



Basic Design Service Report

John's Plumbing & Heating

Project: Example Residence

Prepared: January 1, 2009

April 29, 2009

John's Plumbing & Heating

Attn: John Doe

123 Lincoln Ave

Boston, MA 02101

Office: (800) 888-0001

Fax: (800) 888-0002

RE: Final GSHP System Design Report for Example Residence

Section 1: Manual J Loads, GSHP Schedule, & Operating Cost Comparisons

According to the information provided, the peak loads for the residence were calculated to be as listed in the following table. Several assumptions were employed to estimate the loads, such as internal gain (due to occupancy levels and appliance use), infiltration levels, etc. All loads assume 70/75/50 (heating temp/cooling temp/%-RH) thermostat set points and 0.31 ACH infiltration levels in heating and 0.15 ACH infiltration levels in cooling (average house construction levels). Total conditioned floor area was found to be approximately 4670 ft² (assumed use of a forced-air system on all floors, 3 zones).

Table 1. Peak Loads

Building Zone	Heating Load	Cooling Load (Sens)	Zone SHF
Basement	16,363 Btu/hr	6,823 Btu/hr	0.804
Main Level	18,562 Btu/hr	15,085 Btu/hr	0.857
Upper Level	22,605 Btu/hr	16,224 Btu/hr	0.854
Totals	57,530 Btu/hr	38,132 Btu/hr	0.846

All loads calculated using software in compliance with ACCA Manual J and are based on provided construction of the building (insulation levels, window quality, etc.) The loads provided in the table include ventilation loads (assumed use of an energy recovery ventilator (ERV) for provision of 150 cfm outside AFV with 60% effectiveness).

Based on the calculated peak equipment loads, the recommended heat pump schedule is as follows:

Table 2. Recommended GSHP Equipment Schedule

<i>Space</i>	<i>Brand/Model</i>	<i>Htg Cap.</i>	<i>%-Sizing</i>	<i>Water Flow</i>	<i>Air Flow</i>
Basement & Main Level	Climate Master TT049	37.9 MBH	109%	12.0	1650
Upper Level	Climate Master TT026	19.4 MBH	86%	8.0	950

- *Equipment water flow rate measured in gallons per minute (gpm)*
- *Equipment air flow rate measured in cubic feet per minute (cfm)*
- *Equipment capacities based on 30°F minimum EWT from the loopfield and 70°F EAT from the space in heating*
- *Equipment capacities in cooling not listed because of heating dominance for the home*
- *Dual capacity equipment specified for optimum performance at part-load conditions during the majority of the year in heating in addition to superior dehumidification in low-capacity in cooling mode*
- *Installation of 10-kW backup electric resistance heat recommended for emergency heating capabilities*

The ACCA Manual J peak heating and cooling load calculations as well as the GSHP equipment selection information for the residence are displayed in the following pages. The operating cost calculations were based on an estimated electric rate of \$0.12/kWh.



Project Information

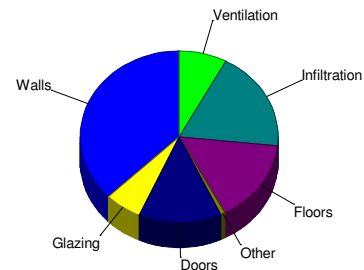
For: John Doe
 123 Lincoln Ave, Boston, MA 20101
 Phone: (888) 800-0001 Fax: (888) 800-0002

Design Conditions

Location: Boston, MA, US Elevation: 30 ft Latitude: 42 °N		Indoor: Indoor temperature (°F) 70 Design TD (°F) 58 Relative humidity (%) 50 Moisture difference (gr/lb) 46.7	Heating 70	Cooling 75
Outdoor: Dry bulb (°F) 12 Daily range (°F) - Wet bulb (°F) - Wind speed (mph) 15.0	Heating 12	Cooling 87		
		15 (L) 71 7.5		
		Infiltration: Method Simplified Construction quality Average Fireplaces 2 (Average)		

