Geothermal Case Study

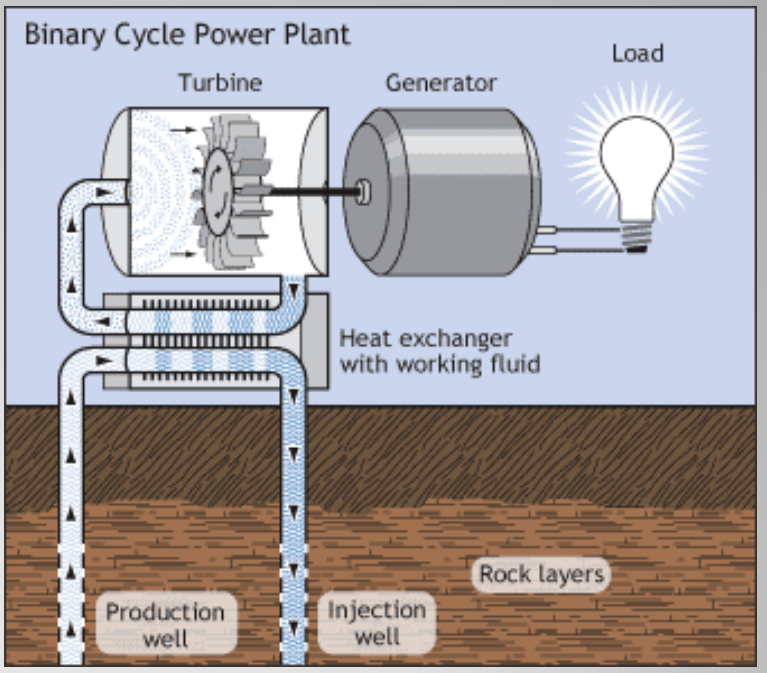
Lieffring Residence—Erdenheim: 2007-2010
Deer River, MN
7 Ton ColdClimate Hydronic Heat/Cool GSHP Application

PRESENTER:
Mark Sakry, CGD
Northern GroundSource Inc.
www.NorthernGroundSource.com

Lieffring Erdenheim—Deer River, MN

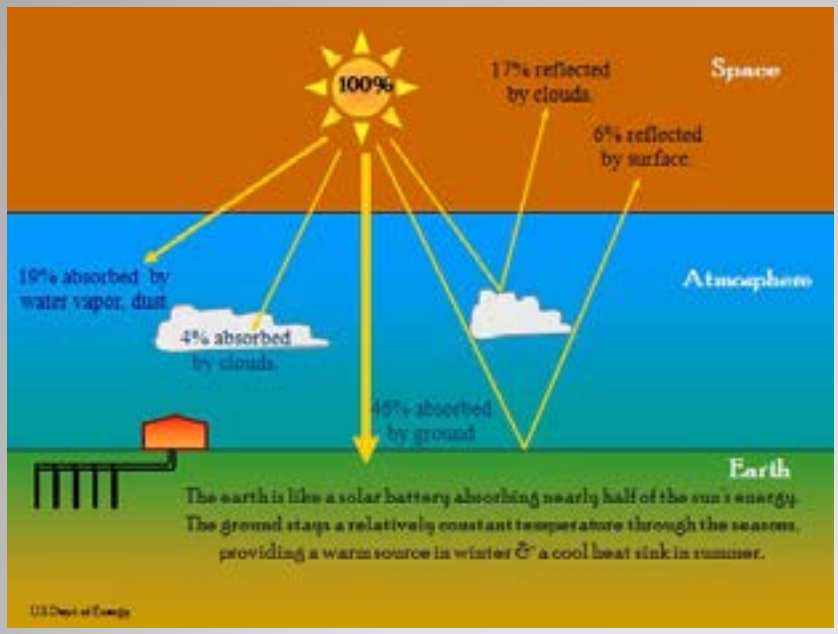
Old Faithful Geyser

“Hot Rocks” Power



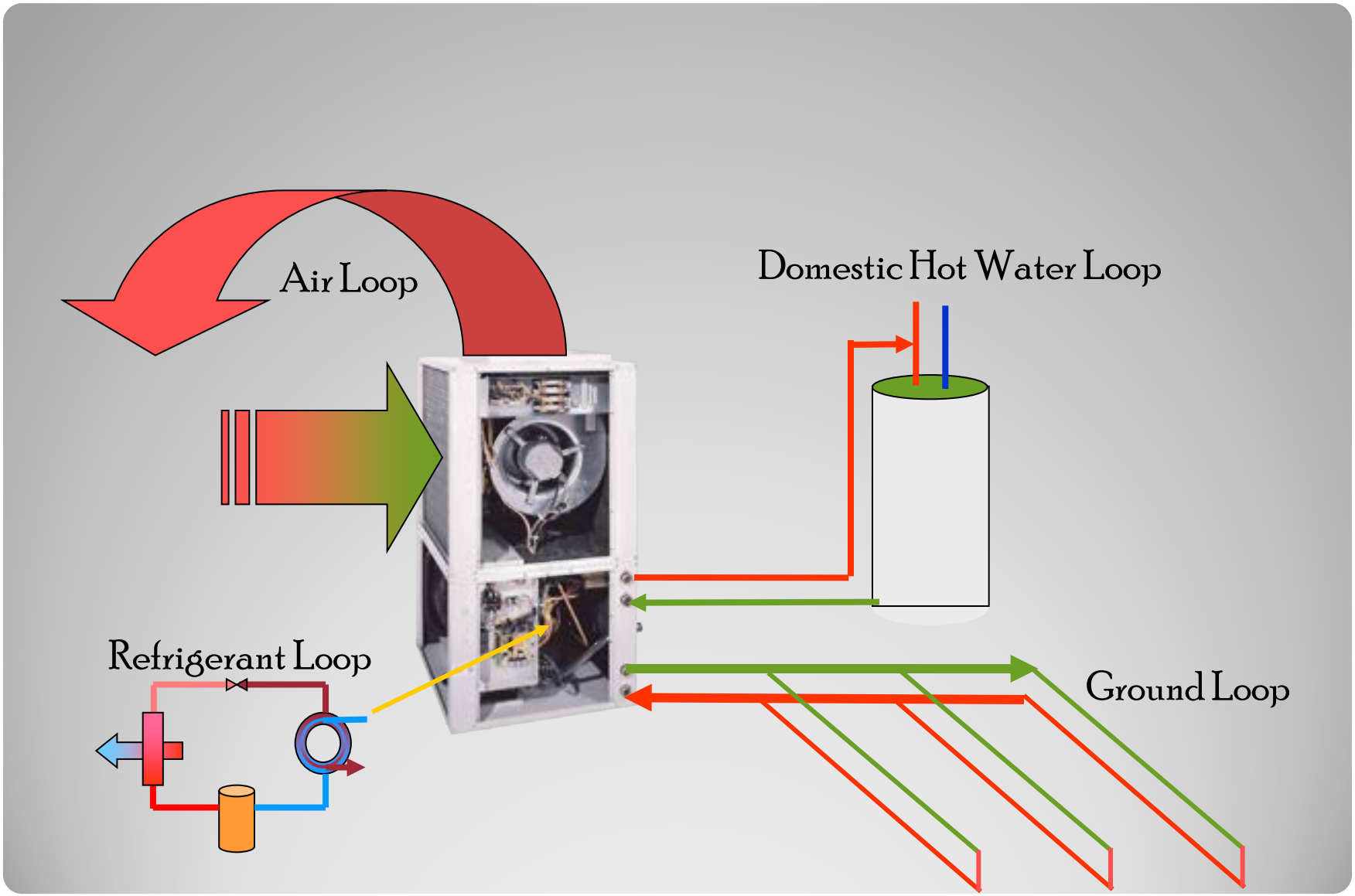
High Grade Geothermal Energy

“Solar” Geothermal



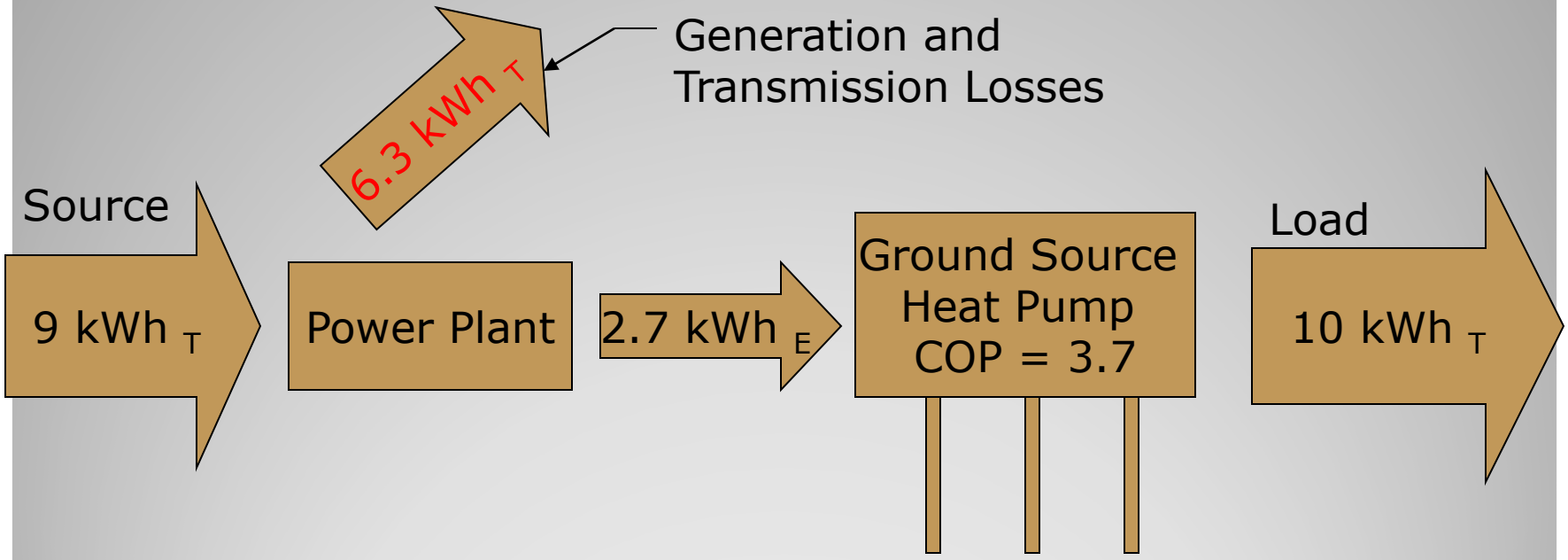
GeoExchange Systems

Low Grade Geothermal Energy



Geothermal Heat Pump System

Load to Source: Sustainability Factor

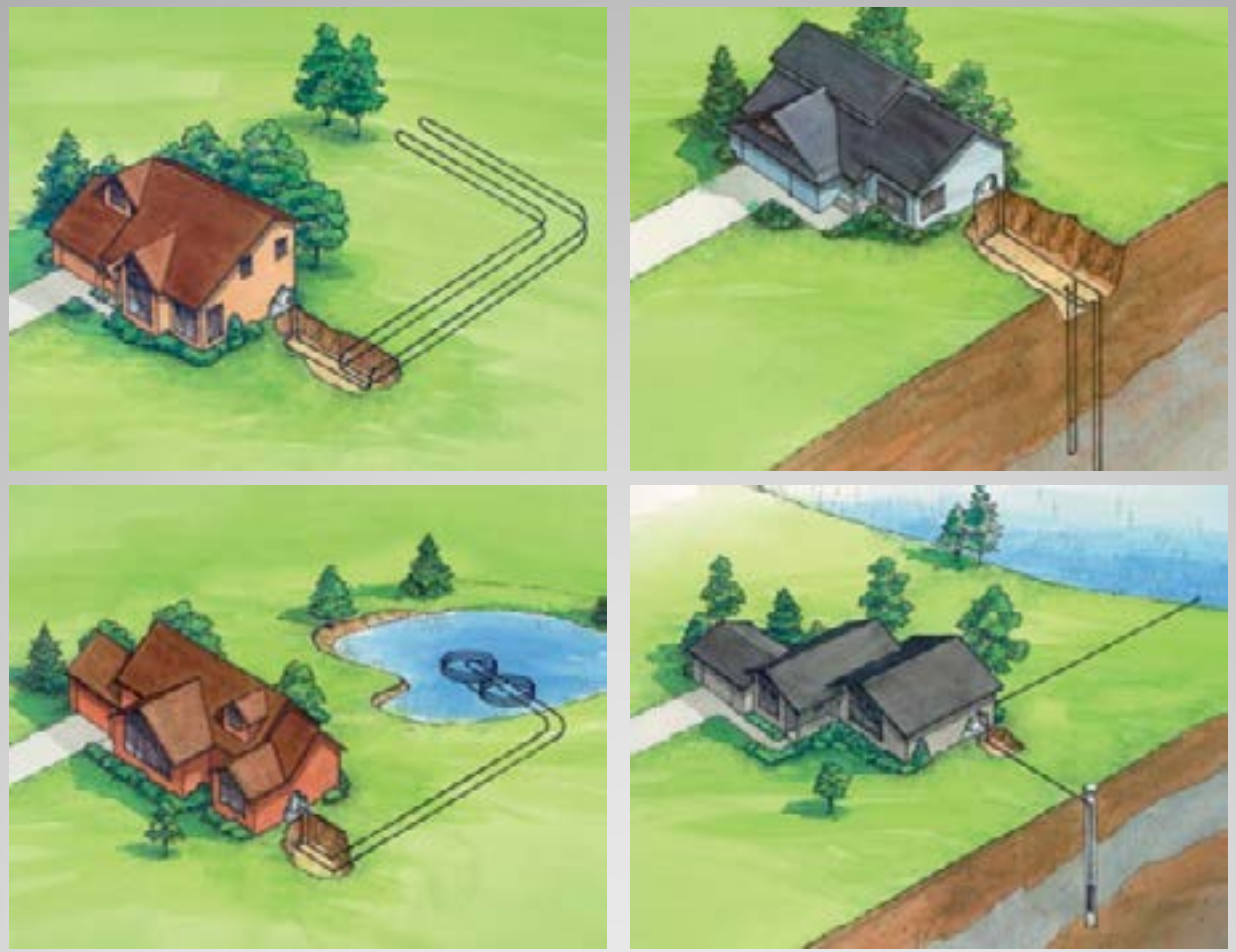


GSHP requires only 9 kWh_T from the source to provide 10 kWh_T to the building since they can provide a COP of 3.7

Water to Air GHP (Forced Air)

Water to Water GHP (Hydronic)

Ground Source Heat Pumps



Many GHEX/Earth Loop Options

(Who decides?... Who designs?)

