Appendix A - Technical Memoranda

Potential Uses for Reclaimed Heat from Raw Sewage and Treated Effluent

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DATE: October 24, 2008

PROJECT NUMBER: 352150.D1.36

The following summary identifies potential uses for reclaimed heat potential in raw sewage and treated effluent.

Wastewater Treatment Plant (WWTP) Uses.

1. Heating of makeup air required to meet NFPA 820 ventilation requirements.
2. Digester sludge heating/pre-heating.
3. Utility water heating for process uses such as chemical feed.
4. General space heating in process and non-process facilities.
5. Tempering of potable water for emergency shower and eyewash stations.
6. Heating/pre-heating for potable hot water systems.
7. Snow melting systems.

Residential, Institutional and Commercial Development Uses.

1. Swimming pool heating.
2. Heating of outside air required for minimum indoor air quality, makeup air for laboratory, kitchen and toilet room exhaust air systems.
3. General space heating.
4. Heating/pre-heating for potable hot water systems.
5. Greenhouse heating for local food production year round.
6. Any industry in need of low cost, low value energy source (economic growth).
7. Snow melting systems.

End of Technical Memorandum

Sewer Heat Recovery – Site Evaluation Screening Process

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DATE: October 24, 2008

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The following discussion represents our current understanding of how we would evaluate various sites as candidates to apply sewer heat recovery to offset current or future heat energy needs.

Coarse Screen Evaluation Criteria

Density of heat demands – Preferences to be given to large point loads over distributed small loads. Low temperature heating applications are appropriate over high temperature applications.

Geographic location – Located in the vicinity of a wastewater treatment plant site, large effluent force main or gravity interceptor. Current criteria distances mapped for each opportunity is 500, 1000, 1500 and 5000 meters from the center point of a defined opportunity location.

Raw GJ/day potential of flow stream(s) – Must meet a minimum scale criteria based on average dry weather flow rates.

Exceed minimum scale factors for technological efficiency – Minimum package sizing criteria for monetary considerations.

Refined Screen Evaluation Criteria

Contact the potential users for information on the existing installations to complete refined evaluation of users.

Type of Heating Demands – Cannot replace steam or high water temperature boilers.

Utilization Factor – Preference given to continuous or near continuous loads.

Green House Gas (GHG) Reduction Potential – Do not replace non-GHG generating heat sources.

Condition of Installed Systems - Preference given to systems in need of replacement or currently scheduled for retrofit.

Reasonable Payback Period – Less than the anticipated equipment life.

Willingness of user to participate in the program.

Raw Sewage Temperature Reduction vs. Process Impact – Prevent adverse treatment plant process impacts.

Final Screen Evaluation Criteria

Evaluate each of the remaining sites against a refined set of criteria. Assign a rating to each of the criteria factors indicating the relative importance of each. Rate each site against the criteria by assigning a relative numerical value. The total score of each site is the sum of the products of the weighting and rating of each criterion. Those with the highest score shall be put forward for preliminary engineering. Criteria include:

Triple Bottom Line Analysis

Payback Period

User Size

Utilization factor

Geographical location

GHG reduction Potential

Condition of installed system

End of Technical Memorandum

Wastewater Heat Recovery – Options for Effluent Heat Recovery at Treatment Plants

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Introduction

This is technical memorandum number 3 of a series written to inform of the various points to consider when examining the possibility of heat reclamation in the Capital Regional District, British Columbia.

The intention of this memo is to outline how waste heat extracted from plant effluent could be used in the processes of wastewater treatment plants (WWTPs) located within the Capital Regional District of British Columbia.

This memo also contains a discussion of three options for heat reclamation from treated effluent that have been determined as possible techniques based on past project experience and research of technologies that have been applied elsewhere in the industry. Applications involving recovery from raw sewage flow streams is discussed separately in another technical memorandum.

Environmental Analysis

Victoria Climate

It is important to first understand the basic environmental conditions under which the wastewater treatment plant (WWTP) will be operating. By determining factors, such as average outside air temperatures, as well as assumed effluent exit temperatures, the concept of effluent heat reclamation can be better analyzed.

General Outside Air Temperature Parameters

Because Victoria BC is located on the coast of the Pacific Ocean the outside air temperatures throughout the year have a fairly low average. **Table 1.0** summarizes the temperature averages for each month out of a typical year.

TABLE 1.0
The average daily low and high temperatures are given in ºC/ºF.

Month	Low	High
January	2/36	6/43
February	3/37	8/46
March	4/40	10/50
April	6/43	13/56
May	8/47	16/61
June	10/50	18/65
July	11/52	20/68
August	11/52	20/68
September	10/50	18/65
October	8/46	14/57
November	5/41	9/49
December	3/38	7/45

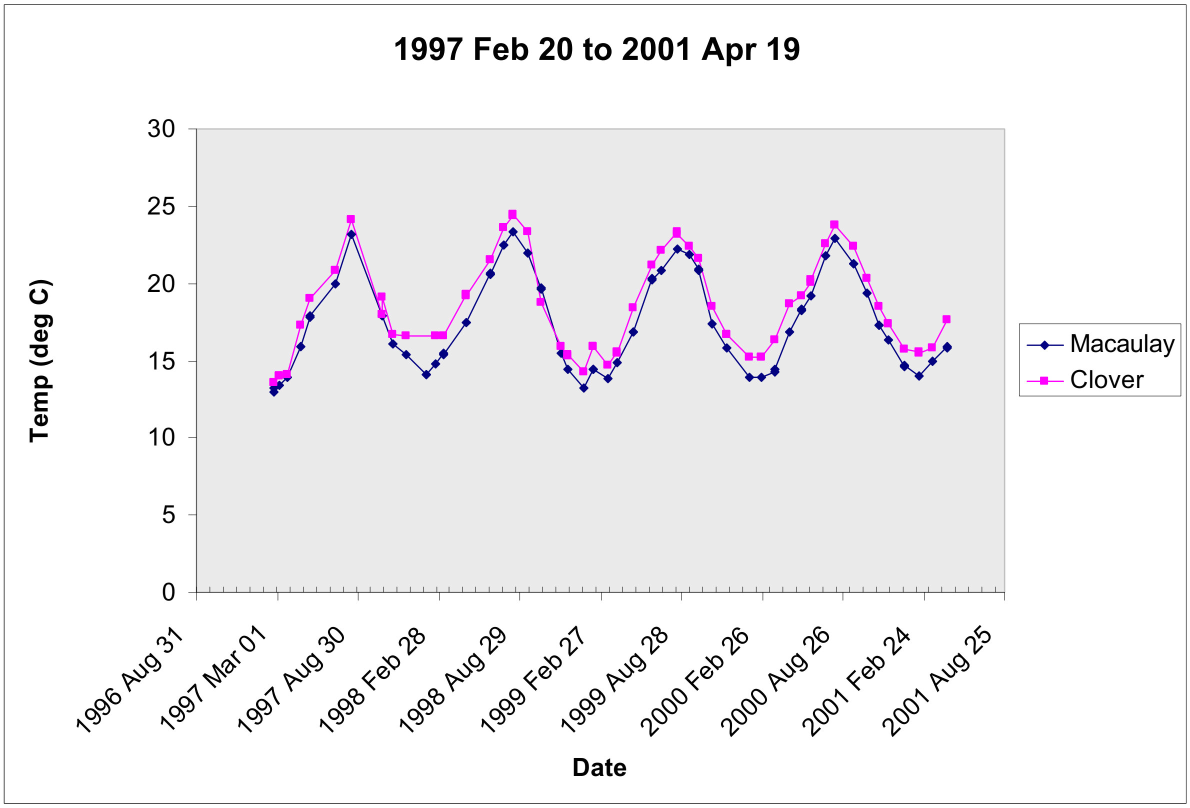
* Data derived from the Airforce Combat Climatology Center, Engineering Weather Data Products, Version 1.0 for the City of Victoria.

It can be seen here that the average high temperature in the summer months is only 20 ºC and the low average for the winter months is just above freezing. While the temperature changes overall are fairly mild, the climate is generally cool and offers conditions conducive to heat recovery.

Effluent Temperature Parameters

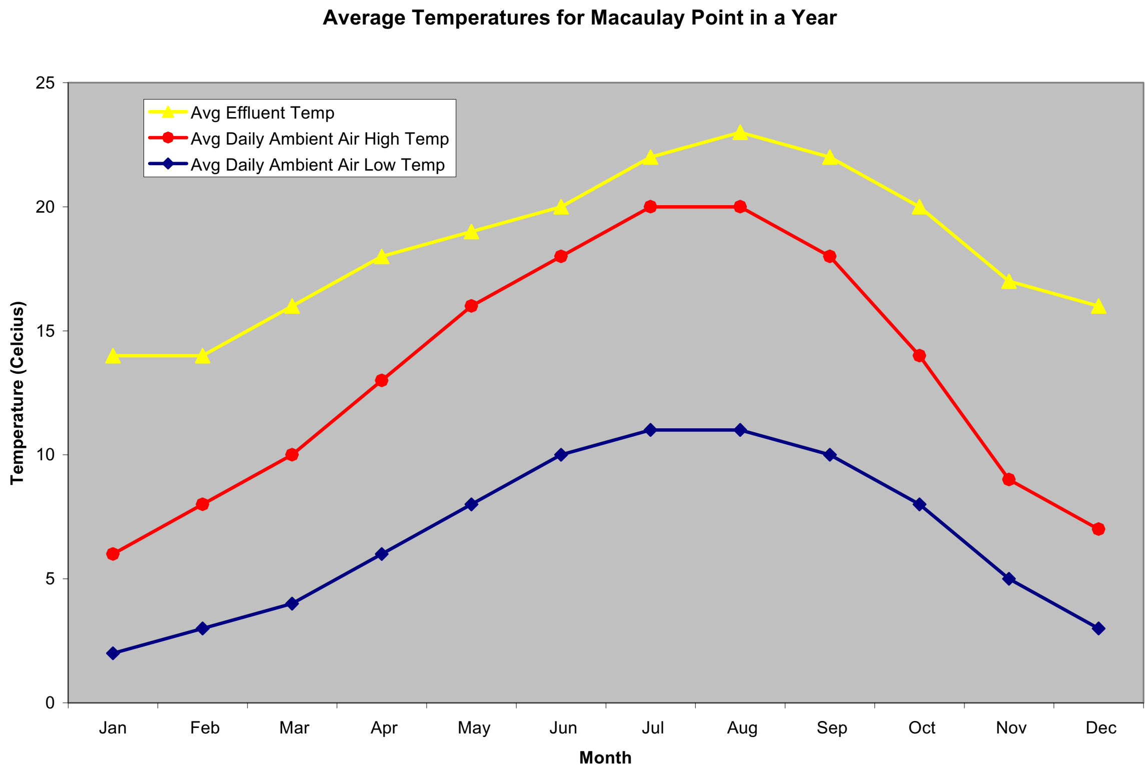
Because the heat is to be recovered from the outflow of treated sewage, the average temperature of the effluent must be analyzed in order to develop an understanding as to what sort of temperature differentials will be used in the process. Below in **Figure 1.0** the average effluent temperatures at both Clover and Macaulay Points are shown over the course of four years.