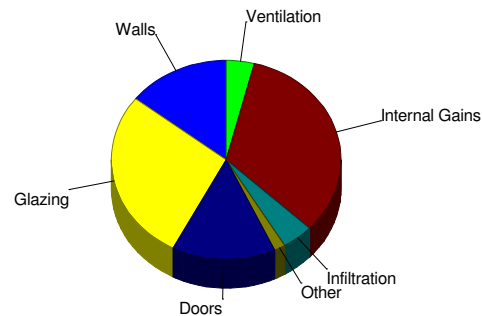
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	3.5	6104	37.3
Glazing	23.8	991	6.1
Doors	15.1	2217	13.5
Ceilings	1.5	123	0.8
Floors	1.6	2566	15.7
Infiltration	2.9	3087	18.9
Ducts		0	0.0
Piping		0	0.0
Humidification		0	0.0
Ventilation		1275	7.8
Adjustments		0	
Total		16363	100.0



Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.6	984	14.4
Glazing	45.7	1906	27.9
Doors	6.8	996	14.6
Ceilings	1.3	105	1.5
Floors	0.0	0	0.0
Infiltration	0.3	304	4.5
Ducts		0	0.0
Ventilation		268	3.9
Internal gains		2260	33.1
Blower		0	0.0
Adjustments		0	
Total		6823	100.0



Overall U-value = 0.055 Btuh/ft²-°F

WARNING: window to floor area ratio = 2.5% - less than 5%.



Project Information

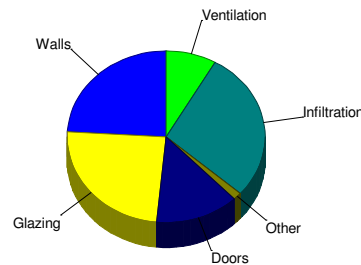
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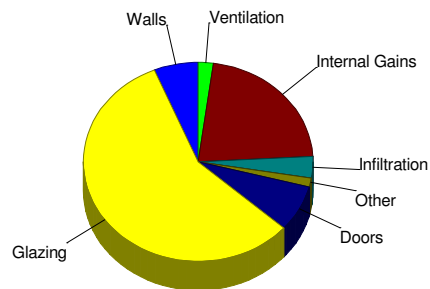
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	3.0	4469	24.1
Glazing	23.8	4525	24.4
Doors	15.1	2533	13.6
Ceilings	1.5	260	1.4
Floors	0.0	0	0.0
Infiltration	2.9	5245	28.3
Ducts		0	0.0
Piping		0	0.0
Humidification		0	0.0
Ventilation		1530	8.2
Adjustments		0	0.0
Total		18562	100.0



Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.6	944	6.3
Glazing	45.3	8622	57.2
Doors	6.8	1138	7.5
Ceilings	1.3	222	1.5
Floors	0.0	0	0.0
Infiltration	0.3	517	3.4
Ducts		0	0.0
Ventilation		322	2.1
Internal gains		3320	22.0
Blower		0	0.0
Adjustments		0	0.0
Total		15085	100.0



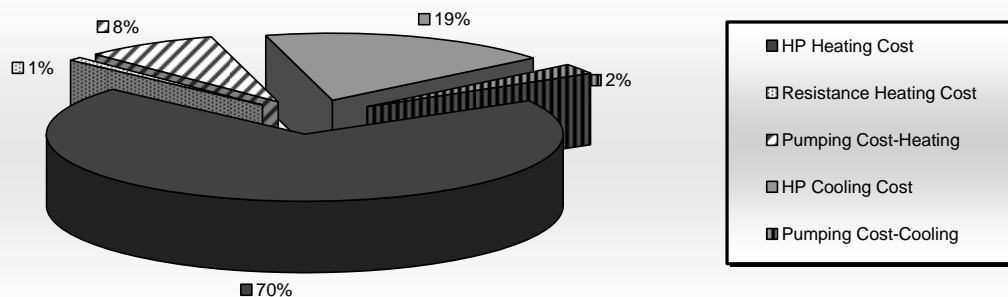
Overall U-value = 0.101 Btuh/ft²-°F

Data entries checked.

GSHP Selection Information for Basement & Main Level:

Print Zone 1		Basement & Main Level			
PEAK LOAD INFORMATION					
Heating			Cooling		
Peak Heating Load	34,925	Btu/hr (@12°F OAT)	Peak Cooling Load (Total)	26,095	Btu/hr (@87°F OAT)
T-Stat Set Point	70	°F	T-Stat Set Point	75	°F
			Zone SHF	0.84	
HEAT PUMP SELECTION					
Heat Pump Type <input checked="" type="checkbox"/> Water-Air <input type="checkbox"/> Water-Water		1-1/2-CAP		Dual Capacity	
Brand Climate Master		Model / Unit SHF		Tranquility TT049	
Htg CAP Correction Factor	1.000	Total Clg CAP Correction Factor	1.000		
Htg DMD Correction Factor	1.000	Sensible Clg CAP Correction Factor	1.000		
No. of Units	1	Clg DMD Correction Factor	1.000		
INSTALLED CAPACITY CHECK					
Heating (EWTmin = 30°F)			Cooling (EWTmax = 90°F)		
Installed Capacity	37,900 Btu/hr		Installed Capacity (SC)	36,075 Btu/hr	
%-Sizing	109%		%-Oversizing (SC)	+65% --> High Cap (+23% --> Low Cap)	
Installed COP _n	3.79		Installed EER _n	14.49	
System Flowrate	12 gpm		System Flowrate	12 gpm	
<i>Installed CAP/COP Based on 70°F EAT, 1650 cfm, & 12 gpm</i>			<i>Installed CAP/EER Based on 80/67°F EAT, 1650 cfm, & 12 gpm</i>		
ENERGY ANALYSIS SUMMARY - ZONE 1					
Heating			Cooling		
HP Energy	5,065	kWh	HP Energy	1,344	kWh
Resistance Energy	68	kWh	Low-Cap Run-Time	656	hrs
Low-Cap Run-Time	1,934	hrs	High-Cap Run-Time	0	hrs
High-Cap Run-Time	275	hrs	Resistance Run-Time	51	hrs
Resistance Run-Time	51	hrs	HP Operating Cost	\$607.78	<i>Specify Elec. Rate</i>
HP Operating Cost	\$607.78		Resistance Operating Cost	\$8.10	
Resistance Operating Cost	\$8.10		Pump Energy	583	kWh
Pump Energy	583	kWh	Pumping Cost	\$69.98	
Pumping Cost	\$69.98		Total Cooling Cost	\$182.00	<i>(Elec. Rate=\$0.12/kWh)</i>
Total Heating Cost	\$685.87	<i>(Elec. Rate=\$0.12/kWh)</i>	Heating Ground Load (HE)	55,352,707	Btu
Heating Ground Load (HE)	55,352,707	Btu	Cooling Ground Load (HR)	-27,733,781	Btu

GSHP Operating Cost Breakdown for Zone 1





Project Information

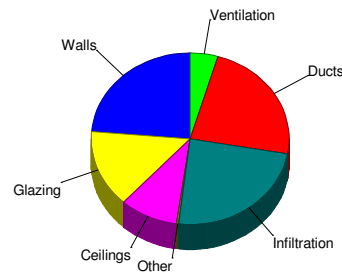
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Outdoor: Dry bulb (°F) Daily range (°F) Wet bulb (°F) Wind speed (mph)	Heating 12 - - 15.0	Cooling 87 15 (L) 71 7.5	Infiltration: Method Construction quality Fireplaces	Simplified Average 2 (Average)	

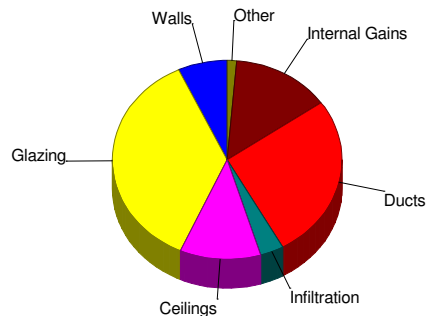
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	3.0	5341	23.6
Glazing	23.8	3294	14.6
Doors	0.0	0	0.0
Ceilings	1.5	2164	9.6
Floors	1.6	78	0.3
Infiltration	2.9	5444	24.1
Ducts		5265	23.3
Piping		0	0.0
Humidification		0	0.0
Ventilation		1020	4.5
Adjustments		-0	
Total		22605	100.0



Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.6	1128	7.0
Glazing	42.6	5903	36.4
Doors	0.0	0	0.0
Ceilings	1.3	1848	11.4
Floors	0.0	0	0.0
Infiltration	0.3	537	3.3
Ducts		4333	26.7
Ventilation		214	1.3
Internal gains		2260	13.9
Blower		0	0.0
Adjustments		-0	
Total		16224	100.0



Overall U-value = 0.055 Btuh/ft²-°F

Data entries checked.

