Earth-to-air Heat Exchanger Design Evaluation

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Disclaimer

1 Introduction

Earth-to-air heat exchanger (EAHX) systems are long metallic, plastic or concrete pipes that are laid underground and are connected to the air intake of buildings, particularly houses. Their purpose is to provide some pre-conditioning of the air – either pre-heating in the winter or pre-cooling in the summer. A previous study by Numerical Logics Inc. for the Yukon Energy Solutions Centre (ESC) analyzed, through a literature search, the current state of the art of such systems, their construction, performance, and potential associated problems. From the literature search it was found that the economics of earth tubes was marginal, particularly for heating. In addition, there were concerns with possible problems with insects, rodents and dust accumulation in earth tubes. The purpose of this study is to evaluate an earth tube design that would respond to these concerns and evaluate the economics. This report summarizes the proposed design, sizing and basic construction of an EAHX system that is designed to be as economical as possible with the current state of technology, and at current prices.

2 Site

A site with no trees was selected so that there would be no tree roots that would interfere with the installation or operation of the earth tubes. The lot layout is shown in Figure 1. The available space in the backyard is roughly 8.0 m deep by 15.0 m wide; a fresh air inlet is located near the corner of the house and is slightly off-center (9 m to one side of the yard, 6 m to the other). The design developed here is specific to that site but is intended to be typical and applicable to any similar house.

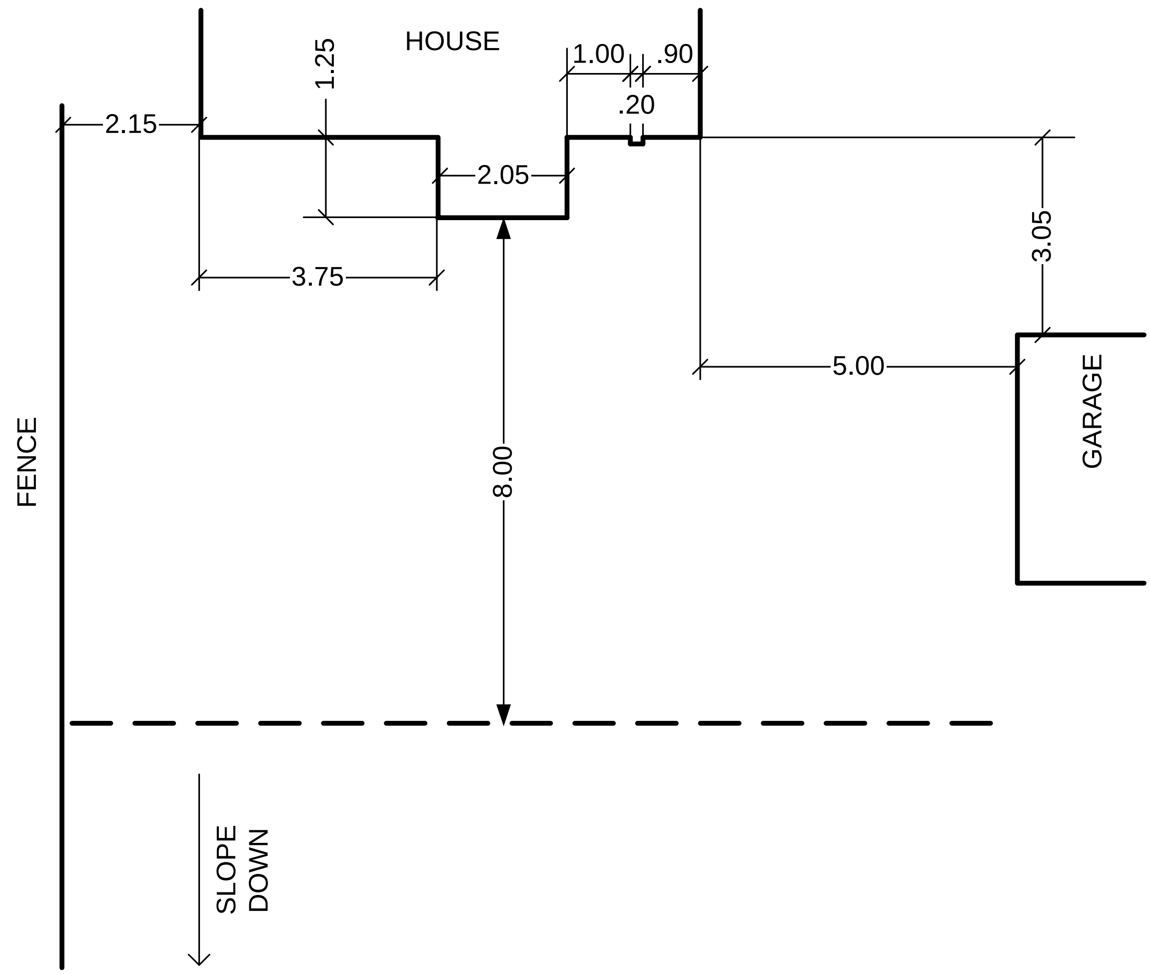


Figure 1 – Lot Layout.

3 Construction options

Two options were considered: a ready-made system available commercially and a custom-made system.

3.1 Ready-made system

EAHX systems are available commercially. At least on manufacturer uses plastic pipes, lined with an anti-microbial, silver-based coating that inhibits bacterial growth, and made with secure joints that prevent gas infiltration. The system has been in use in Europe and has been demonstrated in a few projects in North America.

A number of systems were proposed by one company contacted: a 1-pipe configuration, 40 m long, at a cost of over $2,000 for the pipes alone; a 2-pipe configuration, each pipe being 40 m long, at a cost of over $3,000 for the pipes alone; and a 2-pipe configuration, each pipe being 75 m long, at a cost of over $5,500 for the pipes alone. The system proposed by the company included one single 8" steel air intake, approximately 1.5 m high, which feeds 8" underground polypropylene pipes laid out in a grid pattern. The system also includes an 8" condensation collection shaft.

The two main apparent concerns noted with the commercial system were:

- the antibacterial coating, once covered with dust, may become ineffective since the system lacks a method to clean the tubes with a pig or other means, and
- the cost of the system appears to be too high for applications in the Yukon to have a good payback.

In this report, the design and economics of a custom-made system which addresses these concerns is evaluated.

3.2 Custom-made system

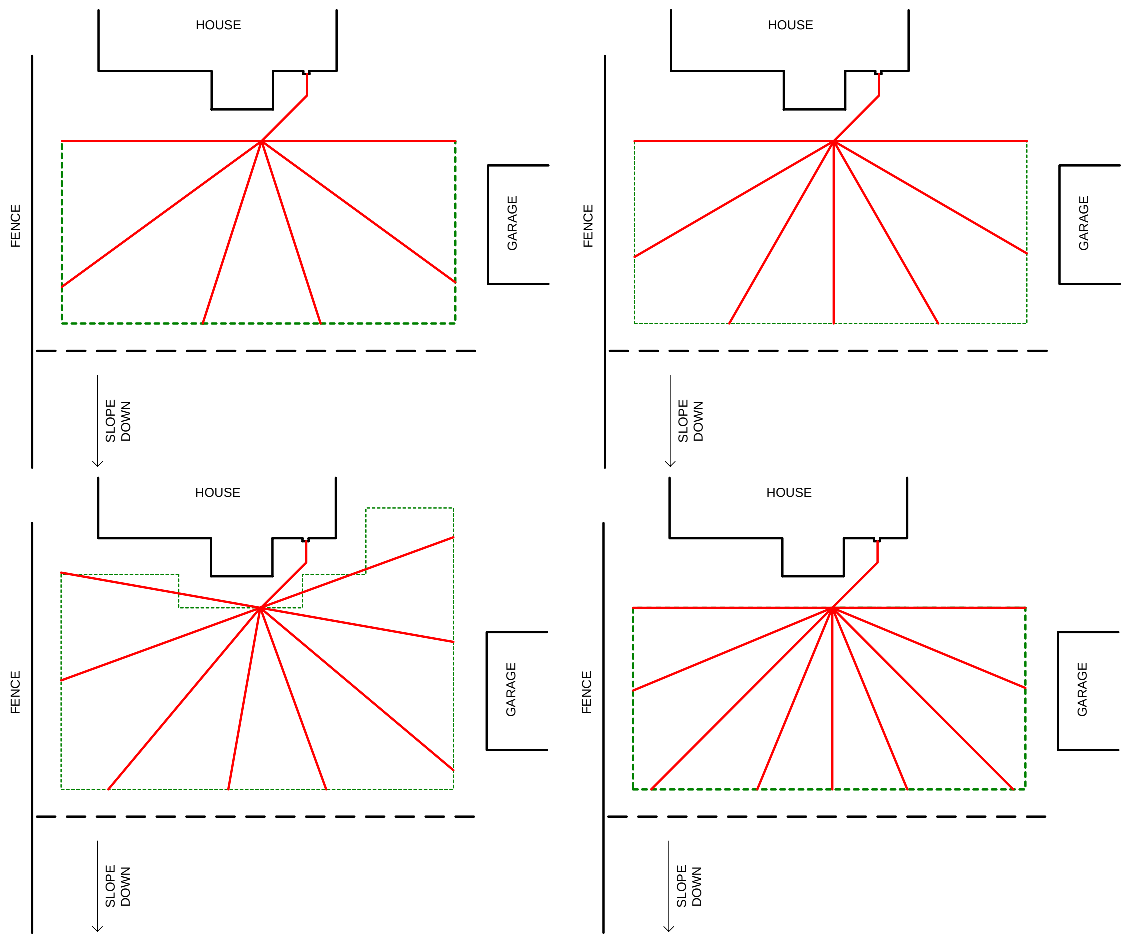


Figure 2 – Some EAHX configurations under consideration.