Figure 1.0



This diagram illustrates the fact that effluent temperatures cycle with the seasons. It also illustrates a very interesting point. During the summer time, the effluent temperature is in the lower twenties, much like the outside air temperature during those months. However during the winter months, the effluent temperature drops to only the mid teens. This low occurs during the time when the outside air temperature falls to five degrees Celsius and below, nearly freezing, creating a temperature differential that shows the potential for recovered effluent heat energy, **Figure 1.1**.

Figure 1.1



The graph shows how the effluent temperature fluctuates much less than the air temperature and maintains a much higher average. It also shows that there is almost always a higher temperature in the effluent than the outside air, creating a potential for heating year round if required.

Cooling

Assessment of using effluent for space is cooling addressed in a separate technical memorandum #9.

Canadian Energy Codes

Energy code requirements in the United States put a limit on the temperature that un-insulated buildings can be heated to. A limit is intended to reduce energy consumption of normally unoccupied process buildings such as those typically found at a WWTP. It has been found that there are no such regulations in place for the Capital Regional District, leaving much of that decision up to the designer's discretion.

Reclaiming Useful Heat from Effluent

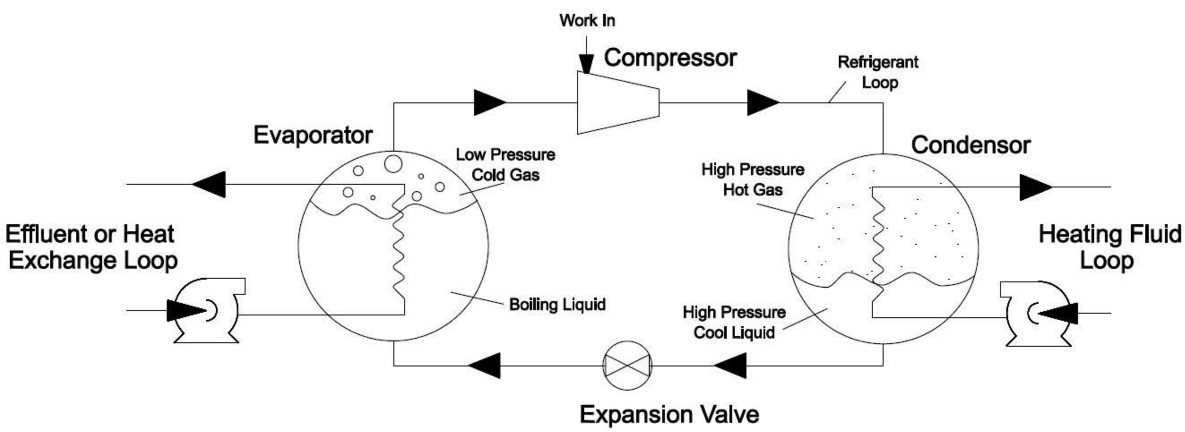
Gross Heat Flow in Effluent Flow Stream

KWL will be mapping a breakdown of the gross heat flow potential of gravity interceptors and force mains upstream of the current sewage discharge points and also map projected flow rates into the future.

Heat Extraction Techniques

Our technology search has directed our conclusion to study three techniques or methods for reclaiming heat from a WWTP effluent flow stream. Each of these options have variations that are possible from the general outline provided here, but ultimately the heat recovery process will be limited to one of the three techniques described below. The basic premise behind all of these techniques is to use a heat pump to elevate the low quality of heat in the plant effluent to a higher quality of heat that can be used to offset or replace the use of fossil fuels for meeting the space heating, domestic water heating and process heating needs at a typical WWTP. **Figure 2.0** shows how the basic heat pump cycle works.

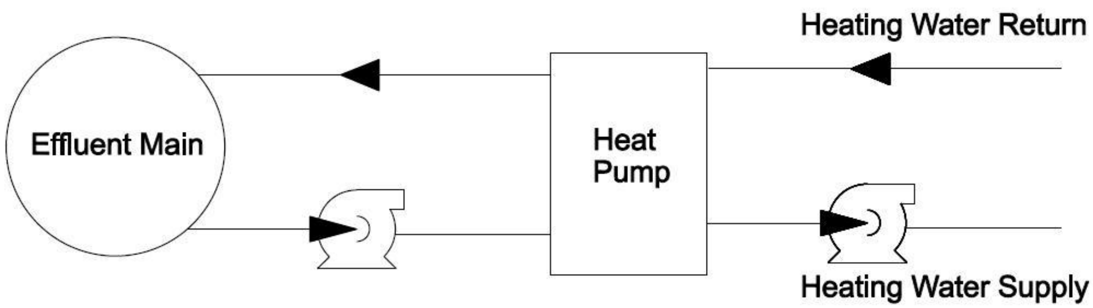
Figure 2.0: STANDARD HEAT PUMP DIAGRAM



Technique 1: Effluent Directly Through Heat Pump

This technique utilizes the low quality heat from the effluent stream directly. From the effluent main, the warmer effluent is pumped to a heat pump where the heat is transferred to the hot water supply line and sent back out into the heating water supply loop. This technique would be the most efficient, however if the effluent does not have a high enough quality, it may foul the heat pump and cause other major problems. Technique 1 is depicted below in **Figure 2.1**.

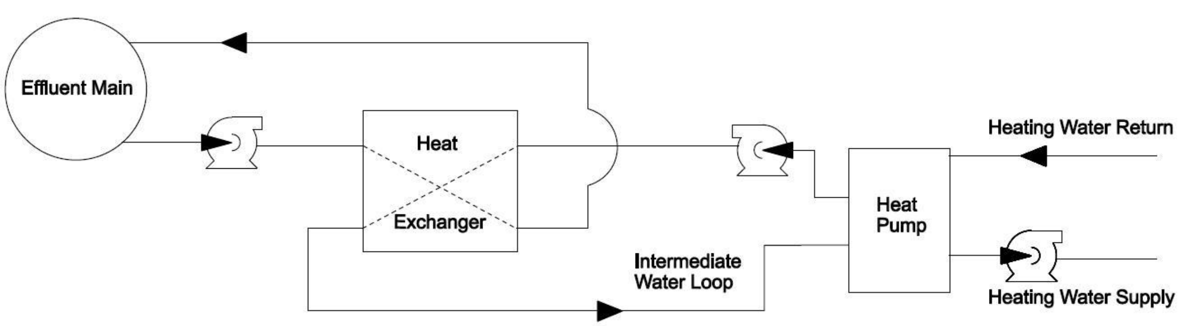
Figure 2.1: DIRECT EFFLUENT SCHEMATIC



Technique 2: Effluent through Heat Exchanger to Heat Pump

With this plan, the effluent from the plant is pumped to a heat exchanger. The heat exchanger's purpose is to protect the heat pump from damage caused by corrosive or high biological content found in the effluent during an upset condition. The quality of the effluent is again critical, as it determines the type of heat exchanger to be used. From the heat exchanger, the preheated solution then travels to a heat pump where the heat is again transferred to the hot water supply that is pumped out into the heating water supply loop. Technique 2 is shown below in **Figure 2.2.**

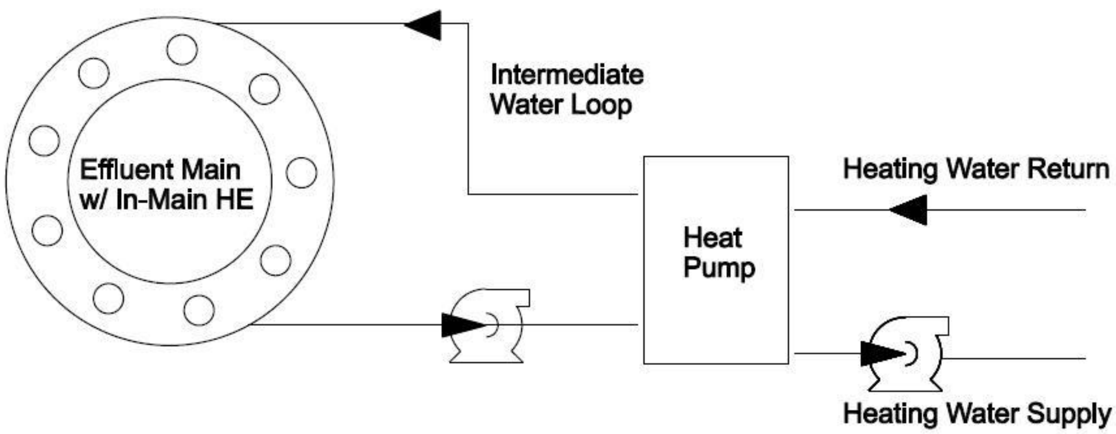
Figure 2.2: HEAT EXCHANGER OPTION SCHEMATIC



Technique 3: In-Main Heat Exchanger to Heat Pump

The final technique utilizes the technology of a heat exchanger directly in the effluent main. In this practice, effluent would run out of the plant unobstructed. Inside the effluent force main, heat would exchange from the effluent across an element to an intermediate water loop. This preheated intermediate loop would be pumped to a heat pump much like the previous two techniques. If this effluent main is a force main, the heat exchange elements could be place around the entire circumference effectively tripling the heat extraction potential seen in gravity flow sewers. The effluent quality is not as important in this technique as there is nothing to get plugged or obstructed. Fouling may occur however, causing the heat exchange elements to become less efficient, if the heat exchange surface is not properly maintained. Below in **Figure 2.3**, the in-main heat recovery technique is illustrated.

Figure 2.3: IN-MAIN HEAT EXCHANGER SCHEMATIC



Scope of Module Sizes

Because of the many criteria for selecting module sizes as well as the large field of options, the sizing information for the systems being discussed will be presented in Technical Memo #4 and will not be discussed here.

Corrosion and Fouling Issues to Consider

The most efficient way of utilizing the effluent heat would be pumping the effluent directly to a heat pump and transferring the effluent heat to the heating water supply for whatever heating process is needed. Although this technique is most efficient, it also requires that the effluent be of a relatively high quality. The manufacturer of the heat pump may not warranty the equipment if the effluent quality is poor and lends itself to fouling or corrosion. Also, if a heat exchanger is to be used to compensate for poor effluent quality, it will have to be able to be cleaned periodically in order to prevent fouling. Finally, the in-main heat exchanger system has the potential to foul as well. Over time, a film can develop over the heat exchange elements and decrease its potential to exchange heat. All these factors relate directly to the quality of effluent.

Beneficial Uses of Reclaimed Heat

Heating of Makeup Air to Meet Ventilation Requirements

The fire protection regulations by NFPA will be followed for any WWTPs in the Capital Regional District. These regulations call for complete air changes up to 12 times per hour for hazard classification reduction and possibly higher for odor control in some areas. With this much outside air needed continuously, there is a demand for heating in the makeup air side of the treatment plant process.

