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September 12, 2011

Village of Silverton
PO Box 14
Silverton, BC
V0G 2B0

RE: GEOEXCHANGE COMMUNITY ENERGY SYSTEM ENGINEERING PRE-FEASIBILITY STUDY

The following report is an overview of the feasibility of using a lake source geoexchange system to provide heating energy to the Village of Silverton. This study has shown that a geoexchange District Energy System (DES) is feasible for the Village with some limitations. There are four municipal buildings whose heating and cooling requirements could be supplied by a DES in a cost effective manner. This report has provided heating load estimates for the four buildings in order to size the required lake loops, source loops, load loops, and distribution system. Details of the proposed DES mechanical system and cost estimates were obtained from a mechanical engineering consultant. The Village is encouraged to continue pursuing the development of a DES for its municipal buildings. The next steps for the Village to pursue would be to:

- Apply for a grant to complete a detailed Feasibility Study for a lake source geoexchange system. This should be completed by a Mechanical Engineering firm familiar with the design and installation of such a system;
- Conduct an Environmental Impact Study of how such a system would impact Slocan Lake;
- Investigate the feasibility of expanding the DES to include other commercial buildings within the Village.

I trust the following report will meet your requirements.

Yours sincerely
WSA ENGINEERING LTD.

Ralf Waters, P.Eng
Senior Engineer

RW:er

THE VILLAGE OF SILVERTON

GEOEXCHANGE COMMUNITY ENERGY SYSTEM

ENGINEERING PRE-FEASIBILITY STUDY

FINAL REPORT

Prepared for the Village of Silverton By

WSA ENGINEERING LTD.

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CONTENTS

1. INTRODUCTION

1.1 Subject

This report presents the results of the Pre-feasibility Study completed to assess the potential for developing a high efficiency geoexchange District Energy System (DES) for the Village of Silverton. This assessment is based on using Slocan Lake as a geothermal source for a community heating and cooling energy system. Three options for a community energy system were considered:

1. Provide energy to several municipal buildings for heating, cooling, and hot water;
2. Develop a Community Energy Utility to provide heating and cooling energy to several commercial buildings as well as to the municipal buildings;
3. Expand the scope of the DES to provide energy to single family dwellings throughout the Village.

The design concept for the community energy system utilizes distributed geoexchange heat pumps to provide heating and cooling energy to the selected buildings. This means that heat pumps are located in the buildings they serve. An exception to this type of layout will be with the municipal buildings where there are three that are located quite close to each other. In this case, a single centrally located heat pump would be used to service all three buildings.

This report describes the technology behind a lake-source geoexchange energy system as well as the methods used to calculate the heating loads for the system. An analysis of the lake water temperatures and depth profiles is also included. A concept design layout of the energy distribution system is provided showing potential sites for the lake heat exchange coils and distribution piping. Cost estimates for the installation of the system will be provided as well. Finally, the report provides recommendations of which of the three options is most suitable for the Village as a phased approach to implementing a geothermal energy system.

1.2 Background

The Village of Silverton is located on the east shore of Slocan Lake in the Central Kootenay Regional District of BC. There are approximately 150 homes in Silverton as well as several commercial buildings and municipal buildings. It is estimated that approximately 80% of the homes heat with wood with electric resistance heating for a backup source. Other sources of heat include electric and fuel oil forced air systems and propane. The Village owns five buildings that are heated with electric and oil forced air systems and electric baseboards.

This assessment studies the feasibility of implementing a centralized geoexchange heating/cooling system using Slocan Lake as the heat/cooling source. This system could be in the form of a community heating utility that would sell heat and cooling energy to the residents and commercial buildings or as a source of energy for the municipal buildings only.

2. THE TECHNOLOGY

2.1 Geoexchange

A geoexchange heating and cooling system uses the consistent temperature of the earth or a large body of water to provide heating, cooling, and hot water for both residential and commercial buildings. For a lake system, a water-propylene glycol solution is circulated through polyethylene pipes in closed loops submersed in the lake and flows through water source heat pumps. The heat pump concentrates the heat from the lake. Even 4^0C water has heat energy in it. A low temperature and low pressure refrigerant in the heat pump vaporizes as it absorbs the heat energy from the lake loop. It then passes through a compressor where the heat energy is increased and the refrigerant becomes a hot vapor. This hot vapor then passes through a condenser where the heat is dissipated to the air that flows across it and into a forced air heating system of the building. The refrigerant then becomes a cooled liquid. It passes through an expansion valve and returns to the evaporator to absorb heat from the lake loop again. This process is reversed during the summer when heat is removed from the buildings and exchanged into the lake.

Unlike traditional air source heat pumps, the geoexchange heat pumps are located indoors and have no noisy fans. A single unit can provide for heating, air conditioning, and hot water.

2.2 Environmental Benefits and Advantages

Due to its higher efficiency, a geoexchange heating/cooling system can reliably reduce heating energy consumption by 70% and cooling energy consumption by 30% for conventional building design. Geoexchange heating/cooling systems also significantly reduce greenhouse gas emissions by replacing fuel oil consumption and wood burning. Outdoor air quality is also improved due to reduced wood smoke and air inversion issues caused by wood burning in residential homes.