Supply Side (GSHP)

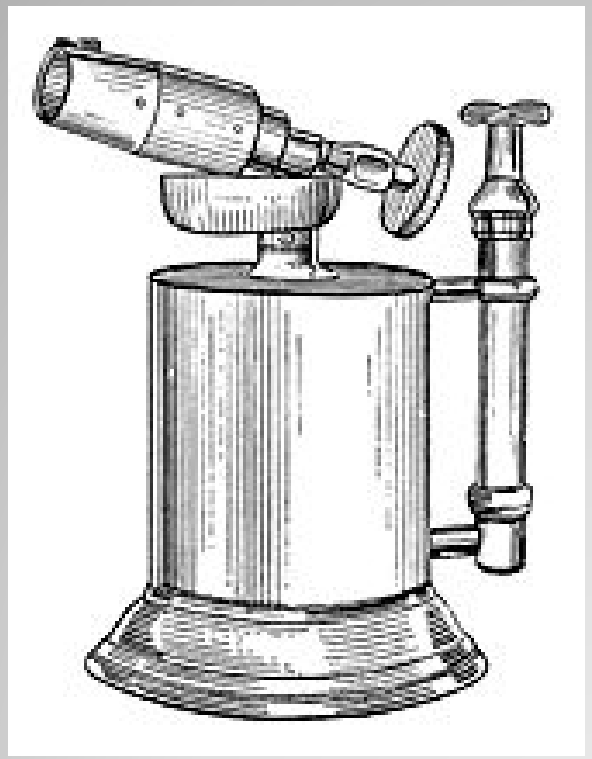
- Ground Heat Exchanger (GHEX)
- Ground Source Heat Pump (GSHP or GHP)
- Loop Pump or Flow Center
- Some Peripheral and Auxiliary Components (incl. Controls)

Delivery Side (HVAC)

- Duct System (incl. Air Exchanger)
- Radiant Floor Tubing, Manifolds, Zone Pumps and Controls
- Radiant Baseboards, Panels, Radiators
- Plumbing/Piping Delivery Systems

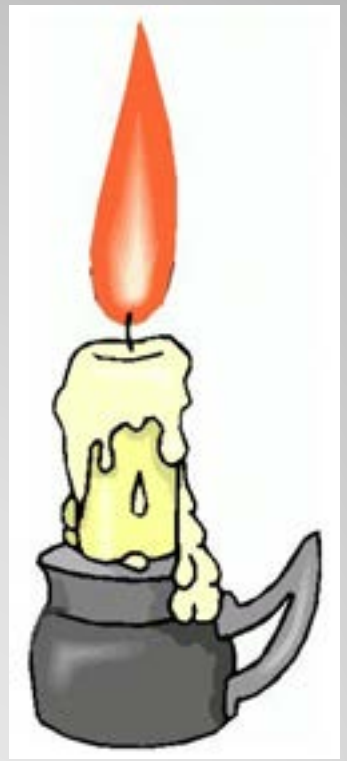
The "geothermal system" is generally assigned to the "supply" side of heating/cooling functions.

High Temp @ 50,000 BTUH!



130°F - 180°F

Low Temp @ 50,000 BTUH!

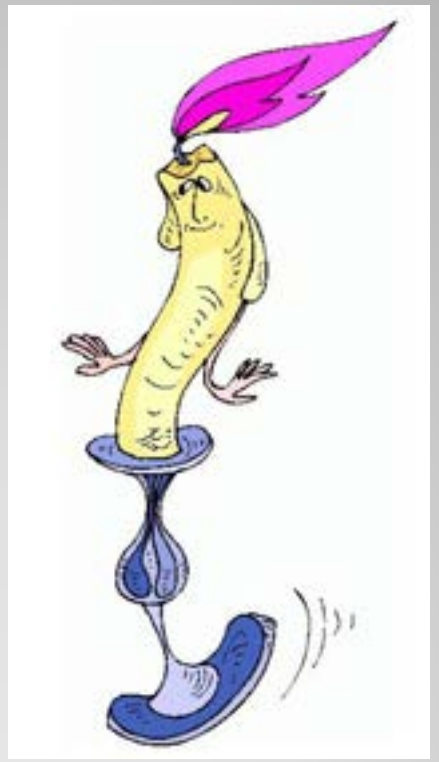


85°F - 115°F

High Temp *versus* Low Temp?

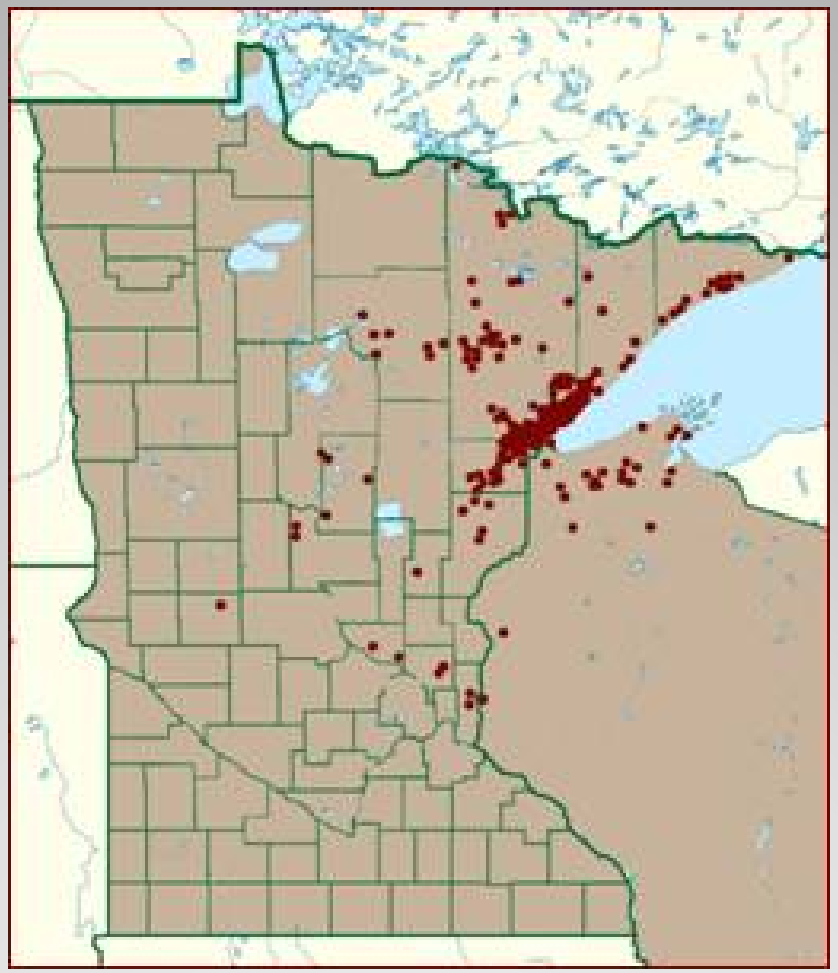
~~**High Temp @**~~
50,000 BTUH!

Low Temp @
50,000 BTUH!

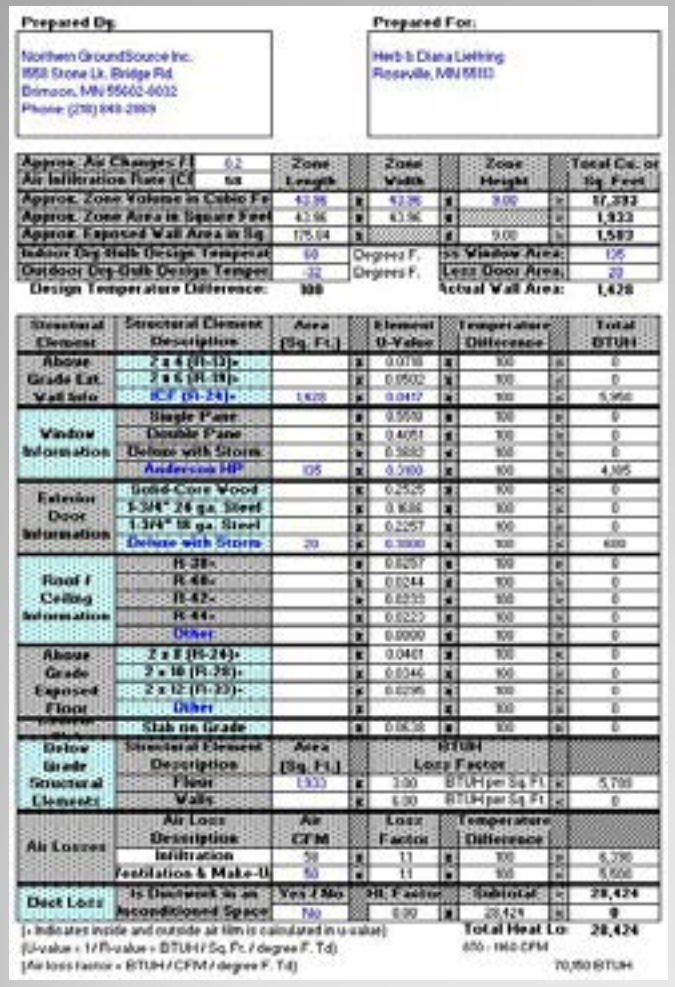


GENERAL PREMISE: The Lower the Temperature—the Higher the Efficiency!

Consider that GSHP installation costs and benefits are *scalable!*



Consider that GSHP Technology is Also Highly Adaptable.



Prepared By:

Northern GroundSource Inc.
8558 Stone Lk. Bridge Rd.
Brimson, MN 55602-8032
Phone: (218) 668-2869

Prepared For:

Herb & Diana Liebling
Roseville, MN 55113

		Zone Length		Zone Width		Zone Height		Total Cu. or Sq. Feet
Approx. Air Changes / Hr.	0.2							
Air Infiltration Rate (CFM)	58							
Approx. Zone Volume in Cubic Feet		43.96	x	43.96	x	9.00	=	17,393
Approx. Zone Area in Square Feet		43.96	x	43.96	x		=	1,933
Approx. Exposed Wall Area in Sq. Ft.		175.84	x		x	9.00	=	1,583
Indoor Dry-Bulb Design Temperature		68	Degrees F.			Less Window Area:		105
Outdoor Dry-Bulb Design Temperature		-32	Degrees F.			Less Door Area:		20
Design Temperature Difference:		100				Actual Wall Area:		1,428

Structural Element	Structural Element Description	Area (Sq. Ft.)		Element U-Value		Temperature Difference		Total BTUH
Above Grade Ext. Wall Info:	2 x 4 (R-13)=		x	0.0769	x	100	=	0
	2 x 6 (R-19)=		x	0.0502	x	100	=	0
	ICF (R-24)=	1428	x	0.0417	x	100	=	5,956
Window Information	Single Pane		x	0.5556	x	100	=	0
	Double Pane		x	0.4651	x	100	=	0
	Deluxe with Storm		x	0.3802	x	100	=	0
	Andersen HP	105	x	0.2700	x	100	=	4,395
Exterior Door Information	Solid-Core Wood		x	0.2525	x	100	=	0
	1-3/4" 24 ga. Steel		x	0.3636	x	100	=	0
	1-3/4" 18 ga. Steel		x	0.2257	x	100	=	0
	Deluxe with Storm	20	x	0.3000	x	100	=	600
Roof / Ceiling Information	R-38=		x	0.0257	x	100	=	0
	R-49=		x	0.0244	x	100	=	0
	R-42=		x	0.0233	x	100	=	0
	R-44=		x	0.0222	x	100	=	0
	Other		x	0.0000	x	100	=	0
Above Grade Exposed Floor	2 x 8 (R-24)=		x	0.0401	x	100	=	0
	2 x 10 (R-28)=		x	0.0346	x	100	=	0
	2 x 12 (R-33)=		x	0.0295	x	100	=	0
	Other		x		x	100	=	0
	Slab on Grade		x	0.0638	x	100	=	0

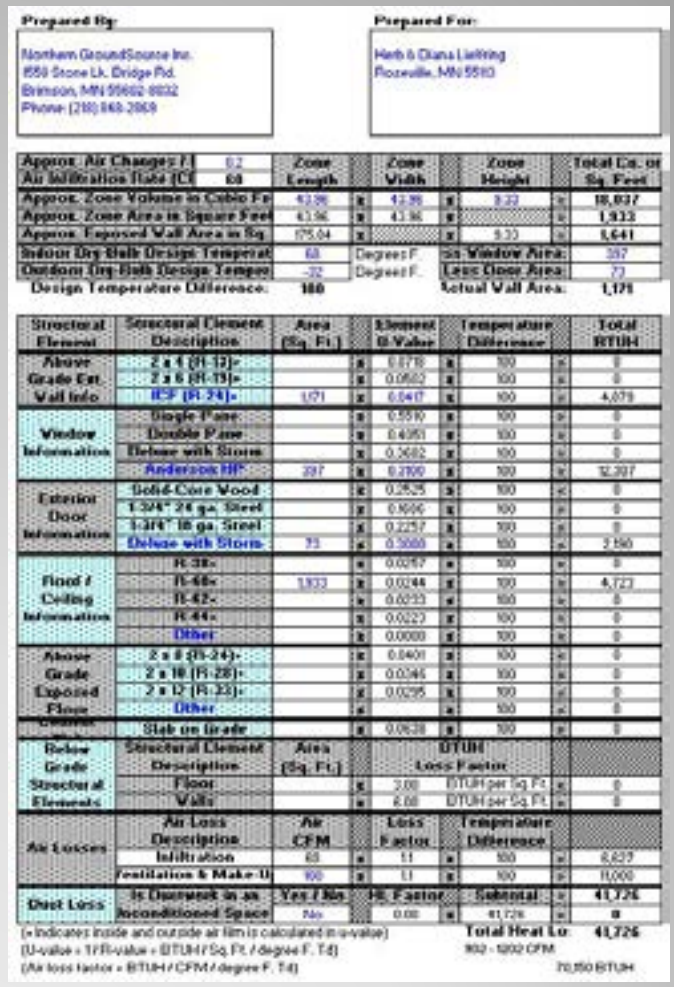
Below Grade Structural Elements	Structural Element Description	Area (Sq. Ft.)		BTUH Loss Factor		
	Floor	1933	x	3.00	BTUH per Sq. Ft.	5,799
	Walls		x	6.00	BTUH per Sq. Ft.	0

Air Losses	Air Loss Description	Air CFM		Loss Factor		Temperature Difference		
	Infiltration	58	x	1.1	x	100	=	6,790
	Ventilation & Make-Up	80	x	1.1	x	100	=	8,800

Duct Loss	Is Ductwork in an Unconditioned Space	Yes / No		Rt. Factor		Subtotal		28,424
		No	x	0.00	=	28,424	=	0

(+ Indicates inside and outside air film is calculated in u-value)
(U-value = 1/R-value = BTUH / Sq. Ft. / degree F. Td)
(Air loss factor = BTUH / CFM / degree F. Td)

Total Heat Loss: 28,424
670 - 1140 CFM
70,150 BTUH



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		Zone Length		Zone Width		Zone Height		Total Cu. or Sq. Feet
Approx. Air Changes / Hr.	0.2							
Air Infiltration Rate (CFM)	58							
Approx. Zone Volume in Cubic Feet		43.96	x	43.96	x	9.00	=	18,837
Approx. Zone Area in Square Feet		43.96	x	43.96	x		=	1,933
Approx. Exposed Wall Area in Sq. Ft.		175.84	x		x	9.00	=	1,641
Indoor Dry-Bulb Design Temperature		68	Degrees F.			Less Window Area:		397
Outdoor Dry-Bulb Design Temperature		-32	Degrees F.			Less Door Area:		73
Design Temperature Difference:		100				Actual Wall Area:		1,171

Structural Element	Structural Element Description	Area (Sq. Ft.)		Element U-Value		Temperature Difference		Total BTUH
Above Grade Ext. Wall Info:	2 x 4 (R-13)=		x	0.0769	x	100	=	0
	2 x 6 (R-19)=		x	0.0502	x	100	=	0
	ICF (R-24)=	1171	x	0.0417	x	100	=	4,879
Window Information	Single Pane		x	0.5556	x	100	=	0
	Double Pane		x	0.4651	x	100	=	0
	Deluxe with Storm		x	0.3802	x	100	=	0
	Andersen HP	397	x	0.2700	x	100	=	10,707
Exterior Door Information	Solid-Core Wood		x	0.2525	x	100	=	0
	1-3/4" 24 ga. Steel		x	0.3636	x	100	=	0
	1-3/4" 18 ga. Steel		x	0.2257	x	100	=	0
	Deluxe with Storm	73	x	0.3000	x	100	=	2,190
Roof / Ceiling Information	R-38=		x	0.0257	x	100	=	0
	R-49=	1933	x	0.0244	x	100	=	4,723
	R-42=		x	0.0233	x	100	=	0
	R-44=		x	0.0222	x	100	=	0
	Other		x	0.0000	x	100	=	0
Above Grade Exposed Floor	2 x 8 (R-24)=		x	0.0401	x	100	=	0
	2 x 10 (R-28)=		x	0.0346	x	100	=	0
	2 x 12 (R-33)=		x	0.0295	x	100	=	0
	Other		x		x	100	=	0
	Slab on Grade		x	0.0638	x	100	=	0

