KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: September 4, 2013

TO: Dan Telford, Capital Regional District
Andy Liu, Capital Regional District

FROM: Mike Homenuke, P.Eng.

RE: **RESOURCE RECOVERY AND USE PLAN**
Concept Design and Cost Estimate for Heat Recovery in Esquimalt
Our File 283.360-300

1. Introduction

The Capital Regional District (CRD) retained Kerr Wood Leidal Associates Ltd. (KWL) to complete a conceptual design and cost estimate for a sewage heat recovery system serving the Township of Esquimalt core area. The project further defines and builds on previous analysis completed by KWL as part of a "Desktop Study for Integrated Resource Recovery" completed for the Township of Esquimalt in March 2013.

1.1 Background

The McLoughlin Point WWTP will be built in the Township of Esquimalt. The proposed WWTP will treat sewage from a number of municipalities in the CRD. The WWTP has a number of opportunities for resource recovery including recovering heat from raw or treated sewage.

The Township of Esquimalt has created a community plan for redevelopment of the core area surrounding the town hall into the Esquimalt Village Project (EVP). The EVP will include high density residential and mixed commercial/residential/civic buildings. Significant densification of Downtown Victoria and remaining infill development in Vic West is included in the City of Victoria's Official Community Plan.

1.2 Scope

The scope of this project is to developing a conceptual design and capital cost opinion for recovering heat from the treated effluent of the McLoughlin Point WWTP for use in a District Energy System (DES) to supply heat to key buildings in the Esquimalt Village.

Additionally, components of the treated effluent supply line were designed to have adequate capacity to allow connections of additional heat recovery projects in a second Phase. An extension of the effluent supply line to Downtown Victoria was considered as the ultimate goal in maximizing use of the treated effluent as a heat source.

1.3 Design Basis

The proposed heat recovery concept is based on pumping treated effluent from McLoughlin Point WWTP to Esquimalt Village and Downtown Victoria, where heat pumps will be used to extract heat for use in district energy systems. The cooled effluent would be returned via a parallel pipe to the WWTP to be pumped through the outfall.

The concept for Esquimalt includes connections to both existing and planned future buildings. Phase 1 will establish the DES and build three mini plants and distribution piping systems (DPS) to serve the existing Esquimalt and Archie Browning Recreation Centres and future buildings in the Esquimalt Village Project and Legion Rise developments.

The extension of the treated effluent supply-return line to Downtown Victoria will involve an additional 3 km to 4 km of twin piping, depending upon the ultimate termination point. At this point in time, a number of potential district energy service areas have been identified based on KWL's experience with other district energy studies in the Core Area and available planning information, including the City of Victoria's Official Community Plan.

A provisional sizing was developed for the effluent supply line based on a total peak heating load of 30 MW to 50 MW, which is assumed to be available by 2030, however the effluent line would be expected to have a lifespan well beyond this time. 50 MW equates to approximately one million square metres (1,000,000 m^2) of connectable building floor area. On average, this equates to approximately 60,000 m^2 of connected area per year – about the same as four highrise residential apartment buildings. Further feasibility work is needed to assess whether this pace of development and connection to district energy is achievable.

The potential service areas identified that fall along the proposed route of the effluent supply-return line include Esquimalt Village, Esquimalt Industrial Area, Songhees, and Downtown Victoria including Centennial Square, the business district and Harris Green.

Figure 1-1 shows the proposed routing and overall plan for the effluent supply-return line.

2. Load Forecast

2.1 Building Inventory

An analysis was performed on buildings that could potentially be connected to the DES to determine if their existing or planned heating systems would be comparable with a DES. For compatible buildings, heat load projections were estimated. Existing buildings with large heat loads in the Esquimalt Village were selected for the analysis. These buildings are municipally owned and their billed energy use was used as the basis for the load analysis. Future buildings potential heat load was estimated based on projected floor area as provided either by the Township or as submitted to the Township for bylaw and building approval.

Limited information was available for heat demands of Department of National Defence (DND) buildings so they were not included in this analysis. The DND have a number of potential heat demands adjacent to Esquimalt Village which could pose to be good candidates for connecting to the proposed DES.

The summary of the building HVAC systems and load analysis is provided in Table 2-1 and Table 2-2.

Table 2-1: Existing Building HVAC System Analysis and Load Summary

Demand Name	Total Floor Area (m^2)	Annual Heat Demand[1] (MWh)	HVAC Summary	Included for Analysis
Town Hall	2,094	109	Air Source Heat pumps, electric duct heaters	Not included
Archie Browning Sport Center	7,000	973	Hydronic baseboard, Heat pump and hot water heated AHUs	Included
Esquimalt Rec. Center	4,400	2,666	Hydronic heat with solar auxiliary heat and heat recovery	Included
Golf Course Works Yard	400	21		Not included
Safety Building	1500	329	Electric baseboards, electric duct heats and 2 electric Heat Recovery Ventilators.	Not included
DND Works Yard	1,400	76	N/A	Not included
Total	**15,294**	**4,175**		

Note:
1. Calculated from billed gas data assuming 75% efficient boilers are used.