There are many advantages to geoexchange heating and cooling over conventional systems:

- Single Unit – heating, cooling, and hot water are provided in one unit;
- Low maintenance;
- Safe – no open flames;
- Clean;
- Dependable and durable – solid state electronics with few moving parts, heat pump will last 30 years;
- Lower cost of operation – due to higher efficiency;
- No waste heat – any heat not used for heating or cooling can be used to preheat domestic hot water.

2.3 District Energy Systems

A district energy system (sometimes called "community energy system") is an integrated large-scale and flexible way to distribute heat to a number of buildings. District energy systems offer the best opportunities for local government to create a sustainable energy utility. Since the heat is provided directly by the community energy system, individual buildings do not require boilers or furnaces. District heating is a long-established technology, providing heat to the residents of many European and North American cities. Many local governments in Canada already own and operate a district heating utility. There are several systems operating in British Columbia including the cities of Vancouver and Revelstoke. Customers are either charged a flat access fee or meters are used to measure heat consumption. District heating and cooling systems are most appropriate where there is a sufficient density of buildings and heating/cooling loads. Ideally, there is a major heat consumer such as a hospital or industrial facility that can serve as a primary customer to anchor the project. Areas of single family homes are generally unsuitable for district heating systems.

3. THE GEOTHERMAL SOURCE

A lake can provide an economical and cost-effective opportunity for a closed loop geoexchange system. Coils of polyethylene pipe are placed into the lake to serve as heat exchangers. Polyethylene pipe is used because it absorbs and rejects energy quickly and it has a relatively low cost and a long useful life.

3.1 Slocan Lake

Slocan Lake is located between the Selkirk and the Valhalla mountain ranges of the West Kootenay Region of BC. It follows Highway 6 and is positioned in a north-south axis. The lake is at an elevation of 541 m and drains to the south into the Slocan River. It is one of the few remaining large lakes in British Columbia for which very little scientific information has been gathered. Some hydrographic surveys were completed in 2000 and 2001 by roger Pieters and in 2008 Galena Environmental began a Slocan Lake water quality monitoring program.

3.2 Water Temperatures and Suitability for Geothermal

Slocan Lake is nearly isothermal with a temperature of 4^0C from 0 to 100m between January and March. As the lake warms during the summer, surface temperatures reach 20^0C by August. Temperatures remain at 5^0C below a depth of 40-60 m throughout the summer. Graphs of Slocan Lake water temperatures with depth are given in Appendix A. The constant temperature of Slocan Lake at 40 m provides an ideal geothermal source for the Village. This constant temperature water can act as a heat sink in the summer months for cooling and a heat source in the winter months for heating.

3.3 Environmental Impacts of Heat Exchangers

Geothermal systems reject heat during the summer and extract heat during the winter from the lake ecosystem. There are two potential environmental concerns of using Slocan Lake for the heat source in a geothermal system:

- First of all, there is the effect on the lake ecosystem due to the heat exchange process. Most of these impacts can be minimized with proper heat exchanger design and correct placement of heat exchange coils.

- Second, there is the concern of a leak in the lake coils. In order to protect the lake ecosystem if a leak occurs, a “food safe” propylene glycol/water mixture is used in the lake coils.

An environmental study should be completed to address these concerns prior to any further detailed design work.

4. DESCRIPTION OF PROPOSED PROJECT

4.1 Intended Energy Use

As mentioned in Section 2.3, district energy systems are best suited for areas of high-density development such as technology parks, malls, municipal office clusters, multi-unit residential buildings, schools and hospitals. Low-density developments such as single family housing are less suitable due to the larger distances over which the heat must be distributed. For this reason, this pre-feasibility study will focus on a geoexchange system to provide energy to four municipal buildings that are located along Highway 6 (Memorial Hall, Village Gallery, Village Shop, and Village Office). These buildings have existing forced air heating systems that are readily adapted to a geoexchange heat pump system. For the purposes of this report, only space heating requirements were looked at. Cooling and hot water energy needs can be integrated into this type of system at a later date.

4.2 Facility Locations and Layout

This energy system will consist of a series of energy exchange loops (lake loops, source loops, and load loops). The lake loops consist of an array of lake coils that will be installed in Slocan Lake off the south end of the alley between Hume Street and Highway 6. A supply and return distribution line will run in the alley to the Memorial Hall and on to the Village Office, the Gallery, and the Shop. There will be two heat pump units in the system, each of which contains a source loop and a load loop. One heat pump unit will be located in the Memorial Hall mechanical room. The other heat pump unit will be installed in the Village Shop to supply heating/cooling energy to the Municipal Office, the Gallery, and the Shop. The proposed layout and site plan are included in Appendix B. More details on the system design are given in Section 5.0.

4.3 Estimation of Building Loads

4.3.1 Building Characteristics

The first step in estimating the heating loads for the proposed energy system involves gathering information on the building characteristics. A heat load calculation sheet was designed to tabulate the information required to determine the heat load for each building of interest. The heat load calculation sheets were completed by the Village and submitted to WSA. A summary of the building characteristics are shown below in Table 1.