Each of the heat extraction techniques described above use the available heat in the effluent flow to heat the evaporator loop of a heat pump cycle. Depending on the technique, the actual amount of heat delivered to the heating supply loop will vary with the efficiency of the heat exchange method. **Table 3.0** has been set up to analyze what it takes to heat 5000 L/s of air from -4.83 ºC (ASHRAE's 99.6% heating design day for Victoria) to 10 ºC (typical process space heating set point temperature) for the purpose of ventilation makeup air for process spaces using each heat recovery technique. A water to water heat pump is being used to send heating water to coils located that heat the air either directly at the air handling unit or indirectly through terminal unit heaters

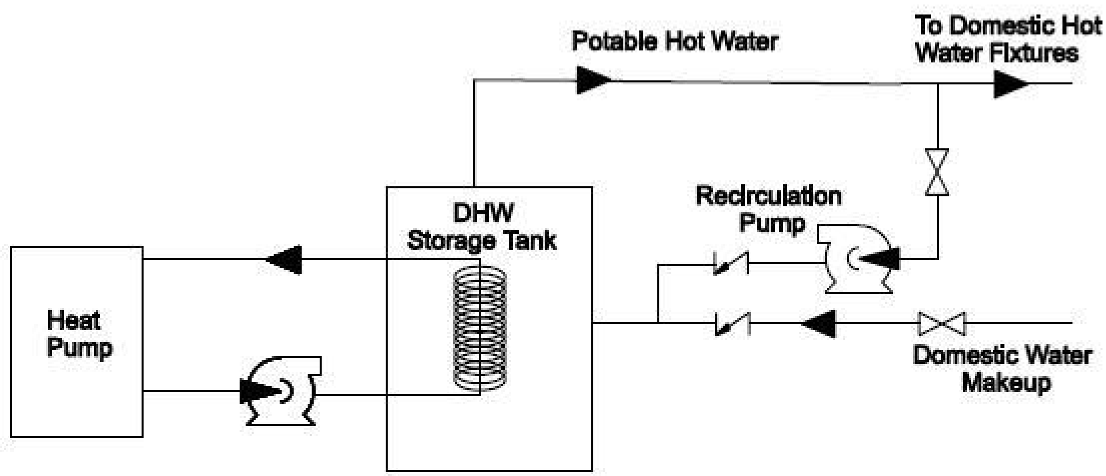
Table 3.0: EFFLUENT FLOW REQUIRED TO HEAT OUTSIDE AIR EVALUATED FOR EACH TECHNIQUE

Technique	Units of Outside Air	Reclaimed Heat Required	Heat Pump Evaporator Energy Required	Effluent Flow Required	Daily Flow Required
1	**5000 L/s**	**91.2kW**	**63.5kW**	**2.73L/s**	**0.236ML**
2	**5000 L/s**	**91.2kW**	**58.16kW**	**2.50L/s**	**0.216ML**
3	**5000 L/s**	**91.2kW**	**63.5kW**	**7.41L/s**	**0.640ML**

Heating/Pre-Heating for Domestic HW Systems and Potable Water for Emergency Shower and Eyewash Stations

For a domestic hot water heating loop to be a viable option, a storage tank would have to be heated by coils from the heat pump. This storage tank would have a mixing cycle to ensure that the water temperature is maintained throughout the tank. Also, there would be a recirculation loop for instances when the water is no longer needed. Ideally, one of these systems could be used for the entire domestic hot water demand in the WWTP.

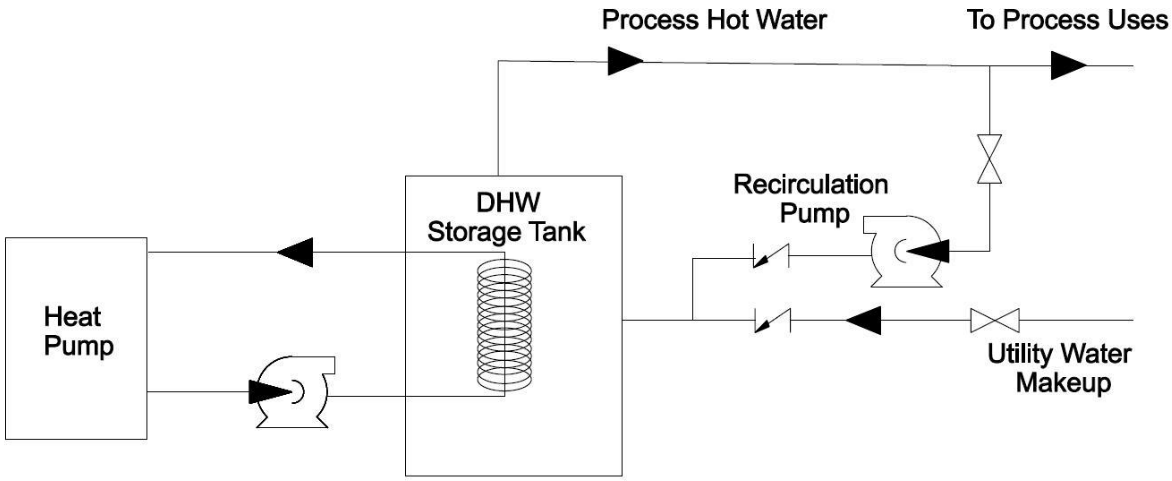
Figure 3.0: DOMESTIC HOT WATER SERVICE SCHEMATIC



Utility Water Heating for Process Uses

The application of hot water for process uses is a relatively straight forward and simple one. The actual process applications that can be served are; digester heating, feed water for high pressure washers, and chemical system feed water. These uses need only a supply water pump to send the preheated water to its destination. This system has the potential to run off of the cold water returned from the domestic hot water system. Because it is process water it would not be a closed loop, it would have to be uncontaminated water incoming.

Figure 3.1: UTLITY/PROCESS WATER SERVICE SCHEMATIC



Heat Requirements at a Wastewater Treatment Plant

Requirement Estimation

In order to get an idea of the required heat energy needed in a WWTP, two plants in Las Vegas were used as an example. These plants were examined as if they had been installed in Victoria, British Columbia and the heating requirements were recalculated using local weather conditions. The plants to be used as estimators were the Henderson, 16 MGD, plant, and the CNLV, 25 MGD Phase 1 and 50 MGD phase 2, plant. Also, the calculations were done with and without solids processing to get an idea for a wider array of plant types. Below in **Table 4.1** is a summary of the heating load calculations in English and SI units.

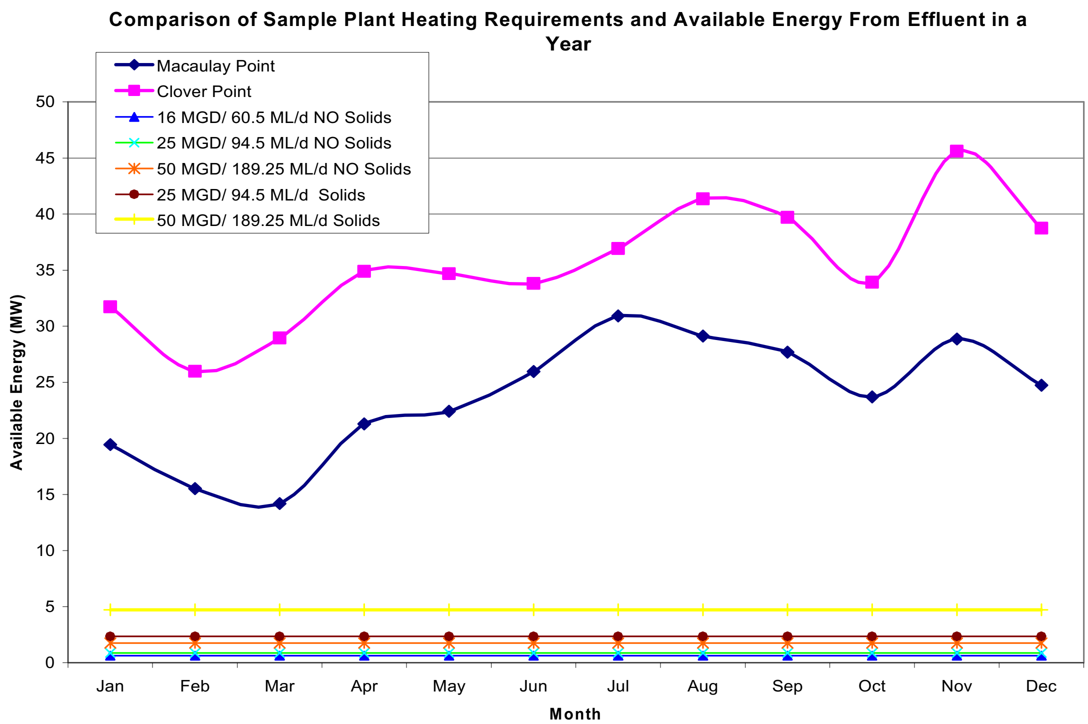
Table 4.1: Sample WWTP Heating Loads

SOLIDS: Yes/No	N	N	N	Y	Y
Size: MGD	16.00	25.00	50.00	25.00	50.00
Heating: MMBH	2.18	3.02	6.05	8.14	16.28
Heating: kW	631.65	876.53	1753.1	2359.88	4719.75
Size: ML/Day	60.56	94.63	189.25	94.63	189.25

Availability of Heat

By knowing the requirements of example treatment plants, it can be shown how the maximum heating demand can be compensated by the available energy in the effluent stream. Discussion Paper 031-DP-6, *Heat Recovery*, speaks to the minimum effluent temperatures. Below in **Figure 4.1**, the available energy of the effluent at Macaulay and Clover Point is shown with the plant heating requirements.

Figure 4.1:



The figure shows the fluctuations in available energy from effluent at both Macaulay and Clover Point. This fluctuation is due to the change in flow as well as change in temperature of the effluent. The flat lines represent the maximum requirement from the example treatment plants. It can be seen from the graph above that the heat energy required by any of the example treatment plants is only a small fraction of the large amount of energy available.

Conclusions

It has been shown that the technology is available to recover the heat from the effluent stream. It should be noted however, that the plant must be designed to be heated by a low temperature (<54.4°C)water system. Retrofitting any systems that currently run on higher temperature heating water or steam would likely be too costly retrofit and would not provide a return period that would warrant such an investment. By offsetting the cost of energy for space heating, the plant itself will become more efficient and by minimizing the use of gas boilers, it also becomes a "greener" facility by reducing greenhouse gas emissions. The analysis performed in this memo shows that there is ample energy available for heating and that there will be additional energy to be used elsewhere, either before or after the treatment process. It can be seen that the amount of heat required and portion of flow that would have to be dedicated to a heating system minimal. For these reasons, this memo suggests that it is advisable to utilize the energy contained in treatment plant effluent as a heat source for the plant itself without limiting other recovery uses beyond the WWTP.

Heat Recovery Systems Minimum Sizing Criteria

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DATE:	July 17, 2008
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The following discussion represents our current understanding of how we would evaluate various sites as candidates to apply sewer or effluent heat recovery based solely on the size of the heat recovery facility.

Factors Affecting Sizing

The following is a discussion of the factors impacting the system installation size. These factors are grouped into three categories based upon whether they are favorable, unfavorable or neutral to increased scale.