The custom-made system was designed so that it is easy to clean. The pipes are fanned out in a radial pattern from a central pipe large enough to enable easy cleaning of all pipes with a pig. It would also be possible to flush each pipe with water from a garden hose as well. Drainage of condensation is provided from the bottom of the central pipe. From this central point, the air that is collected is drawn through a single pipe into to the air intake (or heat recovery ventilator) of the residence. Several configurations were considered including 2 to 9 equally spaced pipes; some examples are shown in Figure 2. In that figure, the dashed lines outline a rectangle with a buffer of 1 m from adjacent buildings, a fence and a sloped area.

The pipe selected was 100 mm (4”) light weight (DR35) smooth (not corrugated) plastic pipe. This pipe has a smooth interior surface resulting in the low pressure drop needed for this application. It also has the structural strength needed to be buried at the depths required, and is readily available. Finally, it is significantly lower in cost than pipe with a silver-oxide coated interior.

4 Sizing

The University of Siegen in Germany has developed a program called GAEA[1] which can be used for the sizing of EAHX. The program was used to complete this preliminary analysis of the efficiency of the proposed EAHX system.

4.1 Simulation parameters

4.1.1 EAHX characteristics

Number of pipes was varied from 2 to 9, as noted above.

The pipe length varied, typically between 6 m (for the pipe facing away from the house) to 8.85 m (the maximum length to the corner of the green rectangle). For the simulation an equivalent radius was used as the pipe length; this was defined as the radius of the semi-circle that would have the same area as the green rectangle shown in Figure 2. The calculated equivalent radius was 7.05 m.

Pipe diameter is set to 100 mm.

Distance between pipes is taken as their average distance, which is approximated by $L\sin(\beta/2)$ where L is the length of the pipe and β is the angle separating the pipes. Equivalent distance between pipes is shown in Table 1.

[1] The program is available at http://nesa1.uni-siegen.de/index.htm?/softlab/gaea_e.htm.

Table 1 – Equivalent distance between pipes, depending on configuration.

Number of pipes in layout	Angle separating adjacent pipes (°)	Equivalent distance between pipes (m)
2	90	5.0
3	45	2.7
4	45	2.7
5	45	2.7
6	36	2.2
7	30	1.8
8	30	1.8
9	22.5	1.4

Depth of pipe was set to 2 m.

Distance from the building was set to 4 m, which is the average distance between the pipes and the house.

4.1.2 Soil

Soil type was set to 'Sandy ground' (density: 1,520 kg/m3; heat capacity: 1.65 kJ/kg/°C; thermal conductivity 1.24 W/m/°C; ground water level at -20 m).

4.1.3 Climate

The program requires only a file with hourly temperatures. Temperatures from the Canadian Weather for Energy Calculations[2] (CWEC) climate file for Whitehorse, which represents a 'typical' year, were used.

4.1.4 HVAC

The quasi-stationary model is used with a building volume of 510 m^3, 0.4 ACH, and a ventilation flow of 204 m^3/h (120 cfm). The EAHX is active in heating mode whenever the outdoor temperature is lower than 18°C, and in cooling mode whenever the outdoor temperature exceeds 25°C. The constant pressure drop in the system is estimated at 25 Pa (1 inch water).

[2] CWEC files are available from Environment Canada.

4.2 Simulation results

Several parameters were analyzed: the number of hours when the system would provide heating or cooling, the maximum and average temperature rise or fall, and the average amount of heating or cooling delivered when the system is in operation.

Total heating and cooling energy delivered as a function of the number of tubes is shown in Table 2 and in graphical form in Figure 3.

Table 2 – Yearly energy delivered as a function of the number of pipes.

Number of pipes	Yearly heating energy delivered (kWh)	Yearly cooling energy delivered (kWh)
2	954	14
3	1232	18
4	1453	18
5	1633	18
6	1723	19
7	1735	19
8	1832	19
9	1731	19

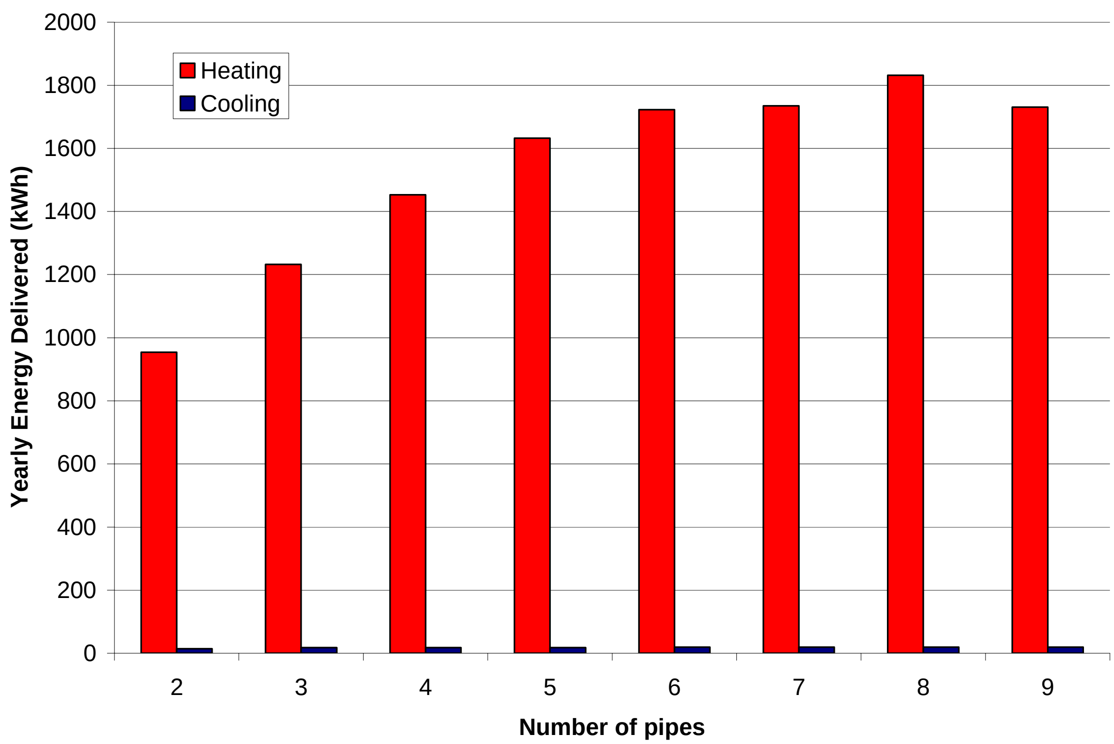


Figure 3 – Yearly energy delivered as a function of the number of pipes.

Detailed simulation summaries are provided in Appendix A.

4.3 Discussion

It appears that the system will be used mostly in heating mode. Cooling mode will be required only marginally in the months of June and July.

Maximum heat gain is obtained with an 8-pipe system, but with a footprint that is slightly larger than for other systems (see Figure 2). Above 6 pipes, additional pipes provide only marginal improvement of system efficiency. Increasing the number of pipes from 8 to 9 actually reduces the energy delivered because the spacing between the pipes becomes insufficient.

All results should be interpreted with caution because some parameters are not known with great certainty (e.g. soil condition) and because the geometry of the system (fan pattern) is not the one simulated by the software (comb or grid pattern).

Based on the results shown in Table 2 and the monthly data provided in Appendix A, it is suggested to go either with a 7 or 8-tube system to maximize performance, or with a 5-tube system which provides only marginally less energy (-10.9% compared to the 8-tube system) but with a simpler design. A full economic analysis (extra energy gained vs. additional cost of digging more trenches) could be done to decide between the various options. In this first design, a 5-tube system is proposed.