Table 2-2: New Building HVAC System Analysis and Load Summary

Demand Name	Total Floor Area (m^2)	Energy Use Intensity (kWh/m^2-yr)	Annual Heat Demand (MWh)	HVAC Summary	Included for Analysis
Esquimalt Village Project Stage 1- Residential	17,000	100	1,700	Requires hydronics	Included
Esquimalt Village Project Stage 1- Commercial	3,200	55	176	Requires hydronics	Included
Legion Rise	10,421	100	1,042	Conceptual design unclear, most likely electric baseboard with gas heated make up air	Included
Total	**30,621**		**2,918**		

2.2 Load Forecast

The buildings identified for connecting to the DES where broken into two phases. The extension to Esquimalt Village will comprise Phase 1, and includes provision for three "mini-plants" to extract heat from the effluent line and supply to buildings. Phase 2 would extend the twinned effluent line to Downtown Victoria.

In Phase 1, three mini-plants are proposed, which would be implemented at different times. Mini-Plant 1 would serve the two recreation centres, and includes special high-temperature heat pumps to match with the existing building hydronic temperatures. Mini-Plant 2 is intended to serve the Legion Rise and EVP Stage 1 loads. Mini-Plant 3 will serve future development in Esquimalt Village (EVP Stage 2).

Mini Plant 1 DES Loads

After reviewing the HVAC systems of existing buildings with large heating demands in the Esquimalt Village, the two recreation centers were determined as the most feasible candidates for connecting with a DES.

The Archie Browning Sport Center has a hydronic heating system distributing heat with air handling units and baseboard heaters. The air handling unit's heat is supplied by two central boilers of approximately 200 kW capacity (according to the boiler registry) and heat pumps. The DES will supply base load heating and Domestic Hot Water (DHW) heating in place of the boilers which will be reserved for peak loads. The DES connection was sized to meet the shoulder season heating demand that is not already met by the heat pumps. A graph of the buildings historical gas use and the assumptions made for sizing the DES connection size are shown in Figure 2-1.

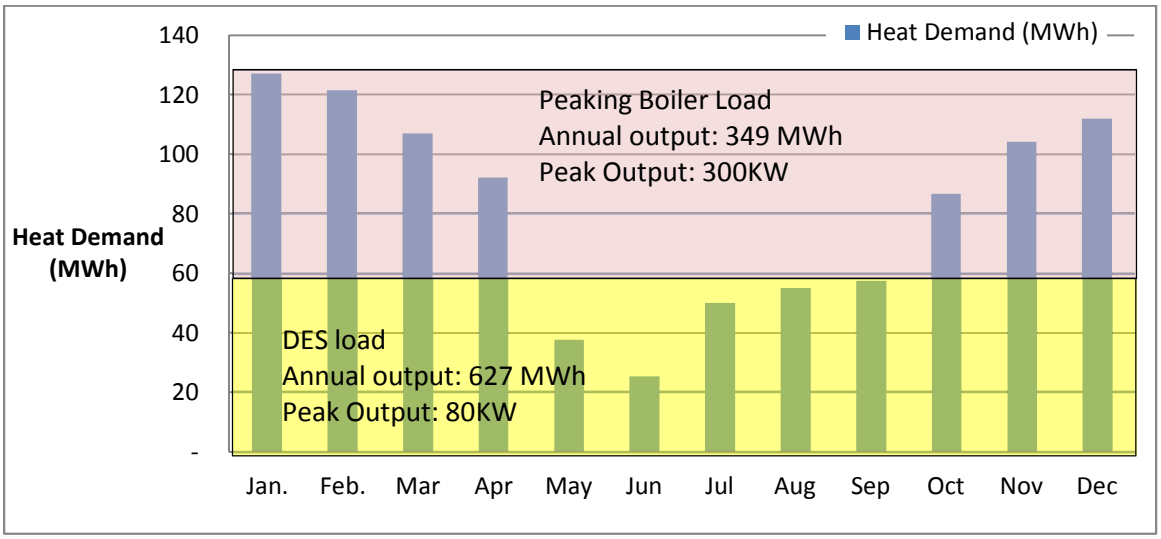


Figure 2-1: Archie Browning Sport Center's Historical Gas Use and DES Sizing Calculations

The Esquimalt Recreation Center has a pool, spa and meeting rooms in the facility and has three central boiler of 450-800 kW capacity. Recent renovations included a heat recovery unit from exhaust pool air that preheats incoming DHW and an auxiliary solar heating array that meets the remaining DHW demand. The DES connection was sized to meet peak seasonal load over and above the baseload which is assumed to be provided by heat recovery and solar heating. A graph of the buildings historical gas use and the assumptions made for sizing the DES connection size are shown in Figure 2-2.