TABLE 1: SUMMARY OF BUILDING CHARACTERISTICS

	Memorial Hall	Village Gallery	Village Shop	Village Office
Building Dimensions				
Length (ft):	80	85	30	60
Width (ft):	50	40	65	30
Height (ft):	30	30	11	20
Wall and Ceiling Insulation Values				
Wall Insulation Level				
No Insulation		X		
R6				
R8				
R10	X			
R12			X	X
R20				
Ceiling Insulation Level				
No Insulation		X		
R12				X
R20			X	
R26				
R32	X			
R40				
Door and Window Values				
Type of Doors				
Wood	1	1,2,3	1	1,2,3
Wood c/w Storm				
Insulated Metal	2,3			
Sliding Glass				
Size of Doors (ft2)				
Door 1	36	30	96	16
Door 2	24	18		16
Door 3	36	18		17

Types of Windows				
Single Pane	X	X	X	
Double Pane				X
Triple Pane				
Size of Windows (ft2)				
Window 1	10	90	12	117.3
Window 2	100			15
Window 3	18			15
Floor Type and Insulation Value				
Concrete Slab (On Grade)				
No Insulation	X	X	X	X
R11				
R28				
Basement Slab (Below Grade)				
No Insulation	X	X	X	X
R11				
R28				
Frame Floors Over unheated Area				
No Insulation		X	X	
R12	X			
R20				X
R32				
R40				
Infiltration Values				
Poor		X		
Average	X		X	X
Good				
Tight				

Poor: loose Construction with no attempt of air sealing

Average: Pre 1970 style of construction c/w air/vapor barriers, no attempt to seal joints within vapor barrier

Good: As above, but attempts to tape and seal air/vapor barrier, floor, joist headers sealed

Tight: New Construction R-2000

4.3.2 Estimated Heating Loads

Table 2 presents a summary of estimated heating loads for the building of interest. Retscreen data for Nakusp was used to determine the heating design temperatures. Heating load estimates were computed using a heating design temperature of -10.5 degree Celsius and an interior design temperature of 22.2 degrees Celsius.

TABLE 2 DESIGN HEAT LOADS

Total Heat Load	Memorial Hall	Village Gallery	Village Shop	Village Office
Watts	79,635	210,735	26,595	23,755
BTUHS	271,794	719,239	90,769	81,076

4.3.3 Heat Pump Sizing

The size of required heat pumps is calculated using the estimated design heat loads from Table 2. The results are shown in Table 3.

TABLE 3 HEAT PUMP REQUIREMENTS

Heat Pump	Memorial Hall	Village Gallery	Village Shop	Village Office
Estimated size of unit (tons of energy)*	23	60	8	7

*Note: 1 ton = 3.51 KW of energy

5. PRELIMINARY SYSTEM DESIGN

5.1 The Lake Loop

The primary energy source for this geoexchange energy system is Slocan Lake. The amount of heat exchanged with the lake depends on the temperature of the lake and the amount of heat required by the system. The lake loop will consist of a series of heat exchange coils located deep in the lake. Each lake coil consists of 300 feet of ¾-inch high-density polyethylene (HDPE) pipe and measures 42 inches in diameter. The HDPE coils are very durable, resist plant and animal growth, and are efficient at heat transfer. This system will consist of four fields of 16 coils with a total of 64 coils. Each 16 coil grid is floated on the surface of the lake to the desired location, pressure checked, and sunk to the desired depth. When assembled as a part of a grid, the coils are easily removable. If need be, the glycol/water mixture can be pumped out of the heat exchanger coil and the entire assemble floats to the surface.

5.2 Source Loop and Load Loop

A 2-inch supply and return line distributes the energy down the alley to the heat pump unit in the Memorial Hall mechanical room and to the heat pump unit in the Shop. The source loop provides supply and return to one side of the heat pumps. The load loop provides supply and return to the other side of the heat pumps that provides energy to the fan coils in the buildings. The Memorial Hall will require two 10-ton heat pumps. The Village Office complex will require three 30-ton heat pumps. Appendix B includes the mechanical schematics of the proposed energy system.

5.3 Circulation Pumps and Backup Boiler

Three 20-25 hp pumps with variable speed drive will be required to circulate the glycol/water mixture through the distribution system and the heat pumps. A backup boiler will be required to provide additional heat to the system whenever the heat load exceeds the amount of heat available from the lake. A solar collector thermal system could also be constructed as another energy source to supplement the lake loop.

6. COST ESTIMATES AND ECONOMIC FEASIBILITY

6.1 Costs

The estimated costs to implement the proposed Silverton geoexchange energy system are given in Table 4. These costs include the construction of the lake loops, the distribution system, and the central heat pump units.

TABLE 4 SILVERTON DISTRICT ENERGY SYSTEM COST ESTIMATES

ITEM	QTY	TON	$/UNIT	$	SUB-TOTAL	TOTAL
Engineering				40,000		**40,000**
Lake Loop	Loops			83,000		
	Distribution			15,000		**98,000**
Hydronic Equipment			$/Ton			
Heat Pump 1	3	30	1,000	30,000	90,000	
Heat Pump 2	2	10	1,300	13,000	26,000	**116,000**
Circulating Pumps				33,000		
Expansion Tanks				4,000		
Glycol fill tank				2,000		
Glycol				10,000		
Pipe, fittings, labour				43,000		
Insulation, labour				7,000		
Gauges				1,000	100,000	**100,000**
Controls						
Valves, sensors, VFD's, etc.				35,000		**35,000**
TOTAL						**389,000**

The above cost estimate is considered a Class C estimate. This estimate, which is prepared with limited site information, is based on probable conditions affecting the project. It represents the summation of all identifiable project component costs. It is used for program planning, to establish a more specific definition of client needs, and to obtain approval in principle. A contingency allowance of 25% plus engineering and other allowances is appropriate for this class of estimate.