Factors neutral to scaling:

COP – The coefficient of performance of a heat pump or the energy moved per unit of energy input is fairly insensitive to the size of the unit. The predominant factor affecting the heat pump COP is the temperature difference between the hot and cold reservoirs that it is working against. The temperatures of the sewer are fairly constant and fluctuate on an annual basis between 12 and 24 degrees C. The temperature of the recovered heat would have to be between approximately 55 and 60 degrees C to be effectively utilized for space, air and domestic water heating. As such there is little benefit one way or the other to changes in unit size.

Factors favorable to large scale:

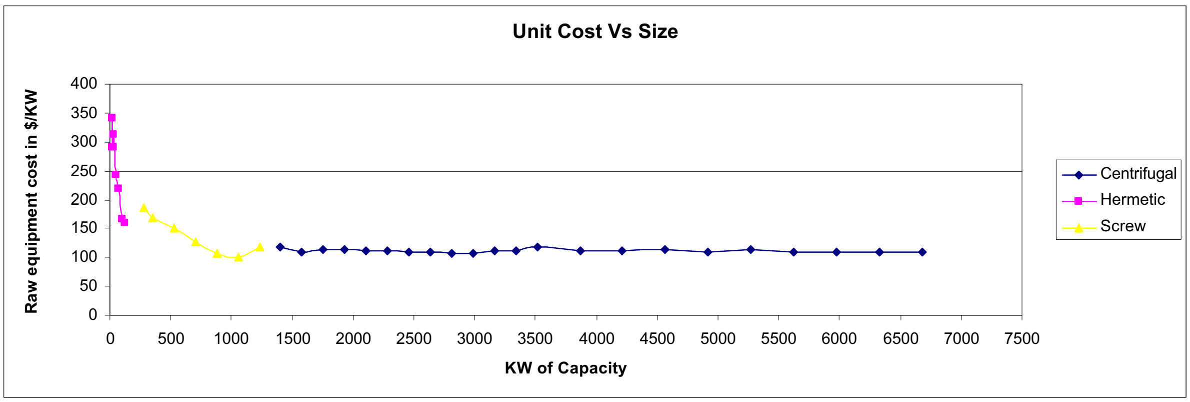
System life – The larger single system technologies such as screw and centrifugal compressors tend to have a mechanical life exceeding that of the reciprocating type used on small scale systems. The fewer number of mechanical components results in fewer failures and a lower operations and maintenance cost.

Parasitic loads – These fairly small constant load demands can severely degrade the overall system performance of smaller systems. When factored into the larger systems they can be negligible.

Concentrated user density – The smaller the distribution area is for the users of a given centralized heat recovery system the smaller the cost of distribution and the smaller the impact on overall system performance. The effect on pumping distance shall be covered in another TM.

Capital cost – The raw equipment cost per unit of installed capacity increases significantly as the unit size decreases. See Figure 1. At or above an approximate size of 500kW the unit cost stabilizes. Above this value there is little advantage to raw equipment cost. Below this value there is significant value to scale. When looking at a return on investment the unit sizes below 500kW will have a much longer payback period due to higher installed costs.

FIGURE 1
Raw heat pump equipment cost based on installed unit capacity.



Factors favorable to small scale:

Available heat potential in the sewer – The available heat potential in a sewer will tend to limit the size of the heat recovery installation. In general the excessive recovery of heat from either the sewer or reclaimed water will increase the differential temperature the system is working against and have a negative impact on the overall system performance. Additionally, the excessive recovery of heat from the sewer can impact the treatment process.

User heat consumption – Many of the potential users are small in size. A small heat recovery system dedicated to a single user has several features favorable to that user. The systems are easier to fit within existing spaces and incorporate in existing systems. The project can be "owned" and operated by the user. Any kind of billing or use metering is greatly simplified.

Low user density – Single small users, especially those very near the source, are good candidates for small systems. The connection of these users to a centralized large system would result in increased complexity and distribution costs.

Available utilities – In existing facilities, building or service areas where the supporting utilities do not exist for the installation of large single systems it can be prohibitively expensive to upgrade or replace the utility infrastructure to support them. In these cases the existing marginal capacity can be used to support small single installations that could achieve a reasonable financial criterion.

Recommended Approach

As an initial starting point a system minimum size of 500kW for a single unit capacity should be analyzed.

Wastewater Heat Recovery – Heating Options in Non-Plant Uses

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DATE: June 27, 2008

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Introduction

This, Technical Memorandum # 5, is part of a series of tech memos that discuss various topics covering the potential to reclaim heat from wastewater systems in the Capital Regional District of Victoria British Columbia.

It has been shown that there is a potential to recover heat from the effluent of a wastewater treatment plant (WWTP) and use it for various processes within that plant. This memo will show the facilities outside of the treatment plant that could benefit from a district heating plant supplied by recovered heat from wastewater.

Heating in Various Developments

The idea of utilizing a system of district heating has been implemented in many current applications. Below is a list of what different heating and cooling opportunities present themselves in different types of developments, what specific systems are there to meet those needs, and how heat recovery from wastewater can be integrated to support a heating solution.

Types of Structures:

Commercial Office Buildings

A typical office building as referenced here would be a high-rise or low-rise building with most of the floor space consisting of offices, cubicles, conference rooms, and bathrooms.

High Density Residential Buildings

Because of the issues of location, cost effectiveness and consumer driven needs, this study will only look at residential buildings that have a relatively high population density. These buildings include mostly high rise condominiums or apartments and other multi family dwellings.

Institutional Buildings

This category of buildings covers the government structures such as the parliament building. It also covers education buildings from grade schools to universities.

Hospitals

Because of the intense sterility requirements as well as the need for twenty-four seven operation, hospitals are an important category to consider.

Industrial Buildings

For the purposes of this report, industrial buildings encompass those large buildings used for storage, manufacturing, and other process intensive systems. These buildings have lots of square footage with fewer internal divisions than other categories.

Heating Requirements:

Most of the development types listed above have the same basic heating requirements. There are however some applications that exist in specific developments. The following is a list of the energy uses of the various developments with consideration to specific needs.

Heating and cooling energy uses:

General:

- Occupant comfort heating and cooling
- Ventilation outside air heating and cooling
- Domestic service hot water heating
- Electrical and computer room air conditioning

Institutional:

- Kitchen/cafeteria ventilation makeup air
- Swimming Pool water heating and facility heating
- Laboratory ventilation air heating and cooling

Hospital:

- Medical hot water uses
- Kitchen/cafeteria ventilation makeup air
- Laundry service water

Industrial:

- Process steam systems
- Process hot water
- Hazardous material ventilation makeup air

Existing solutions to heating and cooling needs:

- Typical Building Heating Systems
  - Boiler circulating heating water
  - Air Handling Units (AHUs) with hydronic coils
  - AHUs with gas or oil fired furnace

  - Perimeter fin tube heaters
  - Terminal heaters such as; unit heaters, cabinet heaters, or fan coil units

- Typical Building Cooling Systems
  - AHUs with chilled water coils
  - AHUs with DX coils
  - AHUs with economizer cooling with outside air

- Typical Service Water Heating Systems
  - Gas, oil or electric water heaters
  - Double wall heat exchanger on a boiler heating water loop

- Steam systems
  - Re-circulated steam for building heating
  - Once through steam for process uses

Implementation and Integration of Recovered Heat

With the needs for heat explained, the investigation will shift to incorporating the recovered heat from wastewater. The idea here is to provide a general overview of what possibilities exist as well as the pros and cons of the options. Where available, we have included references to similar systems currently in use.

Shifting to Wastewater Heat:

Before looking at the possibility of using recovered heat from wastewater, the limitations must be understood. To implement the process of recovering heat from the wastewater stream efficiently, the resulting "hot" water temperature is capped. After a heat exchanger and a heat pump, the heated fluid, (can be water or air), will realistically be no more than 55ºC (131ºF). Because of this limitation, not all of the heating needs can be met with this system, but most all of them can be aided by this very efficient pre-heating process. Although this recovered heat will be sufficient for virtually all the space heating required in a building, there will still be a need to have backup supplemental systems in place for peak demands or an inability to heat or cool with wastewater energy. These back up systems will typically be sized to roughly 75% of the maximum system design condition.

Building Heating Systems with Recovered Heat:

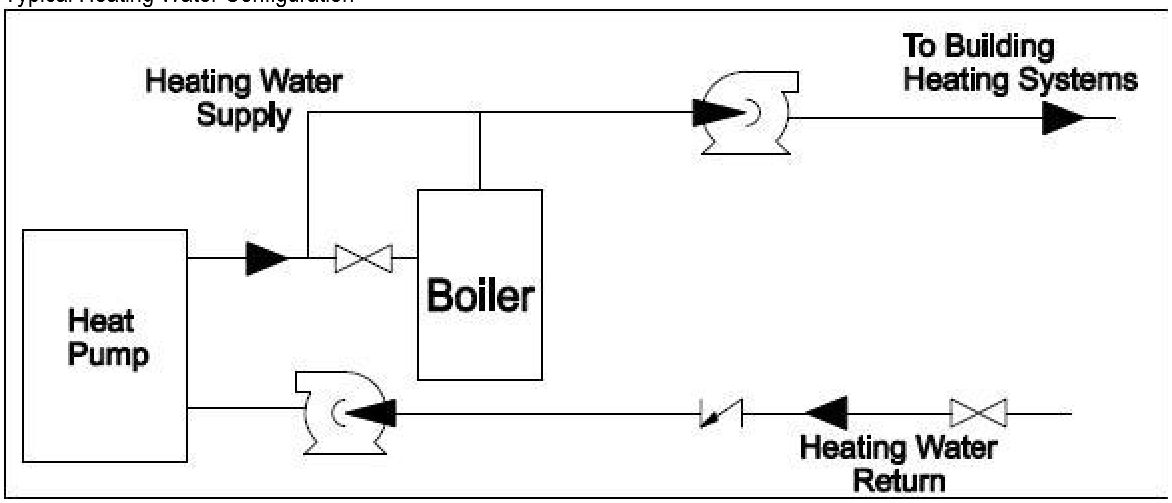
Process Description

Building heating systems could greatly benefit from the heat available in wastewater. With the right system, it is feasible to produce heating water that is 55ºC (131ºF) which would be sufficient to use in a low temperature hydronic heating loop. A large 50+ kW heat pump with a typical coefficient of performance (CoP) of 3-4 would be used to generate heating water at a useful temperature. Heating water is circulated throughout the building to any air handling units, terminal units or equipment used for comfort, domestic service water or process heating systems.

Retrofitting and Implementation

The proposed solution while not suitable for all conditions is geared for buildings that are heated on a hot water loop as opposed to the alternative of low pressure steam coils. By connecting the piping such that it runs from the heat pump to an optional bypass boiler, there will be available supplemental heat during high demand times. The system will operate as a closed loop and a temperature monitor on the supply side will determine whether boiler heating aid is called for. Air handling units with gas or oil fired furnaces do not lend themselves to the possibility of retrofitting to a recovered heating option. These units, unless at the end of their useful life or scheduled for replacement, are not good candidates for the implementation of recovered heat. An example of a possible installation is pictured below in **Figure 1.0**.