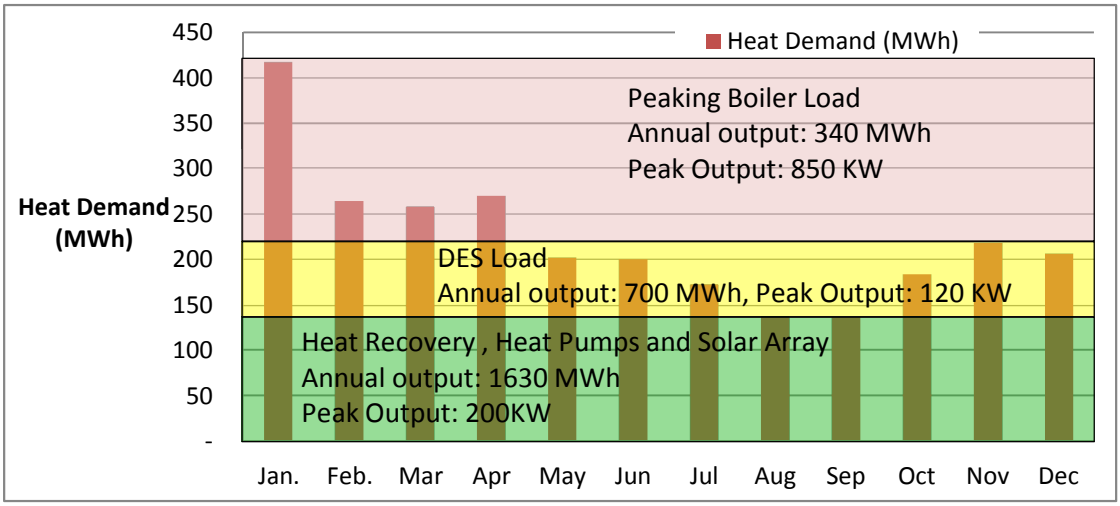


Figure 2-2: Esquimalt Recreation Center's Historical Heating Demand, Proposed DES Connection Size and Assumed Heat Recovery Size

The Mini Plant 1 annual heating loads are summarized in Table 2-3.

Table 2-3: Mini Plant 1 Heating Load Summary

Location	Total Billed Heating Demand (MWh)	Heat & Solar Recovery (MWh)	DES Demand (MWh)	Peaking Demand (MWh)	Peak Load (kW)
Archie Browning Sport Center	976	0	627	349	440
Esquimalt Rec Center	2,666	1,627.5	698	338	850
Total (MWh)	**3,642**	**1,628**	**1,325**	**687**	**1,290**

Mini Plants 2 and 3 DES Loads

The Mini Plant 2 and 3 heating loads were estimated according to the assumptions laid out in Section 2.1. Mini Plant 3 is assumed to be approximately similar in size and output to Mini Plant 2.

The sewage heat recovery system (renewable component) was designed to meet approximately 30% of the peak demand and can provide approximately 80% of the total annual heat demand. A summary of the Mini Plant 2 heat demand and supply is shown in Table 2-4.

Table 2-4: Mini-Plant 2 Heating Load Summary

Development	Total Heating Demand (MWh)	Renewable Demand (MWh)	Peaking Demand (MWh)	Peak Load (kW)
EVP	1,700	1,360	340	400
Legion Rise	1,042	834	208	650
Total	**2,742**	**2,194**	**548**	**1,050**

3. DES Design

3.1 Design Criteria

The energy recovery system concept has a number of important design criteria to be considered. These details are summarized in Table 3-1. The sewer heat recovery system will be sized to meet approximately 30% of the peak load, which should yield 80% of annual energy output.

Table 3-1: Heating System Design Criteria

Criteria	Mini Plant 1	Mini Plants 2 & 3	Phase 2
Design (Diversified) Peak Heating Load (kW)	900	1500	50,000
Heat Pump Size (kW)	250	500	15,000
Peak Boiler Capacity (kW)	Approx. 1300 (Already Installed)	TBD	TBD
Heat Pump COP	2.7	3.0	3.0
Effluent Flow Required (L/s) @ 5 ºC Delta T	8	20	480 (300 at 8 ºC)
Heat Loop Base Temperature (Supply/Return) (ºC)	78/72	65/55	65/55
Heat Loop Peak Temperature (Supply/Return) (ºC)	85/72	85/55	85/55
Boiler Control Scenario	Peaking and Trim	Peaking	Peaking
DES Boiler Efficiency	75%	80%	80%

3.2 DES Phased Development

The DES can be built in phases to expand as resources are available. The Phase 1 will supply heat to existing buildings and provide connections for future developments in the Esquimalt Village.

Phase 2 will extend the treated effluent supply and return line to Victoria opening up the possibility of connecting to potential projects both in Downtown Victoria and along the extended line.

3.3 Supply Line and Pump Station Design

Treated effluent from the WWTP will be diverted and pumped to Esquimalt Village via an effluent supply-return line. The line will have two sections. The first section is designed to have adequate capacity for the potential connection of Phase 2 heat recovery systems in Victoria and runs from the proposed WWTP to a valve chamber on Lyall St near Gore St. The second section is sized to supply the full build out of the EVP and recreation centres and runs from the valve chamber into Esquimalt Village.

The main supply-return line from McLoughlin WWTP is proposed as twin 600 mm dia. pipes, with the branch going to EVP as twin 200 mm dia. pipes. The effluent supply-return line will initially be built with a pump station at the WWTP of adequate size for the full servicing of Phase 1. Space would need to be preserved within the heat recovery area at the WWTP for larger pumps to allow for expansion to serve Phase 2 loads.