Other costs associated with this project will include building modifications, electrical upgrades, piping outside the buildings, and backup boilers. In addition to the initial capital costs, the DES will require ongoing maintenance costs. Components of the DES will also require replacement at the end of their life cycle. Table 5 gives the life cycle estimates for the major components of the system.

TABLE 5 DISTRICT ENERGY SYSTEM LIFE CYCLE ESTIMATES

Equipment	Life Cycle (years)
Heat Pumps	20-25
Circulation Pumps	25-30
Heat Exchangers	10-20
Boilers	35-40
Distribution Piping	50-75
Lake Loops	50-75

6.2 Economic Feasibility

A discussion of the economic feasibility and creative financing of this project is beyond the scope of this pre-feasibility report. In general, payback periods for this type of project run from 10 - 20 years. There are also financing techniques that allow for a positive cash flow to the Village. Some of the impact of the costs for this project can be offset by accounting for the costs of replacing some of the aging and worn out heating systems in these buildings. These types of questions could be answered by a mechanical engineering firm familiar with designinggeothermal systems.

7. CONCLUSIONS AND RECOMMENDATIONS

This report was intended to give an overview of the feasibility of using a lake source geoexchange system to provide heating energy to the Village of Silverton. This study has shown that a geoexchange District Energy System (DES) is feasible for the Village with some limitations. There are four municipal buildings whose heating and cooling requirements could be supplied by a DES in a cost effective manner. This report has provided heating load estimates for the four buildings in order to size the required lake loops, source loops, load loops, and distribution system. Details of the proposed DES mechanical system and cost estimates were obtained from a mechanical engineering consultant. The Village is encouraged to continue pursuing the development of a DES for its municipal buildings. The next steps for the Village to pursue would be to:

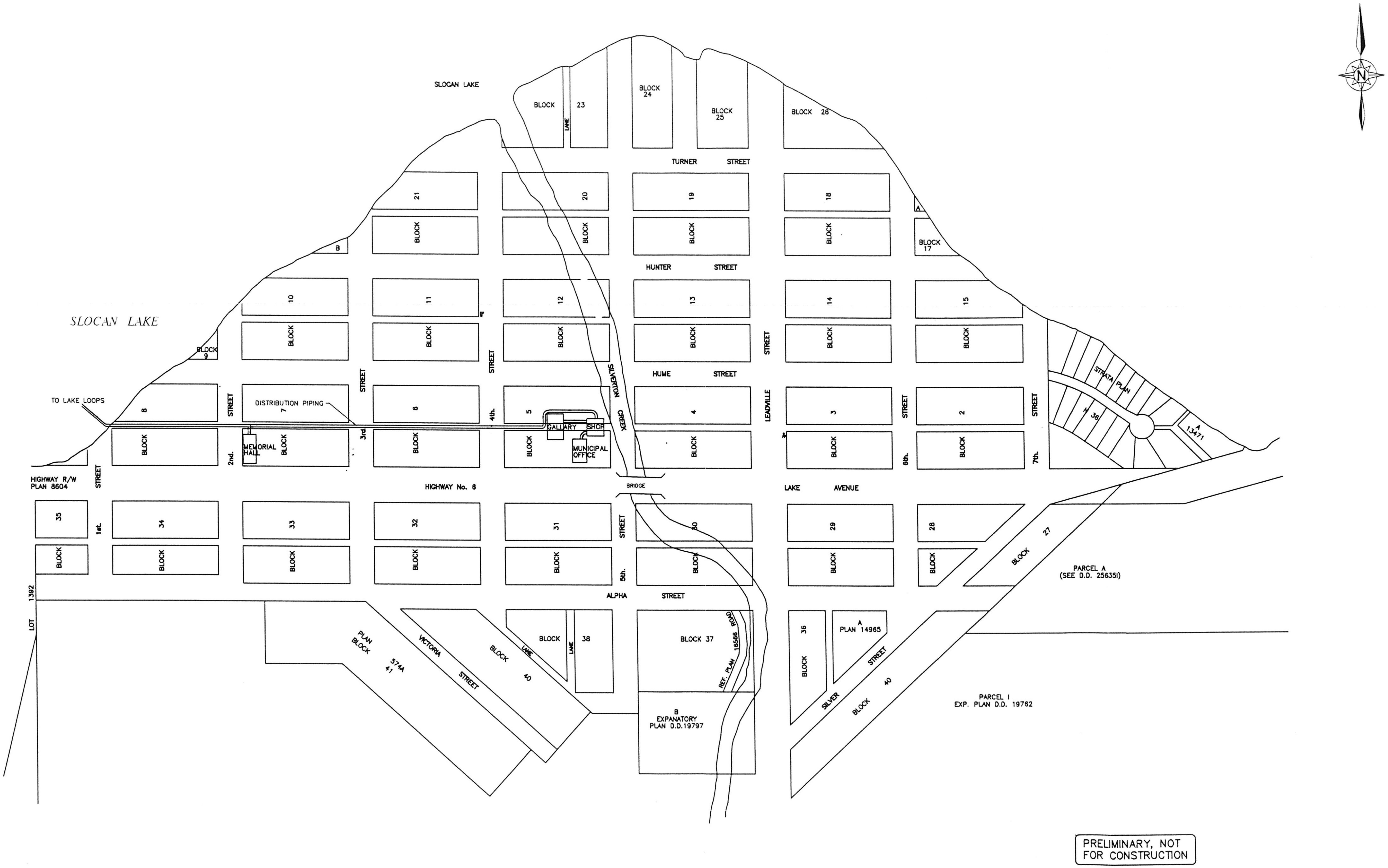
- Apply for a grant to complete a detailed Feasibility Study for a lake source geoexchange system. This should be completed by a Mechanical Engineering firm familiar with the design and installation of such a system;
- Conduct an Environmental Impact Study of how such a system would impact Slocan Lake;
- Investigate the feasibility of expanding the DES to include other commercial buildings within the Village.