Note: height of air intake

The *extreme snow depth* in Whitehorse according to the 1971-2000 Canadian Normals is shown in Table 3. Given this table, it is suggested that the air intake be at least 105 cm (3.5') above ground.

Table 3 – Extreme snow depth in Whitehorse, in cm.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
86	94	94	66	38	0	0	3	20	21	52	69

5 Performance verification

The issue of the performance of the Earth-to-Air HX Project may need to be addressed. The most cost-effective method to verify the energy performance of the field is to utilize a standalone +/- 0.2% data logging system that will store the values of the outside air and supply air temperatures from the field. Two cable-style air temperature sensors can be installed, one in the inlet of the field so as to shield it from solar effects and the other in the inlet to the house. Another possibility is to install the OA sensor in a shaded/shelter area just outside the house. This will establish the temperature rise (benefit) of the system. In order to most cost effectively convert this to energy, it is recommended that the flow from the HRV be measured / calibrated and treated as a constant. This will introduce some error into the calculation but will not effect the overall totalization. If the existing HRV is a two-speed fan system a state logger using a dry contact and a DC cable connection can be used to monitor the simultaneous fan speed operation coinciding with the temperature increase in the field. The amount of data storage depends on the interval of storage. For purposes of a realistic sampling it is recommended that a 5-15 minute sample time be used depending on the frequency of data collection and the particular data logger used. Once collected, that data can be easily converted to energy values in a spreadsheet calculation.

6 Economic analysis

To evaluate the economic benefits of the system, its simple payback is calculated. Two hypotheses are documented: one where the full cost of trenching is borne by the project, and one where the cost of trenching is not charged to the project. The first hypothesis is appropriate for retrofit situations, whereas the second may be suitable for a new construction.

6.1 Costs

6.1.1 Costs including trenching

The following construction costs were used:

Labour

#	Item	Hours	Rate	Total
1	Trenching and backfilling 36 m of 4” pipe at a depth of 2 m	36	50.00	1,800.00
2	Trenching and backfilling 3 m of 6” pipe	3	50.00	150.00
3	Labour to install pipes	8	50.00	400.00
	Total labour			**2,350.00**

Materials

#	Item	Number	Unit price	Total
1	4’ sump pit	1	142.90	142.90
2	1’ sump pit extension	6	57.25	343.50
3	4” PVC piping	144'	2.45	352.80
4	4” PVC 90-degree elbow	5	5.50	27.50
5	6” PVC piping	20'	6.59	131.80
6	6” PVC 90-degree elbow	2	17.18	34.36

7	8” PVC piping	9'	12.40	111.60
8	8” PVC 8-8-8 T-connection	1	85.57	85.57
9	8” to 6”PVC pipe reducer	1	155.43	155.43
10	4” pipe vent	5	*	50.00
11	8”×4” PVC saddle	5	43.58	217.90
12	8” PVC cap	2	36.96	73.92
13	Neoprene foam		*	50.00
14	Clip-on U-nut, 1/4-20	4	*	20.00
15	2” PVC piping	6'	*	15.00
16	4”air intake cap	5	*	50.00
17	6” exhaust port	1		20.00
18	6” flex ducting			20.00
19	8” flex ducting			30.00
20	8” isolation damper	2		100.00
	Freight			175.00
	Total materials			2,207.28

Note: * are estimated values

Contingency costs: 10% of total labour and materials

	Contingency			**455.73**

Total

The grand total is the sum of labour, materials and contingency.

	GRAND TOTAL ($)			**5,013.01**

6.1.2 Costs excluding trenching

If trenching costs can be omitted, labour costs are reduced to $ 400, materials are unchanged at $ 2,207.28, and contingency costs become $ 260.73 for a grand total of $ 2,868.01.

6.2 Avoided costs

Only the heating costs are estimated – cooling costs are assumed to be negligible. Cooling during hot spells will be an added benefit of the system but is not factored into the economic analysis.

Heating cost

Heating fuel costs *r* were as follows, based on prices in Whitehorse, Yukon in March, 2008 as reported at the website www.emr.gov.yk.ca/energy/fuel.html:

- 1.227 $/L for Furnace Oil,
- 1.258 $/L for Arctic Stove Oil,
- 0.935 $/L for Propane.

Calorific value C of the fuels listed above is estimated as follows:

- 38.3 MJ/L for Furnace Oil,
- 37.7 MJ/L for Arctic Stove Oil,
- 25.3 MJ/L for Propane.

(See: http://www.statcan.ca/english/freepub/57-003-XIE/57-003-XIE2005000.htm p. 118 and http://oee.nrcan.gc.ca/commercial/technical-info/tools/gigajoule.cfm?attr=20 for more information.)

Given that the 5-pipe system is expected to deliver 1633 kWh of energy during a typical year, the avoided cost of energy because of the use of the EAHX is:

$$\frac{1633 \cdot 3.6}{C \cdot \eta} \cdot r$$

where η is the efficiency of the furnace, assumed to be 65%, and 3.6 MJ/kWh is a conversion factor. This translates into the following costs:

- 289.75 $/year for Furnace Oil,
- 301.80 $/year for Arctic Stove Oil,
- 334.25 $/year for Propane.

6.3 Simple payback

The simple payback is calculated as the ratio of system cost over the avoided cost. The table below provides the expected payback for the two options (trenching / no trenching) and the three fuels considered.

Table 4 – Simple payback in years according to various fuel and construction options.

	With trenching	Without trenching
Furnace oil	17.3	9.9
Arctic stove oil	16.6	9.5
Propane	15.0	8.6

Appendix A – Detailed simulation results

2-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	10.2	5.0	370	0	-	-	-
2	672	8.1	3.7	274	0	-	-	-
3	744	6.4	2.8	206	0	-	-	-
4	637	4.9	1.3	98	0	-	-	-
5	138	17.7	0.7	52	0	-	-	-
6	6	25.7	0.2	11	24	25.7	6.7	493
7	0	-	-	-	4	31.1	7.3	541
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	25	18.7	1.2	88	0	-	-	-
11	624	9.7	1.8	134	0	-	-	-
12	716	8.9	3.5	259	0	-	-	-
Year (kWh)				**954**				**14**

3-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	13.4	6.5	482	0	-	-	-
2	672	10.6	4.8	355	0	-	-	-
3	744	8.3	3.6	265	0	-	-	-
4	636	5.9	1.7	124	0	-	-	-
5	133	17.7	0.9	67	0	-	-	-
6	6	25.7	0.2	11	24	25.7	8.6	637
7	0	-	-	-	4	31.1	9.4	698
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	1.6	121	0	-	-	-
11	622	9.7	2.3	172	0	-	-	-
12	711	11.7	4.6	338	0	-	-	-
Year (kWh)				**1232**				**18**

4-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	16.0	7.7	572	0	-	-	-
2	672	12.6	5.6	419	0	-	-	-
3	744	9.9	4.2	311	0	-	-	-
4	635	6.9	2.0	145	0	-	-	-
5	132	17.7	1.1	79	0	-	-	-
6	6	25.7	0.2	11	24	25.7	10.1	748
7	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	1.9	141	0	-	-	-
11	622	9.7	2.7	202	0	-	-	-
12	711	14.0	5.4	399	0	-	-	-
Year (kWh)				**1453**				**18**

5-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	18.1	8.7	644	0	-	-	-
2	672	14.3	6.3	470	0	-	-	-
3	744	11.1	4.7	349	0	-	-	-
4	635	7.8	2.2	162	0	-	-	-
5	131	17.7	1.2	88	0	-	-	-
6	6	26.2	0.2	12	21	26.2	11.4	845
7	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	2.1	158	0	-	-	-
11	622	9.8	3.1	226	0	-	-	-
12	711	15.8	6.1	449	0	-	-	-
Year (kWh)				**1633**				**18**

6-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	19.2	9.2	681	0	-	-	-
2	672	15.1	6.7	496	0	-	-	-
3	744	11.7	5.0	368	0	-	-	-
4	635	8.2	2.3	170	0	-	-	-
5	131	17.7	1.2	93	0	-	-	-
6	6	26.2	0.2	14	21	26.2	11.9	885
7	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	2.3	168	0	-	-	-
11	622	10.4	3.2	238	0	-	-	-
12	711	16.7	6.4	474	0	-	-	-
Year (kWh)				**1723**				**19**