3.4 Mini Plant Design

Mini-Plant 1: Recreation Centres

For Mini-Plant 1, high temperature heat pumps will be used to supply the existing recreation centers with 78℃ temperature supply. Depending on the heat demand the existing boilers in each recreation center will be used to trim the supply temperature from the plant up to the required supply temperature of the building. KWT heat pumps from Viessmann are one technology that can supply at the high temperatures required for integrating with the existing buildings. NextEnergy Inc from Ontario was recently selected to represent this line of heat pumps in the North American market and preliminary performance and cost estimates from this supplier were used in developing the conceptual design and cost opinion

Mini-Plant 2: Legion Rise Project Mini Plant

For Mini-Plant 2, the heat pump will deliver 65℃ water with peaking boilers raising the supply temperature to 85℃ during peak demand. A number of heat pump manufacturers can supply heat at 65℃. The plant will ideally be located in the Legion Rise development and incremental building and electrical connection costs are included in our cost opinion.

Mini-Plant 3: Esquimalt Village Project Mini Plant

For Mini-Plant 3, the heat pump will deliver 65℃ water with peaking boilers raising the supply temperature to 85℃ during peak demand. A number of heat pump manufacturers can supply heat at 65℃. The plant will be located in one of the future EVP buildings and incremental building and electrical supply connection are included in our cost opinion.

3.5 Hot Water Distribution Piping Systems

Three hot water distribution piping systems (DPS) will be built for the project. A high temperature DPS will be constructed with Mini-Plant 1 to connect the existing recreation centres with 78℃ hot water supply with a 72℃ return. It will be built from buried 65 mm dia. twin insulated steel pipe connecting the two recreation centres to Mini-Plant 1.

A medium temperature DPS will be built for Mini-Plants 2 and 3 to tie in new buildings in Esquimalt Village. It will be built from buried 100 mm dia. twin insulated steel pipe. It will supply heat at 65℃ but will go up to 85℃ during peak demand periods, and return at a maximum 55℃ in all conditions.

Each building will connect to the DPS with an Energy Transfer Station (ETS) which decouples the building HVAC system from the DES and meters heat use for billing purposes.

The layout of the DES is shown in Figure 3-1 (attached) and design schematics are shown in Figure 3-2 and Figure 3-3 (both attached).

4. Capital Cost

4.1 Phase 1- Esquimalt Village DES

A Class D capital cost opinion was prepared Phase 1. The cost opinion is based on the system schematic as per Figure 3-2 and Figure 3-3 and the following assumptions:

- Supply and installation of a treated effluent pump station to supply Phases 1 and 2 integrated into the McLoughlin WWTP including electrical and mechanical incremental costs;
- Supply and install a treated effluent supply-return line of 780 trench-metres 2 x 600 mm dia. from McLoughlin WWTP to Lyall Street;
- Supply and install a treated effluent supply-return line of 1590 trench-metres 2 x 200 mm dia. along Lyall Street from the 2 x 600 mm dia. line to the Legion Rise development;
- Mini-Plant 1 including a modular building, site preparation, building pad, heat recovery equipment and electrical power supply and controls;
- Supply and install a high temperature DPS of 170 trench-meters of 65mm twin insulated steel pipe and make complete building integration with the recreation centers;
- Mini-Plant 2 and Mini-Plant 3 built as part of one of the EVP buildings including, incremental building cost allowance, heat recovery equipment, boilers and electrical power supply and controls;
- Supply and install two medium temperature DPS of 660 trench-meters of 80mm twin insulated steel pipe and ETS for the EVP and Legion Rise buildings and future EVP developments;
- Land costs are excluded;
- Cost opinions are prepared based on budget pricing from suppliers and KWL's experience with projects of similar size and nature;
- Cost opinions are for budgetary or planning purposes only and are considered indicative;
- Contingency of 30% added to all costs, which is intended to include contractor overhead, bonding, insurance, mobilization/demobilization, minor changes to project scope and schedule, and normal market fluctuations in costs of labour and materials;
- Critical market shortages of labour and materials, geotechnical testing, contaminated sites or other unplanned major impacts to project scope are not included in this opinion;
- Engineering and construction management is included at 20%;
- All applicable taxes are not included; and
- Costs are in 2013 dollars.

The resulting capital costs opinion is summarized in Table 4-1.

Table 4-1: Capital Cost Opinion for Phase 1

Item	Cost ($)
Treated Effluent Pump Station & Supply Line	2,440,000
Mini Plant 1	395,000
Mini Plant 1 - Heat Supply Loop & Building Interface	293,000
Mini Plant 2	568,000
Mini Plant 2 - Heat Supply Loop & Building Interface	498,000
Mini Plant 3	570,000
Mini Plant 3 - Heat Supply Loop	165,000
Subtotal	4,929,000
Engineering and Construction Management (20%)	986,000
Contingencies (30%)	1,479,000
Total Capital	**7,394,000**
SAY	**$7.4 Million**

Optional Treated Effluent Return via Northwest Trunk Sewer

The treated effluent return line from Esquimalt Village to the Lyall valve chamber could be omitted in lieu of discharging the return into the nearby CRD Northwest Trunk Sewer. The cost opinion for this configuration showed marginal capital cost savings that would not warrant the increase in operating costs. Therefore we recommend completing a full treated effluent return line from the Esquimalt Village.