APPENDIX A

SLOCAN LAKE WATER TEMPERATURE DATA

APPENDIX B

SITE PLAN AND ENERGY SYSTEM LAYOUT



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DSGN: RW
DWN: GSG
CHK: DS
DATE DWN. 02/09/11

SILVERTON GEOEXCHANGE FEASIBILITY STUDY
SILVERTON, B.C.
SITE PLAN

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DWG FILE: C10147-010
JOB: C10147-010
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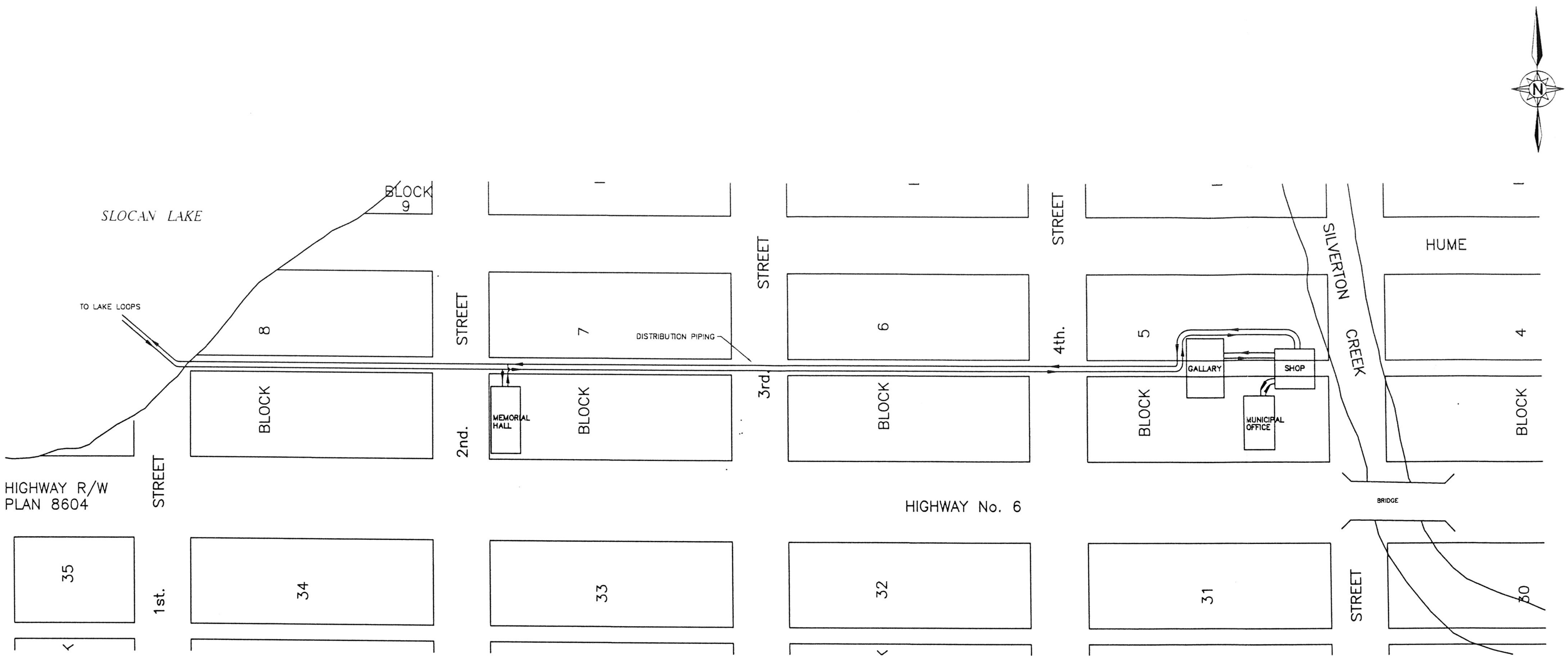

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DSGN: RW
DWN: GSG
CHK: DS
DATE DWN. 02/09/11

SILVERTON GEOEXCHANGE FEASIBILITY STUDY
SILVERTON, B.C.

