5%	1.60	26.8%	0.35	20.7%	0.16
10	83.0%	10.37	80.1%	9.32	66.1%	5.23	50.4%	2.33	31.6%	0.57	24.8%	0.28
11	85.6%	11.37	83.6%	10.62	70.9%	6.48	55.3%	3.08	36.0%	0.85	29.5%	0.47
12	88.4%	12.53	87.0%	11.96	74.0%	7.37	58.6%	3.65	39.0%	1.07	33.3%	0.67
13	90.6%	13.48	89.0%	12.82	76.5%	8.14	61.3%	4.18	41.5%	1.29	36.4%	0.87
14	92.8%	14.51	91.2%	13.75	79.6%	9.17	64.4%	4.84	44.0%	1.55	39.1%	1.08
15	94.9%	15.52	93.7%	14.93	82.7%	10.28	67.3%	5.54	46.4%	1.81	41.4%	1.29
16	95.9%	15.99	95.0%	15.57	84.0%	10.75	68.4%	5.80	47.1%	1.89	42.1%	1.36
17	94.6%	15.36	90.5%	13.43	82.8%	10.30	66.3%	5.29	44.5%	1.60	39.7%	1.14
18	92.5%	14.38	90.6%	13.48	77.4%	8.43	59.5%	3.83	40.6%	1.22	36.0%	0.85
19	90.1%	13.27	86.1%	11.60	70.2%	6.29	54.8%	2.99	37.2%	0.93	32.5%	0.62
20	84.5%	10.95	79.5%	9.14	65.9%	5.20	50.9%	2.39	34.1%	0.72	29.3%	0.46
21	79.6%	9.15	75.6%	7.84	61.5%	4.23	47.5%	1.94	31.5%	0.57	26.6%	0.34
22	76.0%	7.97	71.8%	6.73	57.7%	3.49	44.6%	1.61	29.3%	0.46	24.3%	0.26
23	73.0%	7.05	68.7%	5.89	54.8%	2.98	42.1%	1.36	27.5%	0.38	22.5%	0.21
24	70.9%	6.46	66.3%	5.29	52.2%	2.58	40.2%	1.17	26.0%	0.32	21.1%	0.17
AVG, DAILY CONSUMPTION PER MONTH (KW)		235.67		209.73		121.54		58.60		17.30		11.39

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.102 Daily Pump Consumption (Primary): Model 5

Table G.103 Primary System Annual Utility Cost: Model 5

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	3.62	31	112	$ 0.09	$ 10.11
FEBRUARY	4.79	28	134	$ 0.09	$ 12.06
MARCH	24.15	31	749	$ 0.09	$ 67.39
APRIL	47.36	30	1421	$ 0.09	$ 127.87
MAY	96.64	31	2996	$ 0.09	$ 269.62
JUNE	173.12	30	5194	$ 0.09	$ 467.44
JULY	235.67	31	7306	$ 0.09	$ 657.53
AUGUST	209.73	31	6502	$ 0.09	$ 585.14
SEPTEMBER	121.54	30	3646	$ 0.09	$ 328.15
OCTOBER	58.60	31	1817	$ 0.09	$ 163.49
NOVEMBER	17.30	30	519	$ 0.09	$ 46.72
DECEMBER	11.39	31	353	$ 0.09	$ 31.77
ANNUAL UTILITY CONSUMPTION & COST			30748	KWH	$ 2,767.28

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 5 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY + SECONDARY PUMP CONSUMPTION		
	24.57	BHP
	18.32	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	20.0%	0.15	20.0%	0.15	21.6%	0.18	35.7%	0.83	48.7%	2.12	62.4%	4.46
2	20.0%	0.15	20.0%	0.15	22.3%	0.20	34.4%	0.75	46.5%	1.84	59.8%	3.92
3	20.0%	0.15	20.0%	0.15	22.4%	0.21	33.1%	0.67	44.8%	1.65	57.9%	3.56
4	20.0%	0.15	20.0%	0.15	22.3%	0.20	32.1%	0.61	43.3%	1.49	56.5%	3.30
5	20.0%	0.15	20.0%	0.15	22.6%	0.21	31.4%	0.56	42.5%	1.41	55.4%	3.12
6	20.0%	0.15	20.0%	0.15	22.7%	0.21	31.1%	0.55	42.6%	1.42	56.3%	3.27
7	20.0%	0.15	20.0%	0.15	23.0%	0.22	33.5%	0.69	47.1%	1.92	61.9%	4.34
8	20.0%	0.15	20.0%	0.15	26.2%	0.33	37.9%	1.00	52.9%	2.71	67.2%	5.57
9	20.0%	0.15	20.0%	0.15	31.2%	0.56	42.5%	1.40	57.9%	3.56	71.7%	6.75
10	20.0%	0.15	20.0%	0.15	36.3%	0.88	47.1%	1.92	62.0%	4.37	75.2%	7.78
11	20.0%	0.15	20.0%	0.15	40.4%	1.21	50.6%	2.37	64.9%	5.01	78.8%	8.96
12	20.0%	0.15	21.3%	0.18	43.3%	1.49	53.0%	2.73	67.1%	5.53	81.0%	9.72
13	20.0%	0.15	23.0%	0.22	45.1%	1.68	54.8%	3.02	68.8%	5.96	82.8%	10.40
14	20.6%	0.16	25.1%	0.29	47.2%	1.92	57.2%	3.43	71.1%	6.58	85.1%	11.29
15	20.9%	0.17	27.3%	0.37	49.4%	2.20	59.8%	3.92	73.8%	7.35	87.3%	12.19
16	22.1%	0.20	28.9%	0.44	51.0%	2.43	61.5%	4.27	75.4%	7.86	88.8%	12.81
17	22.1%	0.20	25.0%	0.29	51.4%	2.49	62.1%	4.38	75.5%	7.89	88.2%	12.59
18	20.1%	0.15	28.1%	0.41	49.5%	2.22	60.3%	4.01	73.5%	7.27	86.3%	11.78
19	20.0%	0.15	24.3%	0.26	44.2%	1.59	54.8%	3.02	68.8%	5.96	82.6%	10.31
20	20.0%	0.15	21.1%	0.17	40.2%	1.19	49.7%	2.25	62.1%	4.38	75.2%	7.78
21	20.0%	0.15	20.0%	0.15	36.9%	0.92	46.0%	1.79	58.1%	3.59	70.4%	6.39
22	20.0%	0.15	20.0%	0.15	34.2%	0.73	42.8%	1.44	54.5%	2.96	66.7%	5.44
23	20.0%	0.15	20.0%	0.15	31.8%	0.59	40.2%	1.19	51.6%	2.51	63.7%	4.74
24	20.0%	0.15	20.0%	0.15	30.0%	0.50	38.1%	1.01	49.4%	2.20	61.6%	4.28
AVG, DAILY CONSUMPTION PER MONTH (KW)		3.66		4.83		24.38		47.81		97.55		174.76

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	72.2%	6.90	68.8%	5.96	53.2%	2.76	39.9%	1.17	25.1%	0.29	20.1%	0.15
2	69.3%	6.09	65.6%	5.18	50.3%	2.33	37.9%	1.00	23.9%	0.25	20.0%	0.15
3	67.4%	5.60	63.7%	4.73	48.2%	2.06	36.3%	0.88	22.9%	0.22	20.0%	0.15
4	66.1%	5.28	61.8%	4.33	46.5%	1.84	35.1%	0.79	22.1%	0.20	20.0%	0.15
5	65.1%	5.05	61.0%	4.15	45.5%	1.72	34.2%	0.73	21.7%	0.19	20.0%	0.15
6	64.9%	5.00	60.7%	4.11	45.2%	1.69	34.0%	0.72	21.5%	0.18	20.0%	0.15
7	70.3%	6.37	64.1%	4.82	46.0%	1.78	34.5%	0.75	21.9%	0.19	20.0%	0.15
8	76.3%	8.12	70.6%	6.44	52.6%	2.67	38.4%	1.03	22.8%	0.22	20.0%	0.15
9	80.2%	9.44	76.2%	8.09	60.0%	3.96	44.5%	1.62	26.8%	0.35	20.7%	0.16
10	83.0%	10.47	80.1%	9.40	66.1%	5.28	50.4%	2.35	31.6%	0.58	24.8%	0.28
11	85.6%	11.48	83.6%	10.72	70.9%	6.54	55.3%	3.10	36.0%	0.86	29.5%	0.47
12	88.4%	12.65	87.0%	12.07	74.0%	7.44	58.6%	3.68	39.0%	1.08	33.3%	0.68
13	90.6%	13.60	89.0%	12.94	76.5%	8.22	61.3%	4.22	41.5%	1.31	36.4%	0.88
14	92.8%	14.65	91.2%	13.88	79.6%	9.26	64.4%	4.89	44.0%	1.56	39.1%	1.09
15	94.9%	15.67	93.7%	15.07	82.7%	10.38	67.3%	5.59	46.4%	1.83	41.4%	1.30
16	95.9%	16.14	95.0%	15.72	84.0%	10.85	68.4%	5.85	47.1%	1.91	42.1%	1.37
17	94.6%	15.51	90.5%	13.56	82.8%	10.40	66.3%	5.34	44.5%	1.61	39.7%	1.15
18	92.5%	14.51	90.6%	13.60	77.4%	8.51	59.5%	3.86	40.6%	1.23	36.0%	0.86
19	90.1%	13.39	86.1%	11.71	70.2%	6.35	54.8%	3.02	37.2%	0.94	32.5%	0.63
20	84.5%	11.05	79.5%	9.22	65.9%	5.25	50.9%	2.41	34.1%	0.73	29.3%	0.46
21	79.6%	9.24	75.6%	7.92	61.5%	4.27	47.5%	1.96	31.5%	0.58	26.6%	0.35
22	76.0%	8.05	71.8%	6.79	57.7%	3.53	44.6%	1.62	29.3%	0.46	24.3%	0.26
23	73.0%	7.12	68.7%	5.95	54.8%	3.01	42.1%	1.37	27.5%	0.38	22.5%	0.21
24	70.9%	6.52	66.3%	5.34	52.2%	2.60	40.2%	1.19	26.0%	0.32	21.1%	0.17
AVG, DAILY CONSUMPTION PER MONTH (KW)		237.90		211.71		122.68		59.15		17.47		11.50

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.104 Daily Pump Consumption (Primary/Secondary): Model 5

Table G.105 Primary/Secondary System Annual Utility Cost: Model 5

PRIMARY/SECONDARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	3.66	31	113	$ 0.09	$ 10.20
FEBRUARY	4.83	28	135	$ 0.09	$ 12.17
MARCH	24.38	31	756	$ 0.09	$ 68.02
APRIL	47.81	30	1434	$ 0.09	$ 129.08
MAY	97.55	31	3024	$ 0.09	$ 272.17
JUNE	174.76	30	5243	$ 0.09	$ 471.85
JULY	237.90	31	7375	$ 0.09	$ 663.74
AUGUST	211.71	31	6563	$ 0.09	$ 590.67
SEPTEMBER	122.68	30	3681	$ 0.09	$ 331.25
OCTOBER	59.15	31	1834	$ 0.09	$ 165.03
NOVEMBER	17.47	30	524	$ 0.09	$ 47.16
DECEMBER	11.50	31	356	$ 0.09	$ 32.07
ANNUAL UTILITY CONSUMPTION & COST			31038	KWH	$ 2,793.43

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 5 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS AND PRIMARY PUMP CONSUMPTION		
	31.99	BHP
	23.85	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	20.0%	0.19	20.0%	0.19	21.6%	0.24	35.7%	1.08	48.7%	2.76	62.4%	5.81
2	20.0%	0.19	20.0%	0.19	22.3%	0.27	34.4%	0.97	46.5%	2.40	59.8%	5.10
3	20.0%	0.19	20.0%	0.19	22.4%	0.27	33.1%	0.87	44.8%	2.15	57.9%	4.64
4	20.0%	0.19	20.0%	0.19	22.3%	0.27	32.1%	0.79	43.3%	1.94	56.5%	4.29
5	20.0%	0.19	20.0%	0.19	22.6%	0.27	31.4%	0.74	42.5%	1.84	55.4%	4.06
6	20.0%	0.19	20.0%	0.19	22.7%	0.28	31.1%	0.72	42.6%	1.84	56.3%	4.25
7	20.0%	0.19	20.0%	0.19	23.0%	0.29	33.5%	0.90	47.1%	2.49	61.9%	5.65
8	20.0%	0.19	20.0%	0.19	26.2%	0.43	37.9%	1.30	52.9%	3.53	67.2%	7.25
9	20.0%	0.19	20.0%	0.19	31.2%	0.73	42.5%	1.83	57.9%	4.64	71.7%	8.79
10	20.0%	0.19	20.0%	0.19	36.3%	1.15	47.1%	2.49	62.0%	5.69	75.2%	10.13
11	20.0%	0.19	20.0%	0.19	40.4%	1.58	50.6%	3.09	64.9%	6.53	78.8%	11.67
12	20.0%	0.19	21.3%	0.23	43.3%	1.94	53.0%	3.56	67.1%	7.20	81.0%	12.66
13	20.0%	0.19	23.0%	0.29	45.1%	2.19	54.8%	3.93	68.8%	7.76	82.8%	13.54
14	20.6%	0.21	25.1%	0.38	47.2%	2.50	57.2%	4.47	71.1%	8.57	85.1%	14.70
15	20.9%	0.22	27.3%	0.49	49.4%	2.87	59.8%	5.10	73.8%	9.58	87.3%	15.87
16	22.1%	0.26	28.9%	0.58	51.0%	3.17	61.5%	5.56	75.4%	10.23	88.8%	16.68
17	22.1%	0.26	25.0%	0.37	51.4%	3.24	62.1%	5.70	75.5%	10.27	88.2%	16.39
18	20.1%	0.19	28.1%	0.53	49.5%	2.89	60.3%	5.22	73.5%	9.47	86.3%	15.34
19	20.0%	0.19	24.3%	0.34	44.2%	2.07	54.8%	3.93	68.8%	7.76	82.6%	13.42
20	20.0%	0.19	21.1%	0.22	40.2%	1.55	49.7%	2.94	62.1%	5.70	75.2%	10.13
21	20.0%	0.19	20.0%	0.19	36.9%	1.20	46.0%	2.33	58.1%	4.67	70.4%	8.32
22	20.0%	0.19	20.0%	0.19	34.2%	0.95	42.8%	1.87	54.5%	3.86	66.7%	7.08
23	20.0%	0.19	20.0%	0.19	31.8%	0.77	40.2%	1.55	51.6%	3.27	63.7%	6.17
24	20.0%	0.19	20.0%	0.19	30.0%	0.65	38.1%	1.32	49.4%	2.87	61.6%	5.57
AVG, DAILY CONSUMPTION PER MONTH (KW)		4.76		6.29		31.74		62.25		127.01		227.54

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	72.2%	8.98	68.8%	7.76	53.2%	3.60	39.9%	1.52	25.1%	0.38	20.1%	0.19
2	69.3%	7.92	65.6%	6.74	50.3%	3.04	37.9%	1.30	23.9%	0.33	20.0%	0.19
3	67.4%	7.29	63.7%	6.15	48.2%	2.68	36.3%	1.15	22.9%	0.29	20.0%	0.19
4	66.1%	6.88	61.8%	5.64	46.5%	2.39	35.1%	1.03	22.1%	0.26	20.0%	0.19
5	65.1%	6.57	61.0%	5.41	45.5%	2.24	34.2%	0.96	21.7%	0.24	20.0%	0.19
6	64.9%	6.51	60.7%	5.35	45.2%	2.20	34.0%	0.94	21.5%	0.24	20.0%	0.19
7	70.3%	8.30	64.1%	6.28	46.0%	2.32	34.5%	0.98	21.9%	0.25	20.0%	0.19
8	76.3%	10.58	70.6%	8.38	52.6%	3.47	38.4%	1.35	22.8%	0.28	20.0%	0.19
9	80.2%	12.29	76.2%	10.54	60.0%	5.16	44.5%	2.11	26.8%	0.46	20.7%	0.21
10	83.0%	13.63	80.1%	12.24	66.1%	6.88	50.4%	3.06	31.6%	0.76	24.8%	0.36
11	85.6%	14.94	83.6%	13.96	70.9%	8.52	55.3%	4.04	36.0%	1.11	29.5%	0.61
12	88.4%	16.47	87.0%	15.72	74.0%	9.69	58.6%	4.80	39.0%	1.41	33.3%	0.88
13	90.6%	17.71	89.0%	16.84	76.5%	10.70	61.3%	5.50	41.5%	1.70	36.4%	1.15
14	92.8%	19.07	91.2%	18.07	79.6%	12.05	64.4%	6.36	44.0%	2.03	39.1%	1.42
15	94.9%	20.40	93.7%	19.62	82.7%	13.51	67.3%	7.28	46.4%	2.38	41.4%	1.70
16	95.9%	21.01	95.0%	20.46	84.0%	14.12	68.4%	7.62	47.1%	2.49	42.1%	1.78
17	94.6%	20.19	90.5%	17.66	82.8%	13.54	66.3%	6.95	44.5%	2.10	39.7%	1.50
18	92.5%	18.90	90.6%	17.71	77.4%	11.08	59.5%	5.03	40.6%	1.60	36.0%	1.11
19	90.1%	17.44	86.1%	15.24	70.2%	8.27	54.8%	3.93	37.2%	1.23	32.5%	0.82
20	84.5%	14.39	79.5%	12.01	65.9%	6.83	50.9%	3.14	34.1%	0.94	29.3%	0.60
21	79.6%	12.03	75.6%	10.31	61.5%	5.56	47.5%	2.55	31.5%	0.75	26.6%	0.45
22	76.0%	10.48	71.8%	8.84	57.7%	4.59	44.6%	2.11	29.3%	0.60	24.3%	0.34
23	73.0%	9.27	68.7%	7.75	54.8%	3.92	42.1%	1.78	27.5%	0.50	22.5%	0.27
24	70.9%	8.48	66.3%	6.95	52.2%	3.39	40.2%	1.54	26.0%	0.42	21.1%	0.22
AVG, DAILY CONSUMPTION (KW)		309.74		275.64		159.73		77.01		22.74		14.97

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.106 Daily Pump Consumption (Distributive w/ Primary): Model 5

Table G.107 Distributive w/ Primary System Annual Utility Cost: Model 5

DISTRIBUTIVE W/ PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	4.76	31	148	$ 0.09	$ 13.29
FEBRUARY	6.29	28	176	$ 0.09	$ 15.85
MARCH	31.74	31	984	$ 0.09	$ 88.57
APRIL	62.25	30	1867	$ 0.09	$ 168.07
MAY	127.01	31	3937	$ 0.09	$ 354.36
JUNE	227.54	30	6826	$ 0.09	$ 614.35
JULY	309.74	31	9602	$ 0.09	$ 864.19
AUGUST	275.64	31	8545	$ 0.09	$ 769.04
SEPTEMBER	159.73	30	4792	$ 0.09	$ 431.28
OCTOBER	77.01	31	2387	$ 0.09	$ 214.87
NOVEMBER	22.74	30	682	$ 0.09	$ 61.40
DECEMBER	14.97	31	464	$ 0.09	$ 41.76
ANNUAL UTILITY CONSUMPTION & COST			40411	KWH	$ 3,637.03