4.2 Phase 2 - Downtown Victoria Extension

A Class D capital cost opinion was prepared for Phase 2. The cost opinion is based on the general routing shown in Figure 1-1 and the following assumptions:

- Supply and install a treated effluent supply-return line of 2710 trench-metres 2 x 600 mm dia. from the Lyall Street valve chamber to the Core Residential Area in Victoria;
- Supply and install a harbour crossing of supply-return line of 2 x 600 mm dia. using horizontal drilling.
- Supply and install 4 valve chambers at key tie in locations.
- Land costs are excluded;
- Cost opinions are prepared based on budget pricing from suppliers and KWL's experience with projects of similar size and nature;
- Cost opinions are for budgetary or planning purposes only and are considered indicative;
- Contingency of 78% added to all costs, which is intended to include engineering and construction management, contractor overhead, bonding, insurance, mobilization/demobilization, minor changes to project scope and schedule, and normal market fluctuations in costs of labour and materials; this contingency is higher than used in Phase 1 to reflect limited project definition to date and the potential challenges in construction of large piping through existing urban areas;

- Critical market shortages of labour and materials, geotechnical testing, contaminated sites or other unplanned major impacts to project scope are not included in this opinion;
- All applicable taxes are not included; and
- Costs are in 2013 dollars.

The resulting capital costs opinion is summarized in Table 4-2.

Table 4-2: Capital Cost Opinion for Phase 2 Expansions

Item	Cost ($)
Effluent Line Lyall to Dominion / Esquimalt Road	1,704,000
Contingency (78%)	1,330,000
Effluent Line Dominion / Esquimalt Road to Rail Trail	1,977,000
Contingency (78%)	1,542,000
Effluent Line Rail Trail	1,776,000
Contingency (78%)	1,385,000
Harbour Crossing	1,800,000
Contingency (78%)	1,440,000
Total Capital	**12,954,000**
SAY	**$13 Million**

5. Summary and Recommendations

A conceptual design of a District Energy System for the Esquimalt Village core area was completed by KWL. The design allows for the diversion of treated effluent from the McLoughlin WWTP to be used as a heat supply for sewage heat recovery. Three effluent heat recovery plants were included in the design; one to serve the existing Esquimalt Recreation Center and Archie Brownie Sports Center and two plants to serve new construction heat demands of the Esquimalt Village Project and Legion Rise housing development. Adequate sizing and connections were included for a Phase 2 expansion of the treated effluent supply line to potentials heat demands in the Victoria Downtown area.

A capital cost opinion was developed by KWL based on the conceptual design. For the supply and construction of the Phase 1 DES a capital cost opinion of $7.4 million CAD is given. A cost opinion of $13 million CAD is given for Phase 2 expansion work.

The following recommendations are made:

- A feasibility study should be completed to include operating costs and lifecycle cost estimates.
- Connecting the existing recreation centers is technically challenging and limited as-built information was available. In-depth analysis of the two existing recreation centers would be required should the project move forward to a more detailed design phase. This may include site inspections, interviewing operations staff and temporary data logging to determine how the existing building is operating.

- Engage the Township of Esquimalt to confirm partnership in the proposed DES project and to coordinate hookup of potential customers. The Township would need to mandate hydronic heat systems in buildings to be connected to the proposed DES.
- Work with McLoughlin WWTP proponents to include the proposed effluent pump station and piping in the WWTP design.
- Include the potential connection of buildings on the Department of National Defense's Esquimalt base in future analysis.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

DRAFT

Nathan Chase, E.I.T.
Project Engineer

Reviewed by:

DRAFT

Mike Homenuke, P.Eng
Project Manager

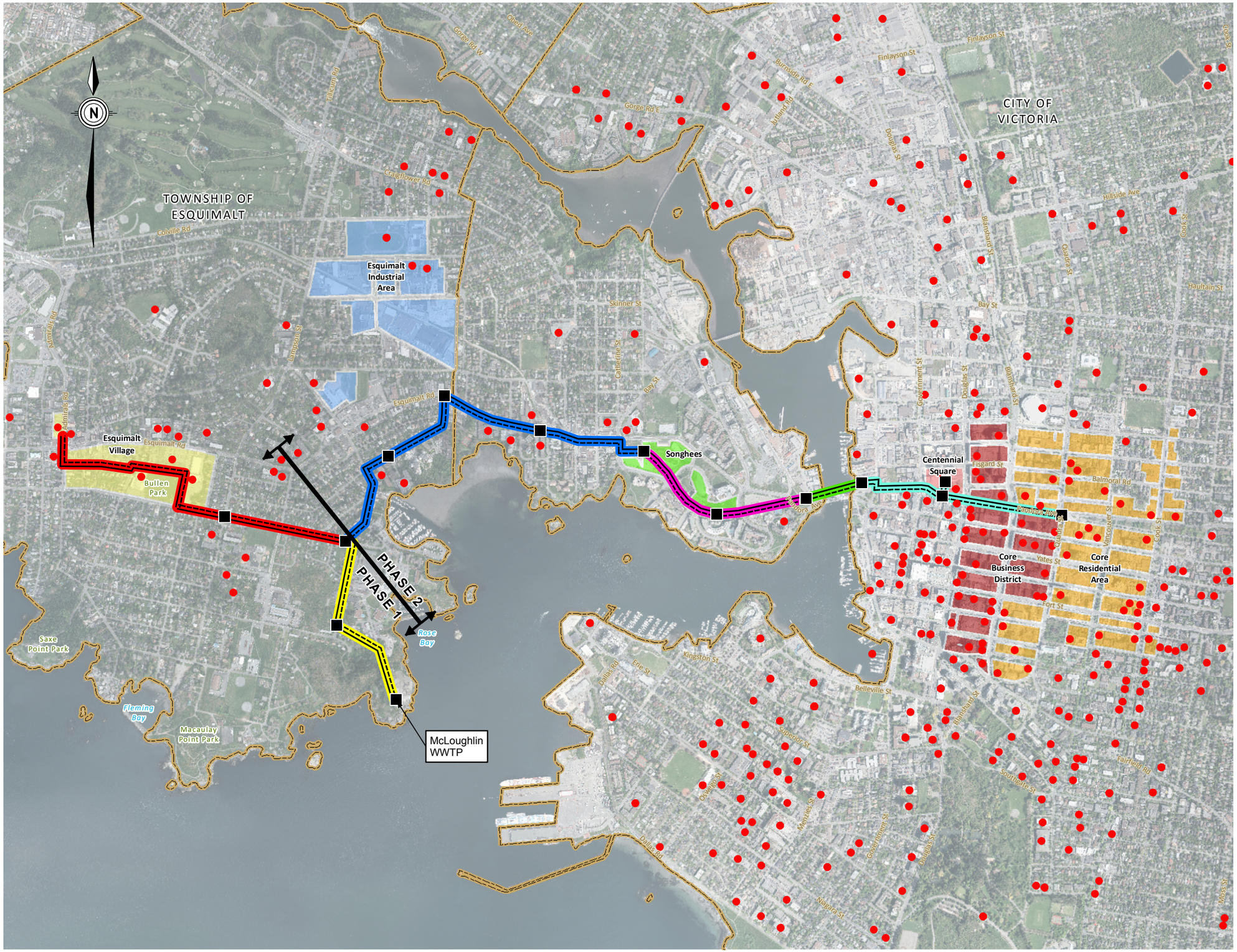
NAC/am

Statement of Limitations

Copyright Notice

Revision History

Revision #	Date	Status	Revision	Author
0	Aug. 2, 2013	Draft		NAC
1	Aug 16, 2013	Draft	Added costs for effluent line to Victoria	MEH
2	Aug 28, 2013	Draft	Updated Mini-Plant Naming convention and Phasing references	NAC
3	Sept 4, 2013	Draft	Integrate comments on contingencies and naming in cost tables	NAC



Capital Regional District
Effluent Heat Recovery Concept

Legend

- Municipal Boundary
- Existing Boiler
- Proposed Chamber
- Proposed District Energy System Pipe

Project Sections

- McLoughlin to Lyall - 2 x 600 mm dia.
- Lyall to Dominion - 2 x 600 mm dia.
- Dominion to Blue Bridge - 2 x 600 mm dia.
- Harbour Crossing - 2 x 600 mm dia.
- Lyall to Esquimalt Village - 2 x 200 mm dia.
- Downtown Victoria - Not Sized

Proposed DES Service Area

- Centennial Square
- Core Business District
- Core Residential Area
- Esquimalt Industrial Area
- Esquimalt Village
- Songhees

KERR WOOD LEIDAL
consulting engineers

Reference: Orthophoto from Bing aerial image map.