SITE PLAN

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JOB: C10147-010
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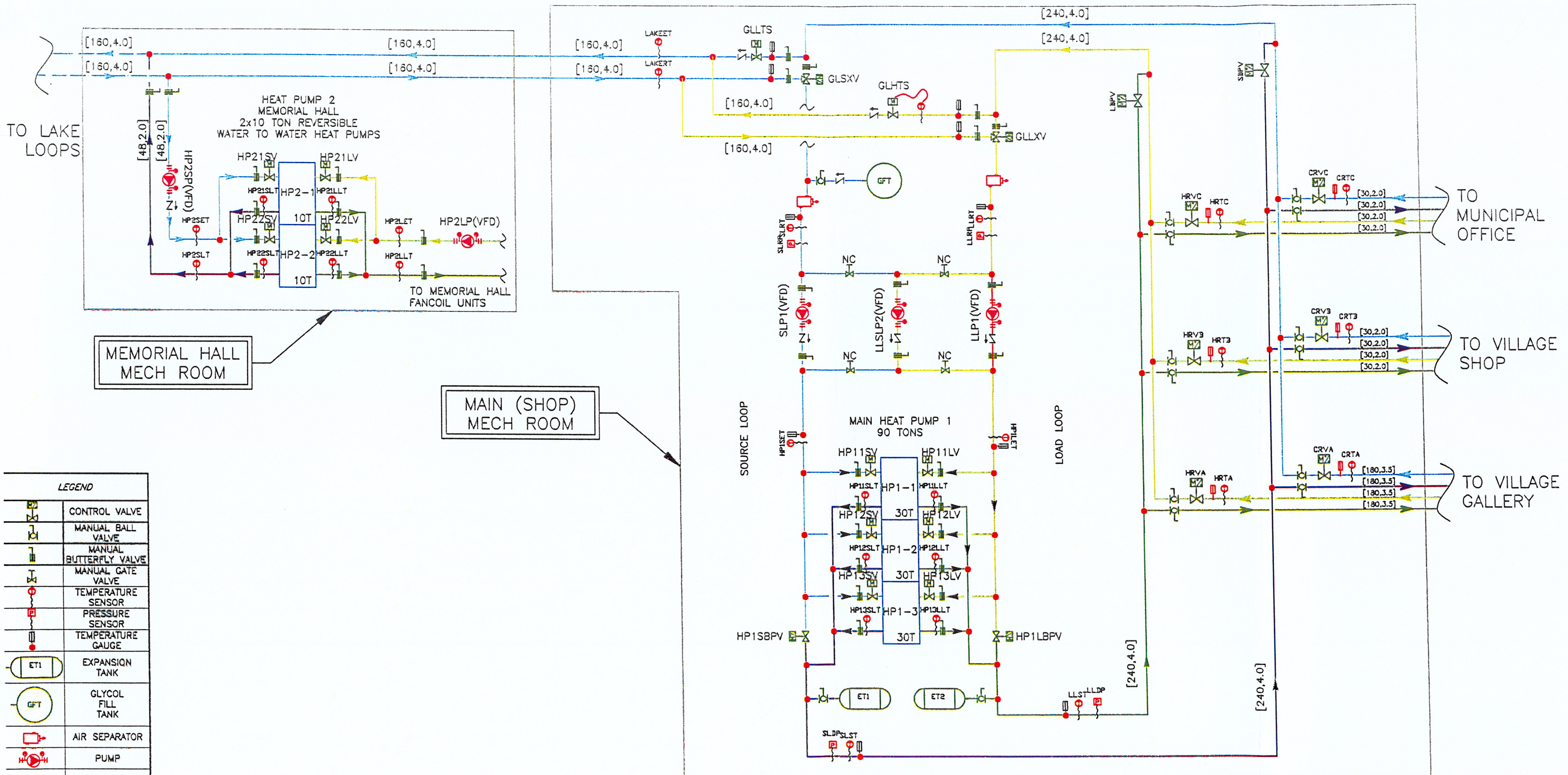

LEGEND

	CONTROL VALVE
	MANUAL BALL VALVE
	MANUAL BUTTERFLY VALVE
	MANUAL GATE VALVE
	TEMPERATURE SENSOR
	PRESSURE SENSOR
	TEMPERATURE GAUGE
ET1	EXPANSION TANK
GFT	GLYCOL FILL TANK
	AIR SEPARATOR
	PUMP
	CHECK VALVE
	MODERATE GLYCOL SUPPLY
	MODERATE GLYCOL RETURN
	CHILLED GLYCOL SUPPLY
	CHILLED GLYCOL RETURN

NO.	REVISION	DATE

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SILVERTON DISTRICT HVAC
SILVERTON, BC