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 5 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS CONSUMPTION	13.11	BHP
	9.78	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	20.0%	0.08	20.0%	0.08	21.6%	0.10	35.7%	0.44	48.7%	1.13	62.4%	2.38
2	20.0%	0.08	20.0%	0.08	22.3%	0.11	34.4%	0.40	46.5%	0.98	59.8%	2.09
3	20.0%	0.08	20.0%	0.08	22.4%	0.11	33.1%	0.36	44.8%	0.88	57.9%	1.90
4	20.0%	0.08	20.0%	0.08	22.3%	0.11	32.1%	0.32	43.3%	0.80	56.5%	1.76
5	20.0%	0.08	20.0%	0.08	22.6%	0.11	31.4%	0.30	42.5%	0.75	55.4%	1.66
6	20.0%	0.08	20.0%	0.08	22.7%	0.11	31.1%	0.29	42.6%	0.76	56.3%	1.74
7	20.0%	0.08	20.0%	0.08	23.0%	0.12	33.5%	0.37	47.1%	1.02	61.9%	2.32
8	20.0%	0.08	20.0%	0.08	26.2%	0.18	37.9%	0.53	52.9%	1.45	67.2%	2.97
9	20.0%	0.08	20.0%	0.08	31.2%	0.30	42.5%	0.75	57.9%	1.90	71.7%	3.60
10	20.0%	0.08	20.0%	0.08	36.3%	0.47	47.1%	1.02	62.0%	2.33	75.2%	4.15
11	20.0%	0.08	20.0%	0.08	40.4%	0.65	50.6%	1.27	64.9%	2.68	78.8%	4.78
12	20.0%	0.08	21.3%	0.09	43.3%	0.80	53.0%	1.46	67.1%	2.95	81.0%	5.19
13	20.0%	0.08	23.0%	0.12	45.1%	0.90	54.8%	1.61	68.8%	3.18	82.8%	5.55
14	20.6%	0.09	25.1%	0.15	47.2%	1.03	57.2%	1.83	71.1%	3.51	85.1%	6.02
15	20.9%	0.09	27.3%	0.20	49.4%	1.18	59.8%	2.09	73.8%	3.92	87.3%	6.51
16	22.1%	0.11	28.9%	0.24	51.0%	1.30	61.5%	2.28	75.4%	4.19	88.8%	6.84
17	22.1%	0.11	25.0%	0.15	51.4%	1.33	62.1%	2.34	75.5%	4.21	88.2%	6.72
18	20.1%	0.08	28.1%	0.22	49.5%	1.18	60.3%	2.14	73.5%	3.88	86.3%	6.29
19	20.0%	0.08	24.3%	0.14	44.2%	0.85	54.8%	1.61	68.8%	3.18	82.6%	5.50
20	20.0%	0.08	21.1%	0.09	40.2%	0.64	49.7%	1.20	62.1%	2.34	75.2%	4.15
21	20.0%	0.08	20.0%	0.08	36.9%	0.49	46.0%	0.95	58.1%	1.91	70.4%	3.41
22	20.0%	0.08	20.0%	0.08	34.2%	0.39	42.8%	0.77	54.5%	1.58	66.7%	2.90
23	20.0%	0.08	20.0%	0.08	31.8%	0.32	40.2%	0.63	51.6%	1.34	63.7%	2.53
24	20.0%	0.08	20.0%	0.08	30.0%	0.27	38.1%	0.54	49.4%	1.18	61.6%	2.28
AVG, DAILY CONSUMPTION PER MONTH (KW)		1.95		2.58		13.01		25.51		52.05		93.25

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	72.2%	3.68	68.8%	3.18	53.2%	1.47	39.9%	0.62	25.1%	0.15	20.1%	0.08
2	69.3%	3.25	65.6%	2.76	50.3%	1.24	37.9%	0.53	23.9%	0.13	20.0%	0.08
3	67.4%	2.99	63.7%	2.52	48.2%	1.10	36.3%	0.47	22.9%	0.12	20.0%	0.08
4	66.1%	2.82	61.8%	2.31	46.5%	0.98	35.1%	0.42	22.1%	0.11	20.0%	0.08
5	65.1%	2.69	61.0%	2.22	45.5%	0.92	34.2%	0.39	21.7%	0.10	20.0%	0.08
6	64.9%	2.67	60.7%	2.19	45.2%	0.90	34.0%	0.39	21.5%	0.10	20.0%	0.08
7	70.3%	3.40	64.1%	2.57	46.0%	0.95	34.5%	0.40	21.9%	0.10	20.0%	0.08
8	76.3%	4.34	70.6%	3.44	52.6%	1.42	38.4%	0.55	22.8%	0.12	20.0%	0.08
9	80.2%	5.04	76.2%	4.32	60.0%	2.12	44.5%	0.86	26.8%	0.19	20.7%	0.09
10	83.0%	5.59	80.1%	5.02	66.1%	2.82	50.4%	1.26	31.6%	0.31	24.8%	0.15
11	85.6%	6.12	83.6%	5.72	70.9%	3.49	55.3%	1.66	36.0%	0.46	29.5%	0.25
12	88.4%	6.75	87.0%	6.44	74.0%	3.97	58.6%	1.97	39.0%	0.58	33.3%	0.36
13	90.6%	7.26	89.0%	6.90	76.5%	4.38	61.3%	2.25	41.5%	0.70	36.4%	0.47
14	92.8%	7.81	91.2%	7.41	79.6%	4.94	64.4%	2.61	44.0%	0.83	39.1%	0.58
15	94.9%	8.36	93.7%	8.04	82.7%	5.54	67.3%	2.98	46.4%	0.98	41.4%	0.69
16	95.9%	8.61	95.0%	8.39	84.0%	5.79	68.4%	3.12	47.1%	1.02	42.1%	0.73
17	94.6%	8.27	90.5%	7.24	82.8%	5.55	66.3%	2.85	44.5%	0.86	39.7%	0.61
18	92.5%	7.74	90.6%	7.26	77.4%	4.54	59.5%	2.06	40.6%	0.66	36.0%	0.46
19	90.1%	7.15	86.1%	6.25	70.2%	3.39	54.8%	1.61	37.2%	0.50	32.5%	0.34
20	84.5%	5.90	79.5%	4.92	65.9%	2.80	50.9%	1.29	34.1%	0.39	29.3%	0.25
21	79.6%	4.93	75.6%	4.22	61.5%	2.28	47.5%	1.05	31.5%	0.31	26.6%	0.18
22	76.0%	4.30	71.8%	3.62	57.7%	1.88	44.6%	0.87	29.3%	0.25	24.3%	0.14
23	73.0%	3.80	68.7%	3.17	54.8%	1.61	42.1%	0.73	27.5%	0.20	22.5%	0.11
24	70.9%	3.48	66.3%	2.85	52.2%	1.39	40.2%	0.63	26.0%	0.17	21.1%	0.09
AVG, DAILY CONSUMPTION (KW)		126.94		112.96		65.46		31.56		9.32		6.13

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.108 Daily Pump Consumption (Distributive): Model 5

Table G.109 Distributive System Annual Utility Cost: Model 5

DISTRIBUTIVE SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.95	31	60	$ 0.09	$ 5.44
FEBRUARY	2.58	28	72	$ 0.09	$ 6.50
MARCH	13.01	31	403	$ 0.09	$ 36.30
APRIL	25.51	30	765	$ 0.09	$ 68.88
MAY	52.05	31	1614	$ 0.09	$ 145.22
JUNE	93.25	30	2797	$ 0.09	$ 251.77
JULY	126.94	31	3935	$ 0.09	$ 354.16
AUGUST	112.96	31	3502	$ 0.09	$ 315.17
SEPTEMBER	65.46	30	1964	$ 0.09	$ 176.75
OCTOBER	31.56	31	978	$ 0.09	$ 88.06
NOVEMBER	9.32	30	280	$ 0.09	$ 25.16
DECEMBER	6.13	31	190	$ 0.09	$ 17.11
ANNUAL UTILITY CONSUMPTION & COST			16561	KWH	$ 1,490.51

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 5 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 48,082.80	$ 5,885.40	$ 309,965.88	$ 62,507.64	$ 11,476.53	$ 177,307.37	$ 2,767.28	$ 218,776.14	$ 600.00	$ 676.00	$ 2,580.00	$ 35,707.97	$ 144.00	$ 11,384.38	$ 753,141.73
PRIMARY/SECONDARY	$ 64,311.00	$ 6,354.60	$ 405,867.25	$ 83,604.30	$ 12,391.47	$ 230,059.45	$ 2,793.43	$ 220,843.51	$ 1,200.00	$ 1,352.00	$ 3,780.00	$ 63,138.72	$ 216.00	$ 17,076.57	$ 936,985.49
DISTRIBUTIVE W/ PRIMARY	$ 93,414.66	$ 8,575.50	$ 585,779.57	$ 121,439.06	$ 16,722.22	$ 331,111.54	$ 3,637.03	$ 287,537.00	$ 600.00	$ 676.00	$ 2,580.00	$ 35,707.97	$ 2,196.00	$ 173,611.78	$ 1,413,747.85
DISTRIBUTIVE	$ 67,287.36	$ 4,117.94	$ 410,115.73	$ 87,473.57	$ 8,029.99	$ 228,879.84	$ 1,490.51	$ 117,837.02	$ -	$ -	$ -	$ -	$ 2,052.00	$ 162,227.40	$ 919,059.98

GENERAL NOTES:

1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. 100% REDUNDANCY WAS ASSUMED FOR ALL PRIMARY AND SECONDARY PUMPING CONFIGURATIONS
13. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table G.110 30-Year Life-Cycle Cost Analysis: Model 5

System Checksums

By ACADEMIC

System - 006

Water Source Heat Pump

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 17; Outside Air: OADB/WB/HR: 95 / 73 / 95

CLG Space Peak — Mo/Hr: Sum of Peaks; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	75,144	75,144	25	0	0
Glass Solar	80,980	0	80,980	27	91,540	48
Glass/Door Cond	16,710	0	16,710	6	12,408	7
Wall Cond	6,574	1,598	8,173	3	6,376	3
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	104,264	76,743	181,007	60	110,324	58
Internal Loads						
Lights	22,474	5,618	28,092	9	22,474	12
People	42,746	0	42,746	14	24,547	13
Misc	18,049	0	18,049	6	18,049	10
Sub Total ==>	83,868	5,618	89,487	29	65,070	34
Ceiling Load	15,653	-15,653	0	0	14,872	8
Ventilation Load	0	0	36,273	12	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	3		3	0	3	0
Exhaust Heat		-5,675	-5,675	-2		
Sup. Fan Heat			2,823	1		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	203,788	61,034	303,718	100.00	190,869	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 4

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-65,068	21.50
Glass Solar	0	0	0.00
Glass/Door Cond	-65,841	-65,841	21.75
Wall Cond	-8,908	-11,162	3.69
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-74,749	-142,071	46.94
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-14,449	0	0.00
Ventilation Load	0	-64,310	21.25
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-101,671	-101,671	33.59
Exhaust Heat		5,398	-1.78
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-190,869	-302,653	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	90.0
Ra Plenum	81.0	64.5
Return	81.0	64.5
Ret/OA	82.4	58.3
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	8,853	8,853
Terminal	8,853	8,853
Main Fan	8,853	8,853
Sec Fan	0	0
Nom Vent	904	904
AHU Vent	904	904
Infil	0	0
MinStop/Rh	0	0
Return	8,853	8,853
Exhaust	904	904
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	10.2	10.2
cfm/ft²	1.08	1.08
cfm/ton	349.79	
ft²/ton	325.21	
Btu/hr·ft²	36.90	-36.77
No. People	99	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	25.3	303.7	267.2	8,853	82.6	63.7	61.2	55.0	51.9	54.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	25.3	303.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	8,231		
Part	0		
Int Door	0		
ExFlr	0		
Roof	5,040	0	0
Wall	4,240	975	23
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-302.7	8,853	58.3	90.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-302.7			

Figure G.76 System Checksums: Model 6

SYSTEM SUMMARY

DESIGN COOLING CAPACITIES

By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

		Peak Plant Loads								Block Plant Loads								
						Stg 1	Stg 2			Time					Stg 1	Stg 2		
		Main	Aux	Opt Vent	Misc	Desic	Desic	Base	Peak	Of	Main	Aux	Opt Vent	Misc	Desic	Desic	Base	Block
		Coil	Coil	Coil	Load	Cond	Cond	Utility	Total	Peak	Coil	Coil	Coil	Load	Cond	Cond	Utility	Total
Plant	System	ton	ton	ton	ton	ton	ton	ton	ton	mo/hr	ton	ton	ton	ton	ton	ton	ton	ton
GCHP		25.3	0.0	0.0	0.0	0.0	0.0	0.0	25.3	7/16	23.1	0.0	0.0	0.0	0.0	0.0	0.0	23.1
	System - 006	25.3	0.0	0.0	0.0	0.0	0.0	0.0	25.3	7/16	23.1	0.0	0.0	0.0	0.0	0.0	0.0	23.1
Building totals		25.3	0.0	0.0	0.0	0.0	0.0	0.0	25.3		23.1	0.0	0.0	0.0	0.0	0.0	0.0	23.1

Building peak load is 25.3 tons.

Building maximum block load of 23.1 tons occurs in July at hour 16 based on system simulation.

Figure G.77 Design Cooling Capacities: Model 6

Load / Airflow Summary

By ACADEMIC

System Zone Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
Alternative 1													
201 - Lobby	Rm Peak	1,250	12.5	48,421	51,289	2,017	9.68	0	0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Peak	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
Zone - 001	Zn Block	1,250	12.5	48,421	51,289	2,017			0	-57,323	2,017	6.8	6.8
205 - Corridor	Rm Peak	175	0.0	2,343	2,655	55	1.90	0	0	-2,036	55	19.0	19.0
207 - Server	Rm Peak	475	0.0	4,625	5,407	197	2.49	0	0	-6,639	197	14.5	14.5
Zone - 002	Zn Peak	650	0.0	6,968	8,062	252			0	-8,675	252	15.5	15.5
Zone - 002	Zn Block	650	0.0	6,942	8,006	252			0	-9,636	252	15.5	15.5
202 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
203 - Interview	Rm Peak	100	2.5	4,495	5,501	200	12.01	0	0	-6,439	200	12.2	12.2
204 - Stair	Rm Peak	242	0.0	9,080	8,949	413	10.25	0	0	-10,804	413	3.5	3.5
Zone - 003	Zn Peak	438	2.5	15,704	16,579	630			0	-17,638	630	6.2	6.2
Zone - 003	Zn Block	438	2.5	14,938	15,540	630			0	-18,598	630	6.2	6.2
208 - 911 Dispatch	Rm Peak	625	31.3	19,243	28,340	471	4.52	0	0	-29,920	471	57.8	57.8
212 - Records	Rm Peak	625	0.0	7,608	9,567	108	1.04	0	0	-7,743	108	69.2	69.2
Zone - 004	Zn Peak	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
Zone - 004	Zn Block	1,250	31.3	26,851	37,907	579			0	-37,663	579	59.9	59.9
209 - Office	Rm Peak	100	0.5	1,856	2,165	52	3.11	0	0	-1,815	52	16.4	16.4
210 - Toilet	Rm Peak	96	0.0	2,129	2,129	17	1.30	0	0	-395	17	0.0	0.0
211 - Break room	Rm Peak	160	4.0	3,725	4,954	102	3.81	0	0	-4,453	102	29.1	29.1
213 - Office	Rm Peak	140	0.7	2,261	2,596	96	4.13	0	0	-3,108	96	12.3	12.3
Zone - 005	Zn Peak	496	5.2	9,970	11,844	266			0	-9,770	266	18.8	18.8
Zone - 005	Zn Block	496	5.2	9,606	11,474	266			0	-9,973	266	18.8	18.8
215 - Open Office (Ext)	Rm Peak	1,350	6.8	46,331	46,783	2,107	9.37	0	0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Peak	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
Zone - 006	Zn Block	1,350	6.8	46,331	46,783	2,107			0	-57,902	2,107	5.4	5.4
216 - Office	Rm Peak	300	1.5	11,378	11,876	459	9.18	0	0	-12,642	459	5.6	5.6
217 - Work Area	Rm Peak	200	0.0	2,712	3,100	65	1.95	0	0	-2,370	65	18.5	18.5
Zone - 007	Zn Peak	500	1.5	14,090	14,976	524			0	-15,012	524	7.2	7.2
Zone - 007	Zn Block	500	1.5	13,954	14,527	524			0	-16,077	524	7.2	7.2
218 - Conference	Rm Peak	350	17.5	10,551	15,238	320	5.48	0	0	-15,067	320	33.9	33.9
219 - Office	Rm Peak	300	1.5	8,116	9,126	279	5.58	0	0	-8,376	279	9.1	9.1
Zone - 008	Zn Peak	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
Zone - 008	Zn Block	650	19.0	18,666	24,365	599			0	-23,443	599	22.4	22.4
215 - Open Office (Int)	Rm Peak	400	2.0	2,469	3,592	93	1.39	0	0	-4,540	93	36.8	36.8
223 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0

* This report does not display heating only systems .

Figure G.78 Load/Airflow Summary (1 of 4): Model 6

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		224 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
	Zone - 009		Zn Peak	600	2.0	4,451	5,573	127			0	5,362	127	26.7	26.7
	Zone - 009		Zn Block	600	2.0	4,464	5,571	127			0	-6,669	127	26.7	26.7
		220 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		221 - Workroom	Rm Peak	100	0.0	881	1,057	38	2.27	0	0	1,311	38	15.9	15.9
		222 - Office	Rm Peak	225	1.1	7,699	8,435	274	7.29	0	0	-7,808	274	7.0	7.0
	Zone - 010		Zn Peak	425	1.1	10,224	11,473	349			0	-10,845	349	10.6	10.6
	Zone - 010		Zn Block	425	1.1	10,224	11,473	349			0	-11,936	349	10.6	10.6
		225 - Records	Rm Peak	175	0.0	2,172	2,471	42	1.45	0	0	-1,728	42	24.8	24.8
		226 - Breakroom	Rm Peak	100	2.5	1,974	2,690	46	2.78	0	0	-2,375	46	39.9	39.9
		227 - Storage	Rm Peak	100	0.0	1,217	1,531	17	1.04	0	0	-1,239	17	69.2	69.2
		228 - Electrical	Rm Peak	100	0.0	1,530	1,707	38	2.27	0	0	-1,311	38	15.9	15.9
		229 - Conference	Rm Peak	450	22.5	17,536	23,862	557	7.43	0	0	-22,848	557	25.0	25.0
	Zone - 011		Zn Peak	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
	Zone - 011		Zn Block	925	25.0	24,429	32,261	701			0	-29,501	701	26.6	26.6
		214 - PS Office	Rm Peak	425	12.1	17,365	21,270	777	10.97	0	0	-24,383	777	11.1	11.1
	Zone - 012		Zn Peak	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
	Zone - 012		Zn Block	425	12.1	17,365	21,270	777			0	-24,383	777	11.1	11.1
		103 - Elev Equip	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		104 - Storage	Rm Peak	150	0.0	978	1,497	34	1.37	0	0	-2,055	34	52.5	52.5
		108 - Quartermaster	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 013		Zn Peak	350	0.5	2,040	3,008	75			0	-4,015	75	43.5	43.5
	Zone - 013		Zn Block	350	0.5	2,045	3,007	75			0	-5,425	75	43.5	43.5
		105 - EOC	Rm Peak	1,250	83.3	38,434	62,341	1,194	5.73	0	0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Peak	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
	Zone - 014		Zn Block	1,250	83.3	38,434	62,341	1,194			0	-76,602	1,194	58.6	58.6
		111 - CD	Rm Peak	880	4.4	5,432	7,902	204	1.39	0	0	-9,988	204	36.8	36.8
	Zone - 015		Zn Peak	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
	Zone - 015		Zn Block	880	4.4	5,432	7,902	204			0	-9,988	204	36.8	36.8
		112 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		113 - Files	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		114 - Storage	Rm Peak	200	0.0	1,110	1,749	35	1.04	0	0	-2,478	35	69.2	69.2
	Zone - 016		Zn Peak	400	1.0	2,345	3,545	81			0	-4,748	81	50.7	50.7
	Zone - 016		Zn Block	400	1.0	2,345	3,545	81			0	-5,571	81	50.7	50.7
		121 - Armory	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		122 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		123 - Storage	Rm Peak	36	0.0	200	315	6	1.04	0	0	-446	6	69.2	69.2
	Zone - 017		Zn Peak	236	0.5	1,372	2,087	47			0	-2,820	47	53.1	53.1
	Zone - 017		Zn Block	236	0.5	1,372	2,087	47			0	-4,760	47	53.1	53.1
		115 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		116 - Holding	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9

* This report does not display heating only systems .