Below Grade Structural Elements	Structural Element Description	Area (Sq. Ft.)		BTUH Loss Factor		
	Floor		x	3.00	BTUH per Sq. Ft.	0
	Walls		x	6.00	BTUH per Sq. Ft.	0

Air Losses	Air Loss Description	Air CFM		Loss Factor		Temperature Difference		
	Infiltration	58	x	1.1	x	100	=	6,837
	Ventilation & Make-Up	80	x	1.1	x	100	=	11,000

Duct Loss	Is Ductwork in an Unconditioned Space	Yes / No		Rt. Factor		Subtotal		41,726
		No	x	0.00	=	41,726	=	0

(+ Indicates inside and outside air film is calculated in u-value)
(U-value = 1/R-value = BTUH / Sq. Ft. / degree F. Td)
(Air loss factor = BTUH / CFM / degree F. Td)

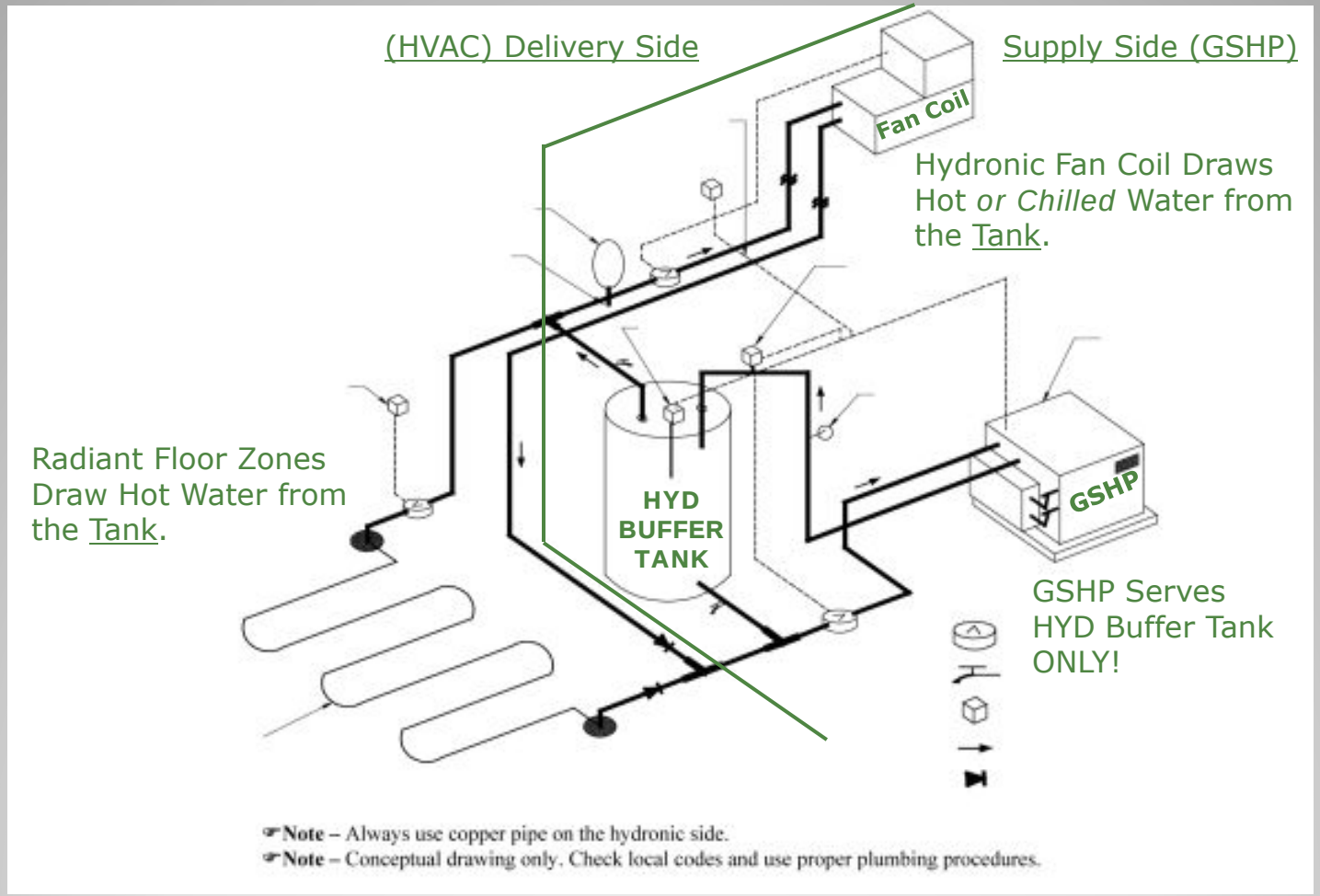
Total Heat Loss: 41,726
802 - 1202 CFM
70,150 BTUH

Heat Loss Calculation = 70,150 BTUH

ERDENHEIM HOUSE: New Construction

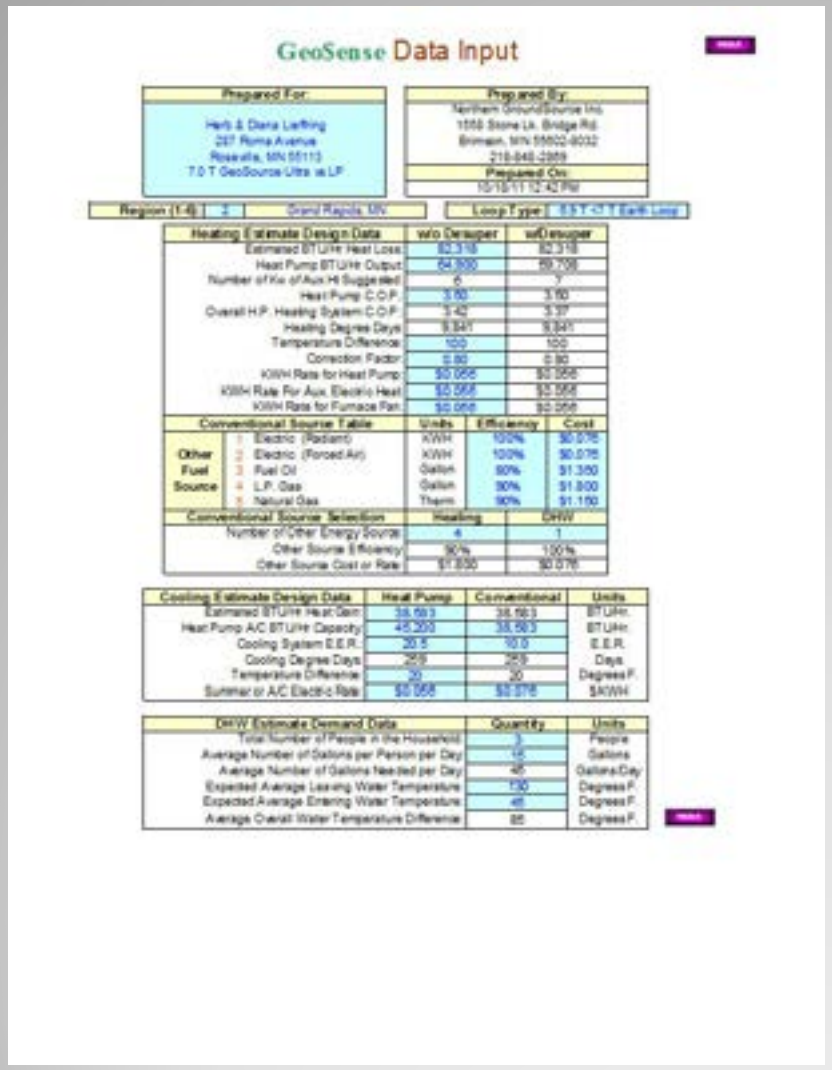
- GRAND RAPIDS, MN (Bin Weather Data)
- 70,150 BTUH Heat Loss (@ -30°F OAT)
- 12,168 BTUH Garage (@ 20 BTUH/sq')
- 38,583 BTUH Heat Gain (@ +84°F OAT)
- Space for No More Than 7T Horz. GHEX
- 7 Ton HYD Heat/Cool GSHP System
- Compare to LP Boiler @ $1.80/Gallon

Heat Loss w/Garage = 82,318 BTUH
(But Limited to 7T GSHP Due to Space!)



Hydronic Heat/Cool GSHP System

5 T HYD GSHP w/ 3 T HYD Fan Coil combines radiant floor heating with F/A heating & cooling



GeoSense Data Input

Prepared For:	Prepared By:
Herb & Diana Laeffing 227 Roma Avenue Roseville, MN 55113 7.0 T GeoSource Ultra w LP	Northern GroundSource Inc. 1555 Stone Lk. Bridge Rd. Brimson, MN 55602-9032 218-848-2859 Prepared On: 10/19/11 12:42 PM

Region (1-6): 4 Grand Rapids, MN — Loop Type: 3/4" HDPE Earth Loop

Heating Estimate Design Data	w/o Desuper	w/Desuper
Estimated BTU/Hr Heat Loss	82,318	82,318
Heat Pump BTU/Hr Output	64,900	59,706
Number of Kw of Aux Ht Suggested	6	7
Heat Pump C.O.P.	3.50	3.50
Overall H.P. Heating System C.O.P.	3.42	3.37
Heating Degree Days	9,941	9,941
Temperature Difference	100	100
Correction Factor	0.80	0.80
KWH Rate for Heat Pump	$0.056	$0.056
KWH Rate For Aux. Electric Heat	$0.056	$0.056
KWH Rate for Furnace Fan	$0.056	$0.056

Conventional Source Table		Units	Efficiency	Cost
Other Fuel Source	1 Electric (Radiant)	KWH	100%	$0.076
	2 Electric (Forced Air)	KWH	100%	$0.076
	3 Fuel Oil	Gallon	80%	$1.350
	4 L.P. Gas	Gallon	90%	$1.800
	5 Natural Gas	Therm	90%	$1.150

Conventional Source Selection	Heating	DHW
Number of Other Energy Source	4	1
Other Source Efficiency	90%	100%
Other Source Cost or Rate	$1.800	$0.076

Cooling Estimate Design Data	Heat Pump	Conventional	Units
Estimated BTU/Hr Heat Gain	38,583	38,583	BTU/Hr.
Heat Pump A/C BTU/Hr Capacity	45,200	38,583	BTU/Hr.
Cooling System E.E.R.	20.5	10.0	E.E.R.
Cooling Degree Days	259	259	Days
Temperature Difference	20	20	Degrees F.
Summer or A/C Electric Rate	$0.056	$0.076	$/KWH

DHW Estimate Demand Data	Quantity	Units
Total Number of People in the Household	3	People
Average Number of Gallons per Person per Day	15	Gallons
Average Number of Gallons Needed per Day	45	Gallons/Day
Expected Average Leaving Water Temperature	130	Degrees F.
Expected Average Entering Water Temperature	45	Degrees F.
Average Overall Water Temperature Difference	85	Degrees F.

Northern GroundSource GSHP Design Input

ColdClimate GSHP Capacity to Peak Heating Load

LOAD = 82,318 BTUH

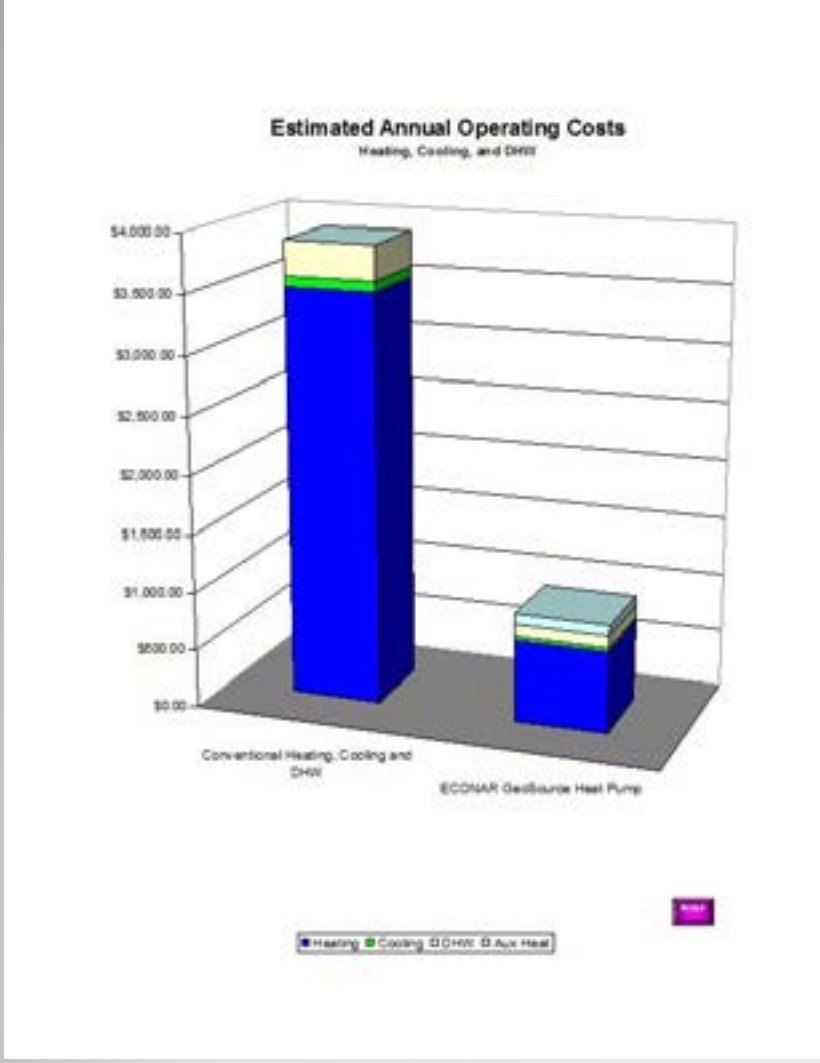
7T GSHP = 64,900 BTUH
@ 30°F EWT / 108°F HYD

SIZING = 78.9%

7 kWh AUX RH Recommended
(14 kWh Modulating RH Boiler)

COP Drops from 3.50 to 3.37

5T HYD Fan Coil for Cooling
(45,200 BTUH Capacity)



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ColdClimate GSHP Capacity to Peak Heating Load

LOAD = 82,318 BTUH

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@ 30°F EWT / 108°F HYD

SIZING = 78.9%

7 kWh AUX RH Recommended
(14 kWh Modulating RH Boiler)

COP Drops from 3.50 to 3.37

5T HYD Fan Coil for Cooling
(45,200 BTUH Capacity)

Estimated Annual Operating Costs

For Herb & Diana Lieffring

7T HYD HEAT/COOL GSHP SYSTEM

Estimated Energy Consumption

			Heating		Cooling	DHW	Estimated Annual Totals	
			w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump		Kwh/yr	12,722	12,540	585	713	13,307	13,838
Auxiliary Ht and Electric Water Htr		Kwh/yr	1,046	1,682		1,071	1,046	2,753
Other Fuel Source	1. Electric (Radiant)	Kwh/yr				3,919	3,919	
	2. Electric (Forced Air)	Kwh/yr			1,199		1,199	
	3. Fuel Oil	Gallons/yr						
	4. LP Gas	Gallons/yr	1,889				1,889	
	5. Natural Gas	Therms/yr						

16,591 kWh

14,222 kWh

Estimated Operating Costs

		Heating		Cooling	DHW	Estimated Annual Totals	
		w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump		$712.43	$702.24	$32.76	$39.94	$745.18	$774.95
Auxiliary Ht and Electric Water Htr		$58.55	$94.18		$59.96	$58.55	$154.14
Other Fuel Source	1. Electric (Radiant)				$297.81	$297.81	
	2. Electric (Forced Air) *			$91.14		$91.14	
	3. Fuel Oil *						
	4. LP Gas *	$3,504.63				$3,504.63	
	5. Natural Gas *						