GSHP Selection Information for Upper Level:

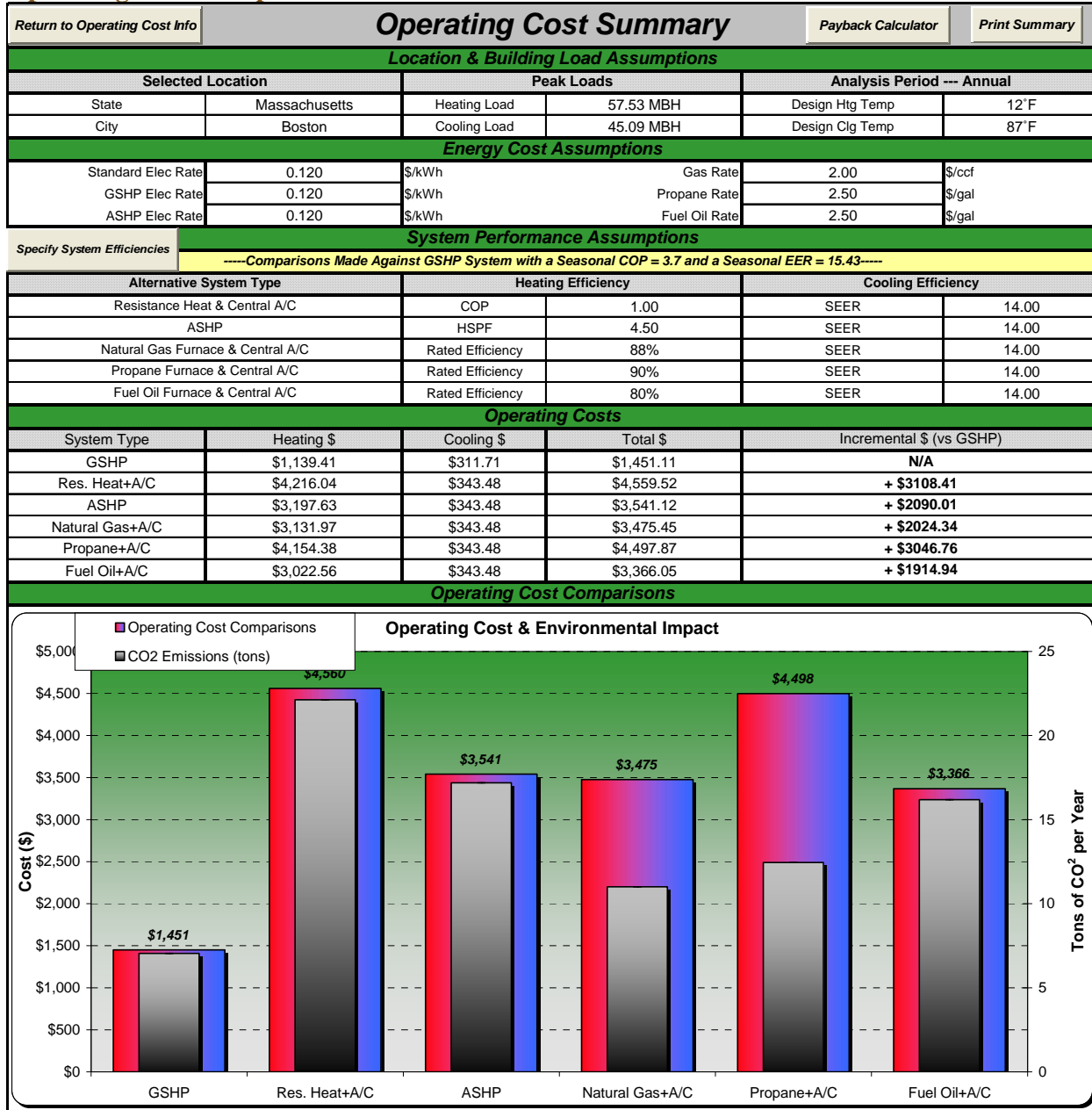
<small>Print Zone 2</small>	Upper Level			
PEAK LOAD INFORMATION				
Heating			Cooling	
Peak Heating Load	22,605	Btu/hr (@12°F OAT)	Peak Cooling Load (Total)	18,990
T-Stat Set Point	70	°F	T-Stat Set Point	75
			Zone SHF	0.85
HEAT PUMP SELECTION				
Heat Pump Type <input checked="" type="checkbox"/> Water-Air <input type="checkbox"/> Water-Water		1-1/2-CAP Dual Capacity		
Brand Climate Master		Model / Unit SHF Tranquility TT026		
Htg CAP Correction Factor	1.000	Clg CAP Correction Factor	1.000	
Htg DMD Correction Factor	1.000	Sensible Clg CAP Correction Factor	1.000	
No. of Units	1	Clg DMD Correction Factor	1.000	
INSTALLED CAPACITY CHECK				
Heating (EWTmin = 30°F)			Cooling (EWTmax = 90°F)	
Installed Capacity	19,400 Btu/hr		Installed Capacity (TC)	21,521 Btu/hr
%-Sizing	86%		%-Oversizing (SC)	+17% --> High Cap (-12% --> Low Cap)
Installed COP _n	3.82		Installed EER _n	14.82
System Flowrate	8 gpm		System Flowrate	8 gpm
Installed CAP/COP Based on 70°F EAT, 950 cfm, & 8 gpm			Installed CAP/EER Based on 80/67°F EAT, 950 cfm, & 8 gpm	
ENERGY ANALYSIS SUMMARY - ZONE 2				
Heating			Cooling	
HP Energy	3,109	kWh	HP Energy	923
Resistance Energy	197	kWh	Low-Cap Run-Time	813
Low-Cap Run-Time	2,026	hrs	High-Cap Run-Time	48
High-Cap Run-Time	552	hrs	HP Operating Cost	\$110.73
Resistance Run-Time	136	hrs		--
HP Operating Cost	\$373.04	<small>Specify Elec. Rate</small>	Pump Energy	158
Resistance Operating Cost	\$23.68		Pumping Cost	\$18.98
Pump Energy	473	kWh	Total Cooling Cost	\$129.71
Pumping Cost	\$56.81	(Elec. Rate=\$0.12/kWh)	Cooling Ground Load (HR)	-20,071,913
Total Heating Cost	\$453.54			
Heating Ground Load (HE)	35,766,622	Btu		