Figure G.79 Load/Airflow Summary (2 of 4): Model 6

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
		117 - Toilet	Rm Peak	100	0.0	991	991	17	1.04	0	0	-411	17	0.0	0.0
		118 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		119 - Interview	Rm Peak	100	2.5	1,420	2,253	46	2.78	0	0	-2,789	46	52.9	52.9
		120 - Patrol	Rm Peak	800	53.3	24,457	39,651	757	5.68	0	0	-48,864	757	59.2	59.2
	Zone - 018		Zn Peak	1,300	63.3	31,126	49,652	960			0	-60,431	960	56.9	56.9
	Zone - 018		Zn Block	1,300	63.3	31,115	49,641	960			0	-60,430	960	56.9	56.9
		124 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		125 - Office	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
		126 - Warrant	Rm Peak	100	0.5	617	898	23	1.39	0	0	-1,135	23	36.8	36.8
	Zone - 019		Zn Peak	300	1.5	1,852	2,694	69			0	-3,405	69	36.8	36.8
	Zone - 019		Zn Block	300	1.5	1,852	2,694	69			0	-5,298	69	36.8	36.8
		127 - Lab	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
		128 - Drugs	Rm Peak	100	0.0	555	874	17	1.04	0	0	-1,239	17	69.2	69.2
	Zone - 020		Zn Peak	200	0.0	1,110	1,749	35			0	-2,478	35	69.2	69.2
	Zone - 020		Zn Block	200	0.0	1,110	1,749	35			0	-4,474	35	69.2	69.2
		129 - Prop/Evid	Rm Peak	360	0.0	1,999	3,148	62	1.04	0	0	-4,460	62	69.2	69.2
		130 - Processing	Rm Peak	150	7.5	3,606	5,821	113	4.52	0	0	-7,181	113	57.8	57.8
	Zone - 021		Zn Peak	510	7.5	5,604	8,969	175			0	-11,641	175	61.8	61.8
	Zone - 021		Zn Block	510	7.5	5,604	8,968	175			0	-11,641	175	61.8	61.8
		131 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		132 - Cell	Rm Peak	180	4.5	2,555	4,055	83	2.78	0	0	-5,020	83	52.9	52.9
		133 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
	Zone - 022		Zn Peak	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
	Zone - 022		Zn Block	348	8.7	4,940	7,839	161			0	-9,705	161	52.9	52.9
		134 - Jail	Rm Peak	175	0.0	972	1,530	30	1.04	0	0	-2,168	30	69.2	69.2
		135 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		136 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		137 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		138 - Cell	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		139 - Holding	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		140 - Irtox	Rm Peak	84	2.1	1,192	1,892	39	2.78	0	0	-2,343	39	52.9	52.9
		141 - Booking	Rm Peak	270	13.5	6,491	10,477	203	4.52	0	0	-12,926	203	57.8	57.8
	Zone - 023		Zn Peak	949	26.1	14,617	23,360	467			0	-29,150	467	56.1	56.1
	Zone - 023		Zn Block	949	26.1	14,617	23,360	467			0	-29,149	467	56.1	56.1
		142 - Mech	Rm Peak	150	0.0	1,176	1,452	49	1.41	0	0	-1,704	49	10.2	10.2
		143 - Storage	Rm Peak	150	0.0	940	1,424	31	1.23	0	0	-1,971	31	58.6	58.6
		146 - Sallyport	Rm Peak	900	0.0	17,172	20,087	481	3.21	0	0	-18,860	481	22.5	22.5
	Zone - 024		Zn Peak	1,200	0.0	19,287	22,963	561			0	-22,535	561	24.1	24.1
	Zone - 024		Zn Block	1,200	0.0	18,920	22,838	561			0	-22,622	561	24.1	24.1
		144 - Kitchen	Rm Peak	150	0.0	667	919	26	1.04	0	0	-1,238	26	34.6	34.6
		145 - Safety	Rm Peak	150	7.5	3,690	5,939	117	4.68	0	0	-7,276	117	55.8	55.8

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Figure G.80 Load/Airflow Summary (3 of 4): Model 6

System	Zone	Room **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	VAV Minimum %	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg
	Zone - 025		Zn Peak	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
	Zone - 025		Zn Block	300	7.5	4,357	6,858	143			0	-8,514	143	51.9	51.9
		110 - Corridor	Rm Peak	475	0.0	12,940	13,837	577	7.29	0	0	-15,659	577	4.9	4.9
		147 - Conference	Rm Peak	240	12.0	8,839	11,895	296	7.41	0	0	-12,162	296	25.1	25.1
	Zone - 026		Zn Peak	715	12.0	21,779	25,733	874			0	-27,821	874	11.8	11.8
	Zone - 026		Zn Block	715	12.0	21,017	25,322	874			0	-27,821	874	11.8	11.8
		148 - Office	Rm Peak	240	1.2	7,223	7,990	259	6.47	0	0	-7,551	259	7.9	7.9
		150 - Storage	Rm Peak	100	0.0	1,644	1,980	38	2.27	0	0	-1,725	38	31.7	31.7
		151 - Toilet	Rm Peak	100	0.0	1,418	1,418	38	2.27	0	0	-897	38	0.0	0.0
		152 - Office	Rm Peak	225	1.1	3,401	4,066	78	2.07	0	0	-3,165	78	24.6	24.6
	Zone - 027		Zn Peak	665	2.3	13,685	15,454	412			0	-13,338	412	12.5	12.5
	Zone - 027		Zn Block	665	2.3	13,622	15,439	412			0	-13,436	412	12.5	12.5
		109 - Corridor	Rm Peak	100	0.0	444	613	17	1.04	0	0	-825	17	34.6	34.6
		110 - Corridor (Int)	Rm Peak	475	0.0	2,111	2,911	82	1.04	0	0	-3,919	82	34.6	34.6
		149 - Reception	Rm Peak	320	9.1	10,443	12,832	161	3.03	0	0	-8,308	161	40.2	40.2
		153 - Office	Rm Peak	225	1.1	2,875	3,498	52	1.39	0	0	-2,554	52	36.8	36.8
	Zone - 028		Zn Peak	1,120	10.3	15,873	19,854	313			0	-15,606	313	37.9	37.9
	Zone - 028		Zn Block	1,120	10.3	15,802	19,639	313			0	-15,606	313	37.9	37.9
		154 - Locker	Rm Peak	400	0.0	4,656	4,656	104	1.55	0	0	-2,458	104	0.0	0.0
		155 - Men	Rm Peak	400	0.0	3,963	3,963	69	1.04	0	0	-1,644	69	0.0	0.0
	Zone - 029		Zn Peak	800	0.0	8,619	8,619	173			0	-4,102	173	0.0	0.0
	Zone - 029		Zn Block	800	0.0	8,619	8,619	173			0	-7,754	173	0.0	0.0
		156 - Women	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		157 - Locker	Rm Peak	225	0.0	2,229	2,229	39	1.04	0	0	-925	39	0.0	0.0
		158 - Toilet	Rm Peak	100	0.0	1,691	1,691	55	3.28	0	0	-1,298	55	0.0	0.0
		159 - Mech	Rm Peak	100	0.0	1,796	1,963	55	3.28	0	0	-1,712	55	11.0	11.0
	Zone - 030		Zn Peak	650	0.0	7,946	8,113	187			0	-4,860	187	3.2	3.2
	Zone - 030		Zn Block	650	0.0	7,777	7,962	187			0	-8,098	187	3.2	3.2
		160 - Workout	Rm Peak	575	2.9	48,899	51,906	2,044	21.33	0	0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Peak	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
	Zone - 031		Zn Block	575	2.9	48,899	51,906	2,044			0	-54,842	2,044	4.5	4.5
		101 - Lobby (Ext)	Rm Peak	420	0.0	2,973	3,712	128	1.82	0	0	-4,763	128	19.8	19.8
		101 - Lobby (Int)	Rm Peak	154	0.0	684	944	27	1.04	0	0	-1,271	27	34.6	34.6
		106 - Breakroom	Rm Peak	100	2.5	1,309	2,034	46	2.78	0	0	-2,375	46	39.9	39.9
	Zone - 032		Zn Peak	674	2.5	4,966	6,691	201			0	-8,409	201	26.4	26.4
	Zone - 032		Zn Block	674	2.5	4,977	6,689	201			0	-8,409	201	26.4	26.4
System - 001			**Sys Peak**	**22,381**	**353.3**	**497,753**	**621,719**	**17,305**				**-672,528**	**17,305**	**22.0**	**22.0**
System - 001			**Sys Block**	**22,381**	**353.3**	**439,737**	**574,626**	**17,305**				**-672,612**	**17,305**	**22.0**	**22.0**

* This report does not display heating only systems .

Figure G.81 Load/Airflow Summary (4 of 4): Model 6

BUILDING COOL HEAT DEMAND

By ACADEMIC

January	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	6.2	5.4	-93,209	0.0	-114,488	0.7	-114,542	0.7	-118,200	0.7	-118,046	0.7
2	5.0	4.1	-96,739	0.3	-118,916	0.7	-118,964	0.7	-122,712	0.6	-122,674	0.6
3	4.2	3.3	-99,489	0.5	-122,649	0.7	-122,701	0.6	-126,953	0.6	-126,979	0.6
4	3.9	3.2	-101,705	0.6	-124,766	0.7	-129,945	0.6	-130,650	0.6	-130,710	0.6
5	4.3	3.5	-103,199	0.6	-125,932	0.7	-131,553	0.6	-131,965	0.6	-132,041	0.6
6	5.4	4.4	-103,758	0.6	-125,143	0.7	-130,755	0.6	-131,175	0.6	-131,258	0.6
7	7.1	6.2	-102,898	0.7	-123,359	0.7	-128,845	0.7	-129,258	0.7	-129,343	0.7
8	9.3	8.3	-103,719	0.7	-119,711	0.7	-124,924	0.7	-125,322	0.7	-125,405	0.7
9	11.8	10.8	-86,983	0.7	-109,834	0.7	-114,032	0.7	-114,411	0.7	-114,505	0.7
10	14.4	13.3	-65,871	0.7	-94,924	0.7	-99,019	0.7	-99,377	0.7	-99,461	0.7
11	16.9	15.4	-34,320	0.8	-77,638	0.7	-81,499	0.7	-81,836	0.7	-81,876	0.7
12	19.1	17.3	-16,607	0.8	-64,884	0.8	-68,355	0.8	-68,672	0.8	-68,717	0.8
13	20.8	18.6	-11,968	0.9	-57,033	0.8	-59,984	0.8	-60,280	0.8	-60,326	0.8
14	21.9	19.5	-8,551	0.9	-51,239	0.8	-51,268	0.8	-53,898	0.8	-53,944	0.8
15	22.3	19.6	-5,991	1.1	-45,415	0.8	-45,443	0.8	-45,445	0.8	-45,446	0.8
16	22.0	19.3	-2,644	2.5	-41,870	0.8	-41,896	0.8	-41,899	0.8	-41,899	0.8
17	21.2	18.7	-2,774	2.8	-44,622	0.8	-44,657	0.8	-44,663	0.8	-44,664	0.8
18	20.0	17.7	-10,874	1.3	-58,133	0.8	-58,158	0.8	-58,162	0.8	-58,162	0.8
19	18.3	16.4	-18,655	0.9	-72,905	0.8	-72,928	0.8	-72,931	0.8	-72,931	0.8
20	16.4	14.8	-25,796	0.8	-85,278	0.7	-85,299	0.7	-85,302	0.7	-85,302	0.7
21	14.2	13.0	-53,514	0.9	-91,856	0.7	-91,875	0.7	-91,878	0.7	-91,878	0.7
22	12.0	10.8	-72,029	0.8	-97,758	0.7	-97,776	0.7	-97,778	0.7	-97,778	0.7
23	9.9	8.8	-81,746	0.8	-103,519	0.7	-103,535	0.7	-103,537	0.7	-103,537	0.7
24	7.9	6.9	-89,024	0.8	-109,120	0.7	-109,135	0.7	-112,489	0.7	-112,610	0.7

February	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	17.2	16.3	-74,690	0.8	-78,050	0.8	-86,983	0.8	-87,014	0.8	-87,016	0.8
2	15.3	14.4	-78,607	0.8	-87,854	0.8	-91,838	0.8	-91,866	0.8	-91,868	0.8
3	13.7	12.7	-81,791	0.8	-95,329	0.7	-96,271	0.7	-96,295	0.7	-96,297	0.7
4	12.4	11.4	-84,279	0.8	-99,682	0.7	-100,141	0.7	-100,162	0.7	-100,164	0.7
5	11.3	10.5	-85,937	0.8	-103,207	0.7	-103,602	0.7	-103,621	0.7	-103,623	0.7
6	10.7	10.0	-88,934	0.8	-105,933	0.7	-106,273	0.7	-106,291	0.7	-106,292	0.7
7	10.5	9.9	-85,815	0.8	-107,911	0.7	-108,205	0.7	-108,220	0.7	-108,222	0.7
8	11.1	10.6	-84,150	0.8	-107,398	0.7	-107,652	0.7	-107,666	0.7	-107,668	0.7
9	12.8	12.2	-62,819	0.8	-97,806	0.7	-98,026	0.7	-98,039	0.7	-98,040	0.7
10	15.3	14.4	-36,095	0.9	-82,941	0.7	-83,133	0.7	-83,144	0.7	-83,145	0.7
11	18.5	16.9	-16,318	1.1	-65,389	0.8	-65,556	0.8	-65,566	0.8	-65,567	0.8
12	21.8	19.8	-8,209	1.3	-52,861	0.8	-53,007	0.8	-53,016	0.8	-53,017	0.8
13	25.0	22.6	-5,010	1.4	-44,619	0.8	-44,718	0.8	-44,724	0.8	-44,725	0.8
14	27.5	24.8	0	1.6	-36,750	0.9	-36,845	0.9	-36,851	0.9	-36,852	0.9
15	29.2	26.3	0	3.0	-28,379	0.9	-28,467	0.9	-28,472	0.9	-28,473	0.9
16	29.8	26.8	0	4.3	-22,301	1.0	-22,378	0.9	-22,383	0.9	-22,384	0.9
17	29.6	26.8	-678	4.4	-22,263	1.0	-22,333	1.0	-22,337	1.0	-22,338	1.0
18	29.0	26.4	0	3.5	-24,646	1.0	-24,709	1.0	-24,713	1.0	-24,713	1.0
19	28.0	25.7	0	1.6	-36,257	0.9	-36,351	0.9	-36,358	0.9	-36,359	0.9
20	26.6	25.0	-330	1.1	-53,758	0.9	-53,815	0.9	-53,819	0.9	-53,820	0.9
21	25.0	23.5	-3,388	1.0	-64,745	0.9	-64,795	0.9	-64,799	0.9	-64,800	0.9
22	23.1	21.9	-15,992	1.0	-71,050	0.8	-71,094	0.8	-71,097	0.8	-71,098	0.8
23	21.2	20.1	-53,036	0.9	-76,772	0.8	-76,811	0.8	-76,814	0.8	-76,814	0.8
24	19.1	18.2	-61,549	0.8	-82,136	0.8	-82,170	0.8	-82,173	0.8	-82,173	0.8

Figure G.82 Building Cool Heat Demand (1 of 6): Model 6

BUILDING COOL HEAT DEMAND

By ACADEMIC

March	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.4	33.4	-20,857	1.3	-790	1.2	-30,476	1.2	-30,586	1.2	-30,599	1.2
2	33.9	31.9	-22,521	1.3	-21,767	1.1	-37,575	1.1	-37,678	1.1	-37,691	1.1
3	32.9	31.1	-27,169	1.3	-27,296	1.1	-42,306	1.1	-42,313	1.1	-42,325	1.1
4	32.6	31.1	-29,304	1.3	-39,984	1.0	-42,548	1.0	-43,707	1.0	-43,766	1.0
5	32.9	31.5	-31,334	1.3	-44,541	1.1	-47,514	1.0	-47,402	1.0	-47,493	1.0
6	33.9	32.5	-32,019	1.3	-44,017	1.1	-48,739	1.1	-49,173	1.1	-49,180	1.1
7	35.4	34.2	-30,241	1.3	-44,961	1.1	-48,052	1.1	-48,153	1.1	-50,210	1.1
8	37.4	36.1	-21,102	1.5	-37,735	1.2	-42,611	1.2	-43,363	1.2	-42,891	1.2
9	39.7	37.9	-10,968	1.8	-26,248	1.4	-30,568	1.4	-31,079	1.4	-30,798	1.4
10	42.1	39.6	-561	1.9	-17,410	1.5	-20,718	1.5	-21,051	1.5	-20,883	1.5
11	44.6	41.5	-98	2.7	-8,881	1.6	-10,510	1.6	-10,734	1.6	-10,635	1.6
12	46.9	43.0	0	4.9	-3,027	1.6	-3,113	1.6	-3,114	1.6	-3,114	1.6
13	48.9	44.3	0	6.5	-365	1.6	-359	1.6	-359	1.6	-360	1.6
14	50.4	45.0	0	8.3	-27	1.6	-34	1.6	-34	1.6	-34	1.6
15	51.4	45.4	0	9.2	0	1.8	0	1.8	0	1.8	0	1.8
16	51.7	45.5	0	10.6	0	2.7	0	2.7	0	2.7	0	2.7
17	51.4	45.1	0	11.5	0	3.3	0	3.3	0	3.3	0	3.3
18	50.4	44.2	0	10.3	0	3.1	0	3.1	0	3.1	0	3.1
19	48.9	43.4	0	7.7	0	2.2	0	2.2	0	2.2	0	2.2
20	46.9	42.8	0	4.9	0	1.7	0	1.7	0	1.7	0	1.7
21	44.6	41.4	0	2.8	-197	1.5	-208	1.5	-209	1.5	-209	1.5
22	42.1	39.6	0	2.2	-480	1.4	-491	1.4	-491	1.4	-491	1.4
23	39.7	37.4	-818	1.9	-5,337	1.3	-5,646	1.3	-5,691	1.3	-5,694	1.3
24	37.4	35.0	0	1.6	-21,245	1.2	-21,358	1.2	-21,371	1.2	-21,372	1.2

April	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	48.1	46.0	-4,021	1.8	-853	1.9	-53	1.7	-102	1.7	-105	1.8
2	45.9	44.2	-6,347	1.8	0	1.6	-336	1.6	-379	1.6	-382	1.6
3	44.1	42.4	-8,560	1.7	-39	1.5	-3,118	1.5	-3,158	1.5	-3,160	1.5
4	42.5	40.9	-10,143	1.7	-5,865	1.4	-13,221	1.4	-13,255	1.4	-13,258	1.4
5	41.3	39.8	-11,228	1.7	-15,094	1.4	-15,959	1.4	-15,974	1.4	-15,975	1.4
6	40.6	39.3	-11,708	1.7	-17,058	1.3	-18,568	1.3	-18,581	1.3	-18,582	1.3
7	40.4	39.1	-9,422	1.9	-19,444	1.4	-22,805	1.3	-22,816	1.3	-22,817	1.3
8	41.1	39.7	-5,172	2.3	-19,793	1.5	-20,577	1.5	-20,586	1.5	-20,586	1.5
9	43.0	40.8	-186	2.8	-15,400	1.6	-15,535	1.6	-15,543	1.6	-15,543	1.6
10	45.9	42.4	0	4.4	-9,313	1.7	-9,422	1.7	-9,429	1.7	-9,430	1.7
11	49.6	44.5	0	6.5	-485	1.9	-543	1.9	-547	1.9	-547	1.9
12	53.4	47.5	0	7.2	-57	2.3	-106	2.3	-109	2.3	-109	2.3
13	57.0	50.1	0	9.9	0	3.0	0	3.0	0	3.0	0	3.0
14	60.0	52.3	0	11.6	0	3.9	0	3.9	0	3.9	0	3.9
15	61.9	53.7	0	13.6	-133	5.8	0	5.8	0	5.8	0	5.8
16	62.6	53.9	0	14.4	0	6.8	0	6.8	0	6.8	0	6.8
17	62.3	53.9	0	14.5	0	6.8	0	6.8	0	6.8	0	6.8
18	61.6	53.4	0	13.5	0	6.3	0	6.4	0	6.4	0	6.4
19	60.5	52.6	0	11.2	0	5.6	0	5.6	0	5.6	0	5.6
20	58.9	52.7	0	8.5	0	4.3	0	4.3	0	4.3	0	4.3
21	57.0	52.5	0	5.9	0	3.0	0	3.1	0	3.1	0	3.1
22	54.9	51.5	0	4.1	-70	2.5	-73	2.5	-76	2.5	-77	2.5
23	52.6	50.0	-1	3.1	-525	2.2	-536	2.2	-537	2.2	-537	2.2
24	50.3	48.0	0	2.5	0	1.9	0	1.9	0	1.9	0	1.9