7-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	19.4	9.3	686	0	-	-	-
2	672	15.2	6.7	499	0	-	-	-
3	744	11.8	5.0	370	0	-	-	-
4	635	8.3	2.3	172	0	-	-	-
5	131	17.7	1.3	93	0	-	-	-
6	6	26.2	0.2	14	21	26.2	12.0	891
7	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	2.3	168	0	-	-	-
11	622	10.5	3.2	240	0	-	-	-
12	711	16.9	6.4	478	0	-	-	-
Year (kWh)				**1735**				**19**

8-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	20.5	9.8	725	0	-	-	-
2	672	16.1	7.1	527	0	-	-	-
3	744	12.5	5.3	390	0	-	-	-
4	635	8.7	2.4	180	0	-	-	-
5	131	17.7	1.3	98	0	-	-	-
6	6	26.6	0.2	14	20	26.6	12.7	940
7	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	2.4	177	0	-	-	-
11	622	11.1	3.4	254	0	-	-	-
12	711	17.9	6.8	504	0	-	-	-
Year (kWh)				**1832**				**19**

9-pipe system

Month	Heating				Cooling			
	Hours heating	Max temp. rise (°C)	Avg temp. rise (°C)	Avg heating power deliv'd (W)	Hours cooling	Max temp. Fall (°C)	Avg temp. Fall (°C)	Avg cooling power deliv'd (W)
1	744	19.4	9.2	685	0	-	-	-
2	672	15.2	6.7	497	0	-	-	-
3	744	11.8	5.0	369	0	-	-	-
4	635	8.3	2.3	170	0	-	-	-
5	131	17.7	1.2	92	0	-	-	-
6	6	26.2	0.2	14	21	26.2	11.9	883
7	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-
10	23	18.7	2.3	168	0	-	-	-
11	622	10.5	3.2	239	0	-	-	-
12	711	16.9	6.4	477	0	-	-	-
Year (kWh)				**1731**				**19**

NO.	REVISIONS	DATE	BY
01	INITIAL RELEASE	26-MAR-08	AS
02	REISSUED FOR CLARITY	01-APR-08	AS
03	ECO 08004 - CUSTOMER REQUESTED CHANGES	09-APR-08	AS

DWG. NO. 08006-M101

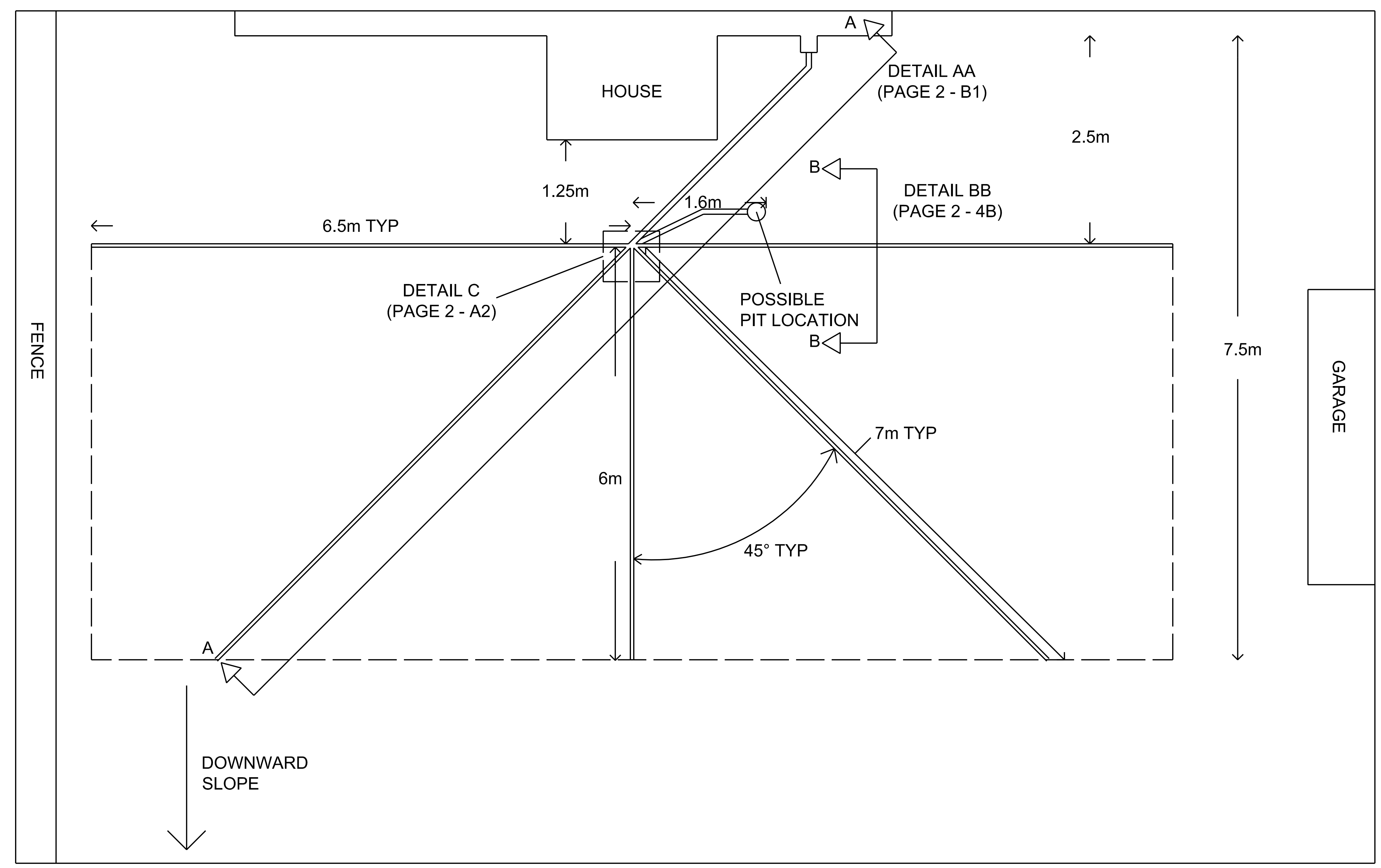
BILL OF MATERIALS

REV 03

ITEM NO	DESCRIPTION	MANUFACTURER (OR EQUIV)	P/N (OR EQUIV)	QTY
01	4' SUMP PIT	SABER	SSP-01	1
02	1' SUMP PIT EXTENSION	SABER	SSP-01E	6
03	4" PVC PIPING SCHEDULE 10	IPEX	-	144'
04	4" PVC 90-DEGREE ELBOW	IPEX	-	5
05	6" PVC PIPING SCHEDULE 10	IPEX	-	20'
06	6" PVC 90-DEGREE ELBOW	IPEX	-	2
07	8" PVC PIPE SCHEDULE 10	IPEX	-	9'
08	8" PVC 8-8-8 T-CONNECTION	IPEX	-	1
09	8" to 6" PVC PIPE REDUCER	IPEX	-	1
10	4" PIPE VENT	ACTIVE VENTILATION PRODUCTS INC.	PV-4	5
11	8" x 4" PVC SADDLE SCHEDULE 10	IPEX	-	5
12	8" PVC CAP SCHEDULE 10	IPEX	-	2
13	NEOPRENE FOAM, 1/4" THK X 2"			A/R
14	CLIP ON U-NUT, 1/4-20	MCMASTER-CARR	94808A360	4
15	2" PVC PIPING SCHEDULE 10	IPEX	-	6'
16	4" AIR INTAKE CAP	-	-	5
17	6" EXHAUST PORT			1
18	6"Ø FLEX DUCTING			A/R
19	8"Ø FLEX DUCTING			A/R
20	8" ISOLATION DAMPER			2

SITE LAYOUT TYPICAL

REV 03



SEQUENCE OF OPERATION

ITEM NO	DESCRIPTION
01	THE HRV SHALL OPERATE CONTINUOUSLY
02	THE OUTSIDE AIR INTAKE CAN BYPASS THE FIELD BY MANUALLY CONNECTING THE HRV O/A INLET TO AN O/A VENT (OPTIONAL)
03	THE 2% GRADE OF THE FIELD DRAINS TO ACCESS PIPE (HEADER) SUMP PIT. IT WILL THEN BE PUMPED FROM THE SUMP. ALL DEBRIS IS GATHERED/COLLECTED IN THE ACCESS TUBE BASE.