GSHP Operating Cost Breakdown for Zone 2

■ HP Heating Cost	64%
▣ Resistance Heating Cost	19%
▤ Pumping Cost-Heating	10%
▥ HP Cooling Cost	4%
▧ Pumping Cost-Cooling	3%

Annual energy usage to heat and cool the building was estimated via the bin analysis. Operating cost comparison calculations were performed based on the utility rates and system efficiencies listed in the table below:

Operating Cost Comparisons:



Section 2: Horizontally-Trenched Ground Loop & Interior Piping Design

As requested, a horizontally-trenched slinky loopfield design and was performed based on peak equipment loads, selected heat pump efficiencies, & predicted equivalent equipment full-load run-time. The geothermal horizontally-trenched slinky loopfield sizing recommendations are as follows:

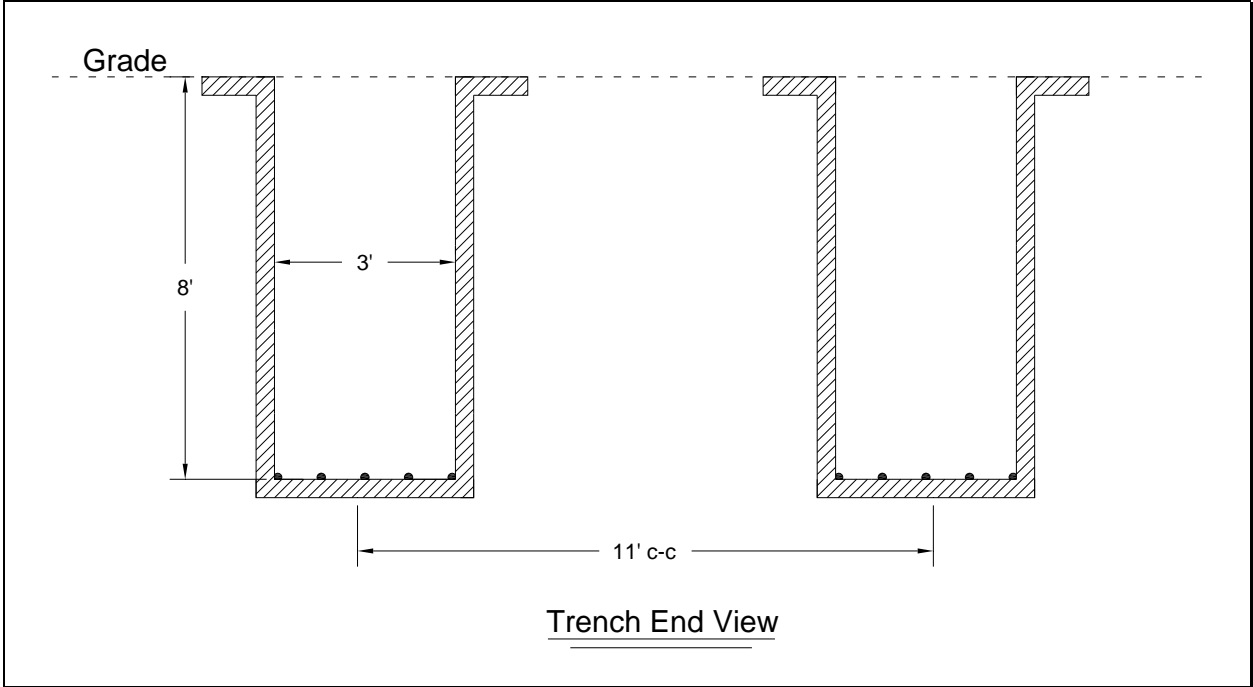
Horizontally-Trenched Slinky Ground Loop Recommendations