FIGURE 1.0
Typical Heating Water Configuration



Building Cooling Systems

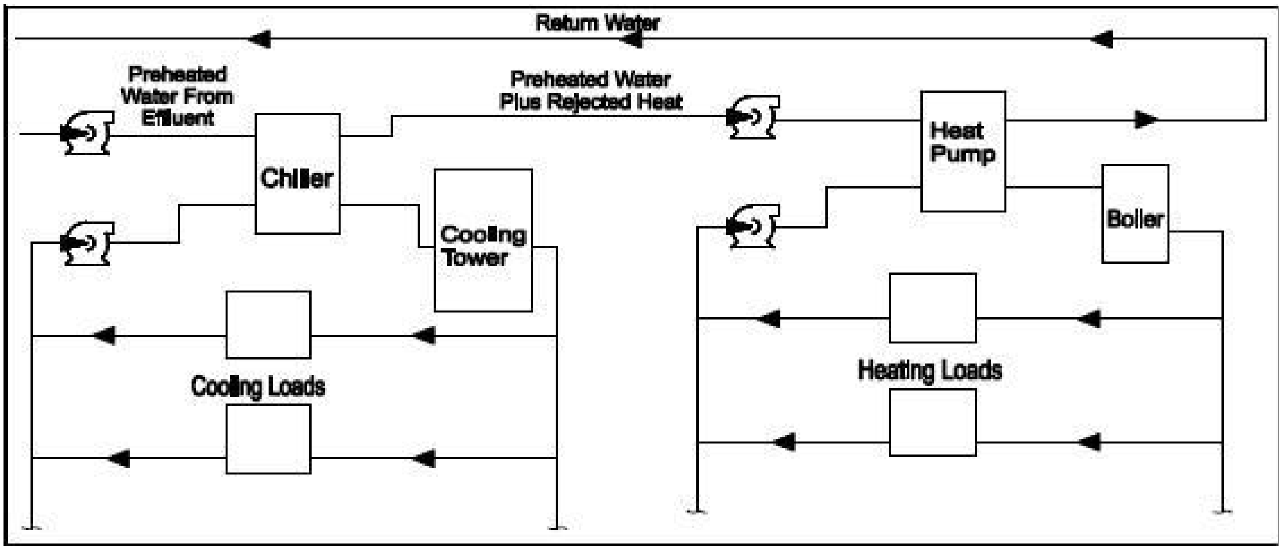
Process Description

A valuable option to consider is the ability to use the preheated water as a heat sink for a cooling loop for the building. Almost all buildings have a computer server room and a mechanical room. These areas are large producers of heat and, for the purposes of comfort and proper operating conditions, must be cooled. The air handling units serving to cool these areas may have hydronic or direct expansion cooling. With either of these techniques there is rejected heat that can be used to add energy to the preheated water.

Retrofitting and Implementation

This process could be easily retrofitted to a system that has a central direct expansion cooling pump. By tapping the chiller into the hot water return, the rejected heat instead of being vented to the outside via a cooling tower, could be added to the incoming preheated water before it hits the heat pump. This would allow for a higher output temperature from the heat pump to the desired heating applications. As with all retrofittings and new installations the current method, in this case a cooling tower, will be left in place for times when the recovered heating system fails, or is down for maintenance. This system is modeled in **Figure 1.1** below.

FIGURE 1.1
Cooling Loop Preceding Heating Loop



Service Water Heating Systems with Recovered Heat:

Process Description

The process of heating water to serve as domestic or process water comes in two flavors. One way to handle this would be to have the preheated water in a loop heating a water storage tank that is to be kept at a certain temperature as illustrated in **Figure 1.2**. This option favors users who have a constant need for hot water. A hospital would fit the bill perfectly for this. During the a day at a large hospital, there is generally an on site laundry facility in constant operation as well as a kitchen serving hot food and washing dishes all day every day. Because of this constant demand for hot water, a large tank supply system would be much more effective than the alternative. That alternative being a loop that allows for the potable water to go through a heat pump directly and then go out to the user as shown in **Figure 1.3**. This system will be designed with a redundant boiler for supplemental heat. This option is best suited for a system where water consumption is moderate and demands can be met by the volume in the heating loop.

Retrofitting and Implementation

Current hot water systems for most buildings consist of an electric or gas powered water heater boiler that serves the domestic hot water needs of that building. Changing to a system that is primarily heated by recovered heat from wastewater would require a few changes. First, the boiler would no longer be the primary heat source, and thus would be taken off the primary loop. The piping would run either directly through a large heat pump, or from a storage tank, depending on the desired method. For a majority of the operating time the 55ºC water, preheated from the wastewater, would be enough to service the needs of most buildings' consumers. For peak heating times such as morning and evening, a secondary bypass loop to the boiler would be used in order to achieve supplementary heating.

FIGURE 1.2
Domestic Hot Water from Heated Storage Tank

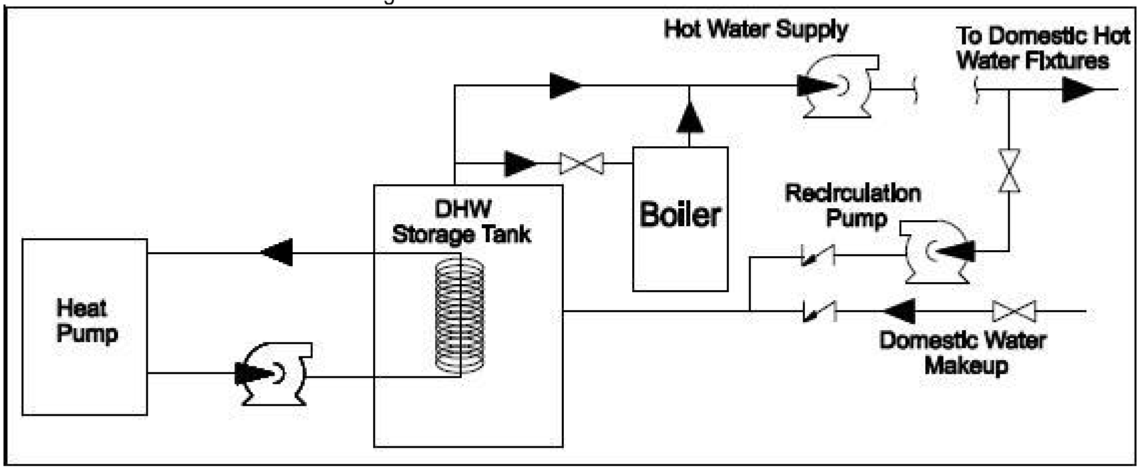
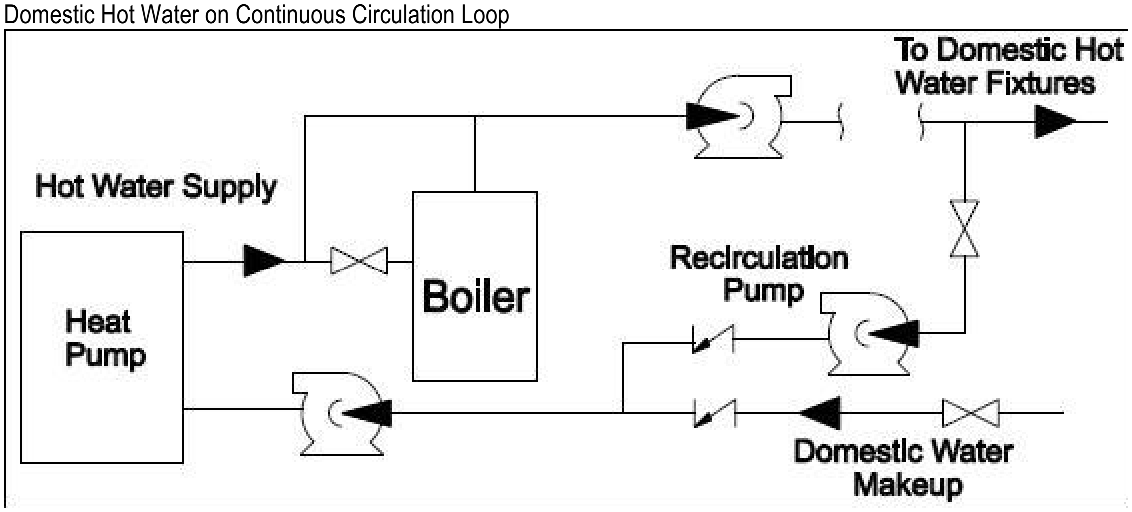


FIGURE 1.3
Domestic Hot Water on Continuous Circulation Loop



Preheating for Steam Systems:

Process Description

The outlook on utilizing the recovered heat from wastewater to aid in steam systems has two basic options. One, if the steam is on a re-circulation loop and sent through heating coils, has little potential. Steam condensate generally returns at a higher temperature than the available preheated water so using recovered heat from wastewater becomes ultimately a very inefficient method. There is however a possibility to use the water to preheat the air for combustion in the boiler. This would increase fuel efficiency as their will be less need for the combustion to heat the air and most all of the heat will go directly to heating the steam. However, it should be noted that most steam boilers are pulling intake air that is already 27ºC so the potential to heat air up with 12-24ºC water with recovered heat is pretty small. The second possibility, and only sensible option, is preheating makeup water to be converted to steam for once-through steam systems generally for process uses. Here there is a greater potential as makeup water could benefit greatly from a boost to the probable 55ºC.

Retrofitting and Implementation

In order to implement a system of preheating incoming air for combustion, a heating coil from the already in place low temp hydronic heating system could be added to the intake side of the boiler. This would allow for convective heating of the air. In order to preheat makeup water for once-through steam systems, the above described system of service water heating, could be routed to the makeup water intake and used at its temperature of 55ºC.

Energy Usage

The three figures below show energy used for space heating (**Figure 2.0**), domestic service water heating (**Figure 2.1**), and space cooling (**Figure 2.2**) in MJ/m² for five different development types up to the year 2005 as found from Natural Resources Canada's B.C. data. <http://www.oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/index.cfm?attr=0> Predictions have been developed to help estimate the demands. The flat line values for the years 2020 to 2065 were chosen by halving the regression line slope between 2005 and 2020. The exponential curves between those times were designed to show an estimate of the leveling out that is expected to be seen as new technology begins to reach its limits. After the figures, is **Table 2.0** summarizing the current and predicted energy use for each development type and usage.