MAIN MECHANICAL SCHEMATIC

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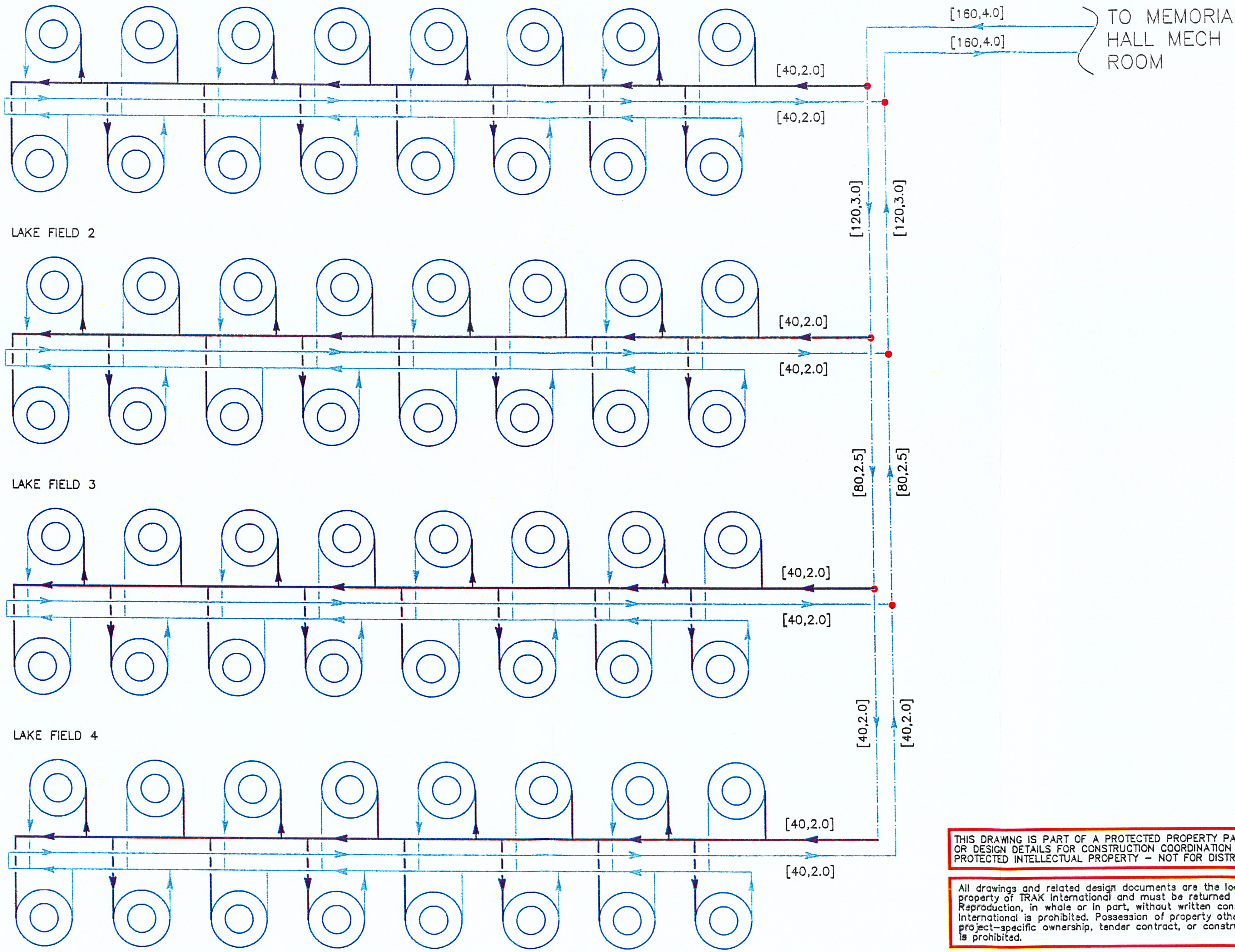

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SILVERTON DISTRICT HVAC
SILVERTON, BC

LAKE LOOPS DISTRIBUTION DETAIL

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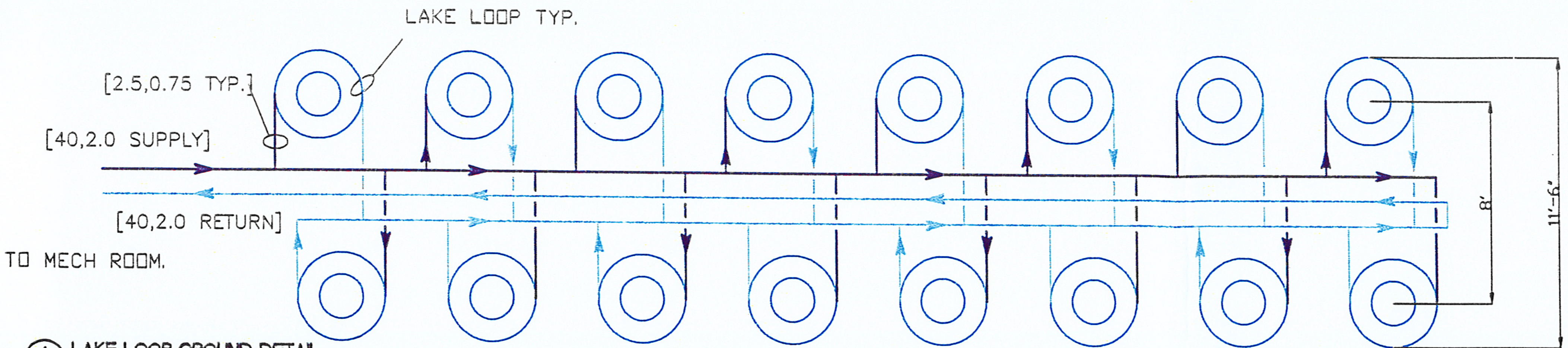
CHECKED:	SCALE: N.T.S.	
	JOB NO. -----	



1 / D-1 LAKE LOOP GROUND DETAIL
SCALE 1/100" = 1'-0"

BILL OF MATERIALS:

QTY	SIZE	DESCRIPTION
150'	2"ø	PE 3608 SDR-11 HDPE PIPE 150'-0" LG
4800'	¾"ø	PE 3608 SDR-11 HDPE PIPE 4800'-0" LG
32	2"x2"x¾"	PE 3608 SDR-11 HDPE PIPE REDUCING TEE LG
2	2"	PE 3608 SDR-11 HDPE PIPE ELBOW LG
2	2"x¾"	PE 3608 SDR-11 HDPE PIPE REDUCING ELBOW LG