Estimated Cost Savings

	Heating		Cooling	DHW		Estimated Annual Totals	
	w/o	w/Desuper		w/o	w/Desuper	w/o Desuper	w/Desuper
Conventional Heating, Cooling and DHW	$3,504.63	$3,504.63	$91.14	$297.81	$297.81	$3,893.58	$3,893.58
ECONAR GeoSource Heat Pump	$770.97	$796.43	$32.76	$297.81	$99.90	$1,101.55	$929.09
Savings Using ECONAR Heat Pump	**$2,733.66**	**$2,708.21**	**$58.38**	**$0.00**	**$197.91**	**$2,792.04**	**$2,964.49**

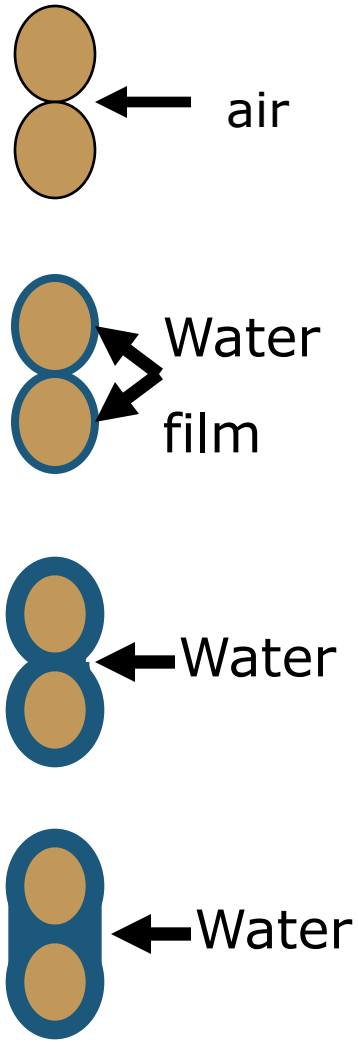
	w/o	w/Desuper	
On a yearly basis, this means the heat pump alone should cover	*97.7%*	*96.3%*	*of the total space heating load annually*
Auxiliary heat shouldn't be needed until the actual outdoor temperature falls to	*-9*	*-3*	*degrees Fahrenheit*
The heat gain to Heat Pump cooling capacity ratio is	*1.2*	*1.2*	*(This ratio should be between 1 and 2)*
On a yearly basis, the heat pump alone should also cover	*0%*	*73%*	*of the total DHW water heating load annually*

96.3% GSHP

INDEX

* = Includes cost of operating the blower

How Moisture Improves Thermal Conductivity of Soil



At complete dryness the heat flow passes mainly through the grains, but has to bridge the air-filled gaps between the grains around their contact points.

At very low water contents the soil particles are covered by thin absorbed water layers

The thickness of these layers increases with increasing water content. At a certain Xw liquid rings start to form around the contact points between the grains; they show a curved air-water interface.

From this point on the thermal conductivity increases rapidly with increasing Xw, until the rings almost completely fill the original gap. When Xw increases still further the complete pores are filled with water, up to saturation. This is reflected by the slower increase of k with Xw.


LOGIX

June through December 2007

Date Meter Read	Non-Interruptible Household Power	Dual Fuel Econar Geothermal/Seisco Microboiler	Off Peak Hot Water Heat Marathon	Total
July 12, 2007	55			55
August 11, 2007	122			122
September 8, 2007	187			187
October 9, 2007	132	[GSHP Commissioned]		132
November 9, 2007	328			328
December 10, 2007	1,868	[GSHP HYD Startup]		1,868
January 10, 2008	1,626	2,094		3,720
TOTAL kWh	**4,318**	**2,094**		**6,412**

January through December 2008

Date Meter Read	Non-Interruptible Household Power	Dual Fuel Econar Geothermal/Seisco Microboiler	Off Peak Hot Water Heat Marathon	Total
February 8, 2008	560	2,418		2,978
March 8, 2008	624	3,957 [Anomaly]		4,581
April 9, 2008	575	1,141		1,716
May 8, 2008	472	309		781
June 9, 2008	353	1,198 [Anomaly]	[DHW Online]	1,551
July 10, 2008	79	263	419	761
August 9, 2008	553			553
September 8, 2008	108	185	634	927
October 8, 2008	378	208	651	1,237
November 8,2008	404	813	548	1,765
December 8, 2008	421	1,802	407	2,630
January 8, 2009	600	2,884	399	3,883
TOTAL kWh	**5,127**	**15,178**	**3,058**	**23,363**
		14,222 kWh	3,919 kWh	

January through December 2009

Date Meter Read	Non-Interruptible Household Power	Dual Fuel Econar Geothermal/Seisco Microboiler	Off Peak Hot Water Heat Marathon	Total
February 11, 2009	580	3,266	406	4,252
March 9, 2009	400	2,225	371	2,996
April 8, 2009	569	1,821	548	2,938
May 8, 2009	447	939	592	1,978
June 11, 2009	544	395	761	1,700
July 8, 2009	524	139	597	1,260
August 8, 2009	557	22	695	1, 274
September 8, 2009	624	114	699	1,437
October 8, 2009	603	220	671	1,494
November 10, 2009	960	992	633	2,585
December 8, 2009	800	1,265	573	2,638
January 8, 2010	1,016	2,098	513	3,627
TOTAL kWh	**7,624**	**13,496**	**7,059**	**28,179**

14,222 kWh 3,919 kWh

January through December 2010

Date Meter Read	Non-Interruptible Household Power	Dual Fuel Econar Geothermal/Seisco Microboiler	Off Peak Hot Water Heat Marathon	Total
February 8, 2010	852	1,995	505	3,352
March 9, 2010	684	1,708	477	2,869
April 9, 2010	740	1,133	605	2,478
May 9, 2010	698	579	600	1,877
June 9, 2010	676	176	697	1,549
July 9, 2010	695	6	711	1,412
August 9, 2010	755	166	785	1,706
September 9, 2010	830	284	769	1,883
October 9, 2010	664	310	719	1,693
November 9, 2010	798	611	738	2,147
December 9, 2010	756	1,524	601	2,881
January 9, 2011	745	2,262	478	3,485
TOTAL kWH	**8,893**	**10,754**	**7,685**	**27,332**

14,222 kWh 3,919 kWh

January through December 2011

Date Meter Read	Non-Interruptible Household Power	Dual Fuel Econar Geothermal/Seisco Microboiler	Off Peak Hot Water Heat Marathon	Total
February 9, 2011	834	1,982 [Offline 10 Days]	490	3,306
March 9, 2011	684	2,203	589	3,476
April 9, 2011	661	956	601	2,218
May 13, 2011	746	586	724	2,056
June 9, 2011	663	0	674	1,337
July 9, 2011	848	152	779	1,779
August 9, 2011	940	460	756	2,156
September 9, 2011	764	234 [IDF LP Upgrade]	708	1,706
October 9, 2011	695	0	707	1,402
November 9, 2011	764	329	676	1,769
December 9, 2011	814	997	586	2,397
January 9, 2012	862	1,359	580	2,801
TOTAL kWH	**9,275**	**9,258**	**7,870**	**26,403**

14,222 kWh 3,919 kWh

January through December 2012

Date Meter Read	Non-Interruptible Household Power	Dual Fuel Econar Geothermal/Seisco Microboiler	Off Peak Hot Water Heat Marathon	Total
February 10, 2012	876	1,370	462	2,717
March 11, 2012	758	1,166	536	2,460
April 10, 2012	767	547	625	1,939
May 9, 2012	691	472	600	1,763
June 9, 2012	760	4	741	1,505
July 8, 2012	817	338	726	1,881
August 9, 2012	986	707	902	2,595
September 9, 2012	847	368	759	1,974
October 10, 2012	765	32	833	1,630
November 11, 2012	869	494	803	2,166
December 9, 2012	816	892	535	1,513
January 10, 2013	948	1,579	495	3,022
TOTAL kWH	**9,900**	**7,969**	**8,017**	**25,886**

14,222 kWh 3,919 kWh

By comparison, the equivalent amount of kWh usage for 100% *conventional* electric heating, cooling & domestic hot water would be 54,000 kWh Annually!


END

Geothermal Design & Application Study

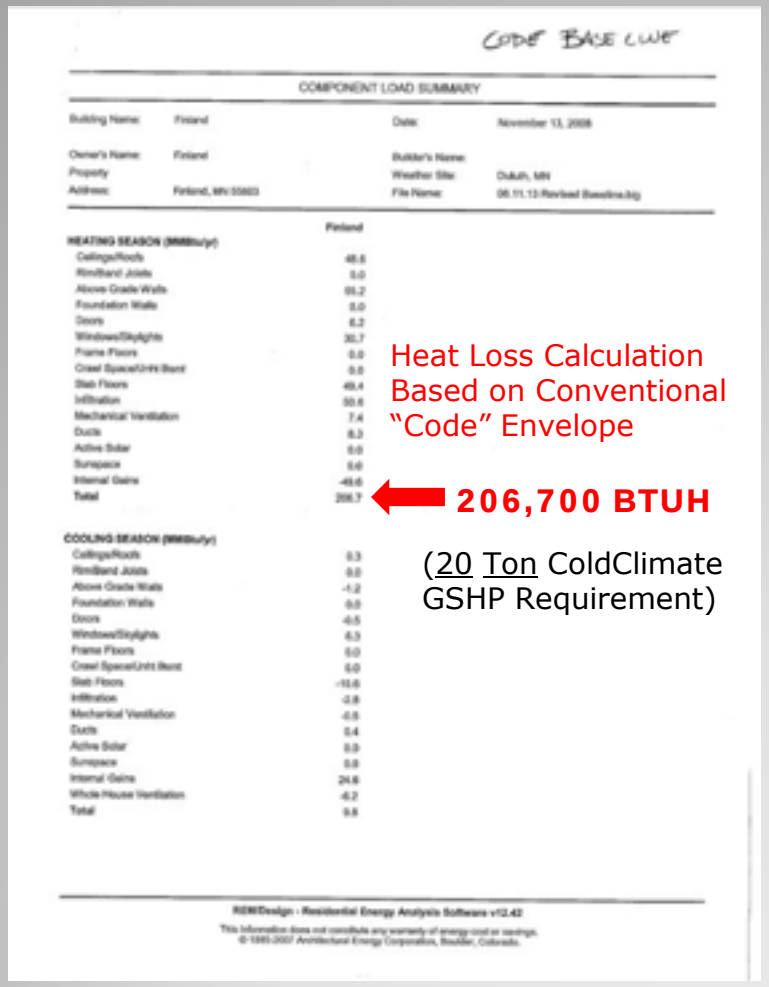
Clair Nelson Intermodal Transportation Center
Finland, MN
16 Ton ColdClimate Hydronic Heat Only GSHP Application

PRESENTER:
Mark Sakry, CGD
Northern GroundSource Inc.
www.NorthernGroundSource.com

"Finland Community Center" Model View

Community Center Conceptual Site Plan

Community Center Architectural Drawings



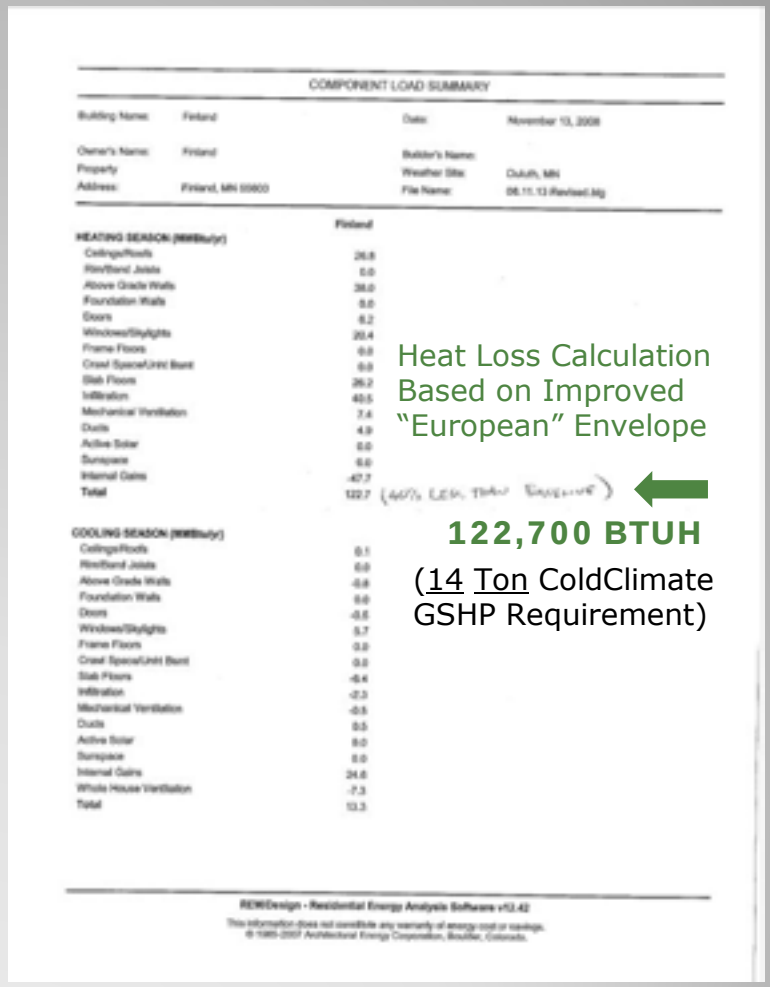
CODE BASE LINE

COMPONENT LOAD SUMMARY

Heat Loss Calculation Based on Conventional "Code" Envelope

206,700 BTUH

(20 Ton ColdClimate GSHP Requirement)



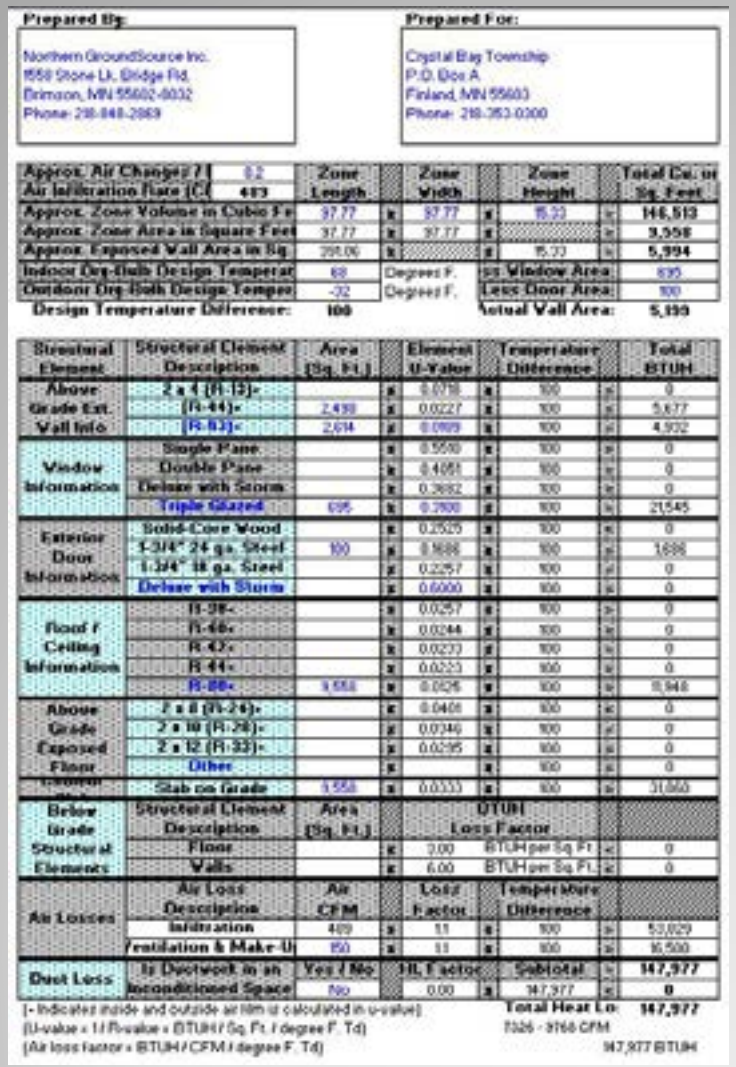
COMPONENT LOAD SUMMARY

Heat Loss Calculation Based on Improved "European" Envelope

122,700 BTUH

(14 Ton ColdClimate GSHP Requirement)