Figure G.83 Building Cool Heat Demand (2 of 6): Model 6

BUILDING COOL HEAT DEMAND

By ACADEMIC

May	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	59.2	56.0	0	3.4	0	3.4	0	3.3	0	3.4	0	3.4
2	56.8	53.8	0	3.5	0	2.9	-84	2.8	-92	2.8	-93	2.8
3	54.8	52.2	0	3.2	0	2.5	-401	2.5	-409	2.5	-410	2.5
4	53.3	50.9	0	3.1	-540	2.3	-728	2.3	-735	2.3	-735	2.3
5	52.3	50.2	-75	2.9	-848	2.2	0	2.1	0	2.1	0	2.1
6	52.0	50.3	-138	3.0	0	2.0	0	2.0	0	2.0	0	2.1
7	52.5	50.8	-113	3.9	-952	2.2	0	2.2	-17	2.2	-28	2.2
8	53.8	51.6	0	5.7	0	2.5	-6	2.5	-65	2.6	-75	2.6
9	55.9	52.4	0	8.0	-599	3.7	-586	4.0	-608	4.0	-610	4.0
10	58.5	53.8	0	10.3	-227	4.8	-266	5.0	-269	5.0	-269	5.0
11	61.6	55.1	0	11.9	0	5.5	0	5.7	0	5.7	0	5.7
12	64.7	56.6	0	13.2	0	6.0	0	6.0	0	6.0	0	6.1
13	67.8	58.2	0	14.3	0	6.8	0	6.9	0	6.9	0	6.9
14	70.4	59.6	0	15.5	0	9.1	0	9.2	0	9.2	0	9.2
15	72.5	61.1	0	16.8	0	10.5	0	10.5	0	10.6	0	10.6
16	73.8	62.4	0	17.8	0	11.1	0	11.2	0	11.2	0	11.3
17	74.3	62.8	0	17.9	0	11.1	0	11.2	0	11.3	0	11.3
18	74.0	62.6	0	17.1	0	10.5	0	10.5	0	10.6	0	10.6
19	73.0	62.1	0	15.3	0	9.7	0	9.7	0	9.7	0	9.7
20	71.5	62.0	0	12.6	0	8.3	0	8.4	0	8.4	0	8.4
21	69.5	63.0	0	9.9	0	7.0	0	7.0	0	7.0	0	7.0
22	67.1	61.9	0	7.6	0	5.7	0	5.7	0	5.7	0	5.7
23	64.5	59.9	0	6.3	0	4.8	0	4.8	0	4.8	0	4.8
24	61.8	58.0	0	5.3	0	4.0	0	4.0	0	4.0	0	4.0

June	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	68.3	64.8	0	7.3	0	6.4	0	6.2	0	6.2	0	6.2
2	66.4	63.3	0	6.7	0	5.5	0	5.5	0	5.5	0	5.5
3	64.8	62.3	0	6.3	0	4.8	0	4.8	0	4.8	0	4.8
4	63.6	61.5	0	5.9	0	4.3	0	4.4	0	4.4	0	4.4
5	62.9	61.0	0	5.7	0	4.1	0	4.1	0	4.1	0	4.1
6	62.6	60.8	0	5.9	-3	4.0	0	4.1	0	4.1	0	4.1
7	63.1	61.4	0	7.8	0	4.7	-55	4.8	-55	4.8	-55	4.8
8	64.5	61.6	0	10.3	0	5.9	0	5.9	0	5.9	0	5.9
9	66.8	62.3	0	12.6	0	7.2	0	7.3	0	7.3	0	7.3
10	69.6	63.9	0	14.1	0	8.9	0	9.0	0	9.0	0	9.0
11	72.7	66.0	0	15.4	0	10.3	0	10.4	0	10.4	0	10.4
12	75.8	67.7	0	16.7	0	11.6	0	11.9	0	11.9	0	11.9
13	78.7	69.7	0	17.9	0	12.5	0	12.9	0	12.9	0	12.9
14	80.9	71.1	0	19.2	0	13.8	0	14.2	0	14.2	0	14.2
15	82.3	71.7	0	20.5	0	15.3	0	15.6	0	15.6	0	15.6
16	82.8	72.0	0	21.5	0	15.9	0	16.1	0	16.1	0	16.1
17	82.6	71.4	0	21.4	0	15.8	0	15.9	0	15.9	0	15.9
18	81.8	71.1	0	20.6	0	15.0	0	15.1	0	15.1	0	15.1
19	80.6	70.5	0	18.9	0	14.1	0	14.1	0	14.1	0	14.1
20	79.0	70.3	0	16.2	0	12.4	0	12.4	0	12.4	0	12.4
21	77.1	70.2	0	13.4	0	10.7	0	10.7	0	10.7	0	10.7
22	75.0	69.6	0	10.8	0	9.1	0	9.1	0	9.1	0	9.1
23	72.7	68.0	0	9.4	0	8.0	0	8.0	0	8.0	0	8.0
24	70.5	66.8	0	8.4	0	7.1	0	7.1	0	7.1	0	7.1

Figure G.84 Building Cool Heat Demand (3 of 6): Model 6

BUILDING COOL HEAT DEMAND

By ACADEMIC

July Hour	Typical Weather (°F) OADB	Typical Weather (°F) OAWB	Design Htg (Btuh)	Design Clg (Tons)	Weekday Htg (Btuh)	Weekday Clg (Tons)	Saturday Htg (Btuh)	Saturday Clg (Tons)	Sunday Htg (Btuh)	Sunday Clg (Tons)	Monday Htg (Btuh)	Monday Clg (Tons)
1	74.2	70.8	0	9.6	0	8.6	0	8.5	0	8.4	0	8.4
2	72.8	69.4	0	9.0	0	8.0	0	7.7	0	7.7	0	7.7
3	71.6	68.6	0	8.6	0	7.2	0	7.2	0	7.2	0	7.2
4	70.6	67.9	0	8.3	0	6.7	0	6.8	0	6.7	0	6.7
5	70.1	67.6	0	8.1	0	6.4	0	6.5	0	6.4	0	6.4
6	69.9	67.5	0	8.1	0	6.2	0	6.2	0	6.2	0	6.2
7	70.2	68.0	0	9.7	0	7.0	0	7.1	0	7.1	0	7.1
8	71.3	68.5	0	12.1	0	8.3	0	8.4	0	8.4	0	8.4
9	73.1	69.1	0	14.5	0	9.7	0	9.9	0	9.9	0	9.9
10	75.2	70.2	0	16.0	0	11.4	0	11.7	0	11.7	0	11.7
11	77.6	71.2	0	17.6	0	12.9	0	13.3	0	13.4	0	13.4
12	80.0	72.8	0	19.2	0	14.5	0	14.9	0	14.9	0	14.9
13	82.2	74.4	0	20.1	0	15.6	0	15.8	0	15.8	0	15.8
14	83.9	76.0	0	21.2	0	16.9	0	17.0	0	17.0	0	17.0
15	85.0	76.6	0	22.3	0	18.1	0	18.2	0	18.2	0	18.2
16	85.4	76.6	0	23.1	0	18.4	0	18.5	0	18.5	0	18.5
17	85.2	76.4	0	22.9	0	18.2	0	18.2	0	18.2	0	18.2
18	84.6	76.2	0	22.2	0	17.3	0	17.3	0	17.3	0	17.3
19	83.7	75.8	0	20.6	0	16.2	0	16.2	0	16.2	0	16.2
20	82.4	76.2	0	17.0	0	14.6	0	14.6	0	14.6	0	14.6
21	81.0	76.1	0	15.2	0	12.9	0	12.8	0	12.8	0	12.8
22	79.3	75.3	0	12.8	0	11.3	0	11.3	0	11.3	0	11.3
23	77.6	73.9	0	11.5	0	10.2	0	10.2	0	10.2	0	10.2
24	75.9	72.5	0	10.6	0	9.3	0	9.3	0	9.3	0	9.3

August Hour	Typical Weather (°F) OADB	Typical Weather (°F) OAWB	Design Htg (Btuh)	Design Clg (Tons)	Weekday Htg (Btuh)	Weekday Clg (Tons)	Saturday Htg (Btuh)	Saturday Clg (Tons)	Sunday Htg (Btuh)	Sunday Clg (Tons)	Monday Htg (Btuh)	Monday Clg (Tons)
1	73.5	69.6	0	8.9	0	8.1	0	8.0	0	8.0	0	8.0
2	71.7	68.0	0	8.2	0	7.2	0	7.2	0	7.2	0	7.2
3	70.1	66.8	0	7.8	0	6.5	0	6.6	0	6.6	0	6.6
4	68.8	65.7	0	7.4	0	6.0	0	6.1	0	6.1	0	6.1
5	67.8	65.2	0	7.2	0	5.6	0	5.7	0	5.7	0	5.7
6	67.2	64.7	0	7.2	0	5.3	0	5.3	0	5.3	0	5.3
7	66.9	64.4	0	8.1	0	5.6	0	5.6	0	5.6	0	5.6
8	67.5	64.6	0	10.4	0	6.7	0	6.7	0	6.7	0	6.7
9	69.2	64.9	0	13.0	0	8.1	0	8.1	0	8.1	0	8.1
10	71.7	66.0	0	15.2	0	10.0	0	10.2	0	10.2	0	10.2
11	74.8	67.8	0	17.2	0	11.8	0	12.2	0	12.2	0	12.2
12	78.0	70.0	0	18.9	0	13.5	0	14.0	0	14.0	0	14.0
13	81.1	72.2	0	19.9	0	14.7	0	15.1	0	15.1	0	15.1
14	83.6	73.7	0	21.0	0	16.0	0	16.3	0	16.3	0	16.3
15	85.3	74.8	0	22.2	0	17.4	0	17.5	0	17.6	0	17.6
16	85.9	75.3	0	22.7	0	18.0	0	18.0	0	18.0	0	18.0
17	85.6	75.0	0	22.4	0	17.5	0	17.5	0	17.5	0	17.5
18	85.0	74.0	0	21.6	0	16.3	0	16.3	0	16.3	0	16.3
19	84.0	75.0	0	19.0	0	14.9	0	14.9	0	14.9	0	14.9
20	82.7	75.4	0	16.2	0	13.4	0	13.4	0	13.4	0	13.4
21	81.1	75.8	0	13.6	0	12.0	0	12.0	0	12.0	0	12.0
22	79.3	74.7	0	11.6	0	10.8	0	10.8	0	10.8	0	10.8
23	77.4	73.1	0	10.4	0	9.8	0	9.8	0	9.8	0	9.8
24	75.4	71.1	0	9.6	0	8.8	0	8.8	0	8.8	0	8.8

Figure G.85 Building Cool Heat Demand (4 of 6): Model 6

BUILDING COOL HEAT DEMAND

By ACADEMIC

September	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	62.0	58.8	0	5.4	0	4.0	0	4.1	0	4.1	0	4.1
2	59.5	56.4	0	4.7	0	3.4	0	3.5	0	3.5	0	3.5
3	57.3	54.7	0	4.1	0	2.9	-93	3.0	-97	3.0	-97	3.0
4	55.7	53.3	0	3.7	-250	2.6	-371	2.7	-375	2.7	-375	2.7
5	54.7	52.7	0	3.6	-565	2.5	-651	2.5	-654	2.5	-655	2.5
6	54.4	52.4	0	3.5	-743	2.4	0	2.3	0	2.3	0	2.3
7	55.0	53.1	0	3.6	-800	2.4	-600	2.4	-694	2.4	-694	2.4
8	57.0	54.8	0	5.2	-702	2.7	0	2.7	0	2.7	0	2.7
9	60.0	56.2	0	8.4	-394	4.1	-256	4.2	-260	4.2	-261	4.2
10	63.7	57.6	0	11.6	0	5.5	0	5.6	0	5.6	0	5.6
11	67.9	59.7	0	13.9	0	6.8	0	6.9	0	6.9	0	6.9
12	72.1	61.7	0	15.4	0	8.9	0	9.0	0	9.0	0	9.0
13	75.9	64.1	0	16.6	0	11.3	0	11.6	0	11.7	0	11.7
14	78.9	65.7	0	18.0	0	12.6	0	13.0	0	13.1	0	13.1
15	80.8	66.9	0	19.4	0	13.7	0	14.0	0	14.0	0	14.0
16	81.5	67.1	0	20.1	0	14.1	0	14.2	0	14.3	0	14.3
17	81.1	67.1	0	19.8	0	13.6	0	13.7	0	13.7	0	13.7
18	80.1	67.3	0	17.6	0	12.4	0	12.4	0	12.4	0	12.4
19	78.5	68.0	0	14.6	0	10.9	0	11.0	0	11.0	0	11.0
20	76.4	69.9	0	11.8	0	9.6	0	9.7	0	9.7	0	9.7
21	73.8	68.7	0	9.5	0	8.3	0	8.3	0	8.3	0	8.3
22	70.9	66.5	0	7.9	0	7.2	0	7.2	0	7.2	0	7.2
23	67.9	64.2	0	6.7	0	6.2	0	6.2	0	6.2	0	6.2
24	64.9	61.3	0	5.8	0	5.1	0	5.1	0	5.1	0	5.1

October	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	46.2	40.6	0	2.7	0	1.7	-232	1.6	-270	1.6	-272	1.6
2	44.9	39.9	-200	2.4	0	1.6	-472	1.5	-484	1.5	-485	1.5
3	44.5	39.9	-489	2.3	-241	1.5	-6,527	1.5	-6,561	1.5	-6,563	1.5
4	44.9	40.5	-682	2.2	-2,665	1.5	-13,001	1.5	-13,016	1.5	-13,017	1.5
5	46.2	41.5	0	2.1	-12,960	1.5	-13,882	1.5	-13,894	1.5	-13,895	1.5
6	48.3	43.8	-645	2.1	-12,857	1.6	-14,157	1.5	-14,167	1.5	-14,168	1.5
7	51.0	46.5	0	2.1	-12,569	1.6	-13,403	1.6	-13,412	1.6	-13,413	1.6
8	54.2	49.8	-350	2.4	-8,984	1.8	-9,307	1.8	-9,315	1.8	-9,315	1.8
9	57.6	52.1	-150	3.6	-2,901	2.0	-3,201	2.0	-3,208	2.0	-3,208	2.0
10	61.0	53.5	0	5.9	-137	2.6	-190	2.6	-194	2.6	-194	2.6
11	64.1	55.0	0	7.9	0	2.8	0	2.8	0	2.8	0	2.8
12	66.9	56.1	0	10.9	0	3.9	0	3.7	0	3.7	0	3.7
13	68.9	57.1	0	12.3	0	5.3	0	5.3	0	5.3	0	5.3
14	70.3	57.3	0	13.9	0	7.2	0	7.2	0	7.2	0	7.2
15	70.7	57.2	0	15.3	0	8.0	0	8.1	0	8.1	0	8.1
16	70.3	56.4	0	15.8	0	8.2	0	8.2	0	8.2	0	8.2
17	69.9	55.3	0	14.9	0	7.9	0	7.9	0	7.8	0	7.8
18	66.9	53.9	0	12.4	0	6.6	0	6.6	0	6.6	0	6.6
19	64.1	52.7	0	9.6	0	5.1	0	5.1	0	5.1	0	5.1
20	61.0	52.0	0	6.9	0	3.6	0	3.6	0	3.6	0	3.6
21	57.6	49.8	0	5.5	0	2.9	0	2.9	0	2.9	0	2.9
22	54.2	47.5	0	4.4	-179	2.4	-182	2.4	-182	2.4	-182	2.4
23	51.0	44.9	0	3.5	-773	2.1	-776	2.1	-776	2.1	-776	2.1
24	48.3	42.6	0	3.0	0	1.8	0	1.8	0	1.8	0	1.8

Figure G.86 Building Cool Heat Demand (5 of 6): Model 6

BUILDING COOL HEAT DEMAND

By ACADEMIC

November	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	35.9	33.1	-690	1.4	-19,098	1.2	-35,688	1.2	-36,142	1.2	-36,178	1.2
2	33.9	31.2	-3,848	1.4	-23,609	1.1	-38,594	1.1	-39,072	1.1	-39,074	1.1
3	32.3	29.8	-17,461	1.3	-36,317	1.0	-45,335	1.1	-45,400	1.1	-45,379	1.1
4	31.0	28.8	-19,194	1.3	-44,341	1.1	-51,345	1.0	-51,926	1.0	-51,998	1.0
5	30.3	27.9	-25,410	1.2	-45,029	1.0	-54,930	1.0	-55,336	1.0	-55,386	1.0
6	30.0	27.7	-30,490	1.2	-49,970	1.0	-57,317	1.0	-57,817	1.0	-57,881	1.0
7	30.5	28.4	-31,799	1.3	-51,399	1.0	-58,799	1.0	-58,917	1.0	-58,924	1.0
8	32.0	30.0	-28,554	1.3	-52,389	1.0	-57,862	1.0	-57,928	1.0	-57,934	1.0
9	34.3	32.0	-14,642	1.5	-42,326	1.2	-47,166	1.2	-47,224	1.2	-47,230	1.2
10	37.1	34.0	-3,949	1.8	-30,269	1.3	-31,924	1.3	-31,975	1.3	-31,980	1.3
11	40.3	36.2	-607	1.9	-14,182	1.3	-15,871	1.3	-15,908	1.3	-15,912	1.3
12	43.5	38.3	-124	2.3	-6,532	1.4	-8,141	1.4	-6,901	1.4	-8,153	1.4
13	46.4	40.1	0	4.9	-3,807	1.5	-5,641	1.4	-5,257	1.5	-5,668	1.4
14	48.6	41.4	0	7.3	-2,492	1.5	-2,640	1.5	-2,458	1.5	-2,640	1.5
15	50.1	42.5	0	8.5	-254	1.5	-332	1.5	-231	1.5	-331	1.5
16	50.6	42.6	0	8.7	-109	1.6	-186	1.6	-92	1.6	-185	1.6
17	50.3	42.5	0	7.7	-53	1.6	-121	1.6	-40	1.6	-121	1.6
18	49.6	42.8	0	5.4	-95	1.7	-156	1.7	-84	1.7	-156	1.7
19	48.4	42.9	0	3.1	-230	1.6	-286	1.6	-221	1.6	-286	1.6
20	46.7	42.2	-69	2.2	-2,402	1.5	-2,425	1.5	-2,397	1.5	-2,425	1.5
21	44.8	41.1	-873	1.9	-4,414	1.5	-4,686	1.5	-4,652	1.5	-4,698	1.4
22	42.6	39.3	0	1.6	-11,248	1.4	-11,336	1.4	-11,324	1.4	-11,339	1.4
23	40.3	37.4	-299	1.6	-25,165	1.3	-25,257	1.3	-25,245	1.3	-25,266	1.3
24	38.0	35.3	-542	1.5	-30,672	1.2	-30,761	1.2	-30,747	1.2	-30,765	1.2

December	Typical Weather (°F)		Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)	Htg (Btuh)	Clg (Tons)
1	23.5	20.5	-38,014	1.2	-45,298	0.8	-66,542	0.8	-66,628	0.8	-66,636	0.8
2	22.9	20.1	-39,779	1.1	-55,484	0.8	-70,594	0.8	-70,670	0.8	-70,676	0.8
3	23.2	20.5	-45,434	1.1	-61,696	0.8	-74,142	0.8	-74,227	0.8	-74,238	0.8
4	24.1	21.7	-50,382	1.1	-64,220	0.9	-75,876	0.9	-75,936	0.9	-75,941	0.9
5	25.5	23.2	-52,307	1.0	-72,239	0.9	-75,482	0.9	-75,535	0.9	-75,539	0.9
6	27.4	25.1	-53,256	1.1	-72,369	0.9	-73,048	0.9	-73,095	0.9	-73,099	0.9
7	29.7	27.4	-52,822	1.1	-68,698	1.0	-69,275	1.0	-69,316	1.0	-69,319	1.0
8	32.3	30.1	-50,446	1.1	-64,083	1.0	-64,573	1.0	-64,609	1.0	-64,612	1.0
9	34.9	32.8	-36,458	1.3	-53,296	1.1	-53,714	1.1	-53,746	1.1	-53,749	1.1
10	37.6	34.9	-15,400	1.5	-38,122	1.3	-38,472	1.3	-38,500	1.3	-38,502	1.3
11	40.1	36.4	-6,359	1.7	-21,796	1.3	-22,002	1.3	-22,024	1.3	-22,025	1.3
12	42.4	37.4	-2,426	1.7	-9,560	1.3	-9,700	1.3	-9,718	1.3	-9,719	1.3
13	44.3	38.1	-104	2.0	-5,858	1.3	-5,924	1.3	-5,933	1.3	-5,933	1.3
14	45.7	38.4	0	4.6	-4,243	1.4	-4,346	1.4	-4,359	1.4	-4,360	1.4
15	46.6	38.6	0	6.4	-2,672	1.4	-2,627	1.4	-2,625	1.4	-2,625	1.4
16	46.9	38.6	0	6.9	-1,932	1.5	-1,927	1.5	-1,926	1.5	-1,925	1.5
17	46.3	38.2	0	5.9	-1,823	1.4	-1,818	1.4	-1,818	1.4	-1,817	1.4
18	44.6	37.6	0	4.1	-3,939	1.4	-3,935	1.4	-3,935	1.4	-3,935	1.4
19	42.0	36.6	0	2.0	-7,546	1.3	-7,543	1.3	-7,542	1.3	-7,542	1.3
20	38.6	34.1	0	1.7	-12,548	1.3	-12,667	1.3	-12,672	1.3	-12,672	1.3
21	34.9	30.9	-65	1.5	-28,445	1.2	-28,482	1.2	-28,484	1.2	-28,484	1.2
22	31.2	27.0	-432	1.4	-41,919	1.1	-44,335	1.1	-44,382	1.1	-44,380	1.1
23	27.9	24.4	-5,336	1.3	-52,761	0.9	-52,679	0.9	-52,721	0.9	-52,726	0.9
24	25.2	22.1	-22,113	1.2	-62,415	0.9	-62,075	0.9	-62,116	0.9	-62,120	0.9