300 0 300 (m)
1:16,000

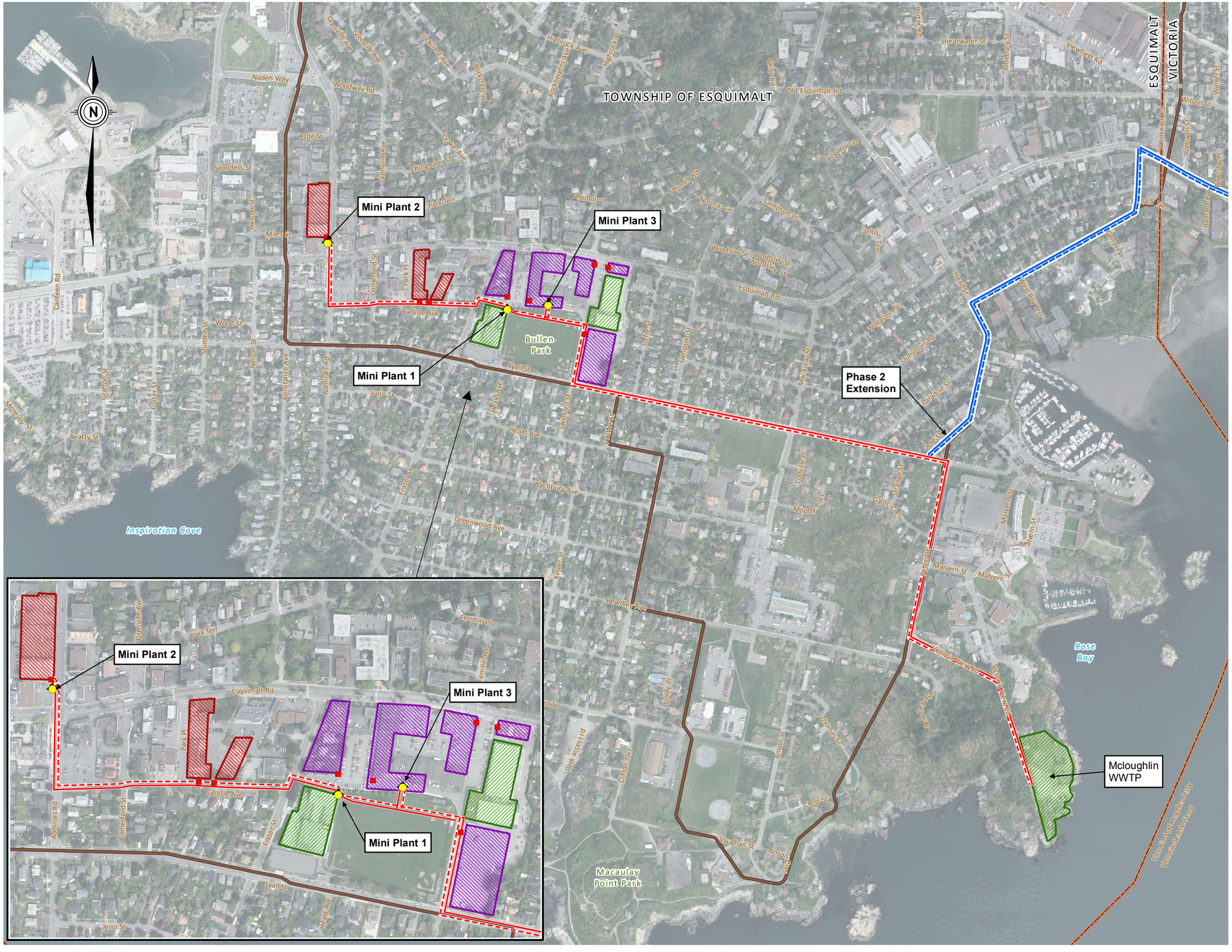
Project No.	Date
283-360	August 2013

Overall Heat Recovery Concept (DRAFT)

Figure 1-1

Path: O:\0200-0299\283-360\430-GIS\MXD-Rp\283360_Figure1-1.mxd Date Saved: 29/08/2013 1:47:26 PM
Author: JLau

Capital Regional District
Resource Recovery and Use Path
Conceptual Design for
Heat Recovery in Esquimalt



Legend

- Municipal Boundary
- Existing Trunk Sewer
- Distribution Area
- Distribution Area
- Distribution Area
- Energy Centre
- High Temperature Energy Transfer Station
- Phase 1 - Ambient Temperature Return (10°C)
- Phase 1 - Ambient Temperature Supply (15°C)
- Phase 2 - Ambient Temperature Return (10°C)
- Phase 2 - Ambient Temperature Supply (15°C)

Note:
Hot water distribution piping not shown.

KERR WOOD LEIDAL
consulting engineers

Reference: 2011 Orthophoto from CRD Atlas Web Map Service.