Horizontal Trench Layout	6 Trenches – 11' c-c Spacing, Single Flow Path/Trench
Horizontal Trench Dimensions	8' Deep x 3' Wide x 120' Long
GHEX Configuration	Laying 5-pipe (36" pitch x 36" dia. slinky x 600' coil)
GHEX Pipe Diameter	0.75 in (nominal)
Supply-Return Piping Details	Inside-the-Builder Header Method Used

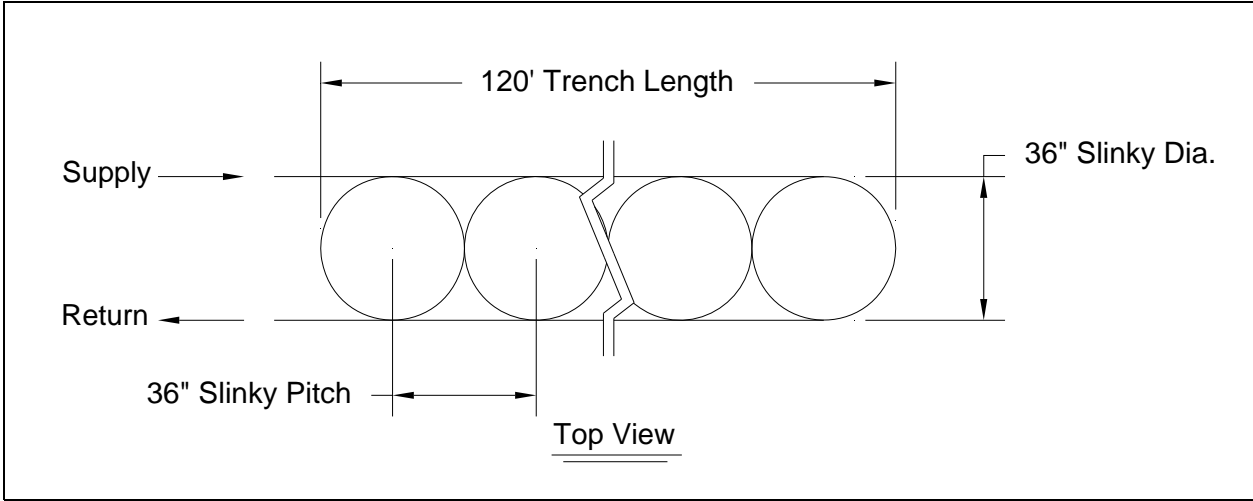
- *Loopfield lengths based on HEATING mode*
- *Average soil temperature at the surface assumed to be 51°F*
- *Annual soil temperature swing assumed to be 21°F*
- *Soil thermal conductivity assumed to be 0.75 Btu/hr-ft-°F*
- *Soil thermal diffusivity assumed to be 0.50 ft²/day*
- *Entering water temperatures will reach a maximum temperature of 70-75°F under worst-case conditions in cooling*
- *Entering water temperatures are designed to reach a minimum temperature of 30°F under worst-case conditions in heating*
- *Loopfield freeze protection to 17°F (10°F below the average loop temperature under design conditions) utilizing 20% propylene glycol by volume (or equivalent) is recommended*

The trench details and slinky construction details are shown below:

Trench Details:



Slinky Construction Details:



For this system, use of a QT 2-Circuit non-pressurized flow center (manufactured by B&D MFG) in conjunction with the inside-the-building header method is recommended (displayed on the next page):