FIGURE 2.0
Energy Used for Space Heating by Development Type

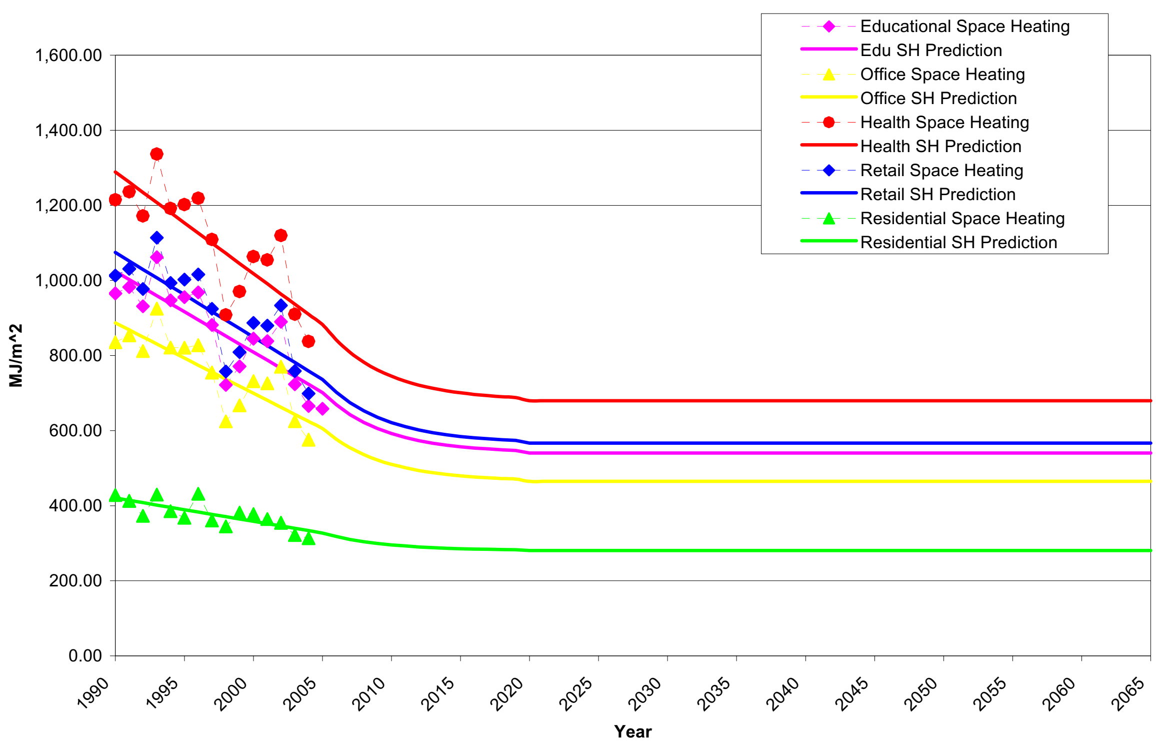


FIGURE 2.1
Energy Used for Water Heating by Development Type

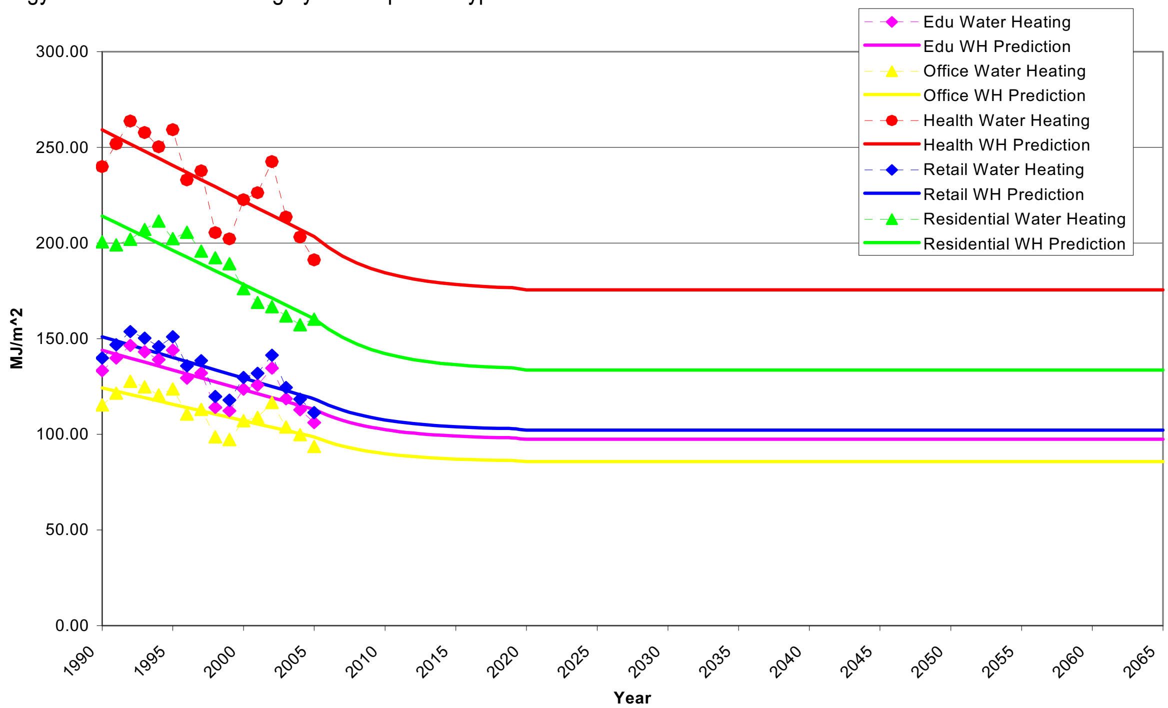


FIGURE 2.2
Energy Used for Space Cooling by Development Type

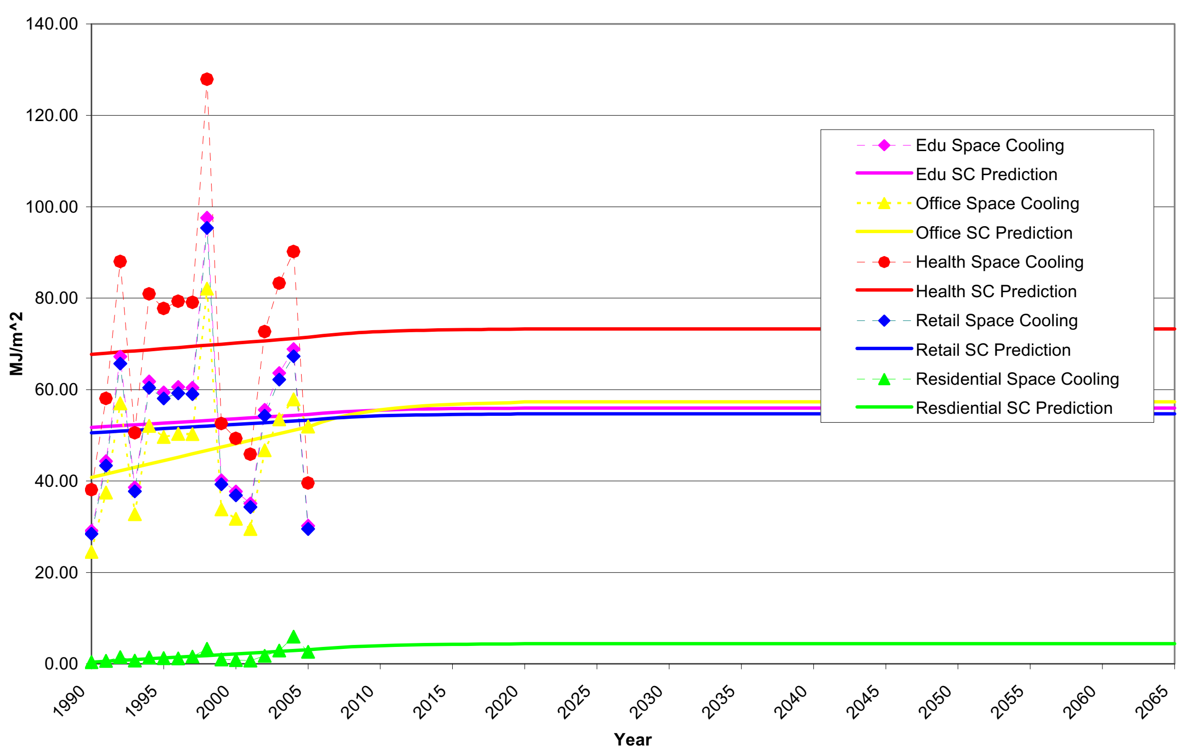


TABLE 2.0

Use Type	Educational		Offices		Health Care		Retail Trade		Residential	
Basis Year	**2005**	**2020 / 2065**	**2005**	**2020 / 2065**	**2005**	**2020 / 2065**	**2005**	**2020 / 2065**	**2005**	**2020 / 2065**
Space Heating MJ/m^2	702	540	606	465	883	680	736	567	327	281
Water Heating MJ/m^2	113	97	99	86	203	175	119	102	160	134
Space Cooling MJ/m^2	55	56	52	57	71	73	53	55	3	4

Zoning and Development Usage

Twenty four zones have been identified in various Official Community Plans (OCP) of the Capital Regional District. These zones are defined by specific development types and densities. By applying the energy use estimates project for years 2020 & 2065 to the zones, a list was developed showing the yearly estimated energy demand per hectare of each individual zone. **Table 2.1** shows the zone designation, the density and makeup of the development and the energy demand for each of the previously defined usage types.

TABLE 2.1

			Energy Demand MJ/ha/yr at Year 2020			
ZONE	**Density (m2/ha)**	**Development**	**Space Heating**	**Water Heating**	**Space Cooling**	**Total**
Residential 1	700	100% Residential	196	94	3	293
Residential 2	3000	100% Residential	842	401	13	1256
Residential 3	3100	100% Residential	870	414	14	1298
Residential 4	6000	100% Residential	1683	802	26	2511
Residential 5	7200	100% Residential	2020	962	32	3014
Residential 6	11500	100% Residential	3226	1537	51	4814
Residential 7	15000	100% Residential	4208	2004	66	6278
Residential 8	20000	100% Residential	5610	2672	88	8370
Residential 9	0	Float Home	0	0	0	0
Commercial 1	7000	100% Retail Trade	3969	716	383	5068
Commercial 2	6000	100% Retail Trade	3402	614	328	4344
Commercial 3	12000	100% Retail Trade	6804	1227	656	8687
Commercial 4	10000	100% Retail Trade	5670	1023	547	7240

TABLE 2.1

			Energy Demand MJ/ha/yr at Year 2020			
ZONE	Density (m2/ha)	Development	Space Heating	Water Heating	Space Cooling	Total
Residential 1	700	100% Residential	196	94	3	293
Mixed Use 1	12000	80% Office 10% Retail Trade 10% Education	5792	1063	683	7538
Mixed Use 2	7500	50% Office 50% Retail Trade	3870	705	420	4995
Mixed Use 3	9000	70% Residential 10% Retail 10% Office 10% Health Care	3308	1169	3308	7785
Mixed Use 4	12000	60% Residential 30% Retail 10% Education	4709	1447	296	6452
Mixed Use 5	15000	40% Residential 25% Office 25% Retail 10% Health Care	6572	1770	557	8899
Mixed Use 6	30000	50% Office 50% Retail	15479	2820	1681	19980
Mixed Use 7	12000	50% Office 50% Retail	6191	1128	672	7991
Institutional 1	12000	100% Education	6483	1170	672	8325
Institutional 2	4000	70% Education 30% Retail	2193	396	222	2811
Recreation 1	500	Open Space	0	0	0	0
Recreation 2	1000	100% Education	540	97	56	693

This data will be used in order to create a GIS-based map that will show the energy demand requirements of polygonal regions of the Capital Regional District.

Conclusions

Bottom Line:

With the demand for the various uses estimated out to 2065, and the definition of the energy requirements of the specific zones, the groundwork has been set for the GIS map of the region. **Table 3.0** was created to summarize the ideas for heating systems discussed at the beginning of this memo.