Figure G.87 Building Cool Heat Demand (6 of 6): Model 6

Geothermal Earth Temperature Summary

By ACADEMIC

Geothermal Plant - Ground Heat Exchanger Temperatures

Alternative: 1 - M6 - Small Office Building

CCHP

	Year 1				
Month	Average Earth Temp. °F	Average Fluid Leaving Temp °F	Average Fluid Entering Temp. °F	Minimum Fluid Entering Temp. °F	Maximum Fluid Entering Temp. °F
Jan	52.70	49.20	47.50	45.00	55.40
Feb	52.60	50.20	49.00	46.70	55.60
Mar	54.50	55.00	55.20	49.10	63.70
Apr	56.10	58.20	59.20	56.10	69.60
May	58.60	63.10	65.30	60.00	76.20
Jun	61.90	69.40	73.00	66.40	83.60
Jul	65.10	74.60	79.20	73.10	89.20
Aug	66.70	75.50	79.80	74.30	91.50
Sep	66.10	71.80	74.60	69.50	88.10
Oct	64.40	67.10	68.40	65.70	81.50
Nov	62.40	62.40	62.40	60.00	71.40
Dec	61.30	60.60	60.20	57.80	67.30
Annual	60.20	63.10	64.50	45.00	91.50

Figure G.88 Geothermal Earth Temperature Summary: Model 6

Table G.111 Heat Pump Selections: Model 6

MODEL 6 - HEAT PUMP SELECTIONS											
HEAT PUMP	**UNIT SIZE	UNIT AIR FLOW	COOLING					HEATING		GPM	WPD
			AIR FLOW	CAPACITY	CLG Q_S	CLG Q_T	CLG LWT	HTG Q_T	HTG LWT		
(HP)	(MBH)	(CFM)	(CFM)	(TONS)	(MBH)	(MBH)	(ºF)	(MBH)	(ºF)		(FT)
1	018	450	380	1.2	13.6	14.6	75.0	-12.2	50.0	2.8	0.5
2	009	300	185	0.8	9.0	9.9	75.0	-6.7	50.0	2.1	2.6
3	024	640	625	2.0	18.6	24.0	75.0	-24.4	50.0	6.0	5.1
4A	042	1400	1330	3.3	37.3	38.9	75.0	-39.5	50.0	11.0	7.4
4B	042	1400	1330	3.3	37.3	38.9	75.0	-39.5	50.0	11.0	7.4
5	018	450	370	1.6	17.0	18.6	75.0	-12.5	50.0	4.1	2.7
6	042	1050	650	3.5	33.7	42.3	75.0	-31.8	50.0	8.3	4.4
7	048	1600	1525	4.0	39.5	47.3	75.0	-52.9	50.0	12.0	8.3
8	030	950	955	2.5	28.9	29.6	75.0	-28.0	50.0	6.0	5.1
9	009	300	330	0.6	6.3	7.1	75.0	-10.4	50.0	2.1	2.6
10	012	265	305	0.7	6.4	8.5	75.0	-11.2	50.0	1.8	0.7
11	006	240	210	0.5	4.1	5.7	75.0	-9.0	50.0	1.5	2.4
12	024	640	650	1.5	15.5	18.5	75.0	-24.6	50.0	4.0	2.3
				25.3		303.8		-302.6		72.7	51.5

GENERAL NOTES

1. HEAT PUMP UNITS SIZED USING CLIMATEMASTER (TS SERIES) PERFORMANCE CHARTS
2. TRACE OUTPUT VALUES TAKEN FROM BUILDING MODEL ZONE CHECKSUMS
3. HIGHLIGHTED HEAT PUMP USED TO CALCULATE PUMP HEAD -- ASSUMED WORSE CASE PRESSURE DROP PATH
4. TOTAL TONNAGE, COOLING Q_T, AND HEATING Q_T WAS COMPARED TO MODEL SYSTEM CHECKSUM

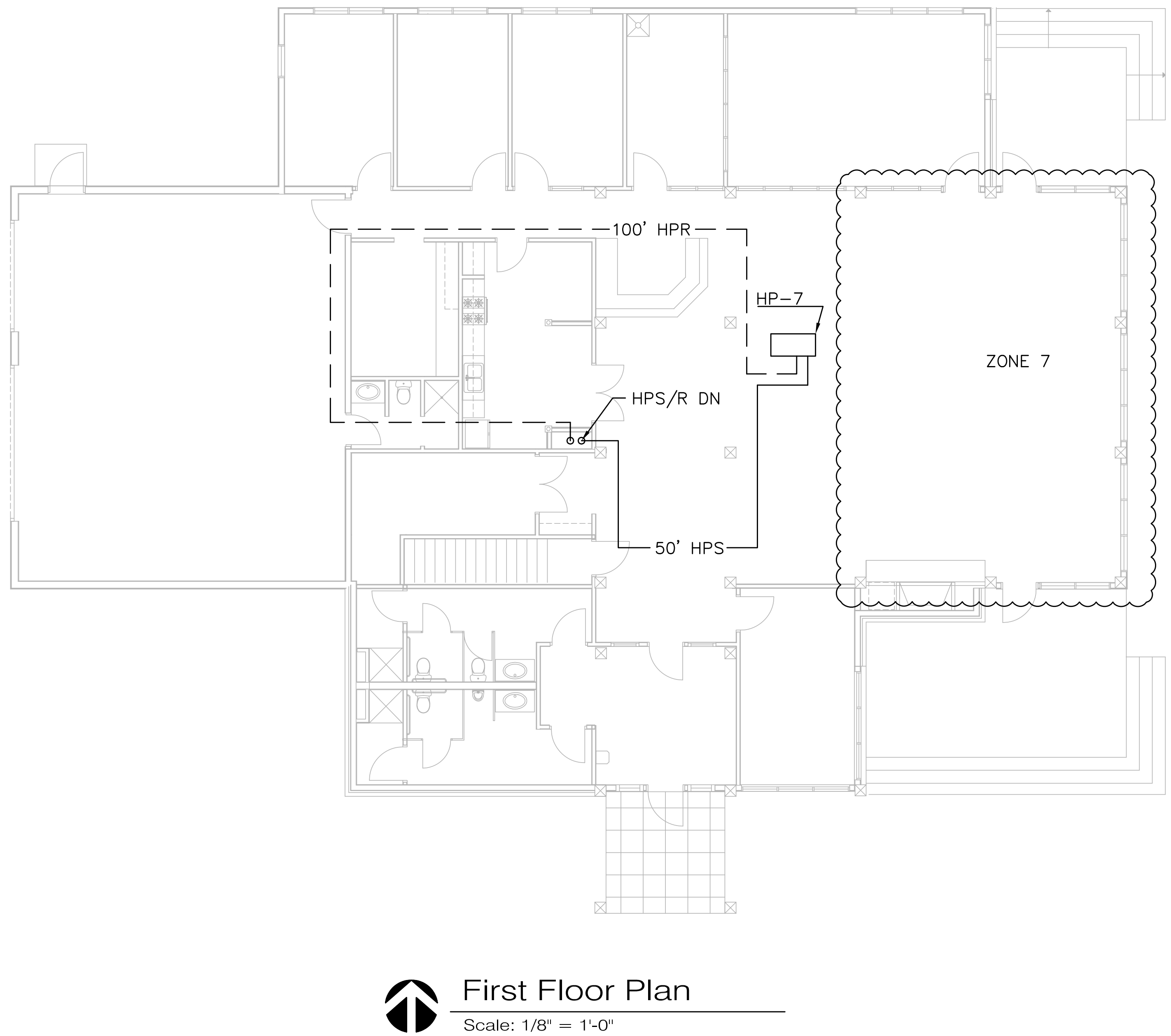

Figure G.89 Building Loop Piping Layout: Model 6

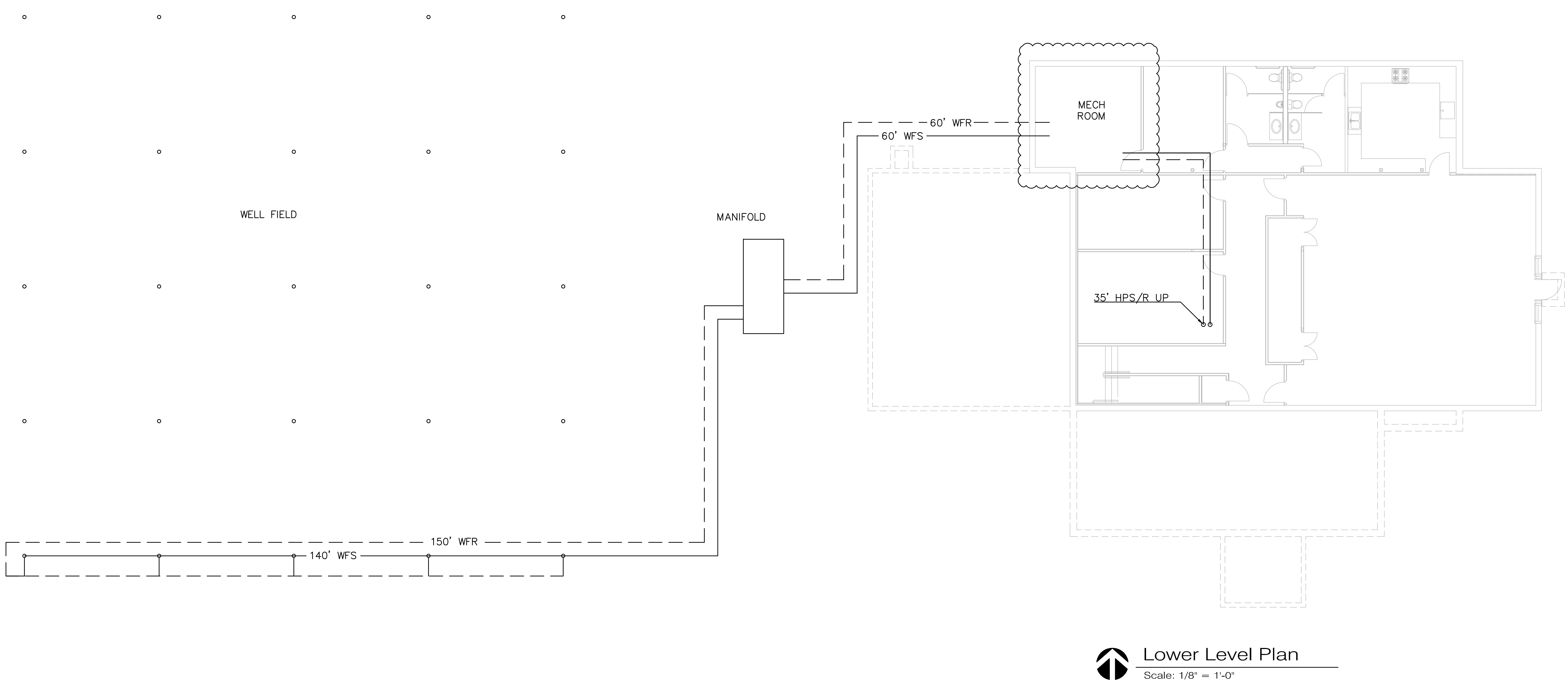

Figure G.90 Ground Loop Piping Layout: Model 6

MODEL	PRIMARY SYSTEM PUMP HEAD CALCULATIONS															PRIMARY SYSTEM PUMP HEAD	TOTAL HEAT PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD		
		SUPPLY	RETURN		SUPPLY	RETURN											
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	5.2	0.033	79.1	2	7.4	88.5	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	5.2	0.033	97.8	3	8.2	109.0	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	5.2	0.033	93.1	1.5	8.3	102.9	370.6
4	310	210	220	500	160	75	1475	2212.5	11.78	57.60	5.2	0.033	75.5	1.5	8.7	85.7	151.9
5	280	420	435	500	400	300	2335	3502.5	11.78	103.90	5.2	0.033	119.6	1.8	7.9	129.3	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	5.2	0.033	58.0	1.5	8.3	67.8	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
7. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.112 Primary Pump Head Calculations: All Models

Table G.113 Primary/Secondary Pump Head Calculations: All Models

MODEL	PRIMARY/SECONDARY SYSTEMS PUMP HEAD CALCULATIONS — PRIMARY LOOP										
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	TOTAL PRIMARY LOOP PIPE LENGTH	PRIMARY LENGTH W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PRIMARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP PUMP HEAD	TOTAL HEAT PUMP GPM
		SUPPLY	RETURN								
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	
1	260	180	200	500	1140	1710	11.78	47.60	0.033	58.4	125.5
2	100	250	260	500	1110	1665	11.78	51.30	0.033	57.0	221.9
3	190	370	380	500	1440	2160	11.78	74.40	0.033	74.1	370.6
4	310	210	220	500	1240	1860	11.78	57.60	0.033	63.7	151.9
5	280	420	435	500	1635	2453	11.78	103.90	0.033	84.7	588.1
6	120	140	150	500	910	1365	11.78	46.40	0.033	47.0	72.7

MODEL	SECONDARY LOOP										
	DISTANCE TO HEAT PUMP		TOTAL P/S LOOP PIPE LENGTH	P/S LENGTH W/ FITTINGS (TOTAL*1.5)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	VALVE PD @ SECONDARY PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	BUILDING LOOP	AIR SEPARATOR PD	WORSE CASE HEAT PUMP WPD	SECONDARY LOOP PUMP HEAD
	SUPPLY	RETURN									
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	(FT OF HD)
1	230	185	415	623	5.2	47.6	0.033	22.3	2	7.4	31.7
2	675	145	820	1230	5.2	51.3	0.033	42.5	3	8.2	53.7
3	280	100	380	570	5.2	74.4	0.033	21.4	1.5	8.3	31.2
4	160	75	235	352.5	5.2	57.6	0.033	13.7	1.5	8.7	23.9
5	400	300	700	1050	5.2	103.9	0.033	38.2	1.8	7.9	47.9
6	85	135	220	330	5.2	46.4	0.033	12.6	1.5	8.3	22.4

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250 FT VERTICAL BORES ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) AT PRIMARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. 3.3'/100' PIPE FRICTION LOSS WAS ASSUMED FOR ALL PIPE
7. **PRIMARY LOOP PUMP** CALCULATION: SUM("PIPE LENGTH W/ FITTINGS","MANIFOLD PD","VALVE PD @ PRIMARY PUMP")*"FRICTION LOSS"
8. P/S = PRIMARY/SECONDARY
9. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES FOR 1" PIPE
10. VALVE PRESSURE DROP (PD) AT SECONDARY PUMP ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
11. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
12. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
13. **BUILDING LOOP (FT OF HD)** CALCULATION: SUM("P/S PIPE LENGTH W/ FITTINGS", "VALVE PD AT HEAT PUMP", VALVE PD AT SECONDARY PUMP")*"FRICTION LOSS"
14. **SECONDARY LOOP PUMP HEAD** CALCULATIONS: SUM("BUILDING LOOP","AIR SEPARATOR","WORSE CASE HEAT PUMP WPD")
15. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

MODEL	DISTRIBUTIVE WITH PRIMARY SYSTEMS - PRIMARY PUMP HEAD CALCULATIONS													PUMP HEAD	PUMP GPM
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL PIPE LENGTH	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ PUMP (EQUIV. LENGTH)	PIPE FRICTION LOSS (3.3'/100')	PRIMARY LOOP TOTAL PD	AIR SEPARATOR PD		
		SUPPLY	RETURN		SUPPLY	RETURN									
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)		
1	260	180	200	500	230	185	1555	2333	11.78	47.60	0.033	78.93	2	80.9	125.5
2	100	250	260	500	675	145	1930	2895	11.78	51.30	0.033	97.62	3	100.6	221.9
3	190	370	380	500	280	100	1820	2730	11.78	74.40	0.033	92.93	1.5	94.4	370.6
4	310	210	220	500	160	75	1475	2213	11.78	57.60	0.033	75.30	1.5	76.8	151.9
5	280	420	435	500	400	300	2335	3503	11.78	103.90	0.033	119.40	1.8	121.2	588.1
6	120	140	150	500	85	135	1130	1695	11.78	46.40	0.033	57.85	1.5	59.4	72.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 250' VERTICAL BORE ASSUMED FOR WELL DEPTH
3. 50% EQUIVALENT LENGTH APPLIED TO ACCOUNT FOR PIPE FITTINGS
4. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
5. VALVE PRESSURE DROP (PD) ASSUMED (1) BALANCING VALVE AND (2) SHUT-OFF VALVES, SIZES VARY
6. FRICTION LOSS ASSUMED TO BE 3.3'/100'
7. **PRIMARY LOOP TOTAL PD** CALCULATION: SUM("TOTAL W/ FITTINGS", "MANIFOLD PD", "VALVE PD")*"FRICTION LOSS"
8. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
9. **PUMP HEAD** CALCULATION: "PRIMARY LOOP TOTAL PD"+"AIR SEPARATOR PD"
10. TOTAL HEAT PUMP GPM TAKEN FROM HEAT PUMP SCHEDULES

Table G.114 Distributive w/ Primary - Primary Pump Head Calculations: All Models

MODEL	DISTRIBUTIVE SYSTEMS - WORSE CASE PUMP HEAD CALCULATIONS															CIRCULATOR PUMP HEAD
	SUPPLY/ RETURN TO MANIFOLD	DISTANCE TO WELL		DISTANCE DOWN/UP WELL	DISTANCE TO HEAT PUMP		TOTAL	TOTAL W/ FITTINGS (TOTAL*1.5)	MANIFOLD PD (EQUIV. LENGTH)	VALVE PD @ HEAT PUMP (EQUIV. LENGTH)	TOTAL EQUIV. LENGTH	PIPE FRICTION LOSS	SYSTEM FRICTION LOSS	AIR SEPARATOR (EQUIV. LENGTH)	WORSE CASE HEAT PUMP WPD	
		SUPPLY	RETURN		SUPPLY	RETURN										
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)		(FT OF HD)	(FT OF HD)	(FT OF HD)	
1	260	180	200	500	230	185	1555	3083	11.78	5.2	3099.5	0.0029	9.0	0.02	7.4	16.4
2	100	250	260	500	675	145	1930	3645	11.78	5.2	3662.0	0.0022	8.2	0.04	8.2	16.4
3	190	370	380	500	280	100	1820	3480	11.78	5.2	3497.0	0.0013	4.7	0.04	8.3	13.0
4	310	210	220	500	160	75	1475	2963	11.78	5.2	2979.5	0.0027	8.0	0.02	8.7	16.7
5	280	420	435	500	400	300	2335	4253	11.78	5.2	4269.5	0.0004	1.9	0.01	7.9	9.8
6	120	140	150	500	85	135	1130	2445	11.78	5.2	2462.0	0.0054	13.4	0.02	8.3	21.7

GENERAL NOTES:

1. MODEL AUTOCAD PLANS USED TO ESTIMATE PIPE DISTANCES
2. 50% EQUIVALENT LENGTH USED TO ACCOUNT FOR PIPE FITTINGS
3. MANIFOLD PRESSURE DROP (PD) ASSUMED (2) 1" BRANCH TEES, (1) 1" BALANCING VALVE, AND (2) 1" SHUT-OFF VALVES
4. VALVE PRESSURE DROP (PD) AT HEAT PUMP ASSUMED (1) CONTROL VALVE, (2) SHUT-OFF VALVES, AND (1) PD SENSOR, LINE SIZED FROM WORSE CASE HEAT PUMP GPM & PD
5. TACO 4900 SERIES PD CHART USED FOR AIR SEPORATOR PRESSURE DROP
6. WORSE CASE HEAT PUMP WPD TAKEN FROM HEAT PUMP SCHEDULES
7. TOTAL HEAT PUMP GPM TAKEN FROM SUM OF ALL HEAT PUMP GPMs IN HEAT PUMP SCHEDULES
8. **TOTAL EQUIV. LENGTH** CALCULATION: (TOTAL W/ FITTINGS)+(MANIFOLD PD)+(AIR SEPARATOR PD)+(VALVE PD)
9. **PIPE FRICTION LOSS** WAS CALCULATED BASED ON WORSE CASE HEAT PUMP CIRCULATOR OPERATING ALONE. FRICTION LOSS EQUATION = (HP GPM/TOTAL GPM)*3.3/100
10. **SYSTEM FRICTION LOSS** CALCULATION: (TOTAL EQUIV. LENGTH)*(FRICTION LOSS/100')
11. **CIRCULATOR PUMP HEAD** CALCULATION: (SYSTEM FRICTION LOSS)+(WORSE CASE HP WPD)