REV 03

UNDERGROUND LAYOUT AND BILL OF MATERIALS

- NOTE: CUSTOMER RESPONSIBLE FOR PERFORMANCE ISSUES INCLUDING LIFE CYCLE FOR DESIGN CHANGES

REV 03

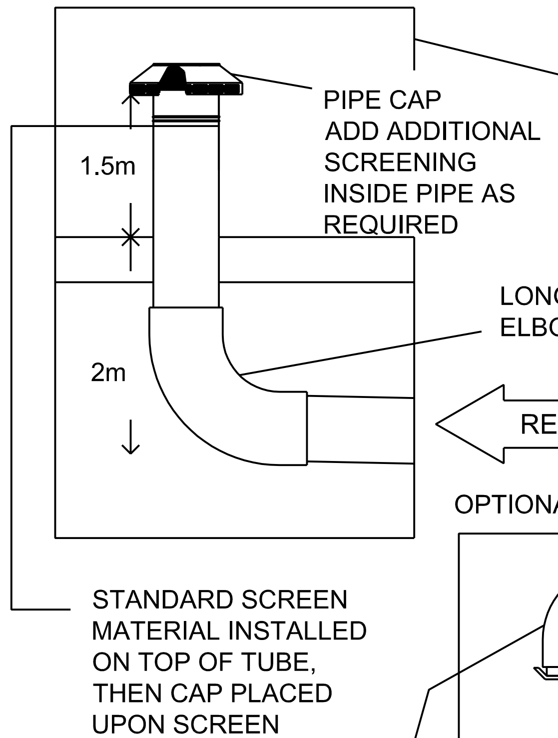
I.B. STOREY
PROFESSIONAL ENERGY SOLUTIONS
129 QUEEN STREET, SUITE 203
CHARLOTTETOWN PEI C1A 4B3

PROFESSIONAL STAMP

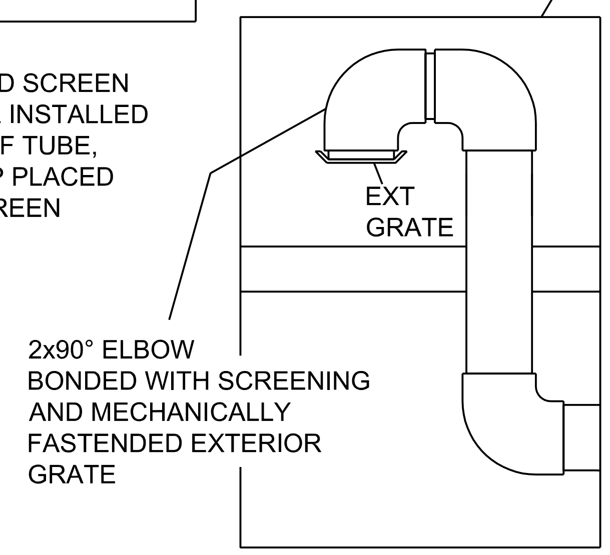
STAMPED COPY ON HAND IN I.B. STOREY LIBRARY

CLIENT	NUMERICAL LOGICS INC
PROJECT	EARTH TO AIR HEAT EXCHANGER
DRAWING	EARTH TO AIR HEAT EXCHANGER
DWG. NO.	08006-M101
DRAWN BY	A. SAVOY
CHECKED BY	I. STOREY
DATE	09-APR-08
SHEET SIZE	C
SCALE	NTS
REVISION	03
SHEET NO.	1 OF 3