Architect's Load Summary Comparisons



Prepared By:

Northern GroundSource Inc.
1558 Stone Lk. Bridge Rd.
Brimson, MN 55602-8032
Phone: 218-848-2869

Prepared For:

Crystal Bay Township
P.O. Box A
Finland, MN 55603
Phone: 218-353-0300

		Zone Length		Zone Width		Zone Height		Total Cu. ft / Sq. Feet
Approx. Air Changes / Hr	0.2							
Air Infiltration Rate (CFM)	489							
Approx. Zone Volume in Cubic Feet		97.77	x	97.77	x	15.33	=	146,513
Approx. Zone Area in Square Feet		97.77	x	97.77	x		=	9,558
Approx. Exposed Wall Area in Sq.		391.06	x		x	15.33	=	5,994
Indoor Dry-Bulb Design Temperature		68	Degrees F.			Less Window Area:		695
Outdoor Dry-Bulb Design Temperature		-32	Degrees F.			Less Door Area:		100
Design Temperature Difference:		100				Actual Wall Area:		5,199

Structural Element	Structural Element Description	Area (Sq. Ft.)		Element U-Value		Temperature Difference		Total BTUH
Above Grade Ext. Wall Info	2 x 4 (R-13)=		x	0.0769	x	100	=	0
	(R-44)=	2,493	x	0.0227	x	100	=	5,677
	(R-53)=	2,614	x	0.0189	x	100	=	4,932
Window Information	Single Pane		x	0.5556	x	100	=	0
	Double Pane		x	0.4651	x	100	=	0
	Deluxe with Storm		x	0.3882	x	100	=	0
	Triple Glazed	695	x	0.2800	x	100	=	21,545
Exterior Door Information	Solid-Core Wood		x	0.2326	x	100	=	0
	1-3/4" 24 ga. Steel	100	x	0.1695	x	100	=	1,695
	1-3/4" 18 ga. Steel		x	0.2257	x	100	=	0
	Deluxe with Storm		x	0.6000	x	100	=	0
Roof / Ceiling Information	R-38=		x	0.0257	x	100	=	0
	R-44=		x	0.0244	x	100	=	0
	R-49=		x	0.0233	x	100	=	0
	R-44=		x	0.0223	x	100	=	0
	R-60=	9,558	x	0.0026	x	100	=	0,948
Above Grade Exposed Floor	2 x 8 (R-24)=		x	0.0408	x	100	=	0
	2 x 10 (R-28)=		x	0.0349	x	100	=	0
	2 x 12 (R-33)=		x	0.0295	x	100	=	0
	Other		x		x	100	=	0
	Slab on Grade	9,558	x	0.0333	x	100	=	31,860

Below Grade Structural Elements	Structural Element Description	Area (Sq. Ft.)		BTUH Loss Factor		
	Floor		x	2.00	BTUH per Sq. Ft. =	0
	Walls		x	6.00	BTUH per Sq. Ft. =	0

Air Losses	Air Loss Description	Air CFM		Loss Factor		Temperature Difference		
	Infiltration	489	x	1.1	x	100	=	53,829
	Ventilation & Make-Up	150	x	1.1	x	100	=	16,500
Duct Loss	Is Ductwork in an Unconditioned Space	Yes / No		HL Factor		Subtotal	=	147,977
		No		0.00	x	147,977	=	0

(- Indicates inside and outside air film is calculated in u-value)
(U-value x 1/ R-value = BTUH / Sq. Ft. / degree F. Td)
(Air loss factor = BTUH / CFM / degree F. Td)

Total Heat Loss: 147,977
7326 - 9768 CFM
147,977 BTUH

Northern GroundSource Calculated Loads

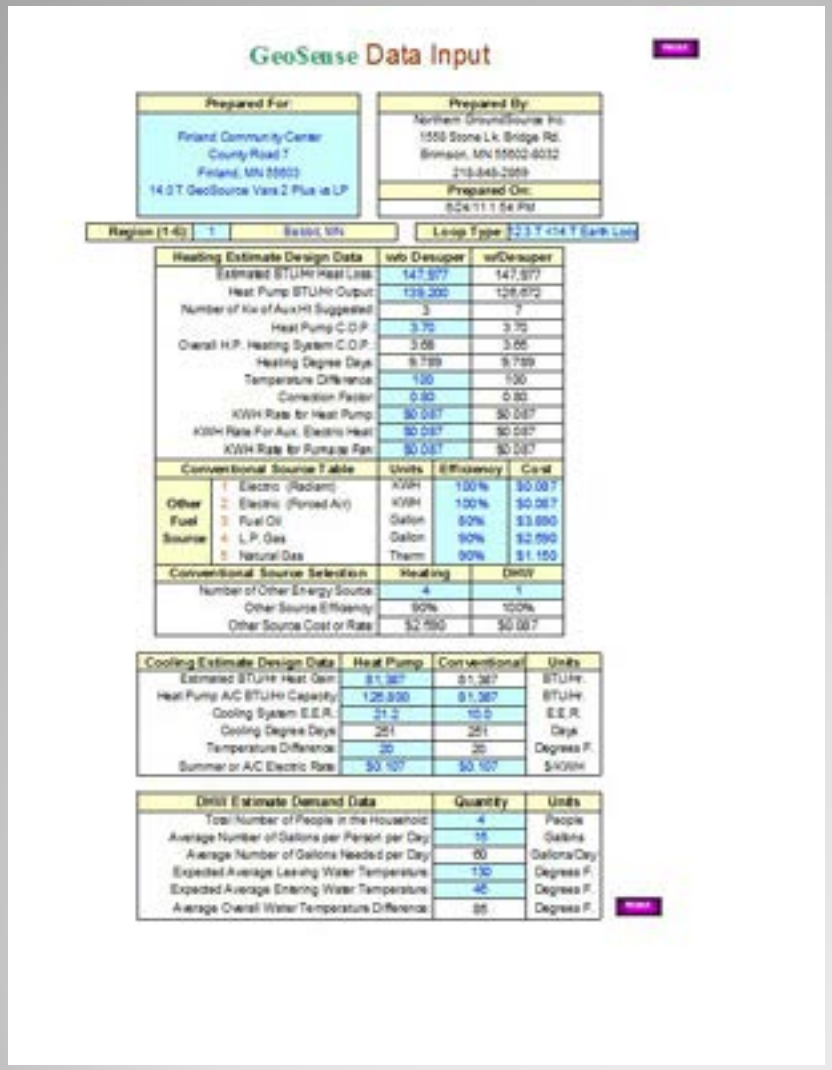
Manual J Calculations
Queried for Unique Location

Considered "Embarrass Effect"

Adjusted Design Temperature Difference (ΔT) to 100°F Between Indoor and Outdoor Conditions

= 147,977 BTUH

= <u>16 Ton ColdClimate GSHP</u>



GeoSense Data Input

Prepared For	Prepared By
Finland Community Center County Road 7 Finland, MN 55603 14.0 T GeoSource Vans 2 Plus w LP	Northern GroundSource Inc. 1558 Stone Lk. Bridge Rd. Brimson, MN 55602-8032 218-848-2959
	Prepared On: 6/24/11 1:54 PM

Region (1-6): 1 Bemidji, MN — Loop Type: 2.2 T 414 T Earth Loop

Heating Estimate Design Data	w/o Desuper	w/Desuper
Estimated BTU/Hr Heat Loss	147,977	147,977
Heat Pump BTU/Hr Output	139,300	126,672
Number of Kw of Aux Ht Suggested	3	7
Heat Pump C.O.P.	3.70	3.70
Overall H.P. Heating System C.O.P.	3.68	3.66
Heating Degree Days	9,789	9,789
Temperature Difference	120	120
Correction Factor	0.80	0.80
KWH Rate for Heat Pump	$0.087	$0.087
KWH Rate For Aux. Electric Heat	$0.087	$0.087
KWH Rate for Pumps/ Fan	$0.087	$0.087

Conventional Source Table		Units	Efficiency	Cost
Other Fuel Source	1 Electric (Radiant)	KWH	100%	$0.087
	2 Electric (Forced Air)	KWH	100%	$0.087
	3 Fuel Oil	Gallon	90%	$3.690
	4 L.P. Gas	Gallon	90%	$2.590
	5 Natural Gas	Therm	90%	$1.150

Conventional Source Selection	Heating	DHW
Number of Other Energy Source	4	1
Other Source Efficiency	90%	100%
Other Source Cost or Rate	$2.590	$0.087

Cooling Estimate Design Data	Heat Pump	Conventional	Units
Estimated BTU/Hr Heat Gain	81,387	81,387	BTU/Hr.
Heat Pump A/C BTU/Hr Capacity	126,000	81,387	BTU/Hr
Cooling System E.E.R.	21.2	10.5	E.E.R.
Cooling Degree Days	261	261	Days
Temperature Difference	20	20	Degrees F.
Summer or A/C Electric Rate	$0.107	$0.107	$/KWH

DHW Estimate Demand Data	Quantity	Units
Total Number of People in the Household	4	People
Average Number of Gallons per Person per Day	15	Gallons
Average Number of Gallons Needed per Day	60	Gallons/Day
Expected Average Leaving Water Temperature	130	Degrees F.
Expected Average Entering Water Temperature	45	Degrees F.
Average Overall Water Temperature Difference	85	Degrees F.

Northern GroundSource GSHP Design Input

ColdClimate GSHP Capacity to Peak Heating Load

Considered "Embarrass Effect"

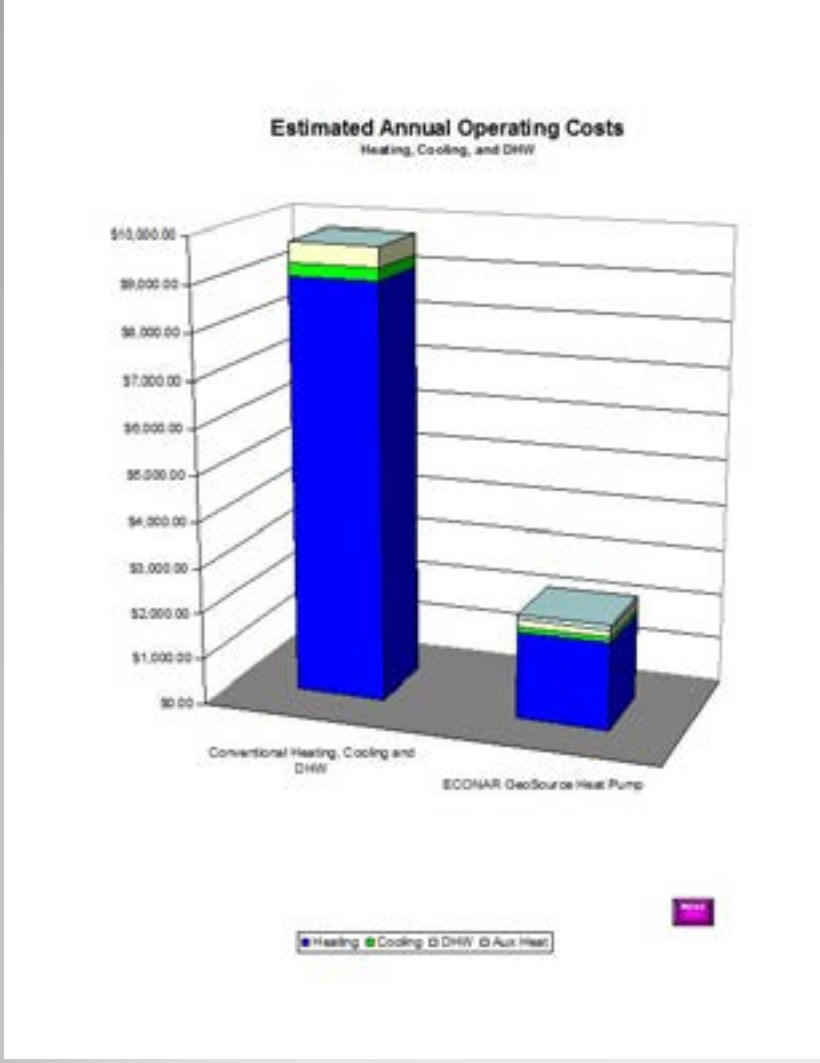
Adjusted Design Temperature Difference (ΔT) to 100°F Between Indoor and Outdoor Conditions

Considered F/A Heat/Cool

Considered 98% Geothermal with Auxiliary RH

= 147,977 BTUH

= <u>14 Ton 3HT/2CL F/A GSHP</u>



Northern GroundSource GSHP Design Input

ColdClimate GSHP Capacity to Peak Heating Load

Considered "Embarrass Effect"

Adjusted Design Temperature Difference (ΔT) to 100°F Between Indoor and Outdoor Conditions

Considered F/A Heat/Cool

Considered 98% Geothermal with Auxiliary RH

= 147,977 BTUH

= <u>14 Ton 3HT/2CL F/A GSHP</u>

Estimated Annual Operating Costs

For Finland Community Center

14T 3HT/2CL F/A GSHP SYSTEM

Estimated Energy Consumption

			Heating		Cooling	DHW	Estimated Annual Totals	
			w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump		Kwh/yr	21,900	21,715	1,157	1,027	23,057	23,900
Auxiliary Ht and Electric Water Htr		Kwh/yr	459	1,140		706	459	1,846
Other Fuel Source	1. Electric (Radiant)	Kwh/yr				5,225	5,225	
	2. Electric (Forced Air)	Kwh/yr			2,454		2,454	
	3. Fuel Oil	Gallons/yr						
	4. LP Gas	Gallons/yr	3,377				3,377	
	5. Natural Gas	Therms/yr						

25,746kWh

[Includes Cooling!]