WORSE CASE HEAT PUMP GPM	TOTAL SYSTEM GPM	PERCENT OF TOTAL SYSTEM
		(%)
11	125.5	8.8%
15	221.9	6.8%
15	370.6	4.0%
12.4	151.9	8.2%
8	588.1	1.4%
12	72.7	16.5%

Table G.115 Distributive Circulator Pump Head Calculations: All Models

MODEL	PUMP MANUF.	PRIMARY SYSTEMS PUMP SCHEDULES							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 1 1/2 BC	88.5	125.5	1750	4.52	7.5	63.1%	$ 10,065.00
2	B & G	1510, 2AC	109.0	221.9	3500	8.57	10	71.5%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	102.9	370.6	3500	13.13	15	75.9%	$ 13,350.00
4	B & G	1510, 1 1/2AC	85.7	151.9	3500	4.97	7.5	66.8%	$ 10,065.00
5	B & G	1510, 3AC	129.3	588.1	3500	24.34	30	78.7%	$ 19,870.00
6	B & G	90, 1 1/2AA	67.8	72.7	3450	2.18	3	57.9%	$ 2,885.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.116 Primary Pump Schedules: All Models

MODEL	PUMP MANUF.	PRIMARY/SECONDARY SYSTEMS PUMP SCHEDULES															
		GROUND LOOP (PRIMARY)								BUILDING LOOP (SECONDARY)							
		MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	1510, 2BC	58.4	125.5	1750	2.85	5	66.1%	$ 8,260.00	1510, 1 1/2 AC	31.7	125.5	1750	1.59	2	65.7%	$ 6,060.00
2	B & G	1510, 2BC	57.0	221.9	1750	5.06	7.5	63.8%	$ 10,065.00	1510, 2 1/2 BB	53.7	221.9	1750	4.14	5	74.3%	$ 8,260.00
3	B & G	1510. 2 1/2 AB	74.1	370.6	3500	10.24	15	69.9%	$ 13,350.00	1510, 3BC	31.2	370.6	1150	3.67	5	78.0%	$ 9,015.00
4	B & G	1510, 2AC	63.7	151.9	3500	3.94	5	65.1%	$ 8,260.00	1510, 2 1/2 AB	23.9	151.9	1750	1.31	1.5	70.1%	$ 5,435.00
5	B & G	1510, 4E	84.7	588.1	1750	15.67	20	80.5%	$ 15,860.00	1510, 4BC	47.9	588.1	1750	8.9	10	82.1%	$ 13,150.00
6	B & G	90, 1 1/2AA	47.0	72.7	3450	1.54	2	57.3%	$ 2,332.00	90, 2AA	22.4	72.7	1725	0.63	0.75	64.8%	$ 1,568.00

GENERAL NOTES:
1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.117 Primary/Secondary Pump Schedules: All Models

DISTRIBUTIVE SYSTEM - PRIMARY PUMP SCHEDULE									
MODEL	PUMP MANUF.	MODEL	HEAD (FT)	GPM	RPM	BHP	MOTOR HP	PUMP EFFICIENCY (%)	BARE COST ($)
1	B & G	90, 2AA	80.9	125.5	3450	3.98	5	64.5%	$ 3,305.00
2	B & G	1510, 2AC	100.6	221.9	3500	8.04	10	70.7%	$ 13,150.00
3	B & G	1510, 2 1/2 AB	94.4	370.6	3500	11.81	15	72.2%	$ 13,350.00
4	B & G	90, 2AA	76.8	151.9	3450	4.57	5	65.6%	$ 3,305.00
5	B & G	1510, 3AC	121.2	588.1	3500	23.79	25	78.1%	$ 17,360.00
6	B & G	90, 1 1/2AA	59.4	72.7	3450	1.89	3.0	57.8%	$ 2,885.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL 1510 - BASE MOUNTED, END SUCTION PUMP
3. MODEL 90 - VERTICAL IN-LINE PUMP
4. PUMP UNIT PRICE TAKEN FROM RSMEANS MECHANICAL COST DATA: 2011

Table G.118 Distributive w/ Primary - Primary Pump Schedules: All Models

Table G.119 Distributive w/ Primary - Circulator Schedule: Model 6

DISTRIBUTIVE PUMPING SYSTEM W/ PRIMARY - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-9F/LW	2.8	0.5	2800	0.055	41	115	$ 449.00
2	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
3	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
4A	B & G	NRF-22	11.0	7.4	2940	0.123	92	115	$ 664.00
4B	B & G	NRF-22	11.0	7.4	2940	0.123	92	115	$ 664.00
5	B & G	NRF-9F/LW	4.1	2.7	2800	0.055	41	115	$ 449.00
6	B & G	NRF-22	8.3	4.4	2940	0.123	92	115	$ 664.00
7	B & G	NRF-22	12.0	8.3	2940	0.123	92	115	$ 664.00
8	B & G	NRF-22	6.0	5.1	2940	0.123	92	115	$ 664.00
9	B & G	NRF-9F/LW	2.1	2.6	2800	0.055	41	115	$ 449.00
10	B & G	NRF-9F/LW	1.8	0.7	2800	0.055	41	115	$ 449.00
11	B & G	NRF-9F/LW	1.5	2.4	2800	0.055	41	115	$ 449.00
12	B & G	NRF-9F/LW	4.0	2.3	2800	0.055	41	115	$ 449.00
						1.12	839		$7,127.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

Table G.120 Distributive - Circulator Schedule: Model 6

DISTRIBUTIVE PUMPING SYSTEM - CIRCULATOR SCHEDULE									
HP	PUMP MANUF.	MODEL	GPM	HEAD (FT)	RPM	EQUIV. MOTOR HP	FULL-LOAD (WATTS)	VOLTAGE	UNIT PRICE
1	B & G	NRF-36	2.8	21.7	3300	0.362	270	115	$ 1,368.00
2	B & G	NRF-36	2.1	21.7	3300	0.362	270	115	$ 1,368.00
3	B & G	NRF-36	6.0	21.7	3300	0.362	270	115	$ 1,368.00
4A	B & G	NRF-36	11.0	21.7	3300	0.362	270	115	$ 1,368.00
4B	B & G	NRF-36	11.0	21.7	3300	0.362	270	115	$ 1,368.00
5	B & G	NRF-36	4.1	21.7	3300	0.362	270	115	$ 1,368.00
6	B & G	NRF-36	8.3	21.7	3300	0.362	270	115	$ 1,368.00
7	B & G	NRF-36	12.0	21.7	3300	0.362	270	115	$ 1,368.00
8	B & G	NRF-36	6.0	21.7	3300	0.362	270	115	$ 1,368.00
9	B & G	NRF-36	2.1	21.7	3300	0.362	270	115	$ 1,368.00
10	B & G	NRF-36	1.8	21.7	3300	0.362	270	115	$ 1,368.00
11	B & G	NRF-36	1.5	21.7	3300	0.362	270	115	$ 1,368.00
12	B & G	NRF-36	4.0	21.7	3300	0.362	270	115	$ 1,368.00
						4.71	3510		$ 17,784.00

GENERAL NOTES:

1. B & G - BELL AND GOSSETT, PUMP MANUFACTURER
2. MODEL NRF - WET-ROTOR CIRCULATOR
3. **EQUIVALENT MOTOR HP** CALCULATION: "FULL-LOAD"/"746 W/HP"
4. GPM & FT OF HEAD FROM PUMP HEAD CALCULATIONS

MODEL 6 - MONTHLY PUMP CONSUMPTION

AVERAGE DAY	COOLING DESIGN LOAD	HEATING DESIGN LOAD	JANUARY					FEBRUARY					MARCH					APRIL					MAY					JUNE				
			CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL
HOURS	TONS	MBH	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%
1	25.3	302.6	0.0	0.0%	93.2	30.8%	30.8%	0.8	3.2%	74.7	24.7%	27.8%	1.3	5.1%	20.9	6.9%	12.0%	1.8	7.1%	4.0	1.3%	8.4%	3.4	13.4%	0.0	0.0%	13.4%	7.3	28.9%	0.0	0.0%	28.9%
2	25.3	302.6	0.3	1.2%	96.7	32.0%	33.1%	0.8	3.2%	78.6	26.0%	29.1%	1.3	5.1%	22.5	7.4%	12.6%	1.8	7.1%	6.3	2.1%	9.2%	3.5	13.8%	0.0	0.0%	13.8%	6.7	26.5%	0.0	0.0%	26.5%
3	25.3	302.6	0.5	2.0%	99.5	32.9%	34.9%	0.8	3.2%	81.8	27.0%	30.2%	1.3	5.1%	27.2	9.0%	14.1%	1.7	6.7%	8.6	2.8%	9.6%	3.2	12.6%	0.0	0.0%	12.6%	6.3	24.9%	0.0	0.0%	24.9%
4	25.3	302.6	0.6	2.4%	101.7	33.6%	36.0%	0.8	3.2%	84.3	27.9%	31.0%	1.3	5.1%	29.3	9.7%	14.8%	1.7	6.7%	10.1	3.3%	10.1%	3.1	12.3%	0.0	0.0%	12.3%	5.9	23.3%	0.0	0.0%	23.3%
5	25.3	302.6	0.6	2.4%	103.2	34.1%	36.5%	0.8	3.2%	85.9	28.4%	31.5%	1.3	5.1%	31.3	10.3%	15.5%	1.7	6.7%	11.2	3.7%	10.4%	2.9	11.5%	0.1	0.0%	11.5%	5.7	22.5%	0.0	0.0%	22.5%
6	25.3	302.6	0.6	2.4%	103.8	34.3%	36.7%	0.8	3.2%	88.9	29.4%	32.5%	1.3	5.1%	32.0	10.6%	15.7%	1.7	6.7%	11.7	3.9%	10.6%	3.0	11.9%	0.1	0.0%	11.9%	5.9	23.3%	0.0	0.0%	23.3%
7	25.3	302.6	0.7	2.8%	102.9	34.0%	36.8%	0.8	3.2%	85.8	28.4%	31.5%	1.3	5.1%	30.2	10.0%	15.1%	1.9	7.5%	9.4	3.1%	10.6%	3.9	15.4%	0.1	0.0%	15.4%	7.8	30.8%	0.0	0.0%	30.8%
8	25.3	302.6	0.7	2.8%	103.7	34.3%	37.0%	0.8	3.2%	84.2	27.8%	31.0%	1.5	5.9%	21.1	7.0%	12.9%	2.3	9.1%	5.2	1.7%	10.8%	5.7	22.5%	0.0	0.0%	22.5%	10.3	40.7%	0.0	0.0%	40.7%
9	25.3	302.6	0.7	2.8%	87.0	28.8%	31.5%	0.8	3.2%	62.8	20.8%	23.9%	1.8	7.1%	11.0	3.6%	10.7%	2.8	11.1%	0.2	0.1%	11.1%	8.0	31.6%	0.0	0.0%	31.6%	12.6	49.8%	0.0	0.0%	49.8%
10	25.3	302.6	0.7	2.8%	65.9	21.8%	24.5%	0.9	3.6%	36.1	11.9%	15.5%	1.9	7.5%	0.6	0.2%	7.7%	4.4	17.4%	0.0	0.0%	17.4%	10.3	40.7%	0.0	0.0%	40.7%	14.1	55.7%	0.0	0.0%	55.7%
11	25.3	302.6	0.8	3.2%	34.3	11.3%	14.5%	1.1	4.3%	16.3	5.4%	9.7%	2.7	10.7%	0.1	0.0%	10.7%	6.5	25.7%	0.0	0.0%	25.7%	11.9	47.0%	0.0	0.0%	47.0%	15.4	60.9%	0.0	0.0%	60.9%
12	25.3	302.6	0.8	3.2%	16.6	5.5%	8.6%	1.3	5.1%	8.2	2.7%	7.8%	4.9	19.4%	0.0	0.0%	19.4%	7.2	28.5%	0.0	0.0%	28.5%	13.2	52.2%	0.0	0.0%	52.2%	16.7	66.0%	0.0	0.0%	66.0%
13	25.3	302.6	0.9	3.6%	12.0	4.0%	7.5%	1.4	5.5%	5.0	1.7%	7.2%	6.5	25.7%	0.0	0.0%	25.7%	9.9	39.1%	0.0	0.0%	39.1%	14.3	56.5%	0.0	0.0%	56.5%	17.9	70.8%	0.0	0.0%	70.8%
14	25.3	302.6	0.9	3.6%	8.6	2.8%	6.4%	1.6	6.3%	0.0	0.0%	6.3%	8.3	32.8%	0.0	0.0%	32.8%	11.6	45.8%	0.0	0.0%	45.8%	15.5	61.3%	0.0	0.0%	61.3%	19.2	75.9%	0.0	0.0%	75.9%
15	25.3	302.6	1.1	4.3%	6.0	2.0%	6.3%	3.0	11.9%	0.0	0.0%	11.9%	9.2	36.4%	0.0	0.0%	36.4%	13.6	53.8%	0.0	0.0%	53.8%	16.8	66.4%	0.0	0.0%	66.4%	20.5	81.0%	0.0	0.0%	81.0%
16	25.3	302.6	2.5	9.9%	2.6	0.9%	10.7%	4.3	17.0%	0.0	0.0%	17.0%	10.6	41.9%	0.0	0.0%	41.9%	14.4	56.9%	0.0	0.0%	56.9%	17.8	70.4%	0.0	0.0%	70.4%	21.5	85.0%	0.0	0.0%	85.0%
17	25.3	302.6	2.8	11.1%	2.7	0.9%	12.0%	4.4	17.4%	0.7	0.2%	17.6%	11.5	45.5%	0.0	0.0%	45.5%	14.5	57.3%	0.0	0.0%	57.3%	17.9	70.8%	0.0	0.0%	70.8%	21.4	84.6%	0.0	0.0%	84.6%
18	25.3	302.6	1.3	5.1%	10.9	3.6%	8.7%	3.5	13.8%	0.0	0.0%	13.8%	10.3	40.7%	0.0	0.0%	40.7%	13.5	53.4%	0.0	0.0%	53.4%	17.1	67.6%	0.0	0.0%	67.6%	20.6	81.4%	0.0	0.0%	81.4%
19	25.3	302.6	0.9	3.6%	18.7	6.2%	9.7%	1.6	6.3%	0.0	0.0%	6.3%	7.7	30.4%	0.0	0.0%	30.4%	11.2	44.3%	0.0	0.0%	44.3%	15.3	60.5%	0.0	0.0%	60.5%	18.9	74.7%	0.0	0.0%	74.7%
20	25.3	302.6	0.8	3.2%	25.8	8.5%	11.7%	1.1	4.3%	0.3	0.1%	4.4%	4.9	19.4%	0.0	0.0%	19.4%	8.5	33.6%	0.0	0.0%	33.6%	12.6	49.8%	0.0	0.0%	49.8%	16.2	64.0%	0.0	0.0%	64.0%
21	25.3	302.6	0.9	3.6%	53.5	17.7%	21.2%	1.0	4.0%	3.4	1.1%	5.1%	2.8	11.1%	0.0	0.0%	11.1%	5.9	23.3%	0.0	0.0%	23.3%	9.9	39.1%	0.0	0.0%	39.1%	13.4	53.0%	0.0	0.0%	53.0%
22	25.3	302.6	0.8	3.2%	72.0	23.8%	27.0%	1.0	4.0%	16.0	5.3%	9.2%	2.2	8.7%	0.0	0.0%	8.7%	4.1	16.2%	0.0	0.0%	16.2%	7.6	30.0%	0.0	0.0%	30.0%	10.8	42.7%	0.0	0.0%	42.7%
23	25.3	302.6	0.8	3.2%	81.7	27.0%	30.2%	0.9	3.6%	53.0	17.5%	21.1%	1.9	7.5%	0.8	0.3%	7.8%	3.1	12.3%	0.0	0.0%	12.3%	6.3	24.9%	0.0	0.0%	24.9%	9.4	37.2%	0.0	0.0%	37.2%
24	25.3	302.6	0.8	3.2%	89.0	29.4%	32.6%	0.8	3.2%	61.5	20.3%	23.5%	1.6	6.3%	0.0	0.0%	6.3%	2.5	9.9%	0.0	0.0%	9.9%	5.3	20.9%	0.0	0.0%	20.9%	8.4	33.2%	0.0	0.0%	33.2%