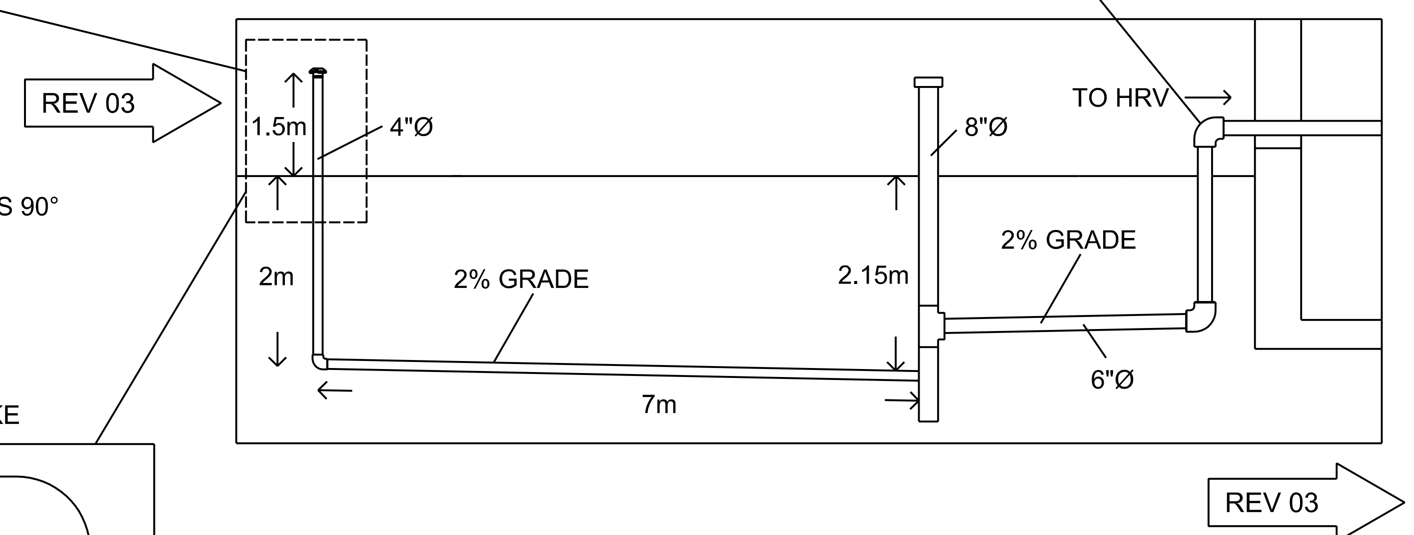
PIPE CAP



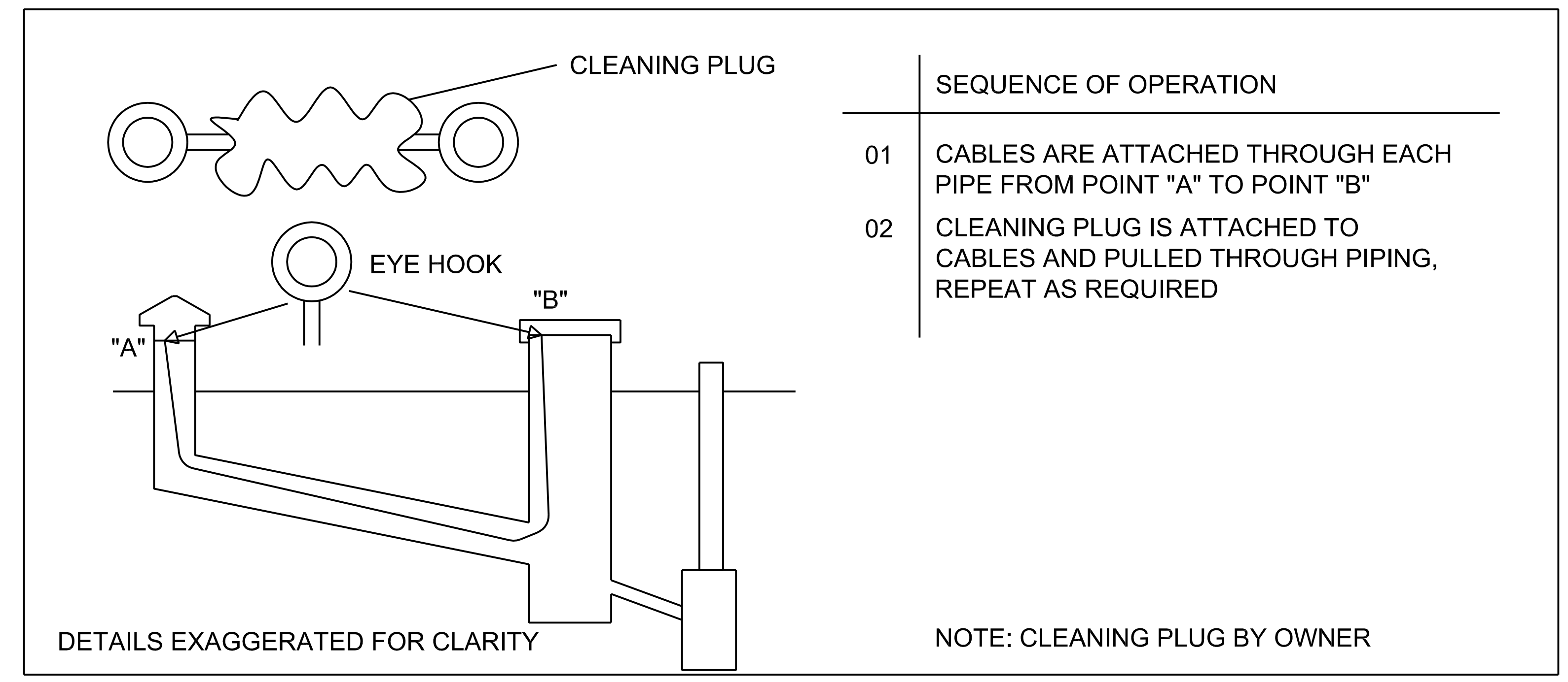
OPTIONAL INTAKE

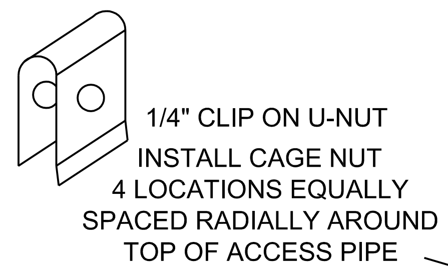


DETAIL AA - HEADER ARRANGEMENT

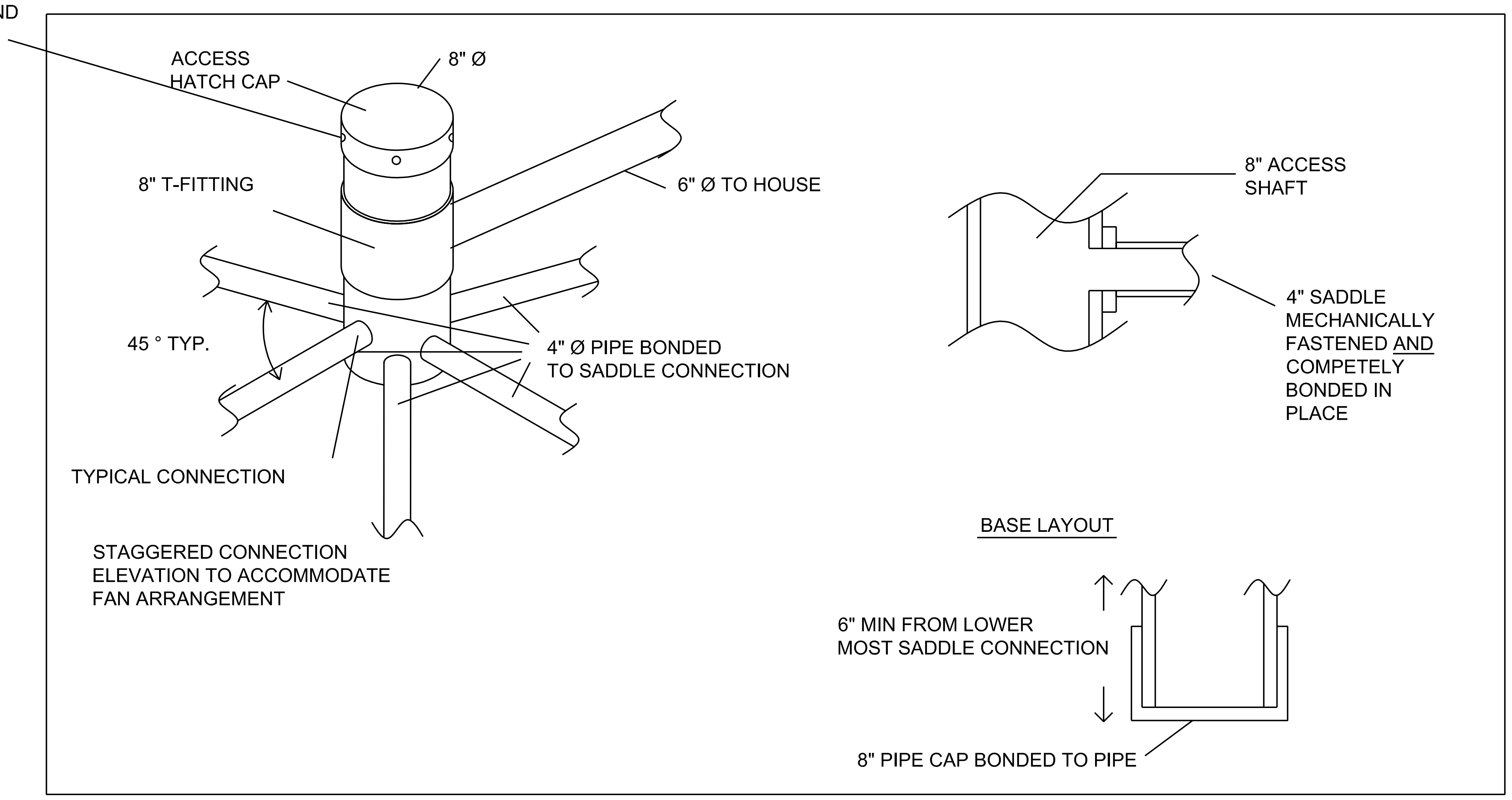


PIGGING METHOD

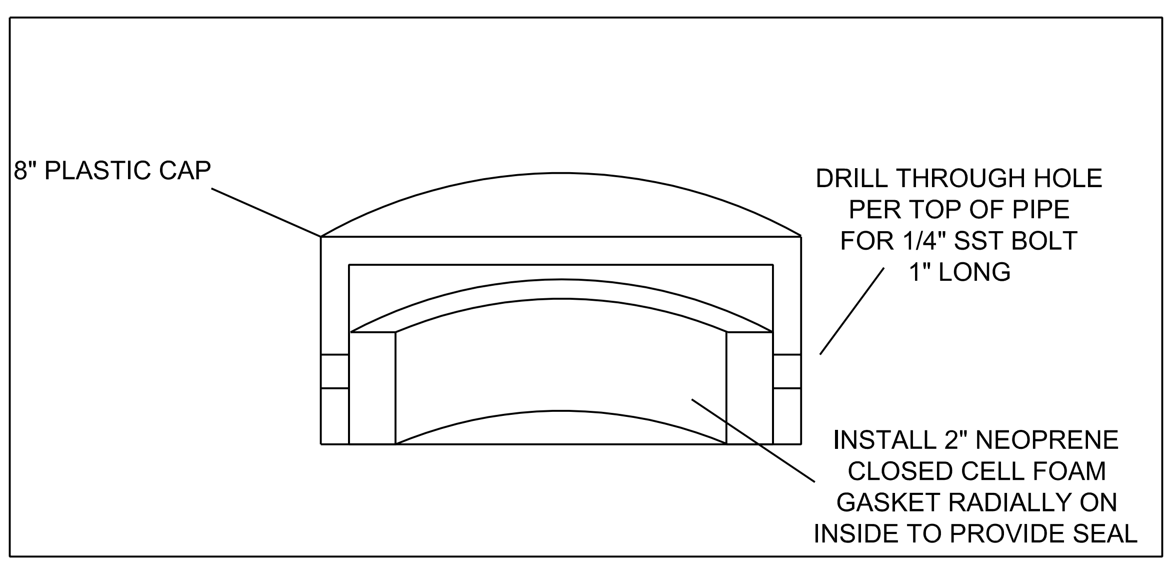




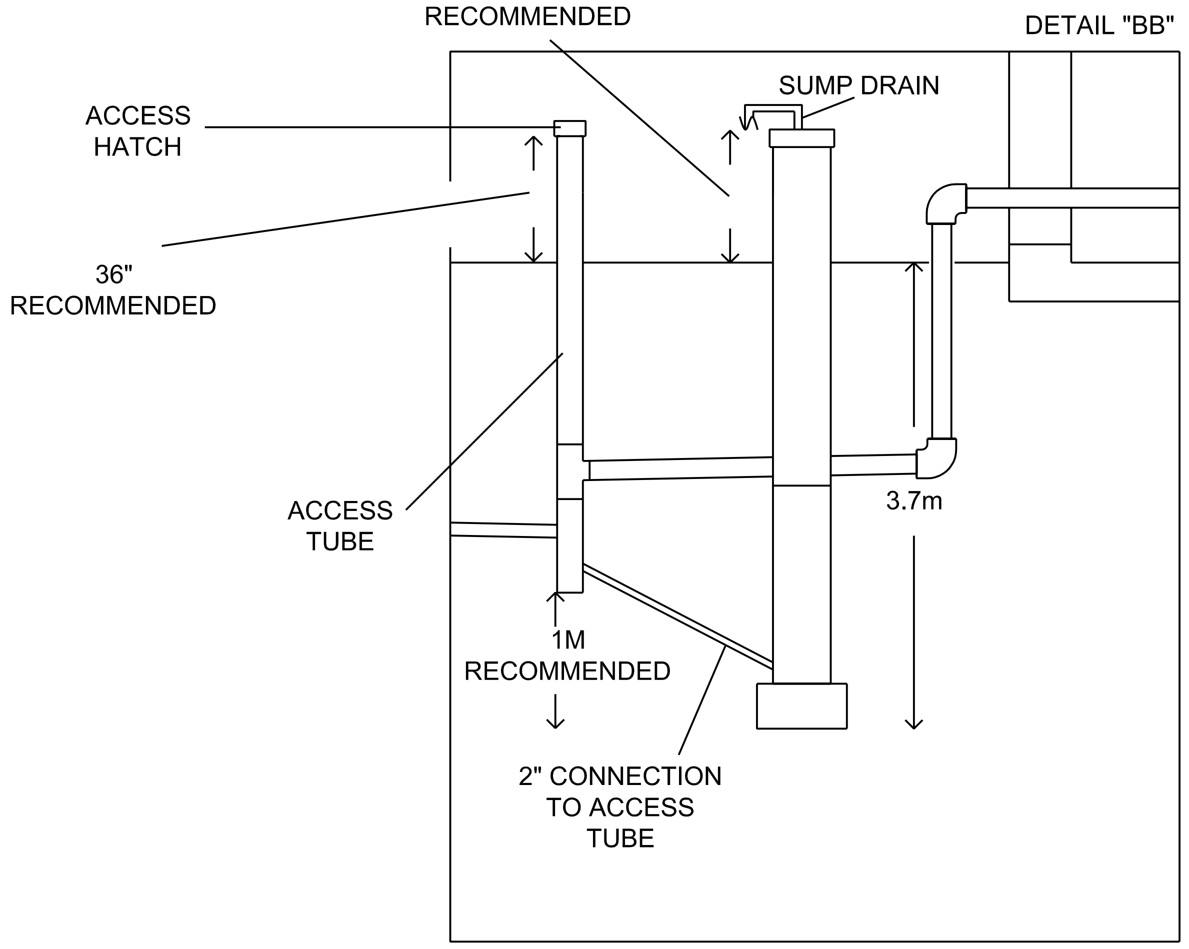
DETAIL "C" - HEADER ARRANGEMENT