Estimated Operating Costs

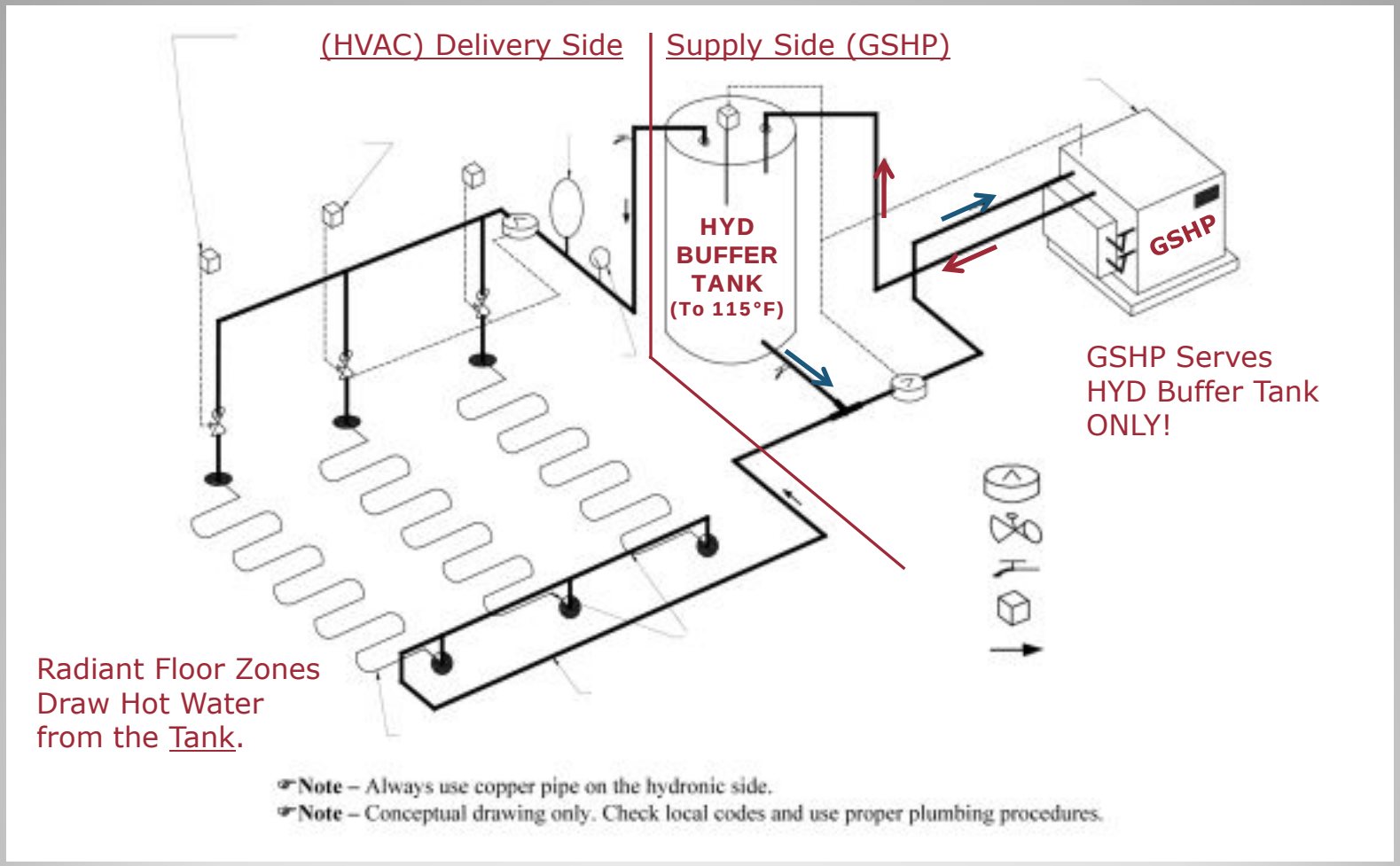
		Heating		Cooling	DHW	Estimated Annual Totals	
		w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump		$1,905.29	$1,889.28	$123.84	$89.36	$2,029.13	$2,102.48
Auxiliary Ht and Electric Water Htr		$39.93	$99.17		$61.44	$39.93	$160.61
Other Fuel Source	1. Electric (Radiant)				$454.56	$454.56	
	2. Electric (Forced Air) *			$262.54		$262.54	
	3. Fuel Oil *						
	4. LP Gas *	$9,039.65				$9,039.65	
	5. Natural Gas *						

Estimated Cost Savings

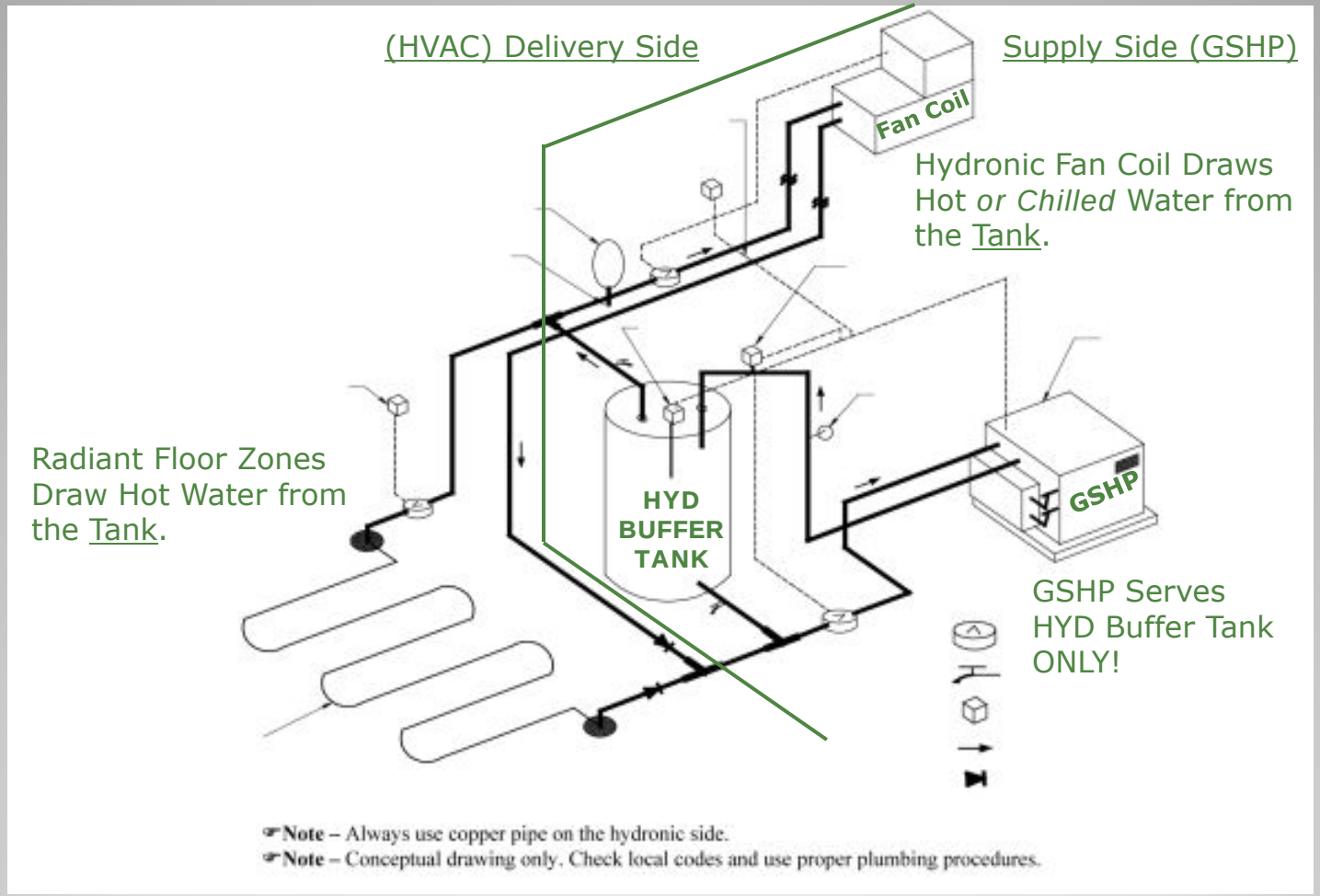
	Heating		Cooling	DHW		Estimated Annual Totals	
	w/o	w/Desuper		w/o	w/Desuper	w/o Desuper	w/Desuper
Conventional Heating, Cooling and DHW	$9,039.65	$9,039.65	$262.54	$454.56	$454.56	$9,755.74	$9,755.74
ECONAR GeoSource Heat Pump	$1,945.22	$1,988.45	$123.84	$454.56	$150.80	$2,523.62	$2,263.09
Savings Using ECONAR Heat Pump	**$7,093.42**	**$7,050.19**	**$138.70**	**$0.00**	**$303.76**	**$7,232.12**	**$7,492.65**

	w/o	w/Desuper	
On a yearly basis, this means the heat pump alone should cover	*99.4%*	*98.6%*	*of the total space heating load annually*
Auxiliary heat shouldn't be needed until the actual outdoor temperature falls to	*-24*	*-16*	*degrees Fahrenheit.*
The heat gain to Heat Pump cooling capacity ratio is	*1.6*	*1.6*	*(This ratio should be between 1 and 2)*
On a yearly basis, the heat pump alone should also cover	*0%*	*86%*	*of the total DHW water heating load annually*

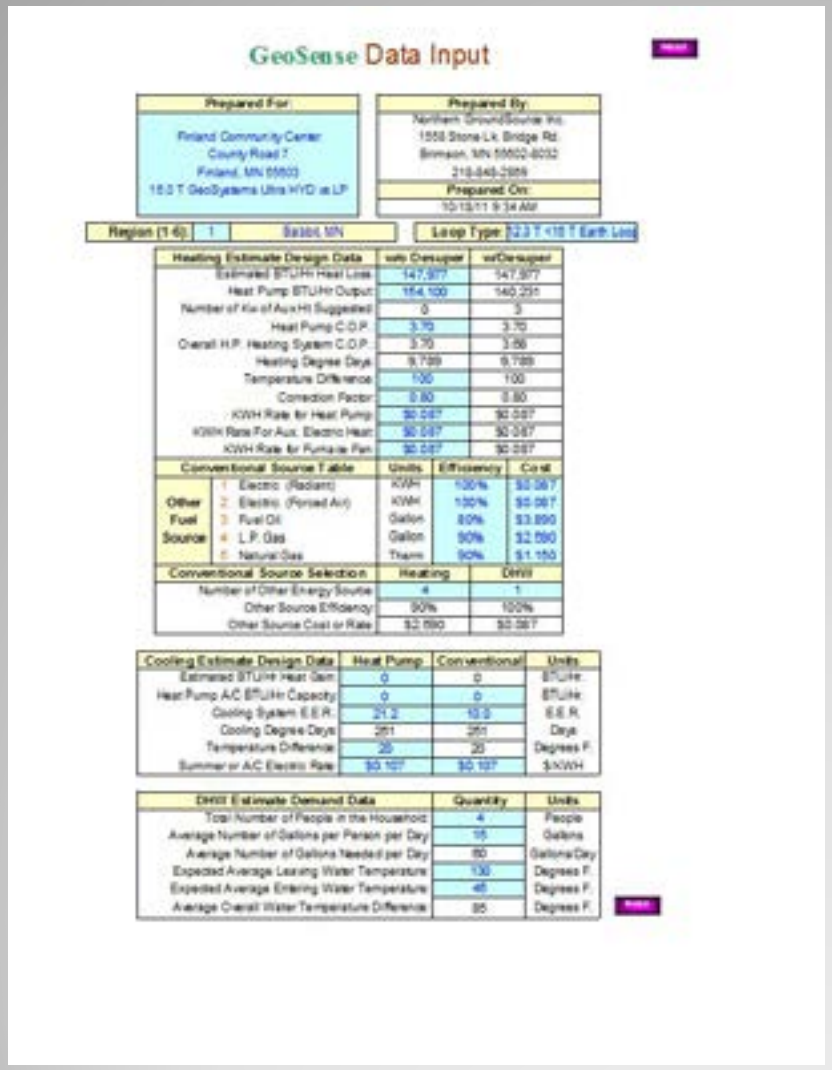
* = includes cost of operating the blower



Hydronic "Heat Only" GSHP System



Hydronic Heat/Cool GSHP System



GeoSense Data Input

Prepared For:	Prepared By:
Finland Community Center County Road 7 Finland, MN 55603 15.0 T GeoSystems Ultra HYD at LP	Northern GroundSource Inc. 1558 Stone Lk. Bridge Rd. Brimson, MN 55602-8032 218-848-2888 Prepared On: 10/13/11 9:34 AM

Region (1-6): 1 Bemidji, MN — Loop Type: 12.0 T <15 T Earth Loop

Heating Estimate Design Data	w/o Desuper	w/Desuper
Estimated BTU/Hr Heat Loss	147,977	147,977
Heat Pump BTU/Hr Output	154,100	140,231
Number of Kw of Aux Ht Suggested	0	3
Heat Pump C.O.P.	3.70	3.70
Overall H.P. Heating System C.O.P.	3.70	3.66
Heating Degree Days	9,709	9,709
Temperature Difference	100	100
Correction Factor	0.80	0.80
KWH Rate for Heat Pump	$0.087	$0.087
KWH Rate For Aux. Electric Heat	$0.087	$0.087
KWH Rate for Furnace Fan	$0.087	$0.087

Conventional Source Table		Units	Efficiency	Cost
Other Fuel Source	1 Electric (Radiant)	KWH	100%	$0.087
	2 Electric (Forced Air)	KWH	100%	$0.087
	3 Fuel Oil	Gallon	80%	$3.890
	4 L.P. Gas	Gallon	90%	$2.590
	5 Natural Gas	Therm	90%	$1.150

Conventional Source Selection	Heating	DHW
Number of Other Energy Source	4	1
Other Source Efficiency	90%	100%
Other Source Cost or Rate	$2.590	$0.087

Cooling Estimate Design Data	Heat Pump	Conventional	Units
Estimated BTU/Hr Heat Gain	0	0	BTU/Hr.
Heat Pump A/C BTU/Hr Capacity	0	0	BTU/Hr
Cooling System E.E.R.	21.2	10.0	E.E.R.
Cooling Degree Days	351	351	Days
Temperature Difference	20	20	Degrees F.
Summer or A/C Electric Rate	$0.107	$0.107	$/KWH

DHW Estimate Demand Data	Quantity	Units
Total Number of People in the Household	4	People
Average Number of Gallons per Person per Day	15	Gallons
Average Number of Gallons Needed per Day	60	Gallons/Day
Expected Average Leaving Water Temperature	130	Degrees F.
Expected Average Entering Water Temperature	45	Degrees F.
Average Overall Water Temperature Difference	85	Degrees F.

Northern GroundSource GSHP Design Input

ColdClimate GSHP Capacity to Peak Heating Load

Considered "Embarrass Effect"

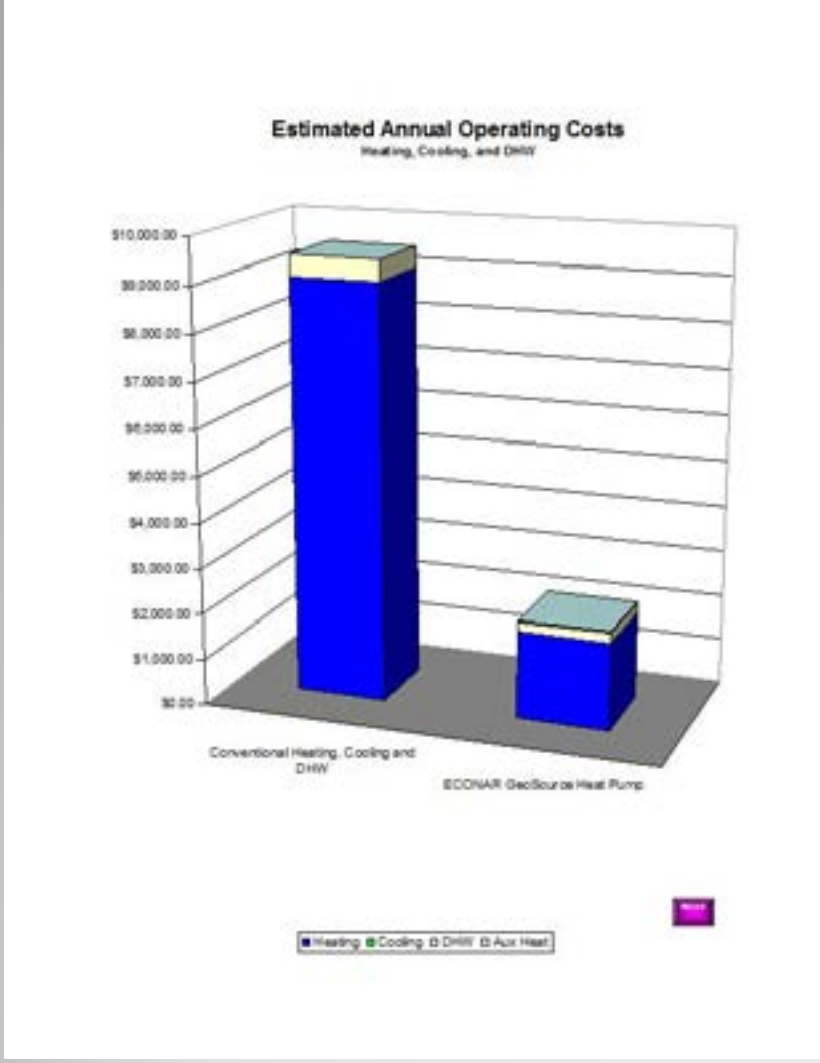
Adjusted Design Temperature Difference (ΔT) to 100°F Between Indoor and Outdoor Conditions