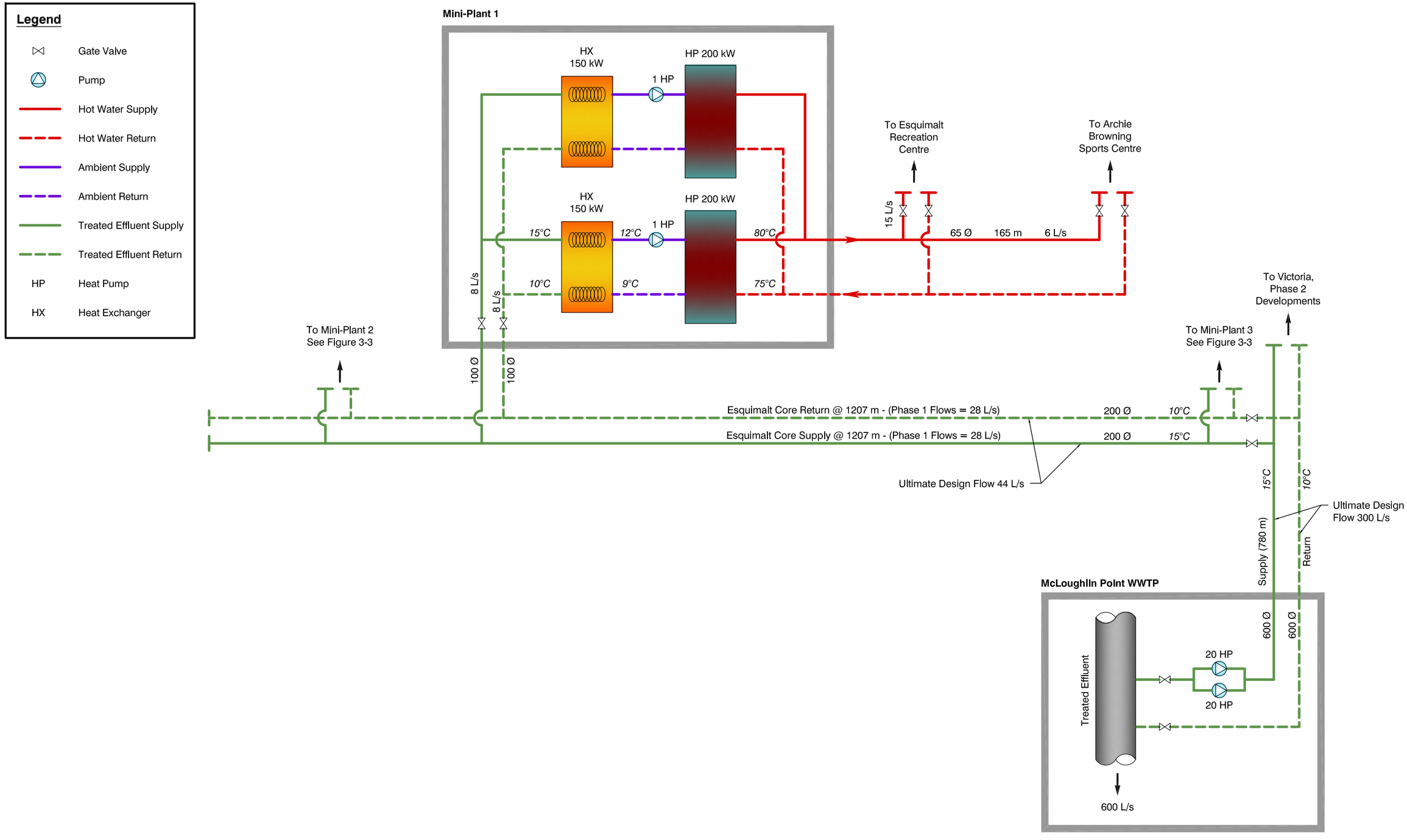
80 0 80 (m)
1:7,500

Project No.	Date
283-360	August 2013

Heat Recovery and DES Conceptual Schematic Esquimalt Detail

Figure 3-1

Path: O:\0200-0299\283-360\430-GIS\MXD-Rp\283360_Figure3-1.mxd Date Saved: 8/29/2013 3:33:02 PM
Author: NChase



August-29-13 1:57:05 PM

O:\0200-0299\283-360\500-Drawings\283360Fig3-2_EsquimaltCoreAreaHeatRecoverySchematic.dwg

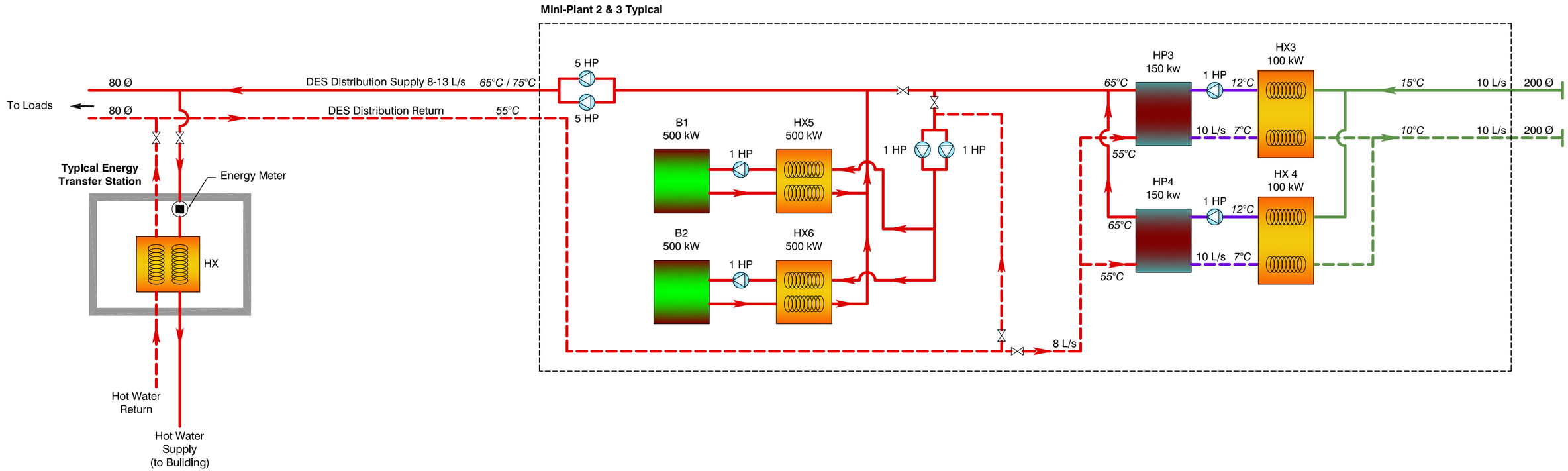
KERR WOOD LEIDAL
consulting engineers

Esquimalt Core Area Heat Recovery and Reuse System Schematic - Phase 1

Figure 3-2

Legend

- Gate Valve
- Pump
- Hot Water Supply
- Hot Water Return
- Ambient Supply
- Ambient Return
- Treated Effluent Supply
- Treated Effluent Return
- HP — Heat Pump
- HX — Heat Exchanger
- B — Boiler



Typical Mini-Plant 2 and 3 and Distribution Piping Schematic

KERR WOOD LEIDAL
consulting engineers

Figure 3-3