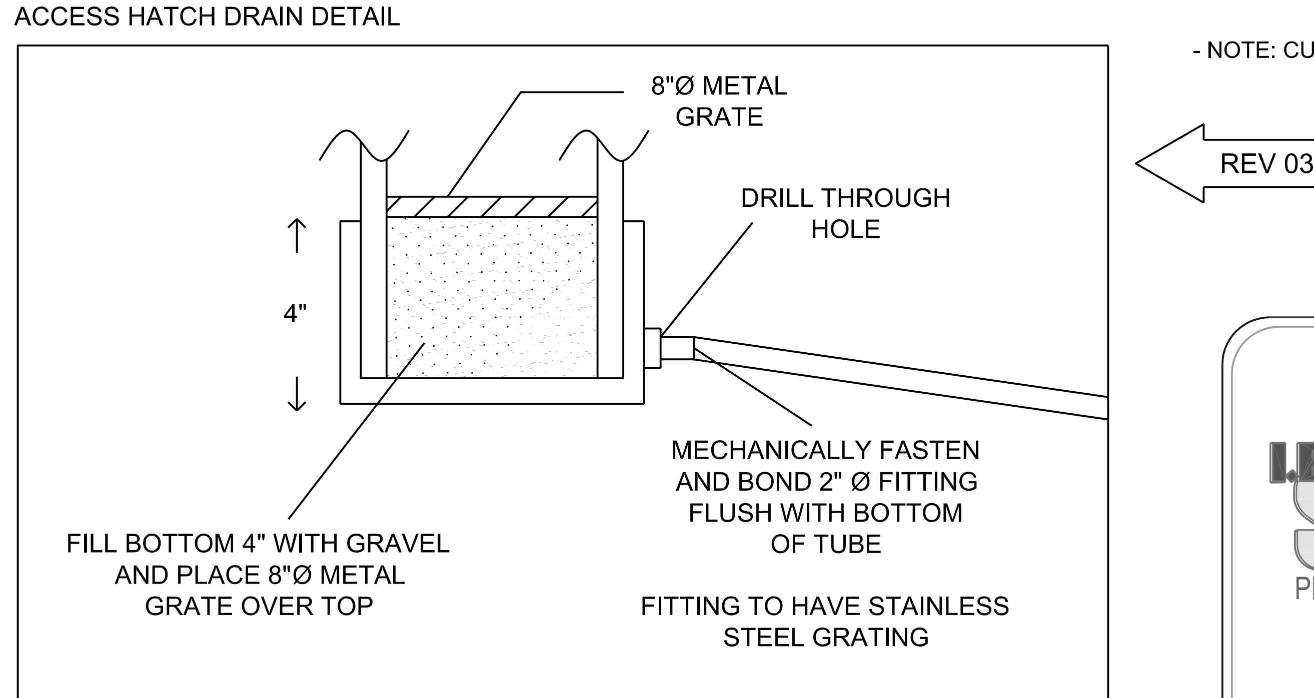
ACCESS HATCH CAPPING



DETAIL "BB"



ACCESS HATCH DRAIN DETAIL



- NOTE: CUSTOMER RESPONSIBLE FOR PERFORMANCE ISSUES INCLUDING LIFE CYCLE FOR DESIGN CHANGES

REV 03

UNDERGROUND PIPING DETAILS

NOTE: DRAWINGS NOT TO SCALE

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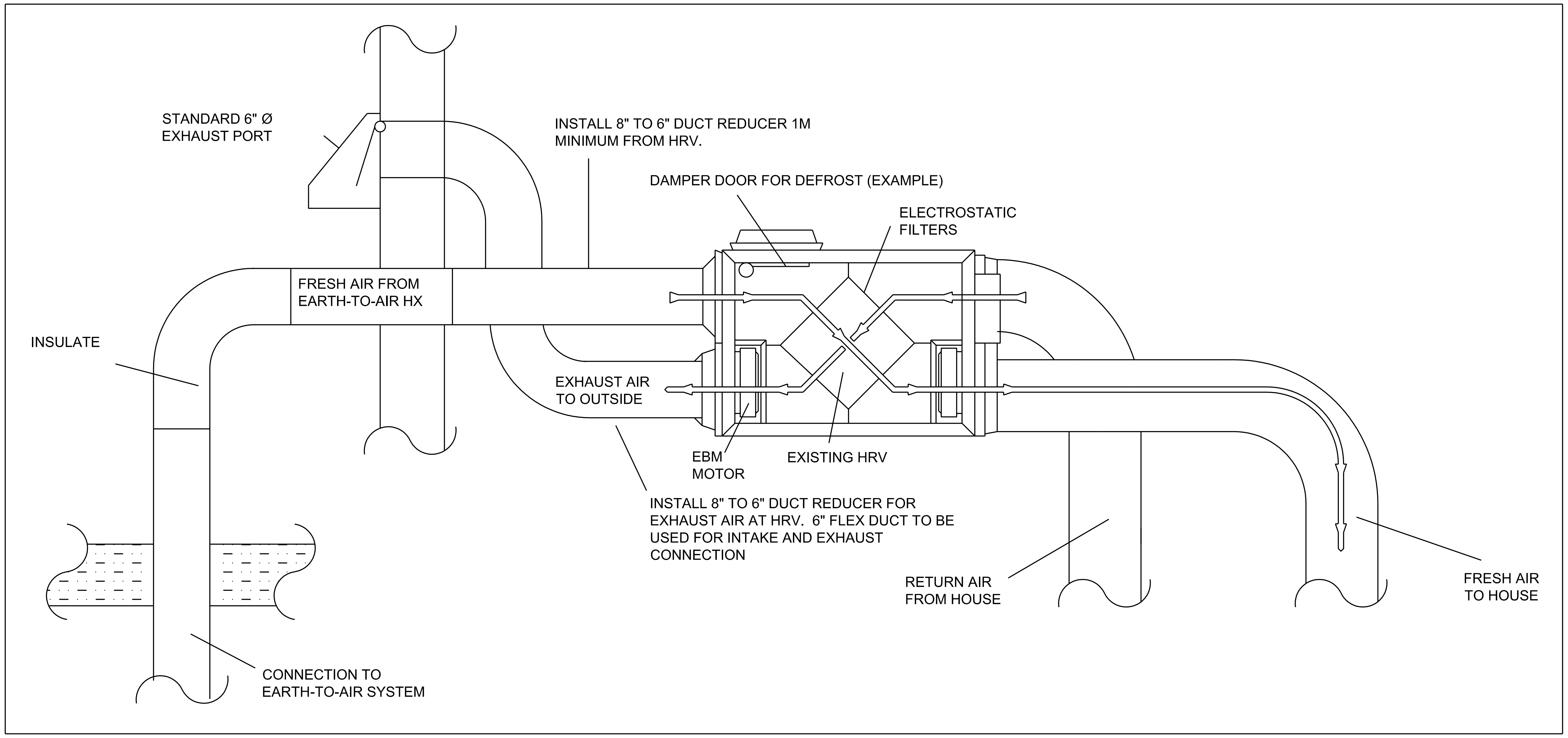
HRV CONNECTION DETAILS