Considered HYD "Heat Only"

Considered 100% Geothermal

= 147,977 BTUH

= <u>16 Ton HYD HEAT ONLY</u>



Northern GroundSource GSHP Design Input

ColdClimate GSHP Capacity to Peak Heating Load

Considered "Embarrass Effect"

Adjusted Design Temperature Difference (ΔT) to 100°F Between Indoor and Outdoor Conditions

Considered HYD "Heat Only"

Considered 100% Geothermal

= 147,977 BTUH

= <u>16 Ton HYD HEAT ONLY</u>

Estimated Annual Operating Costs

For Finland Community Center

16T HYD "HEAT ONLY" GSHP SYSTEM

Estimated Energy Consumption

			Heating		Cooling	DHW	Estimated Annual Totals	
			w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump		Kwh/yr	22,024	21,915		1,027	22,024	22,942
Auxiliary Ht and Electric Water Htr		Kwh/yr		404		1,424		1,829
Other Fuel Source	1. Electric (Radiant)	Kwh/yr				5,225	5,225	
	2. Electric (Forced Air)	Kwh/yr						
	3. Fuel Oil	Gallons/yr						
	4. LP Gas	Gallons/yr	3,377				3,377	
	5. Natural Gas	Therms/yr						

22,319 kWh

23,776kWh

Estimated Operating Costs

		Heating		Cooling	DHW	Estimated Annual Totals	
		w/o	w/Desuper		w/Desuper	w/o Desuper	w/Desuper
ECONAR GeoSource Heat Pump		$1,916.09	$1,906.58		$89.36	$1,916.09	$1,995.94
Auxiliary Ht and Electric Water Htr			$35.17		$123.93		$159.10
Other Fuel Source	1. Electric (Radiant)				$454.56	$454.56	
	2. Electric (Forced Air) *						
	3. Fuel Oil *						
	4. LP Gas *	$9,038.65				$9,038.65	
	5. Natural Gas *						

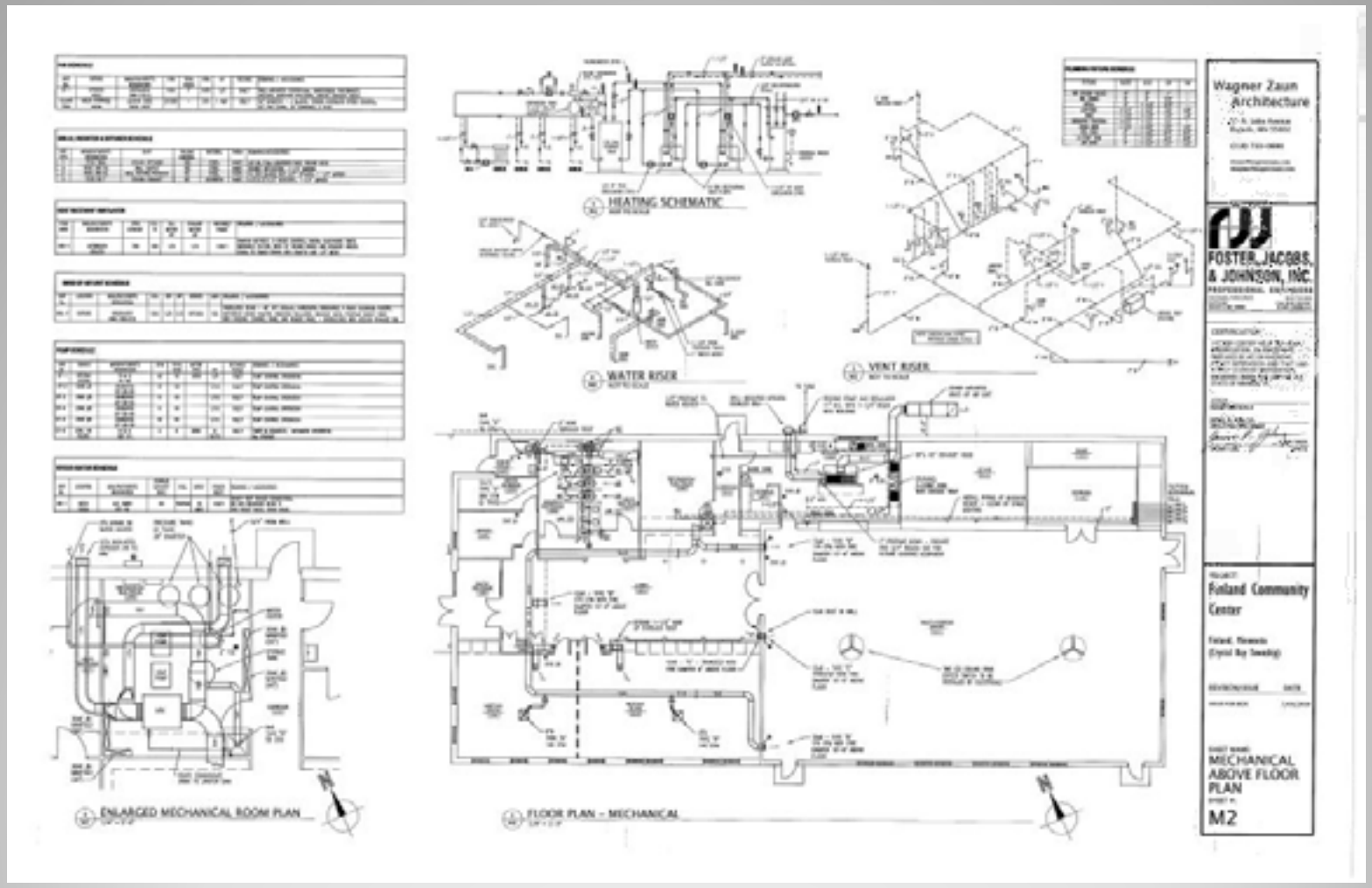
Estimated Cost Savings

	Heating		Cooling	DHW		Estimated Annual Totals	
	w/o	w/Desuper		w/o	w/Desuper	w/o Desuper	w/Desuper
Conventional Heating, Cooling and DHW	$9,038.65	$9,038.65	$0.00	$454.56	$454.56	$9,493.20	$9,493.20
ECONAR GeoSource Heat Pump	$1,916.09	$1,941.75	$0.00	$454.56	$213.29	$2,370.64	$2,155.04
Savings Using ECONAR Heat Pump	**$7,122.56**	**$7,096.89**	**$0.00**	**$0.00**	**$241.27**	**$7,122.56**	**$7,338.17**

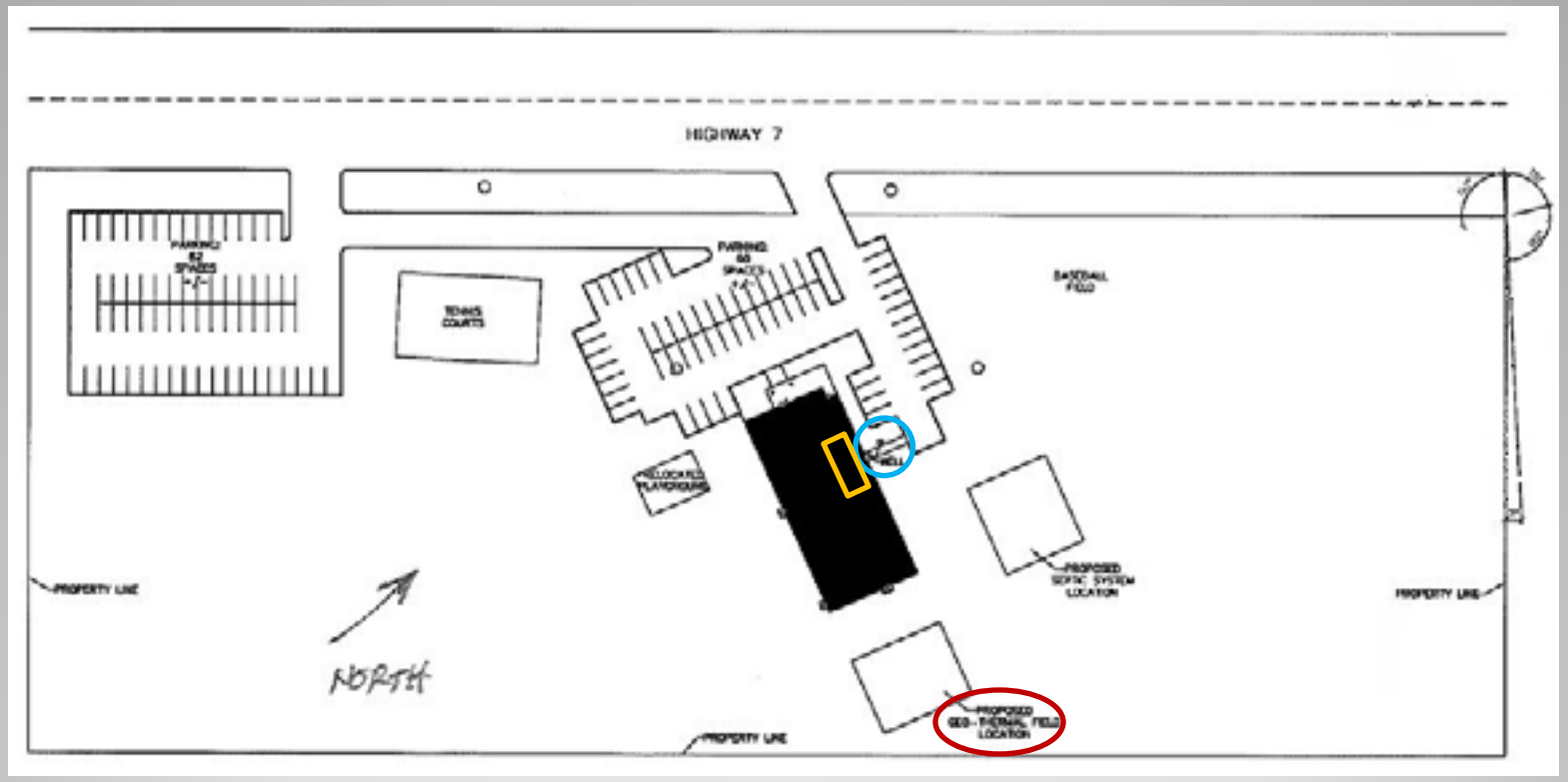
	w/o	w/Desuper	
On a yearly basis, this means the heat pump alone should cover	*100.0%*	*99.5%*	*of the total space heating load annually*
Auxiliary heat shouldn't be needed until the actual outdoor temperature falls to	*-34*	*-26*	*degrees Fahrenheit.*
The heat gain to Heat Pump cooling capacity ratio is	*0.0*	*0.0*	*(This ratio should be between 1 and 2)*
On a yearly basis, the heat pump alone should also cover	*0%*	*73%*	*of the total DHW water heating load annually.*

99.5% GSHP

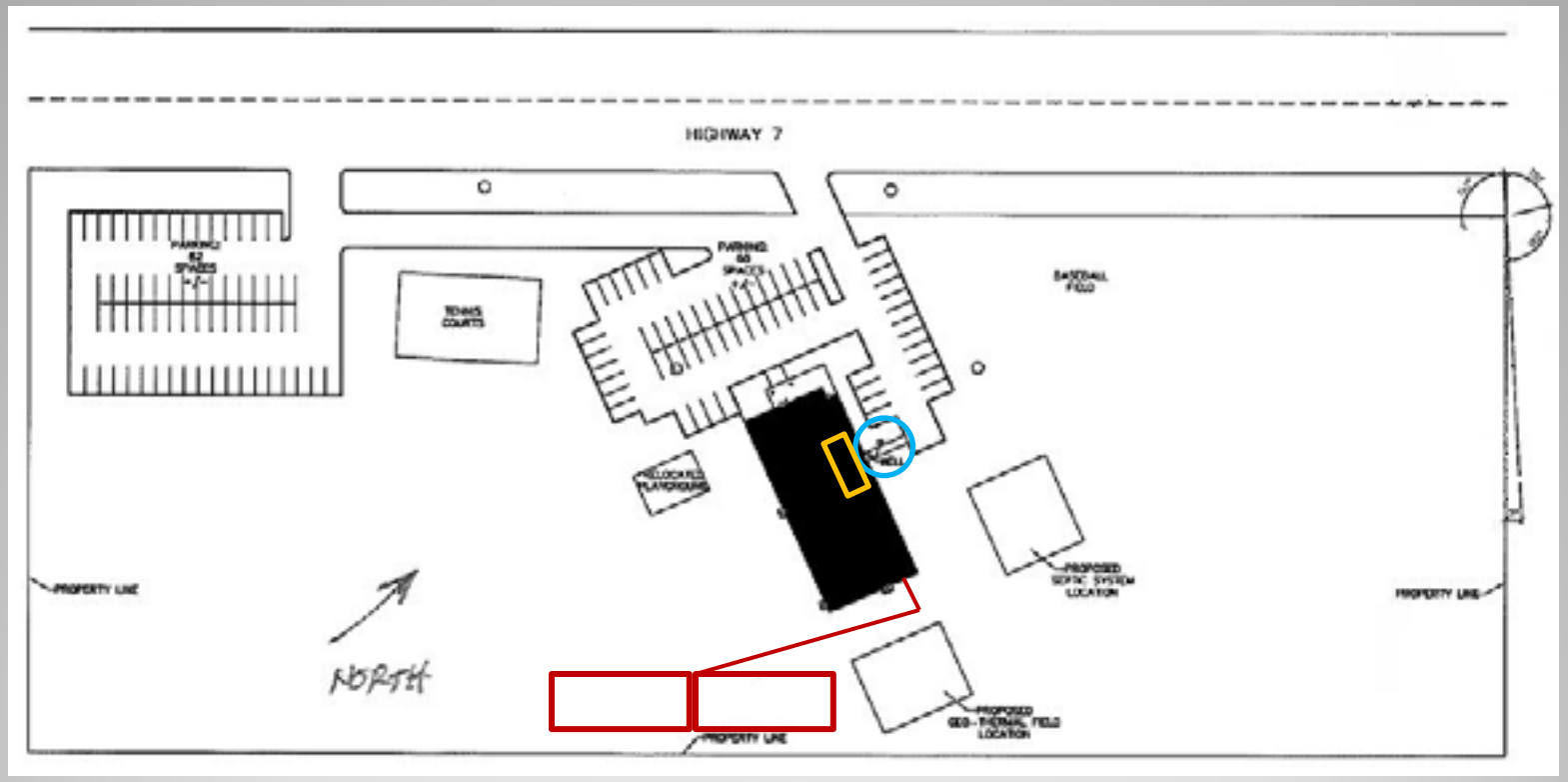
* = Includes cost of operating the blower