TABLE 3.0

Application and Integration Method	Best Suited Applications	Pros	Cons
BUILDING HEATING SYSTEM			
Low temperature hot water loop	*All Types*: heating for occupant comfort as well as building requirements	Extremely efficient and easily retrofitted to a current low temp hot water heating loop.	Not easily retrofitted to buildings currently using higher temperature media

TABLE 3.0

Application and Integration Method	Best Suited Applications	Pros	Cons
			such as steam.
<u>BUILDING COOLING</u>			
Cooling loop with preheated water as a heat sink	*All Types*: computer server rooms and mechanical rooms	Additional heat capabilities from heat pump. Easily retrofitted to current central chiller.	
<u>DOMESTIC WATER HEATING</u>			
Hot water heated from storage tank	*Institutional*: pools, showers, cafeterias *Hospitals*: laundry, cafeterias *Industrial*: high volume consumption processes	Efficient way to keep a large, constant demand for hot water satisfied. Easy to work out owner/ operator responsibilities.	Not suitable for small volume users.
DHW heated directly from heat pump	*All Types*: all low volume domestic hot water uses	Constant circulation of hot water to user outlets. Peak use times can be supplemented by traditional water heater.	Logistics of ownership may be complicated.
<u>STEAM HEATING SYSTEM</u>			
Preheating air for boiler combustion process	*All Types*: steam building heating systems	Potential to raise air temperature for combustion thus increasing fuel efficiency.	Difficult to implement with a significant cost benefit ratio.
Preheating makeup water for steam	*Industrial*: Process steam uses	Requires less added heat to achieve steam increasing efficiency.	Only applicable to once-through steam systems

Available Wastewater Heat Reclamation Technologies

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DATE: October 27, 2008

PROJECT NUMBER: 352150.D1.36

Introduction

The purpose of this technical memo is to familiarize the reader with the conditions of, and available options for, recovering heat from raw wastewater mains before any sort of plant treatment occurs. This memo is intended to be a brief outline of the options available for

Points to Consider

When looking at recovering heat directly from raw wastewater lines, "interceptors", one has to make note of a few key issues. The first being location. Location is critical to the process of heat recovery, as there must be not only a large enough cache of heat within the wastewater, but there must also be a ready consumer near by to make heat recovery an efficient choice of green energy. The specifics of pumping distance and locations are discussed in a later Tech Memo and will not be discussed in detail here. Second, is fouling. Fouling for the purposes of this memo will be any sort of blockage, build up, corrosion, or other malfunction of the heat exchange equipment caused by the condition of the utilized raw wastewater. Fouling is very important on the interceptor side of the treatment process, as there will be matter of varying consistencies and sizes that will be running through the main lines. It is also crucial because biological scum can accumulate over the heat exchange elements causing reduced efficiency or even failure.

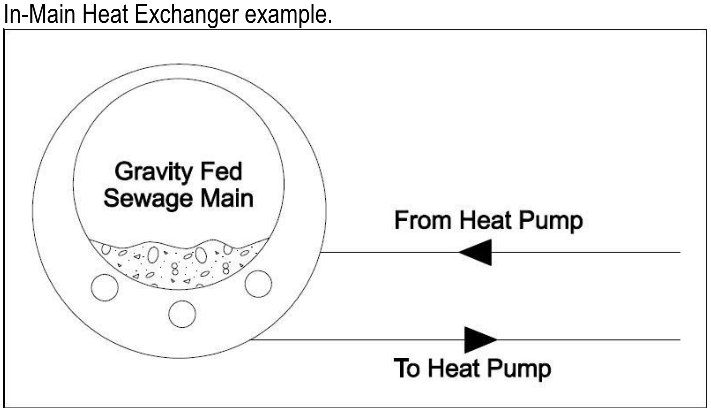
Heat Recovery Options

There are two main ideas when it comes to how to recover the heat from the wastewater main. You are either going to extract the heat from the wastewater while it continues on its path through the interceptor line, "In-Main Heat Exchanger". Or, you must re route the wastewater so that it becomes manageable for an outside heat exchanger, "Flow Diversion Heat Exchanger". Both of these methods have their pros and cons as well as variations on a main idea.

In-Main Heat Exchangers

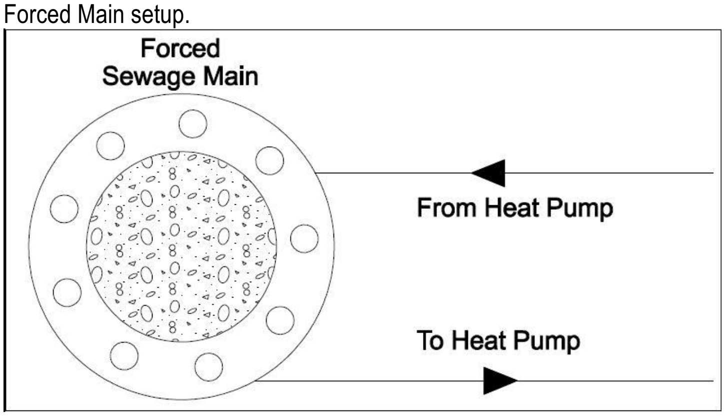
In main heat exchangers would effectively replace any existing interceptor lines in the area that is scheduled to be served. This new main is equipped with a heating exchange element on the surface in contact with the wastewater, with a pre-heat loop running from a heat pump or user of some kind to the In-Main Heat Exchanger and back. An example of an In-Main Heat Exchanger is shown below in **Figure 1.0.a.**

FIGURE1.0.A
In-Main Heat Exchanger example.



There are a couple different technologies out there for a setup of this nature. One technology is Rabtherm®. This technology requires an entire replacement of the wastewater main. The heat exchanger resembles a normal interceptor in terms of size and appearance. The actual heat exchanger is the surface of the pipe that comes into contact with the wastewater stream. The low temperature loop to be heated runs through smaller pipes imbedded in the larger main. A heat exchange media, commonly used is an alcohol-water solution is circulated up and down the flow of main line then once heated leaves to a user. The loop returns and the process repeats continuously all without interrupting the wastewater flow in any way. In a best case scenario, the In-Main Heat Exchanger would be put after a pump enabling the heat exchange element to effectively cover the entire circumference of the interceptor and tripling the unit's ability to extract heat. A forced main setup is shown in **Figure 1.0.b.**

FIGURE 1.0.B
Forced Main setup.

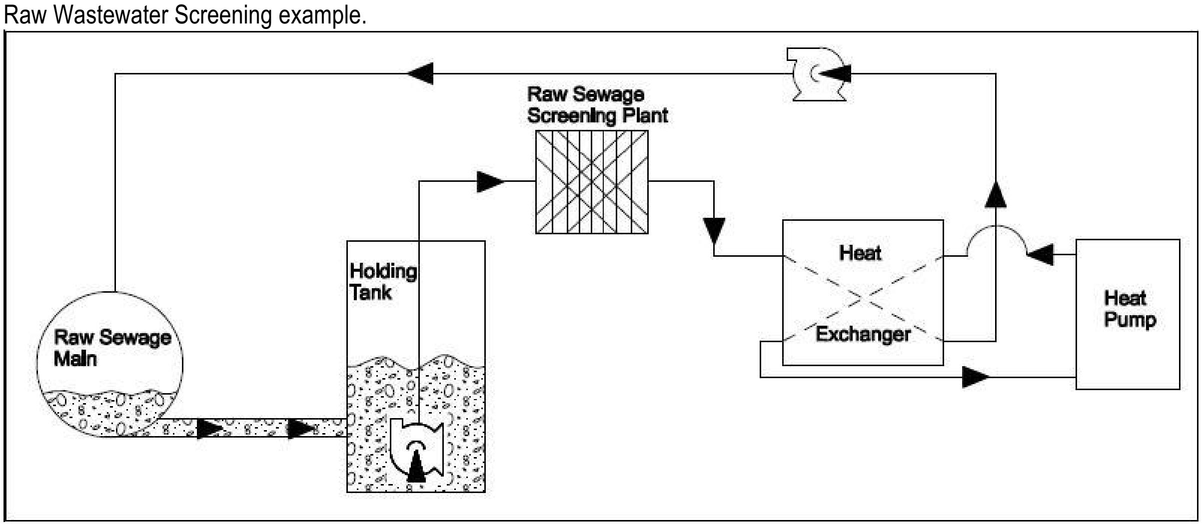


Another technology in this category of In-Main Heat Exchangers comes from FITR. With this technology the heat exchange element and tubes are laid into existing interceptor lines. The idea here is an ability to put in a heat exchange system without having to completely replace to existing system. This is a retrofitting technique and because of what has been defined as cost effective for this project, will most likely not be considered.

Flow Diversion Heat Exchangers

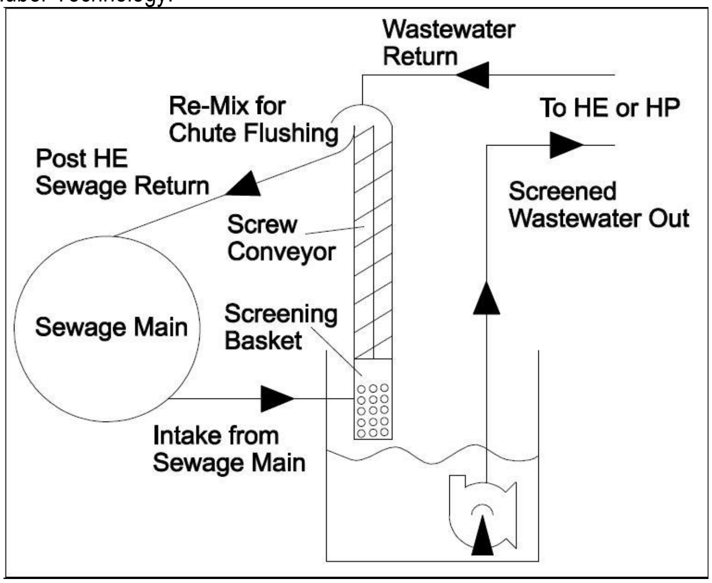
Diverting a portion of the raw wastewater to be used in a heat exchanger is really the only other option for heat recovery. The factors plaguing this idea are how to deal with fouling. In order to divert flow from the main and utilize it in a heat exchanger, there must be some sort of screening process to cut out the large debris that will clog a normal heat exchanger. As there are many different heat exchanger technologies commonly used today, there will not be a discussion on every type; the topic to be covered in detail is wastewater screening. A basic example of a raw wastewater screening solution is shown in **Figure 1.1.**

FIGURE 1.1
Raw Wastewater Screening example.



Huber has developed a scalping mechanism that not only removes solids from the diverted stream, it uses the heat exchanger loop on the wastewater side to flush the removed solids back into the interceptor. The screen removes the solids using a well screen. From there, the solids are elevated via a screw conveyor and are deposited into a chute. The returning wastewater from the heat exchanger is then used to rinse the chute contents back into the interceptor. This system has many benefits. Chiefly, it can be installed in a very small excavation, required to be only as large as a manhole. A line diagram of the Huber technology is shown in **Figure 1.2**.