AVERAGE DAY	COOLING DESIGN LOAD	HEATING DESIGN LOAD	JULY					AUGUST					SEPTEMBER					OCTOBER					NOVEMBER					DECEMBER				
			CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL	CLG		HTG		TOTAL
HOURS	TONS	MBH	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%	DESIGN TONS	%	DESIGN MBH	%	%
1	25.3	302.6	9.6	37.9%	0.0	0.0%	37.9%	8.9	35.2%	0.0	0.0%	35.2%	5.4	21.3%	0.0	0.0%	21.3%	2.7	10.7%	0.0	0.0%	10.7%	1.4	5.5%	0.7	0.2%	5.8%	1.2	4.7%	38.0	12.6%	17.3%
2	25.3	302.6	9.0	35.6%	0.0	0.0%	35.6%	8.2	32.4%	0.0	0.0%	32.4%	4.7	18.6%	0.0	0.0%	18.6%	2.4	9.5%	0.2	0.1%	9.6%	1.4	5.5%	3.8	1.3%	6.8%	1.1	4.3%	39.8	13.2%	17.5%
3	25.3	302.6	8.6	34.0%	0.0	0.0%	34.0%	7.8	30.8%	0.0	0.0%	30.8%	4.1	16.2%	0.0	0.0%	16.2%	2.3	9.1%	0.5	0.2%	9.3%	1.3	5.1%	17.2	5.7%	10.8%	1.1	4.3%	45.4	15.0%	19.4%
4	25.3	302.6	8.3	32.8%	0.0	0.0%	32.8%	7.4	29.2%	0.0	0.0%	29.2%	3.7	14.6%	0.0	0.0%	14.6%	2.2	8.7%	0.7	0.2%	8.9%	1.3	5.1%	17.5	5.8%	10.9%	1.1	4.3%	50.4	16.7%	21.0%
5	25.3	302.6	8.1	32.0%	0.0	0.0%	32.0%	7.2	28.5%	0.0	0.0%	28.5%	3.6	14.2%	0.0	0.0%	14.2%	2.1	8.3%	0.0	0.0%	8.3%	1.2	4.7%	19.2	6.3%	11.1%	1.0	4.0%	52.3	17.3%	21.2%
6	25.3	302.6	8.1	32.0%	0.0	0.0%	32.0%	7.2	28.5%	0.0	0.0%	28.5%	3.5	13.8%	0.0	0.0%	13.8%	2.1	8.3%	0.6	0.2%	8.5%	1.2	4.7%	25.4	8.4%	13.1%	1.1	4.3%	50.5	16.7%	21.0%
7	25.3	302.6	9.7	38.3%	0.0	0.0%	38.3%	8.1	32.0%	0.0	0.0%	32.0%	3.6	14.2%	0.0	0.0%	14.2%	2.1	8.3%	0.0	0.0%	8.3%	1.3	5.1%	30.5	10.1%	15.2%	1.1	4.3%	36.5	12.1%	16.4%
8	25.3	302.6	12.1	47.8%	0.0	0.0%	47.8%	10.4	41.1%	0.0	0.0%	41.1%	5.2	20.6%	0.0	0.0%	20.6%	2.4	9.5%	0.4	0.1%	9.6%	1.3	5.1%	31.8	10.5%	15.6%	1.1	4.3%	15.4	5.1%	9.4%
9	25.3	302.6	14.5	57.3%	0.0	0.0%	57.3%	13.0	51.4%	0.0	0.0%	51.4%	8.4	33.2%	0.0	0.0%	33.2%	3.6	14.2%	0.2	0.1%	14.3%	1.5	5.9%	28.6	9.5%	15.4%	1.3	5.1%	6.4	2.1%	7.3%
10	25.3	302.6	16.0	63.2%	0.0	0.0%	63.2%	15.2	60.1%	0.0	0.0%	60.1%	11.6	45.8%	0.0	0.0%	45.8%	5.9	23.3%	0.0	0.0%	23.3%	1.8	7.1%	14.6	4.8%	11.9%	1.5	5.9%	2.4	0.8%	6.7%
11	25.3	302.6	17.6	69.6%	0.0	0.0%	69.6%	17.2	68.0%	0.0	0.0%	68.0%	13.9	54.9%	0.0	0.0%	54.9%	7.9	31.2%	0.0	0.0%	31.2%	1.9	7.5%	3.9	1.3%	8.8%	1.7	6.7%	0.1	0.0%	6.8%
12	25.3	302.6	19.2	75.9%	0.0	0.0%	75.9%	18.9	74.7%	0.0	0.0%	74.7%	15.4	60.9%	0.0	0.0%	60.9%	10.9	43.1%	0.0	0.0%	43.1%	2.3	9.1%	0.6	0.2%	9.3%	1.7	6.7%	0.0	0.0%	6.7%
13	25.3	302.6	20.1	79.4%	0.0	0.0%	79.4%	19.9	78.7%	0.0	0.0%	78.7%	16.6	65.6%	0.0	0.0%	65.6%	12.3	48.6%	0.0	0.0%	48.6%	4.9	19.4%	0.1	0.0%	19.4%	2.0	7.9%	0.0	0.0%	7.9%
14	25.3	302.6	21.2	83.8%	0.0	0.0%	83.8%	21.0	83.0%	0.0	0.0%	83.0%	18.0	71.1%	0.0	0.0%	71.1%	13.9	54.9%	0.0	0.0%	54.9%	7.3	28.9%	0.0	0.0%	28.9%	4.6	18.2%	0.0	0.0%	18.2%
15	25.3	302.6	22.3	88.1%	0.0	0.0%	88.1%	22.2	87.7%	0.0	0.0%	87.7%	19.4	76.7%	0.0	0.0%	76.7%	15.3	60.5%	0.0	0.0%	60.5%	8.5	33.6%	0.0	0.0%	33.6%	6.4	25.3%	0.0	0.0%	25.3%
16	25.3	302.6	23.1	91.3%	0.0	0.0%	91.3%	22.7	89.7%	0.0	0.0%	89.7%	20.1	79.4%	0.0	0.0%	79.4%	15.8	62.5%	0.0	0.0%	62.5%	8.7	34.4%	0.0	0.0%	34.4%	6.9	27.3%	0.0	0.0%	27.3%
17	25.3	302.6	22.9	90.5%	0.0	0.0%	90.5%	22.4	88.5%	0.0	0.0%	88.5%	19.8	78.3%	0.0	0.0%	78.3%	14.9	58.9%	0.0	0.0%	58.9%	7.7	30.4%	0.0	0.0%	30.4%	5.9	23.3%	0.0	0.0%	23.3%
18	25.3	302.6	22.2	87.7%	0.0	0.0%	87.7%	21.6	85.4%	0.0	0.0%	85.4%	17.6	69.6%	0.0	0.0%	69.6%	12.4	49.0%	0.0	0.0%	49.0%	5.4	21.3%	0.0	0.0%	21.3%	4.1	16.2%	0.0	0.0%	16.2%
19	25.3	302.6	20.6	81.4%	0.0	0.0%	81.4%	19.0	75.1%	0.0	0.0%	75.1%	14.6	57.7%	0.0	0.0%	57.7%	9.6	37.9%	0.0	0.0%	37.9%	3.1	12.3%	0.0	0.0%	12.3%	2.0	7.9%	0.0	0.0%	7.9%
20	25.3	302.6	17.9	70.8%	0.0	0.0%	70.8%	16.2	64.0%	0.0	0.0%	64.0%	11.8	46.6%	0.0	0.0%	46.6%	6.9	27.3%	0.0	0.0%	27.3%	2.2	8.7%	0.1	0.0%	8.7%	1.7	6.7%	0.0	0.0%	6.7%
21	25.3	302.6	15.2	60.1%	0.0	0.0%	60.1%	13.6	53.8%	0.0	0.0%	53.8%	9.5	37.5%	0.0	0.0%	37.5%	5.5	21.7%	0.0	0.0%	21.7%	1.9	7.5%	0.9	0.3%	7.8%	1.5	5.9%	0.1	0.0%	6.0%
22	25.3	302.6	12.8	50.6%	0.0	0.0%	50.6%	11.6	45.8%	0.0	0.0%	45.8%	7.9	31.2%	0.0	0.0%	31.2%	4.4	17.4%	0.0	0.0%	17.4%	1.6	6.3%	0.0	0.0%	6.3%	1.4	5.5%	0.4	0.1%	5.7%
23	25.3	302.6	11.5	45.5%	0.0	0.0%	45.5%	10.4	41.1%	0.0	0.0%	41.1%	6.7	26.5%	0.0	0.0%	26.5%	3.5	13.8%	0.0	0.0%	13.8%	1.6	6.3%	0.3	0.1%	6.4%	1.3	5.1%	5.3	1.8%	6.9%
24	25.3	302.6	10.6	41.9%	0.0	0.0%	41.9%	9.6	37.9%	0.0	0.0%	37.9%	5.8	22.9%	0.0	0.0%	22.9%	3.0	11.9%	0.0	0.0%	11.9%	1.5	5.9%	0.5	0.2%	6.1%	1.2	4.7%	22.1	7.3%	12.0%

GENERAL NOTES:

1. COOLING AND HEATING DESIGN PEAKS TAKEN FROM TRACE OUTPUT "SYSTEM CHECKSUMS"
2. COOLING AND HEATING DESIGN TONS AND MBH, RESPECTIVELY, TAKEN FROM TRACE OUTPUT "BUILDING COOL HEAT DEMAND"
3. **COOLING %** CALCULATION: "COOLING DESIGN TONS PER HOUR"/"COOLING DESIGN PEAK"*100
4. **HEATING %** CALCULATION: "HEATING DESIGN MBH PER HOUR"/"HEATING DESIGN PEAK"*100
5. **TOTAL %** CALCULATION: "COOLING %"+"HEATING %". REPRESENTS SIMULTANEOUS HEATING AND COOLING PER HOUR PER MONTH.

Table G.121 Monthly Simultaneous Heating and Cooling Part-Load % Per Hour: Model 6

MODEL 6 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY PUMP CONSUMPTION		
	2.18	BHP
	1.63	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	30.8%	0.05	27.8%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	28.9%	0.04
2	33.1%	0.06	29.1%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	26.5%	0.03
3	34.9%	0.07	30.2%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	24.9%	0.03
4	36.0%	0.08	31.0%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	23.3%	0.02
5	36.5%	0.08	31.5%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	22.5%	0.02
6	36.7%	0.08	32.5%	0.06	20.0%	0.01	20.0%	0.01	20.0%	0.01	23.3%	0.02
7	36.8%	0.08	31.5%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	30.8%	0.05
8	37.0%	0.08	31.0%	0.05	20.0%	0.01	20.0%	0.01	22.5%	0.02	40.7%	0.11
9	31.5%	0.05	23.9%	0.02	20.0%	0.01	20.0%	0.01	31.6%	0.05	49.8%	0.20
10	24.5%	0.02	20.0%	0.01	20.0%	0.01	20.0%	0.01	40.7%	0.11	55.7%	0.28
11	20.0%	0.01	20.0%	0.01	20.0%	0.01	25.7%	0.03	47.0%	0.17	60.9%	0.37
12	20.0%	0.01	20.0%	0.01	20.0%	0.01	28.5%	0.04	52.2%	0.23	66.0%	0.47
13	20.0%	0.01	20.0%	0.01	25.7%	0.03	39.1%	0.10	56.5%	0.29	70.8%	0.58
14	20.0%	0.01	20.0%	0.01	32.8%	0.06	45.8%	0.16	61.3%	0.37	75.9%	0.71
15	20.0%	0.01	20.0%	0.01	36.4%	0.08	53.8%	0.25	66.4%	0.48	81.0%	0.86
16	20.0%	0.01	20.0%	0.01	41.9%	0.12	56.9%	0.30	70.4%	0.57	85.0%	1.00
17	20.0%	0.01	20.0%	0.01	45.5%	0.15	57.3%	0.31	70.8%	0.58	84.6%	0.98
18	20.0%	0.01	20.0%	0.01	40.7%	0.11	53.4%	0.25	67.6%	0.50	81.4%	0.88
19	20.0%	0.01	20.0%	0.01	30.4%	0.05	44.3%	0.14	60.5%	0.36	74.7%	0.68
20	20.0%	0.01	20.0%	0.01	20.0%	0.01	33.6%	0.06	49.8%	0.20	64.0%	0.43
21	21.2%	0.02	20.0%	0.01	20.0%	0.01	23.3%	0.02	39.1%	0.10	53.0%	0.24
22	27.0%	0.03	20.0%	0.01	20.0%	0.01	20.0%	0.01	30.0%	0.04	42.7%	0.13
23	30.2%	0.04	21.1%	0.02	20.0%	0.01	20.0%	0.01	24.9%	0.03	37.2%	0.08
24	32.6%	0.06	23.5%	0.02	20.0%	0.01	20.0%	0.01	20.9%	0.01	33.2%	0.06
AVG, DAILY CONSUMPTION PER MONTH (KW)		0.93		0.60		0.81		1.82		4.20		8.25

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	37.9%	0.09	35.2%	0.07	21.3%	0.02	20.0%	0.01	20.0%	0.01	20.0%	0.01
2	35.6%	0.07	32.4%	0.06	20.0%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
3	34.0%	0.06	30.8%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
4	32.8%	0.06	29.2%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	21.0%	0.02
5	32.0%	0.05	28.5%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	21.2%	0.02
6	32.0%	0.05	28.5%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	21.0%	0.02
7	38.3%	0.09	32.0%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
8	47.8%	0.18	41.1%	0.11	20.6%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
9	57.3%	0.31	51.4%	0.22	33.2%	0.06	20.0%	0.01	20.0%	0.01	20.0%	0.01
10	63.2%	0.41	60.1%	0.35	45.8%	0.16	23.3%	0.02	20.0%	0.01	20.0%	0.01
11	69.6%	0.55	68.0%	0.51	54.9%	0.27	31.2%	0.05	20.0%	0.01	20.0%	0.01
12	75.9%	0.71	74.7%	0.68	60.9%	0.37	43.1%	0.13	20.0%	0.01	20.0%	0.01
13	79.4%	0.82	78.7%	0.79	65.6%	0.46	48.6%	0.19	20.0%	0.01	20.0%	0.01
14	83.8%	0.96	83.0%	0.93	71.1%	0.59	54.9%	0.27	28.9%	0.04	20.0%	0.01
15	88.1%	1.11	87.7%	1.10	76.7%	0.73	60.5%	0.36	33.6%	0.06	25.3%	0.03
16	91.3%	1.24	89.7%	1.17	79.4%	0.82	62.5%	0.40	34.4%	0.07	27.3%	0.03
17	90.5%	1.21	88.5%	1.13	78.3%	0.78	58.9%	0.33	30.4%	0.05	23.3%	0.02
18	87.7%	1.10	85.4%	1.01	69.6%	0.55	49.0%	0.19	21.3%	0.02	20.0%	0.01
19	81.4%	0.88	75.1%	0.69	57.7%	0.31	37.9%	0.09	20.0%	0.01	20.0%	0.01
20	70.8%	0.58	64.0%	0.43	46.6%	0.16	27.3%	0.03	20.0%	0.01	20.0%	0.01
21	60.1%	0.35	53.8%	0.25	37.5%	0.09	21.7%	0.02	20.0%	0.01	20.0%	0.01
22	50.6%	0.21	45.8%	0.16	31.2%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01
23	45.5%	0.15	41.1%	0.11	26.5%	0.03	20.0%	0.01	20.0%	0.01	20.0%	0.01
24	41.9%	0.12	37.9%	0.09	22.9%	0.02	20.0%	0.01	20.0%	0.01	20.0%	0.01
AVG, DAILY CONSUMPTION PER MONTH (KW)		11.35		10.08		5.54		2.23		0.48		0.36

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.122 Daily Pump Consumption (Primary): Model 6

Table G.123 Primary System Annual Utility Cost: Model 6

PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	0.93	31	29	$ 0.09	$ 2.59
FEBRUARY	0.60	28	17	$ 0.09	$ 1.52
MARCH	0.81	31	25	$ 0.09	$ 2.27
APRIL	1.82	30	55	$ 0.09	$ 4.91
MAY	4.20	31	130	$ 0.09	$ 11.72
JUNE	8.25	30	248	$ 0.09	$ 22.28
JULY	11.35	31	352	$ 0.09	$ 31.66
AUGUST	10.08	31	312	$ 0.09	$ 28.11
SEPTEMBER	5.54	30	166	$ 0.09	$ 14.96
OCTOBER	2.23	31	69	$ 0.09	$ 6.22
NOVEMBER	0.48	30	14	$ 0.09	$ 1.28
DECEMBER	0.36	31	11	$ 0.09	$ 1.00
ANNUAL UTILITY CONSUMPTION & COST			1428	KWH	$ 128.53

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 6 - DAILY PUMP CONSUMPTION

TOTAL PRIMARY + SECONDARY PUMP CONSUMPTION		
	2.17	**BHP**
	1.62	**KW**

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	30.8%	0.05	27.8%	0.03	20.0%	0.01	20.0%	0.01	20.0%	0.01	28.9%	0.04
2	33.1%	0.06	29.1%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	26.5%	0.03
3	34.9%	0.07	30.2%	0.04	20.0%	0.01	20.0%	0.01	20.0%	0.01	24.9%	0.02
4	36.0%	0.08	31.0%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	23.3%	0.02
5	36.5%	0.08	31.5%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	22.5%	0.02
6	36.7%	0.08	32.5%	0.06	20.0%	0.01	20.0%	0.01	20.0%	0.01	23.3%	0.02
7	36.8%	0.08	31.5%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01	30.8%	0.05
8	37.0%	0.08	31.0%	0.05	20.0%	0.01	20.0%	0.01	22.5%	0.02	40.7%	0.11
9	31.5%	0.05	23.9%	0.02	20.0%	0.01	20.0%	0.01	31.6%	0.05	49.8%	0.20
10	24.5%	0.02	20.0%	0.01	20.0%	0.01	20.0%	0.01	40.7%	0.11	55.7%	0.28
11	20.0%	0.01	20.0%	0.01	20.0%	0.01	25.7%	0.03	47.0%	0.17	60.9%	0.36
12	20.0%	0.01	20.0%	0.01	20.0%	0.01	28.5%	0.04	52.2%	0.23	66.0%	0.47
13	20.0%	0.01	20.0%	0.01	25.7%	0.03	39.1%	0.10	56.5%	0.29	70.8%	0.57
14	20.0%	0.01	20.0%	0.01	32.8%	0.06	45.8%	0.16	61.3%	0.37	75.9%	0.71
15	20.0%	0.01	20.0%	0.01	36.4%	0.08	53.8%	0.25	66.4%	0.47	81.0%	0.86
16	20.0%	0.01	20.0%	0.01	41.9%	0.12	56.9%	0.30	70.4%	0.56	85.0%	0.99
17	20.0%	0.01	20.0%	0.01	45.5%	0.15	57.3%	0.30	70.8%	0.57	84.6%	0.98
18	20.0%	0.01	20.0%	0.01	40.7%	0.11	53.4%	0.25	67.6%	0.50	81.4%	0.87
19	20.0%	0.01	20.0%	0.01	30.4%	0.05	44.3%	0.14	60.5%	0.36	74.7%	0.67
20	20.0%	0.01	20.0%	0.01	20.0%	0.01	33.6%	0.06	49.8%	0.20	64.0%	0.42
21	21.2%	0.02	20.0%	0.01	20.0%	0.01	23.3%	0.02	39.1%	0.10	53.0%	0.24
22	27.0%	0.03	20.0%	0.01	20.0%	0.01	20.0%	0.01	30.0%	0.04	42.7%	0.13
23	30.2%	0.04	21.1%	0.02	20.0%	0.01	20.0%	0.01	24.9%	0.02	37.2%	0.08
24	32.6%	0.06	23.5%	0.02	20.0%	0.01	20.0%	0.01	20.9%	0.01	33.2%	0.06
AVG, DAILY CONSUMPTION PER MONTH (KW)		0.92		0.60		0.81		1.81		4.18		8.22

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	0.28	52.4%	0.23	21.3%	0.02	20.0%	0.01	20.0%	0.01	20.0%	0.01
2	54.2%	0.26	50.8%	0.21	20.0%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
3	53.4%	0.25	49.7%	0.20	20.0%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
4	52.9%	0.24	48.7%	0.19	20.0%	0.01	20.0%	0.01	20.0%	0.01	21.0%	0.01
5	52.6%	0.23	48.5%	0.18	20.0%	0.01	20.0%	0.01	20.0%	0.01	21.2%	0.02
6	52.8%	0.24	48.7%	0.19	20.0%	0.01	20.0%	0.01	20.0%	0.01	21.0%	0.02
7	56.0%	0.28	50.8%	0.21	20.0%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
8	61.7%	0.38	55.9%	0.28	20.6%	0.01	20.0%	0.01	20.0%	0.01	20.0%	0.01
9	69.0%	0.53	63.3%	0.41	33.2%	0.06	20.0%	0.01	20.0%	0.01	20.0%	0.01
10	75.3%	0.69	70.2%	0.56	45.8%	0.16	23.3%	0.02	20.0%	0.01	20.0%	0.01
11	80.4%	0.84	76.8%	0.73	54.9%	0.27	31.2%	0.05	20.0%	0.01	20.0%	0.01
12	85.1%	1.00	82.7%	0.91	60.9%	0.36	43.1%	0.13	20.0%	0.01	20.0%	0.01
13	88.4%	1.12	86.9%	1.06	65.6%	0.46	48.6%	0.19	20.0%	0.01	20.0%	0.01
14	90.8%	1.21	89.0%	1.14	71.1%	0.58	54.9%	0.27	28.9%	0.04	20.0%	0.01
15	91.6%	1.24	89.8%	1.17	76.7%	0.73	60.5%	0.36	33.6%	0.06	25.3%	0.03
16	91.2%	1.23	89.5%	1.16	79.4%	0.81	62.5%	0.39	34.4%	0.07	27.3%	0.03
17	89.5%	1.16	87.6%	1.09	78.3%	0.78	58.9%	0.33	30.4%	0.05	23.3%	0.02
18	86.1%	1.03	83.4%	0.94	69.6%	0.54	49.0%	0.19	21.3%	0.02	20.0%	0.01
19	81.3%	0.87	77.7%	0.76	57.7%	0.31	37.9%	0.09	20.0%	0.01	20.0%	0.01
20	75.6%	0.70	69.8%	0.55	46.6%	0.16	27.3%	0.03	20.0%	0.01	20.0%	0.01
21	68.2%	0.51	63.6%	0.42	37.5%	0.09	21.7%	0.02	20.0%	0.01	20.0%	0.01
22	62.8%	0.40	58.7%	0.33	31.2%	0.05	20.0%	0.01	20.0%	0.01	20.0%	0.01
23	59.3%	0.34	55.1%	0.27	26.5%	0.03	20.0%	0.01	20.0%	0.01	20.0%	0.01
24	57.0%	0.30	52.7%	0.24	22.9%	0.02	20.0%	0.01	20.0%	0.01	20.0%	0.01
AVG, DAILY CONSUMPTION PER MONTH (KW)		15.33		13.43		5.52		2.22		0.47		0.36

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.124 Daily Pump Consumption (Primary/Secondary): Model 6

Table G.125 Primary/Secondary System Annual Utility Cost: Model 6

PRIMARY/SECONDARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	0.92	31	29	$ 0.09	$ 2.57
FEBRUARY	0.60	28	17	$ 0.09	$ 1.51
MARCH	0.81	31	25	$ 0.09	$ 2.25
APRIL	1.81	30	54	$ 0.09	$ 4.88
MAY	4.18	31	130	$ 0.09	$ 11.66
JUNE	8.22	30	246	$ 0.09	$ 22.18
JULY	15.33	31	475	$ 0.09	$ 42.78
AUGUST	13.43	31	416	$ 0.09	$ 37.48
SEPTEMBER	5.52	30	166	$ 0.09	$ 14.90
OCTOBER	2.22	31	69	$ 0.09	$ 6.19
NOVEMBER	0.47	30	14	$ 0.09	$ 1.28
DECEMBER	0.36	31	11	$ 0.09	$ 1.00
ANNUAL UTILITY CONSUMPTION & COST			1652	KWH	$ 148.69