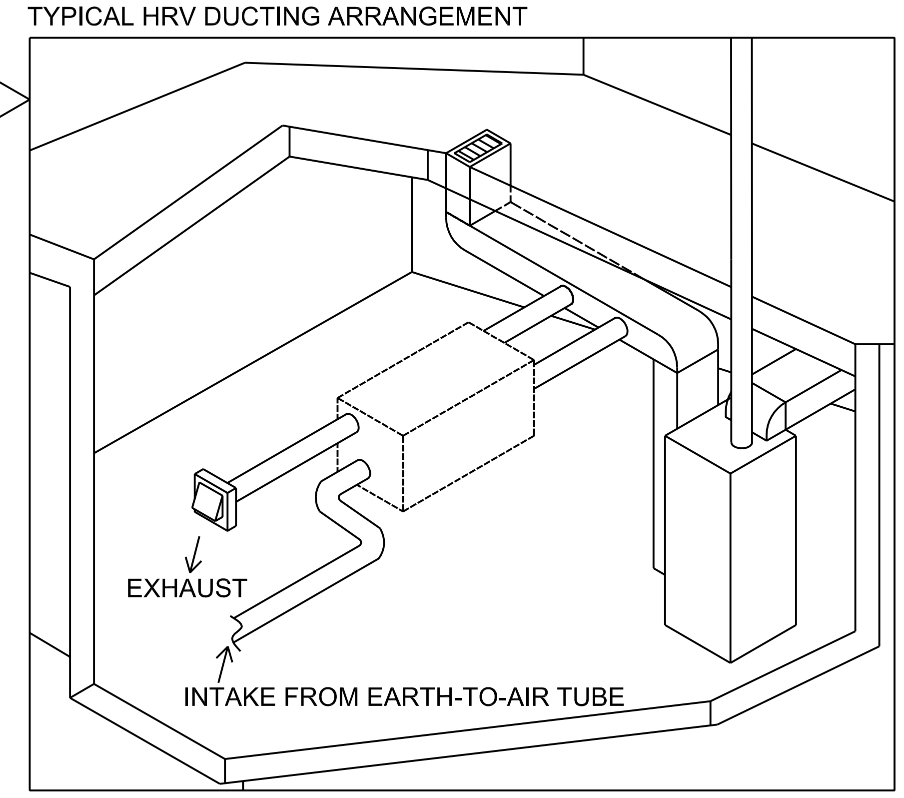
REV 03

HRV/FURNACE ARRANGEMENT

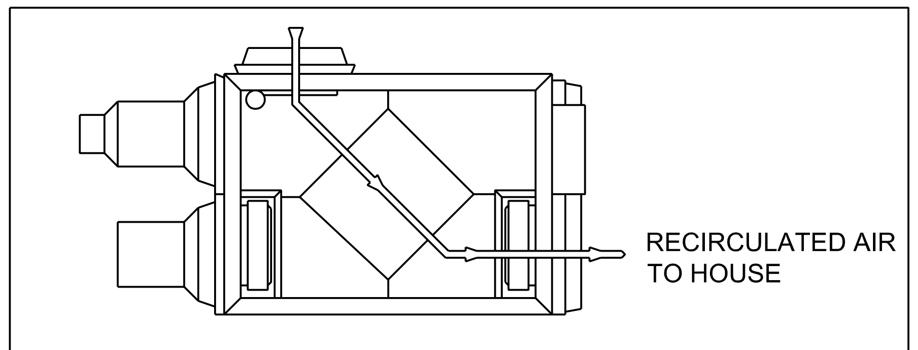


REV 03

TYPICAL HRV DUCTING ARRANGEMENT

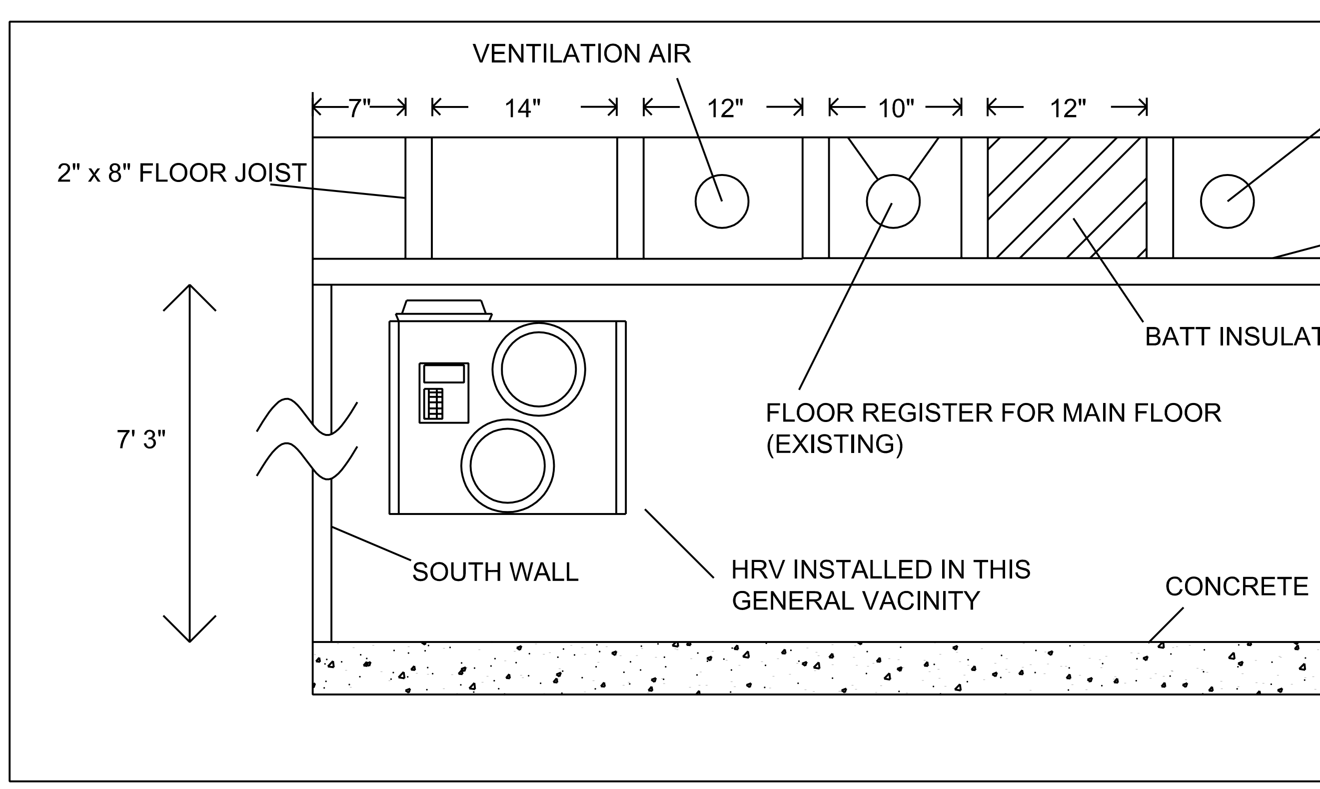


DEFROST SEQUENCE (EXAMPLE ONLY)



DEFROST: DURING THE DEFROST SEQUENCE, A MOTORIZED DAMPER TEMPORARILY BLOCKS THE INCOMING FRESH AIR STREAM SO THAT THE WARM AIR FROM THE HOUSE CAN CIRCULATE THROUGH THE HRV. THE EXHAUST BLOWER SHUTS DOWN AND THE SUPPLY BLOWER SWITCHES INTO HIGH SPEED TO MAXIMIZE THE EFFECTIVENESS OF THE DEFROST STRATEGY. DURING THIS CYCLE, HOUSEHOLD ODORS FROM THE KITCHEN OR BATHROOM ARE PREVENTED FROM ENTERING THE HOME AS THE UNIT WILL NOT CREATE NEGATIVE PRESSURE.

HRV PLACEMENT (TYPICAL)



REV 03

NOTE: HANG HRV 1.5' APPROX. FROM SOUTH & EAST WALLS ON BOTTOM OF FIRST FLOOR JOIST. (EXAMPLE ONLY)

REV 03

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