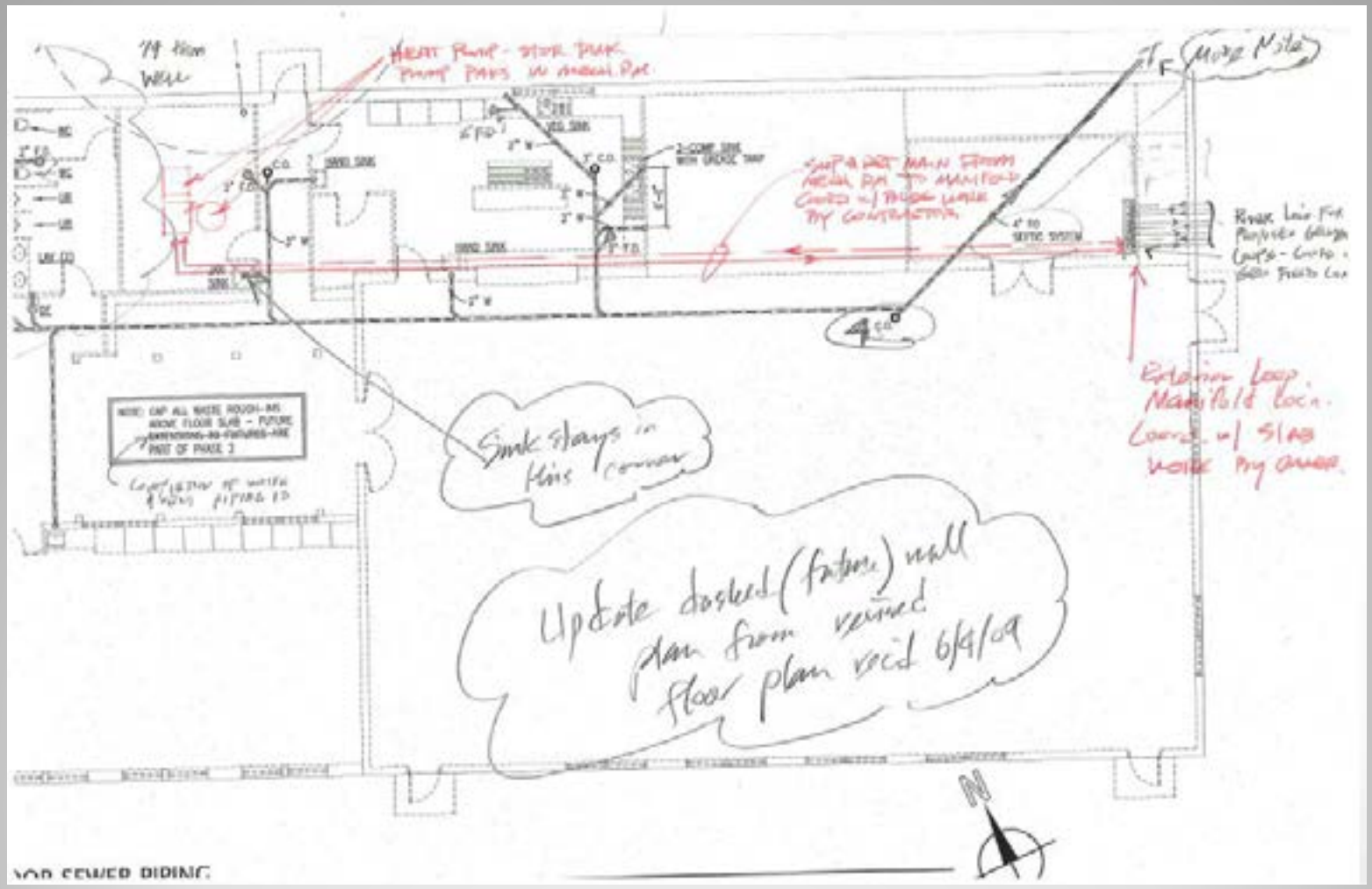
Community Center Mechanical Plan



Community Center Proposed GHEX Layout



Community Center Actual GHEX Layout



Community Center Interior Geo-Pipe Routing

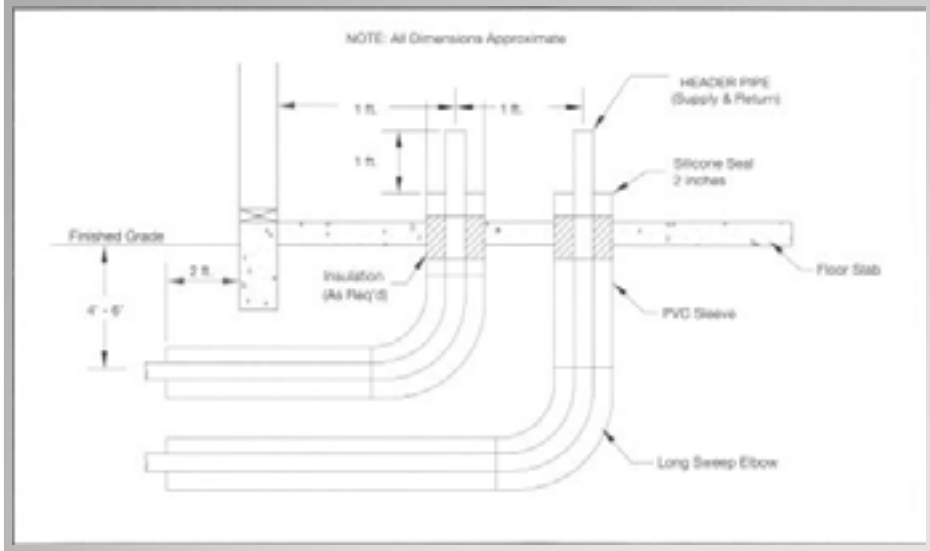

ZIEGLER RENTAL

IGSHPA STANDARD 3A.11 (1996)

All pipes passing through walls will be **sleeved** and **sealed** with non-hardening caulking material [emphasis added].

Long Sweep Elbows for Pipe Bends!…

Proper pipe sleeve sizing and configuration will make it a lot easier to place geothermal HDPE supply/return header pipes later.



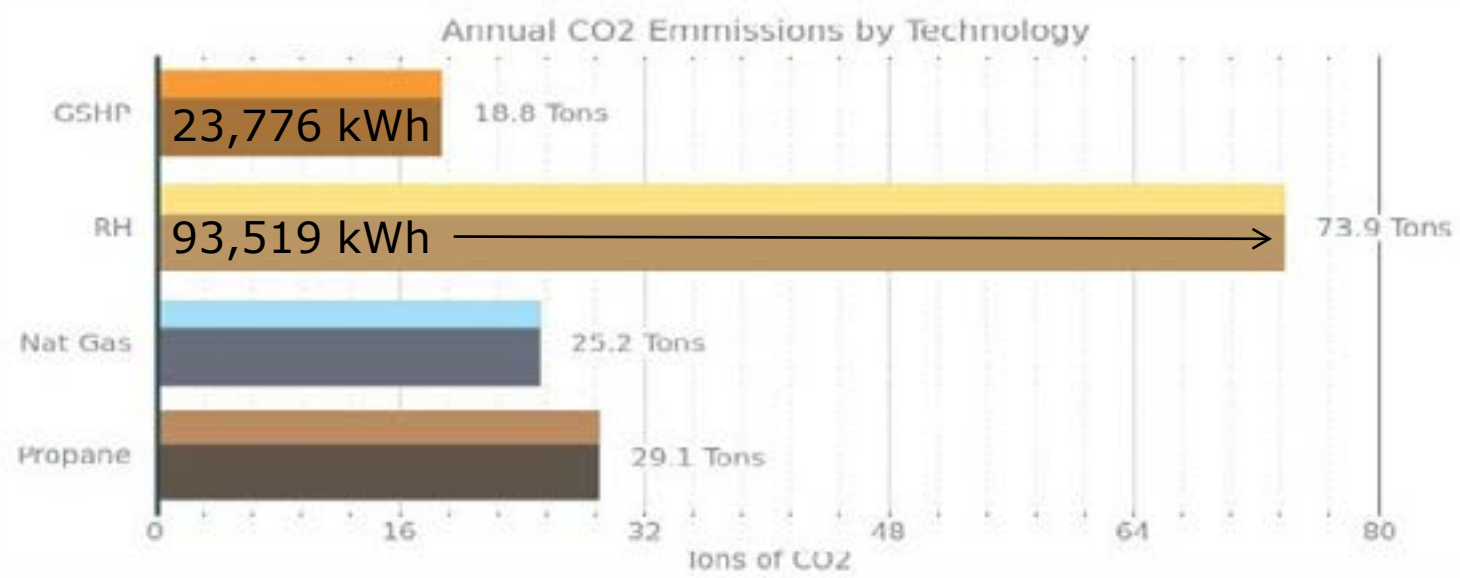
Subheader S/R Slab Penetrations

Clair Nelson Intermodal Transportation Center, Finland, MN

2 X 8T Hydronic "Heat Only" GSHP System Served by Integrated 2 X 8T Horizontal Slinky GHEX.

Heats Approximately 10,000 sq' Radiant Slab with NO Backup or Auxiliary Heat!

100% HYD "HEAT ONLY" GSHP System

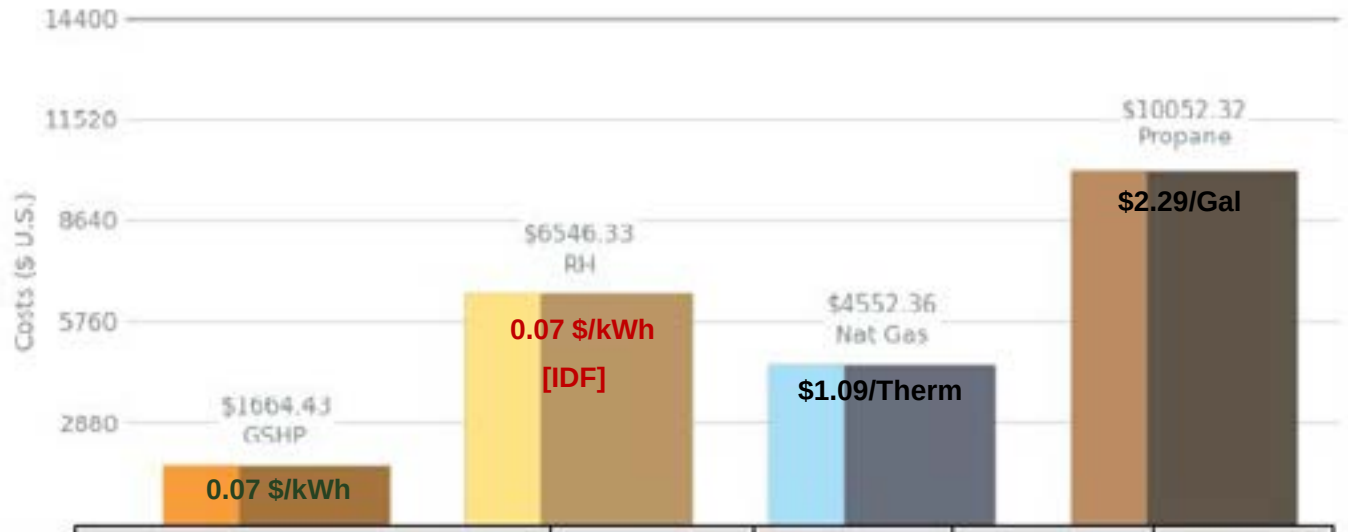

Annual CO2 Emmissions by Technology
GSHP
23,776 kWh
18.8 Tons
RH
93,519 kWh
73.9 Tons
Nat Gas
25.2 Tons
Propane
29.1 Tons
0
16
32
48
64
80
Tons of CO2

Heating		Cooling	
High Capacity Runtime	1,883 hrs	High Capacity Runtime	0 hrs
Resistance Heat Runtime	26 hrs		
Heat Pump Energy Use	22,810 kWh	Heat Pump Energy Use	0 kWh
Resistance Heat Energy Use	71 kWh	Pumping Energy Use	0 kWh
Pumping Energy Use	895 kWh		

GSHP Operating Cost Breakdown for Zone Name

Based on the annual power consumption of the system and the price per kilowatt hour in your area the estimated cost to maintain the set points for this zone are as follows:

Heating		Cooling	
HP Operating Cost	$1,596.76	HP Operating Cost	$0.00
Resistance Heat Operating Cost	$5.02	Pumping Cost	$0.00
Pumping Cost	$62.66	Total Cost	$0.00
Total Cost	$1,664.43		



System Type	Heating	Cooling	Total	vs. GSHP
Ground Source Heat Pump (GSHP)	$1,664.43	$0.00	$1,664.43	———
RH	$6,546.33	$0.00	$6,546.33	$4,881.90
Nat Gas	$4,552.36	$0.00	$4,552.36	$2,887.93
Propane	$10,052.32	$0.00	$10,052.32	$8,387.89

Resistance Heat w/ Central A/C		GSHP	
Installation Cost	$10,000.00	Installation Cost	$52,400.00
Incentives	$0.00	Incentives	$11,000.00
Actual Cost	$10,000.00	Actual Cost	$41,400.00
Down Payment	$0.00	Down Payment	$0.00
Loan Amount	$10,000.00	Loan Amount	$41,400.00
Loan Interest Rate	0.000%	Loan Interest Rate	0.000%
Loan Term	0 years	Loan Term	0 years
Monthly Payment (P&I only)	$0.00	Monthly Payment (P&I only)	$0.00
Fuel Inflation Rate	3.5%	Fuel Inflation Rate	3.5%
COP	1.00	Avg. COP	3.93
SFFR	15.00	Avg FFR	0.00

Economics: Cost of Ownership

GSHP Savings Overview

Monthly Operating Cost Savings **$406.82**

Incremental Loan Payment **$0.00**

Monthly Savings from GSHP **$406.82**

Total Savings (After 30 Years) **$220,616.59**

Simple Payback

GSHP Install Cost **$41,400.00** − Conventional Install Cost **$10,000.00**

Conventional Operating Cost **$6,546.33** − GSHP Operating Cost **$1,664.43**

$$\Rightarrow \frac{\$31,400.00}{\$4,881.84} = \text{Simple Payback Period } 6.4 \text{ years}$$

January -- December 2011

[GSHP SYSTEM COMMISSIONED : 11/11/2010]

Metered Month	Meter No. 0101883032	Meter No. 0107477721	Meter No. 092804277 Ground Source Heat	Total
December 2010	720	234	3,773	4,727
January 2011	880	88	3,136	4,104
February 2011	1,720	107	2,420	4,247
March 2011	2,120	67	2,234	4,421
April 2011	1,400	43	1,485	2,928
May 2011	1,720	124	804	2,648
June 2011	1,840	93	174	2,737
July 2011	2,240	129	48	2,417
August 2011	2,240	209	45	2,494
September 2011	2,400	251	291	2,942
October 2011	1,720	120	710	2,550
November 2011	1,200	98	1,463	2,761
December 2011	1,240	67	2,429	3,736
TOTAL kWh	**20,200**	**1,563**	**15,239**	**38,346**

$1,011.87
($0.066/kWh)

23,776 kWh
$1,664.43

January -- December 2012

Metered Month	Meter No. 0101883032	Meter No. 0107477721	Meter No. 092804277 Ground Source Heat	Total
January 2012	1,680	105	2,799	4,584
February 2012	1,960	235	2,014	4,209
March 2012	1,640	136	1,179	2,955
April 2012	1,240	118	498	1,856
May 2012	1,840	160	120	2,120
June 2012	2,000	81	42	2,123
July 2012	2,200	94	38	2,332
August 2012	2,320	186	43	2,549
September 2012	1,720	164	27	1,911
October 2012	1,640	183	945	2,768
November 2012	1,960	230	1,913	4,103
December 2012	2,080	264	2,464	4,808fs
TOTAL kWh	**22,280**	**1,956**	**12,082**	**36,318**

$ 802.24
($0.066/kWh)

23,776 kWh
$1,664.43


The Clair Nelson Intermodal Transportation Center
Finland, MN—Construction Completed October 2010

FIN

RESOURCES:

- Minnesota Geothermal Heat Pump Association
  www.MNGHPA.org
- Wisconsin Geothermal Association
  www.wisgeo.org
- International Ground Source Heat Pump Association
  www.igshpa.okstate.edu
- GeoExchange
  www.GeoExchange.org
- Association of Energy Engineers
  www.aeecenter.org

END