3408 SDR-11 HDPE MAY BE SUBSTITUTED

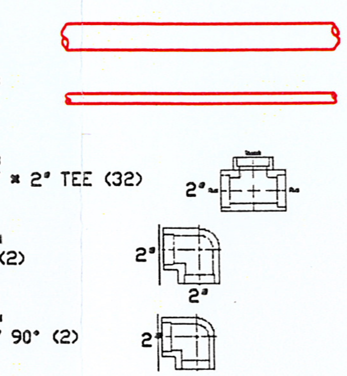
PART 1: 2" PIPE

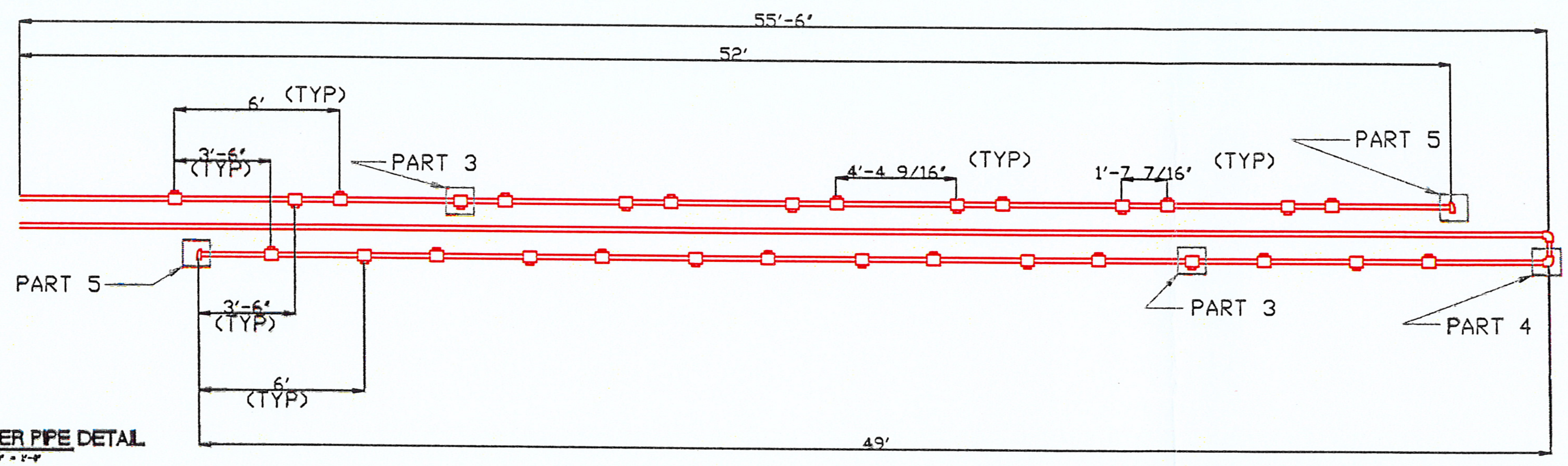
PART 2: ¾" PIPE

PART 3: 2" x ¾" x 2" TEE (32)

PART 4: 2" 90° (2)

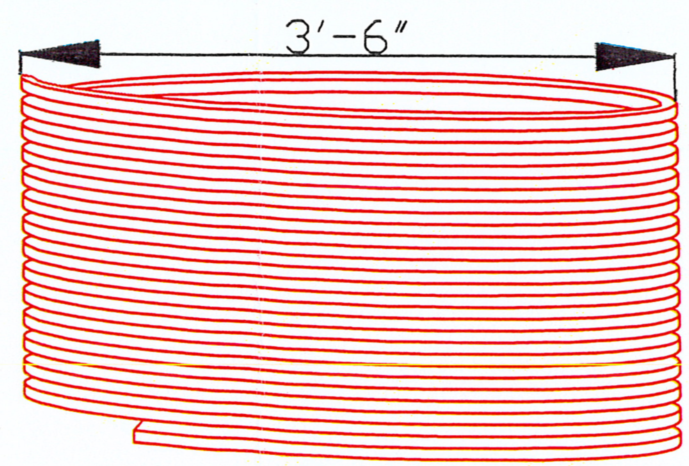
PART 5: 2" x ¾" 90° (2)





2 / D-1 HEADER PIPE DETAIL
SCALE 1/100" = 1'-0"

ASSEMBLY 1 (2): HEADER PIPE DETAIL
FUSE 15 2" x ¾" x 2" TEES INTO 2" PIPE
ALTERNATING OPPOSITE DIRECTIONS AND
A 2" x ¾" 90° ON ONE END



3 / D-1 LAKE LOOP COIL
SCALE 1/16" = 1'-0"

ASSEMBLY 3 (16): LAKE LOOP COIL
300' x ¾" COIL, 42" DIA ± 2" (TYP)
APPLYING SPACERS BETWEEN EACH COIL

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SILVERTON DISTRICT HVAC
SILVERTON, BC

LAKE LOOP MECHANICAL DETAILS

DRAWN: KJWH	DATE: 25/07/11	SHEET:
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