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 6 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS AND PRIMARY PUMP CONSUMPTION	3.01	BHP
	2.24	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	30.8%	0.07	27.8%	0.05	20.0%	0.02	20.0%	0.02	20.0%	0.02	45.7%	0.21
2	33.1%	0.08	29.1%	0.06	20.0%	0.02	20.0%	0.02	20.0%	0.02	44.9%	0.20
3	34.9%	0.10	30.2%	0.06	20.0%	0.02	20.0%	0.02	20.0%	0.02	44.0%	0.19
4	36.0%	0.10	31.0%	0.07	20.0%	0.02	20.0%	0.02	20.0%	0.02	43.4%	0.18
5	36.5%	0.11	31.5%	0.07	20.0%	0.02	20.0%	0.02	20.0%	0.02	42.9%	0.18
6	36.7%	0.11	32.5%	0.08	20.0%	0.02	20.0%	0.02	20.0%	0.02	43.5%	0.18
7	36.8%	0.11	31.5%	0.07	20.0%	0.02	20.0%	0.02	20.0%	0.02	46.7%	0.23
8	37.0%	0.11	31.0%	0.07	20.0%	0.02	20.0%	0.02	22.5%	0.03	52.4%	0.32
9	31.5%	0.07	23.9%	0.03	20.0%	0.02	20.0%	0.02	31.6%	0.07	59.6%	0.47
10	24.5%	0.03	20.0%	0.02	20.0%	0.02	20.0%	0.02	40.7%	0.15	66.1%	0.65
11	20.0%	0.02	20.0%	0.02	20.0%	0.02	25.7%	0.04	47.0%	0.23	72.2%	0.84
12	20.0%	0.02	20.0%	0.02	20.0%	0.02	28.5%	0.05	52.2%	0.32	76.3%	1.00
13	20.0%	0.02	20.0%	0.02	25.7%	0.04	39.1%	0.13	56.5%	0.41	79.7%	1.14
14	20.0%	0.02	20.0%	0.02	32.8%	0.08	45.8%	0.22	61.3%	0.52	82.3%	1.25
15	20.0%	0.02	20.0%	0.02	36.4%	0.11	53.8%	0.35	66.4%	0.66	83.4%	1.30
16	20.0%	0.02	20.0%	0.02	41.9%	0.17	56.9%	0.41	70.4%	0.78	83.3%	1.30
17	20.0%	0.02	20.0%	0.02	45.5%	0.21	57.3%	0.42	70.8%	0.79	81.5%	1.22
18	20.0%	0.02	20.0%	0.02	40.7%	0.15	53.4%	0.34	67.6%	0.69	77.9%	1.06
19	20.0%	0.02	20.0%	0.02	30.4%	0.06	44.3%	0.19	60.5%	0.50	72.6%	0.86
20	20.0%	0.02	20.0%	0.02	20.0%	0.02	33.6%	0.09	49.8%	0.28	65.4%	0.63
21	21.2%	0.02	20.0%	0.02	20.0%	0.02	23.3%	0.03	39.1%	0.13	58.5%	0.45
22	27.0%	0.04	20.0%	0.02	20.0%	0.02	20.0%	0.02	30.0%	0.06	53.3%	0.34
23	30.2%	0.06	21.1%	0.02	20.0%	0.02	20.0%	0.02	24.9%	0.03	49.7%	0.28
24	32.6%	0.08	23.5%	0.03	20.0%	0.02	20.0%	0.02	20.9%	0.02	47.6%	0.24
AVG, DAILY CONSUMPTION PER MONTH (KW)		1.28		0.83		1.12		2.51		5.80		14.73

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	0.39	52.4%	0.32	21.3%	0.02	20.0%	0.02	20.0%	0.02	20.0%	0.02
2	54.2%	0.36	50.8%	0.29	20.0%	0.02	20.0%	0.02	20.0%	0.02	20.0%	0.02
3	53.4%	0.34	49.7%	0.28	20.0%	0.02	20.0%	0.02	20.0%	0.02	20.0%	0.02
4	52.9%	0.33	48.7%	0.26	20.0%	0.02	20.0%	0.02	20.0%	0.02	21.0%	0.02
5	52.6%	0.33	48.5%	0.26	20.0%	0.02	20.0%	0.02	20.0%	0.02	21.2%	0.02
6	52.8%	0.33	48.7%	0.26	20.0%	0.02	20.0%	0.02	20.0%	0.02	21.0%	0.02
7	56.0%	0.39	50.8%	0.29	20.0%	0.02	20.0%	0.02	20.0%	0.02	20.0%	0.02
8	61.7%	0.53	55.9%	0.39	20.6%	0.02	20.0%	0.02	20.0%	0.02	20.0%	0.02
9	69.0%	0.74	63.3%	0.57	33.2%	0.08	20.0%	0.02	20.0%	0.02	20.0%	0.02
10	75.3%	0.96	70.2%	0.77	45.8%	0.22	23.3%	0.03	20.0%	0.02	20.0%	0.02
11	80.4%	1.16	76.8%	1.02	54.9%	0.37	31.2%	0.07	20.0%	0.02	20.0%	0.02
12	85.1%	1.38	82.7%	1.27	60.9%	0.51	43.1%	0.18	20.0%	0.02	20.0%	0.02
13	88.4%	1.55	86.9%	1.47	65.6%	0.63	48.6%	0.26	20.0%	0.02	20.0%	0.02
14	90.8%	1.68	89.0%	1.58	71.1%	0.81	54.9%	0.37	28.9%	0.05	20.0%	0.02
15	91.6%	1.72	89.8%	1.63	76.7%	1.01	60.5%	0.50	33.6%	0.09	25.3%	0.04
16	91.2%	1.70	89.5%	1.61	79.4%	1.13	62.5%	0.55	34.4%	0.09	27.3%	0.05
17	89.5%	1.61	87.6%	1.51	78.3%	1.08	58.9%	0.46	30.4%	0.06	23.3%	0.03
18	86.1%	1.43	83.4%	1.30	69.6%	0.76	49.0%	0.26	21.3%	0.02	20.0%	0.02
19	81.3%	1.20	77.7%	1.05	57.7%	0.43	37.9%	0.12	20.0%	0.02	20.0%	0.02
20	75.6%	0.97	69.8%	0.76	46.6%	0.23	27.3%	0.05	20.0%	0.02	20.0%	0.02
21	68.2%	0.71	63.6%	0.58	37.5%	0.12	21.7%	0.02	20.0%	0.02	20.0%	0.02
22	62.8%	0.55	58.7%	0.45	31.2%	0.07	20.0%	0.02	20.0%	0.02	20.0%	0.02
23	59.3%	0.47	55.1%	0.38	26.5%	0.04	20.0%	0.02	20.0%	0.02	20.0%	0.02
24	57.0%	0.42	52.7%	0.33	22.9%	0.03	20.0%	0.02	20.0%	0.02	20.0%	0.02
AVG, DAILY CONSUMPTION (KW)		21.27		18.63		7.65		3.08		0.66		0.50

GENERAL NOTES:
1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.126 Daily Pump Consumption (Distributive w/ Primary): Model 6

Table G.127 Distributive w/ Primary System Annual Utility Cost: Model 6

DISTRIBUTIVE W/ PRIMARY SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	1.28	31	40	$ 0.09	$ 3.57
FEBRUARY	0.83	28	23	$ 0.09	$ 2.10
MARCH	1.12	31	35	$ 0.09	$ 3.13
APRIL	2.51	30	75	$ 0.09	$ 6.77
MAY	5.80	31	180	$ 0.09	$ 16.18
JUNE	14.73	30	442	$ 0.09	$ 39.76
JULY	21.27	31	659	$ 0.09	$ 59.34
AUGUST	18.63	31	578	$ 0.09	$ 51.99
SEPTEMBER	7.65	30	230	$ 0.09	$ 20.66
OCTOBER	3.08	31	95	$ 0.09	$ 8.59
NOVEMBER	0.66	30	20	$ 0.09	$ 1.77
DECEMBER	0.50	31	15	$ 0.09	$ 1.39
ANNUAL UTILITY CONSUMPTION & COST			2392	KWH	$ 215.25

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 6 - DAILY PUMP CONSUMPTION

TOTAL DISTRIBUTIVE PUMPS CONSUMPTION		
	4.71	BHP
	3.51	KW

AVERAGE DAY	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	30.8%	0.10	27.8%	0.08	20.0%	0.03	20.0%	0.03	20.0%	0.03	45.7%	0.33
2	33.1%	0.13	29.1%	0.09	20.0%	0.03	20.0%	0.03	20.0%	0.03	44.9%	0.32
3	34.9%	0.15	30.2%	0.10	20.0%	0.03	20.0%	0.03	20.0%	0.03	44.0%	0.30
4	36.0%	0.16	31.0%	0.10	20.0%	0.03	20.0%	0.03	20.0%	0.03	43.4%	0.29
5	36.5%	0.17	31.5%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	42.9%	0.28
6	36.7%	0.17	32.5%	0.12	20.0%	0.03	20.0%	0.03	20.0%	0.03	43.5%	0.29
7	36.8%	0.17	31.5%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03	46.7%	0.36
8	37.0%	0.18	31.0%	0.10	20.0%	0.03	20.0%	0.03	22.5%	0.04	52.4%	0.51
9	31.5%	0.11	23.9%	0.05	20.0%	0.03	20.0%	0.03	31.6%	0.11	59.6%	0.74
10	24.5%	0.05	20.0%	0.03	20.0%	0.03	20.0%	0.03	40.7%	0.24	66.1%	1.01
11	20.0%	0.03	20.0%	0.03	20.0%	0.03	25.7%	0.06	47.0%	0.37	72.2%	1.32
12	20.0%	0.03	20.0%	0.03	20.0%	0.03	28.5%	0.08	52.2%	0.50	76.3%	1.56
13	20.0%	0.03	20.0%	0.03	25.7%	0.06	39.1%	0.21	56.5%	0.63	79.7%	1.78
14	20.0%	0.03	20.0%	0.03	32.8%	0.12	45.8%	0.34	61.3%	0.81	82.3%	1.96
15	20.0%	0.03	20.0%	0.03	36.4%	0.17	53.8%	0.55	66.4%	1.03	83.4%	2.04
16	20.0%	0.03	20.0%	0.03	41.9%	0.26	56.9%	0.65	70.4%	1.22	83.3%	2.03
17	20.0%	0.03	20.0%	0.03	45.5%	0.33	57.3%	0.66	70.8%	1.24	81.5%	1.90
18	20.0%	0.03	20.0%	0.03	40.7%	0.24	53.4%	0.53	67.6%	1.08	77.9%	1.66
19	20.0%	0.03	20.0%	0.03	30.4%	0.10	44.3%	0.30	60.5%	0.78	72.6%	1.34
20	20.0%	0.03	20.0%	0.03	20.0%	0.03	33.6%	0.13	49.8%	0.43	65.4%	0.98
21	21.2%	0.03	20.0%	0.03	20.0%	0.03	23.3%	0.04	39.1%	0.21	58.5%	0.70
22	27.0%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03	30.0%	0.10	53.3%	0.53
23	30.2%	0.10	21.1%	0.03	20.0%	0.03	20.0%	0.03	24.9%	0.05	49.7%	0.43
24	32.6%	0.12	23.5%	0.05	20.0%	0.03	20.0%	0.03	20.9%	0.03	47.6%	0.38
AVG, DAILY CONSUMPTION PER MONTH (KW)		2.00		1.30		1.75		3.93		9.07		23.04

AVERAGE DAY	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR	PART-LOAD % EACH HOUR	PART-LOAD CONSUMPTION PER HOUR
HOURS	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)	%	(KWH)
1	55.6%	0.60	52.4%	0.51	21.3%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
2	54.2%	0.56	50.8%	0.46	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
3	53.4%	0.54	49.7%	0.43	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
4	52.9%	0.52	48.7%	0.41	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.0%	0.03
5	52.6%	0.51	48.5%	0.40	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.2%	0.03
6	52.8%	0.52	48.7%	0.41	20.0%	0.03	20.0%	0.03	20.0%	0.03	21.0%	0.03
7	56.0%	0.62	50.8%	0.46	20.0%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
8	61.7%	0.83	55.9%	0.61	20.6%	0.03	20.0%	0.03	20.0%	0.03	20.0%	0.03
9	69.0%	1.15	63.3%	0.89	33.2%	0.13	20.0%	0.03	20.0%	0.03	20.0%	0.03
10	75.3%	1.50	70.2%	1.21	45.8%	0.34	23.3%	0.04	20.0%	0.03	20.0%	0.03
11	80.4%	1.82	76.8%	1.59	54.9%	0.58	31.2%	0.11	20.0%	0.03	20.0%	0.03
12	85.1%	2.16	82.7%	1.98	60.9%	0.79	43.1%	0.28	20.0%	0.03	20.0%	0.03
13	88.4%	2.43	86.9%	2.30	65.6%	0.99	48.6%	0.40	20.0%	0.03	20.0%	0.03
14	90.8%	2.63	89.0%	2.48	71.1%	1.26	54.9%	0.58	28.9%	0.08	20.0%	0.03
15	91.6%	2.70	89.8%	2.54	76.7%	1.58	60.5%	0.78	33.6%	0.13	25.3%	0.06
16	91.2%	2.66	89.5%	2.52	79.4%	1.76	62.5%	0.86	34.4%	0.14	27.3%	0.07
17	89.5%	2.52	87.6%	2.36	78.3%	1.68	58.9%	0.72	30.4%	0.10	23.3%	0.04
18	86.1%	2.24	83.4%	2.04	69.6%	1.18	49.0%	0.41	21.3%	0.03	20.0%	0.03
19	81.3%	1.88	77.7%	1.65	57.7%	0.67	37.9%	0.19	20.0%	0.03	20.0%	0.03
20	75.6%	1.52	69.8%	1.19	46.6%	0.36	27.3%	0.07	20.0%	0.03	20.0%	0.03
21	68.2%	1.12	63.6%	0.91	37.5%	0.19	21.7%	0.04	20.0%	0.03	20.0%	0.03
22	62.8%	0.87	58.7%	0.71	31.2%	0.11	20.0%	0.03	20.0%	0.03	20.0%	0.03
23	59.3%	0.73	55.1%	0.59	26.5%	0.07	20.0%	0.03	20.0%	0.03	20.0%	0.03
24	57.0%	0.65	52.7%	0.51	22.9%	0.04	20.0%	0.03	20.0%	0.03	20.0%	0.03
AVG, DAILY CONSUMPTION (KW)		33.28		29.16		11.97		4.82		1.03		0.78

GENERAL NOTES:

1. 20% MINIMUM PUMP SPEED ASSUMED
2. PART-LOAD % EACH HOUR TAKEN FROM SIMULTANEOUS HEATING AND COOLING PART-LOAD
3. **PART-LOAD CONSUMPTION PER HOUR** CALCULATION: ("TOTAL PUMP KW")*("PART-LOAD % PER HOUR")^3
4. **AVG DAILY CONSUMPTION PER MONTH (KWH/DAY)** CALCULATION: SUM OF "PART-LOAD CONSUMPTION PER HOUR" FOR 24-HOURS

Table G.128 Daily Pump Consumption (Distributive): Model 6

Table G.129 Distributive System Annual Utility Cost: Model 6

DISTRIBUTIVE SYSTEM ANNUAL UTILITY COST					
MONTH	AVG. DAILY CONSUMPTION (KWH/DAY)	DAYS PER MONTH	MONTHLY CONSUMPTION (KWH)	COST PER KWH	MONTHLY UTILITY COST
JANUARY	2.00	31	62	$ 0.09	$ 5.59
FEBRUARY	1.30	28	36	$ 0.09	$ 3.28
MARCH	1.75	31	54	$ 0.09	$ 4.89
APRIL	3.93	30	118	$ 0.09	$ 10.60
MAY	9.07	31	281	$ 0.09	$ 25.32
JUNE	23.04	30	691	$ 0.09	$ 62.22
JULY	33.28	31	1032	$ 0.09	$ 92.85
AUGUST	29.16	31	904	$ 0.09	$ 81.36
SEPTEMBER	11.97	30	359	$ 0.09	$ 32.33
OCTOBER	4.82	31	149	$ 0.09	$ 13.44
NOVEMBER	1.03	30	31	$ 0.09	$ 2.77
DECEMBER	0.78	31	24	$ 0.09	$ 2.17
ANNUAL UTILITY CONSUMPTION & COST			3742	KWH	$ 336.82

GENERAL NOTES:

1. AVG. DAILY CONSUMPTION TAKEN FROM DAILY PUMP CONSUMPTION SPREAD SHEET
2. **MONTHLY CONSUMPTION** CALCULATION: "AVG. DAILY CONSUMPTION"*"DAYS PER MONTH"
3. $0.09 PER KWH ASSUMED FOR TOPEKA, KS
4. **MONTHLY UTILITY COST** CALCULATION: "MONTHLY CONSUMPTION"*"COST PER KWH"
5. **ANNUAL UTILITY COST** CALCULATION: SUM OF MONTHLY UTILITY COST FOR 12 MONTHS

MODEL 6 - 30-YEAR LIFE CYCLE COST ANALYSIS

SYSTEM	INITIAL COST			REPLACEMENT COST			UTILITY		REGULAR MAINTENANCE				PREVENTATIVE MAINT.		TOTAL 30-YEAR LIFE CYCLE COST
	TOTAL UNIT COST	TOTAL INSTALL COST	30-YEAR PROJECTED COST	TOTAL NEW UNIT COST	TOTAL LABOR COST	30-YEAR PROJECTED COST	ANNUAL COST	30-YEAR PROJECTED COST	LUBRICATION (ANNUAL COST)	PACKING (ANNUAL COST)	SEALS (ANNUAL COST)	30-YEAR PROJECTED COST	MONITORING (ANNUAL COST)	30-YEAR PROJECTED COST	
PRIMARY ONLY	$ 7,293.00	$ 1,815.60	$ 52,315.16	$ 9,480.90	$ 3,540.42	$ 31,206.35	$ 128.53	$ 10,161.35	$ 600.00	$ 676.00	$ 1,580.00	$ 29,709.98	$ 144.00	$ 11,384.38	$ 134,777.23
PRIMARY/SECONDARY	$ 11,179.20	$ 2,550.00	$ 78,853.54	$ 14,532.96	$ 4,972.50	$ 46,745.97	$ 148.69	$ 11,755.16	$ 1,200.00	$ 1,352.00	$ 2,180.00	$ 53,541.94	$ 216.00	$ 17,076.57	$ 207,973.18
DISTRIBUTIVE W/ PRIMARY	$ 15,347.94	$ 1,408.98	$ 96,243.20	$ 19,952.32	$ 2,747.51	$ 54,401.46	$ 215.25	$ 17,017.27	$ 600.00	$ 676.00	$ 1,580.00	$ 29,709.98	$ 403.20	$ 31,876.26	$ 229,248.18
DISTRIBUTIVE	$ 18,139.68	$ 1,110.17	$ 110,561.33	$ 23,581.58	$ 2,164.83	$ 61,702.77	$ 336.82	$ 26,628.38	$ -	$ -	$ -	$ -	$ 259.20	$ 20,491.88	$ 219,384.37

GENERAL NOTES:

1. PUMP INITIAL UNIT AND INSTALLATION COST FROM RS MEANS MECHANICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
2. VFD INITIAL UNIT AND INSTALLATION COST FROM RS MEANS ELECTRICAL COST DATA: 2011, WITH 2% INFLATION TO CONVERT TO 2012 COSTS
3. **UNIT REPLACEMENT LABOR** CALCULATION: (INITIAL INSTALL)*1.5*1.3 TO ACCOUNT FOR PUMP REMOVAL AND 15-YEAR INFLATION (NOTE: 2% INFLATION RATE PER YEAR)
4. 15-YEAR REPLACEMENT FOR ALL PUMPS AND VFDs WAS ASSUMED, WITH 2% INFLATION PER YEAR
5. UTILITY ANNUAL COST FROM UTILITY CALCULATION TABLES
6. PUMP LUBRICATION ASSUMED 30 MINUTES AND $5 MATERIAL COST
   - MOTORS: 1 PER YEAR
   - PUMPS: 1 PER MONTH, 12 PER YEAR
   - THEREFORE, 13 LUBRICATIONS PER YEAR PER PUMP
7. PUMP PACKING ASSUMED 1 DAY AND $50 MATERIAL COST
   - ONCE EVERY 3 YEARS
8. PUMP SEALS ASSUMED 1 DAY AND $400-$1000 MATERIAL COST
   - ONCE EVERY 10 YEARS
   - MATERIAL COST VARIES FROM SMALLER TO LARGER PUMP SIZES
9. PUMP MONITORING ASSUMED 3 MINUTES, ONCE A MONTH FOR EACH CIRCULATOR PUMP, 10 MINUTES, TWICE A MONTH FOR THE PRIMARY PUMPS AND AN ADDITIONAL 5 MINUTES, TWICE A MONTH FOR THE SECONDARY PUMPS (WHEN APPLICABLE)
10. ALL "30-YEAR PROJECTED COST" EQUIVICATE THEIR RESPECTIVE COSTS TO A FUTURE COST, WHERE n=30
11. INTEREST (i) ASSUMED TO BE 6% FOR ALL CALCULATIONS
12. 100% REDUNDANCY WAS ASSUMED FOR ALL PRIMARY AND SECONDARY PUMPING CONFIGURATIONS
13. VFDs INSTALLED ON ALL PRIMARY AND SECONDARY PUMPS

Table G.130 30-Year Life-Cycle Cost Analysis: Model 6