FIGURE 1.2
Huber Technology.



Comparison of Wastewater to Ambient Air as Heat Sources for Heat Pumps

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DATE: October 27, 2008

PROJECT NUMBER: 352150.D1.36

Introduction

This is technical memo number seven in a series developed to inform the reader on various parts of the Capital Regional District sewage energy reclamation project. The purpose of this tech memo is to inform the reader of the reasons why utilizing wastewater treatment plant effluent as well as raw sewage as a source for heat extraction is preferable to using outside air in a similar fashion.

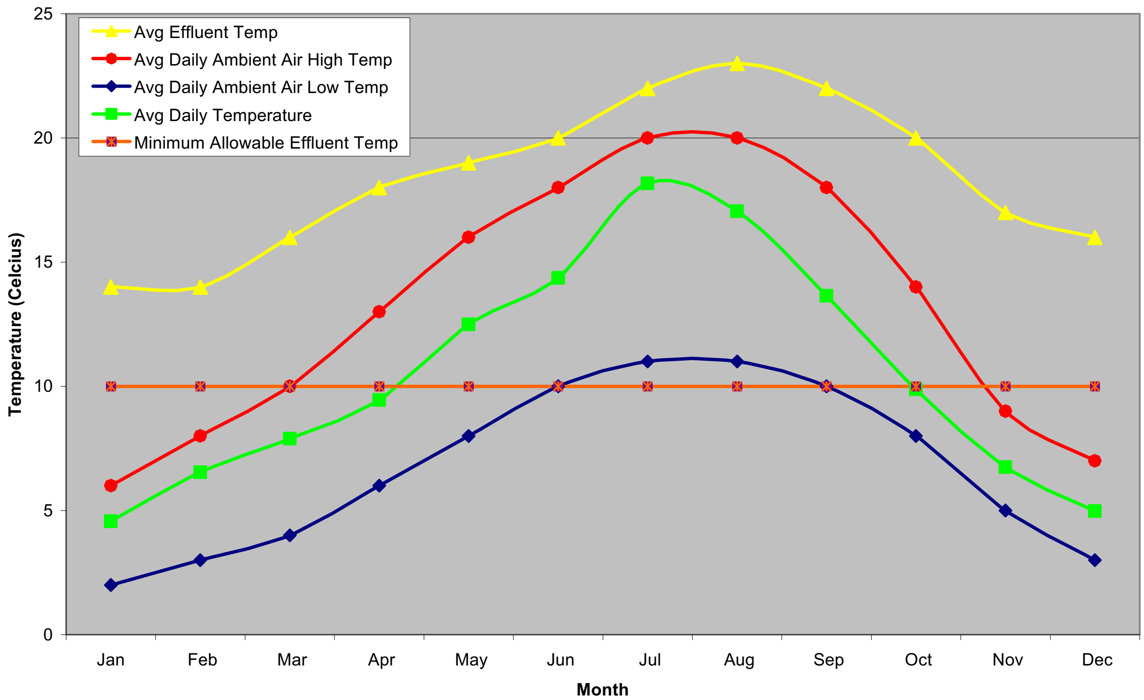
Heat Sources

Under current examination is the idea of utilizing the heat found in wastewater as a source for extracting and generating efficient useful heat by means of a heat pump. Many facilities, such as residential homes, currently have a similar technology that extracts heat from outside air and by means of a heat pump convert it to useful heat. This analysis has been performed to show that the utilization of wastewater is more effective than the method of utilizing outside air.

It is important to note that this analysis utilizes the temperature of the effluent out of a wastewater treatment plant. Given the type of treatment occurring at Macaulay Point, the effluent flow characteristics can be said to directly reflect the influent characteristics. This makes this analysis applicable all along most all of the sewer mains, not just at the plant exit.

Firstly, average temperatures must be analyzed to obtain an idea of the available heat from each different source. **Figure 1** shows these temperatures.

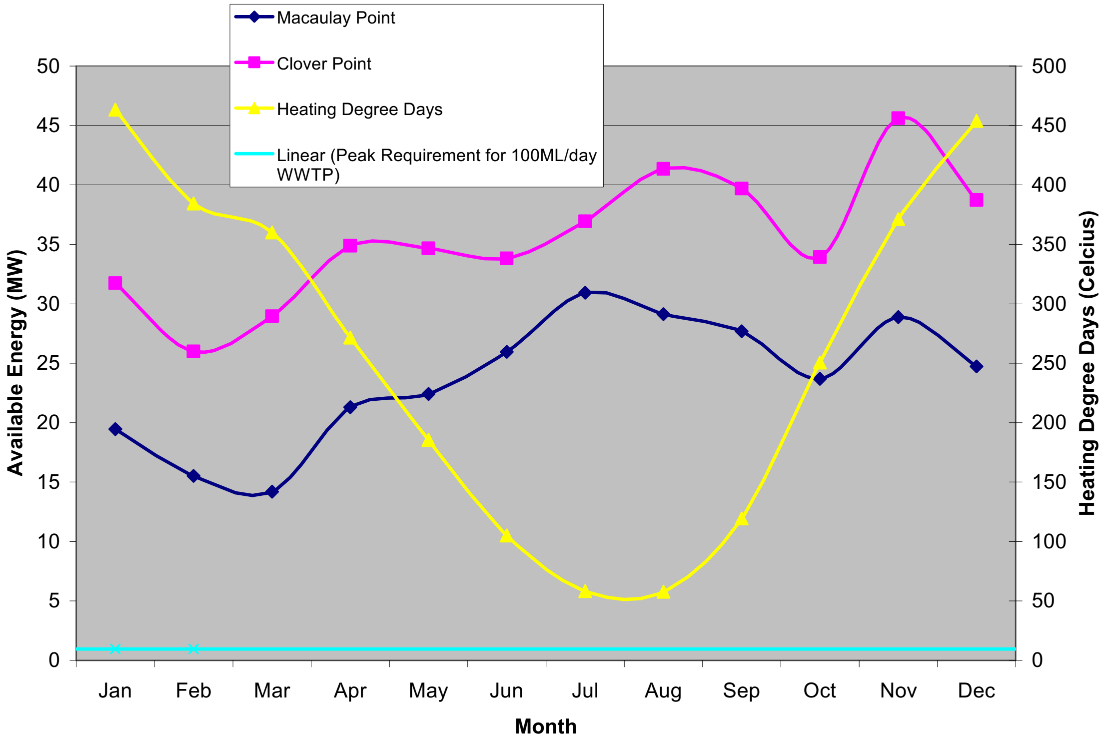
FIGURE 1
Average Monthly Temperatures for Macaulay Point



The graph above shows the high, low, and average outside temperatures for Macaulay Point, as well as the average effluent temperature. It can be seen that the average effluent temperature for every month out of the year is higher than the corresponding outside air temperature. Also on the graph is the minimum allowable effluent temperature. There has been a limit set at 10°C for the wastewater temperature. Simply put, heat extraction can only occur in an amount that will not drop the sewer main below 10°C. This chart shows that in terms of temperature alone, effluent has greater potential as a heat source than outside air. Discussion Paper 031-DP-6, *Heat Recovery*, discusses the temperature boundary.

In order to really get an idea of whether or not the effluent has any real capacity to heat when there is demand. **Figure 2** has been set up to show the correlation between demand, in terms of heating degree days, and waste water supply, in terms of a flow rate.

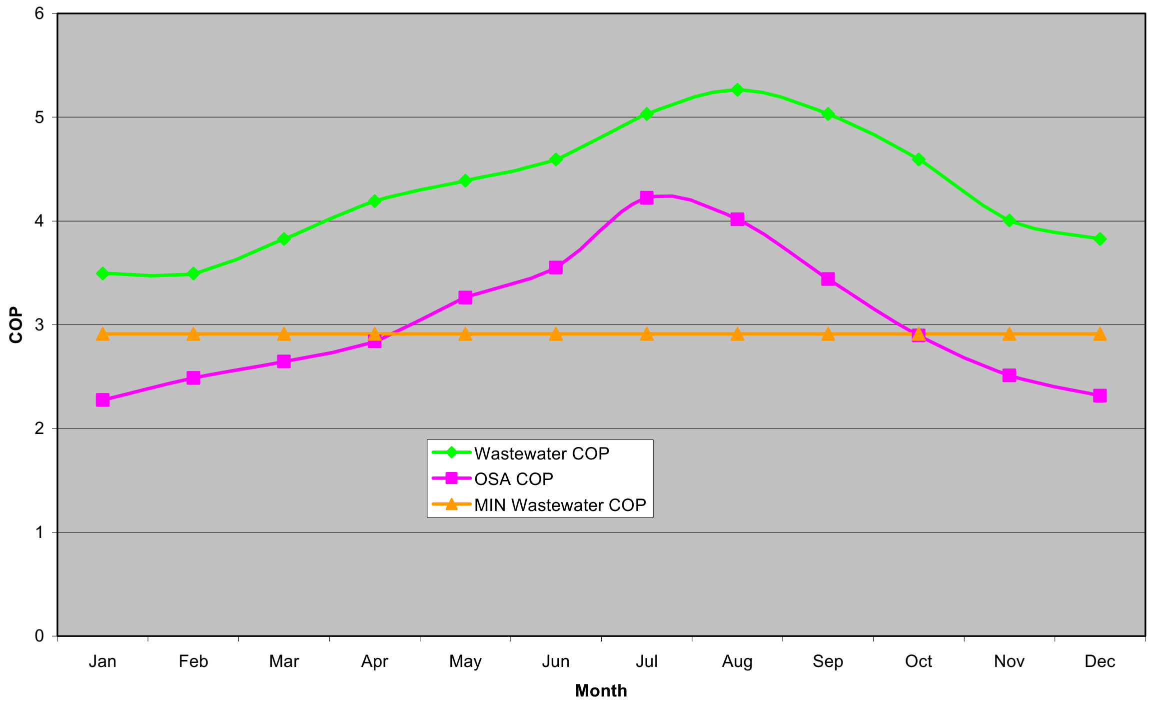
FIGURE 2
Comparison of Heating Degree Days and Available Energy from Effluent in a Year



This diagram shows that at both Macaulay and Clover Points, there is a year round supply of energy that varies at most by 50%. In order to put a scope to the above diagram, the light blue line was added. This horizontal line represents the peak heating load for a wastewater treatment plant the sized to handle the current Clover or Macaulay flows. It can be seen that even after heat has been extract for immediate plant usage, there will be, at all times of the year, multiple Megawatts of energy left over to be utilized elsewhere.

Another criterion for selection is the coefficient of performance, a direct measure of system efficiency. This unit-less factor is calculated by taking the amount of units of useful heat output and dividing by the units of work input. The COP is a function of the type and size of heat pump unit as well as the temperature parameters that it operates under. To do an easy "apples to apples" comparison, a single heat pump was analyzed using the same type and size while varying the heat source temperature to represent the difference between the COP's of an air to water and water to water heat pump throughout the year, shown in **Figure 3**. Also, the heat pump's performance is based on a constant output water temperature of 55°C with a varying incoming source type and temperature.

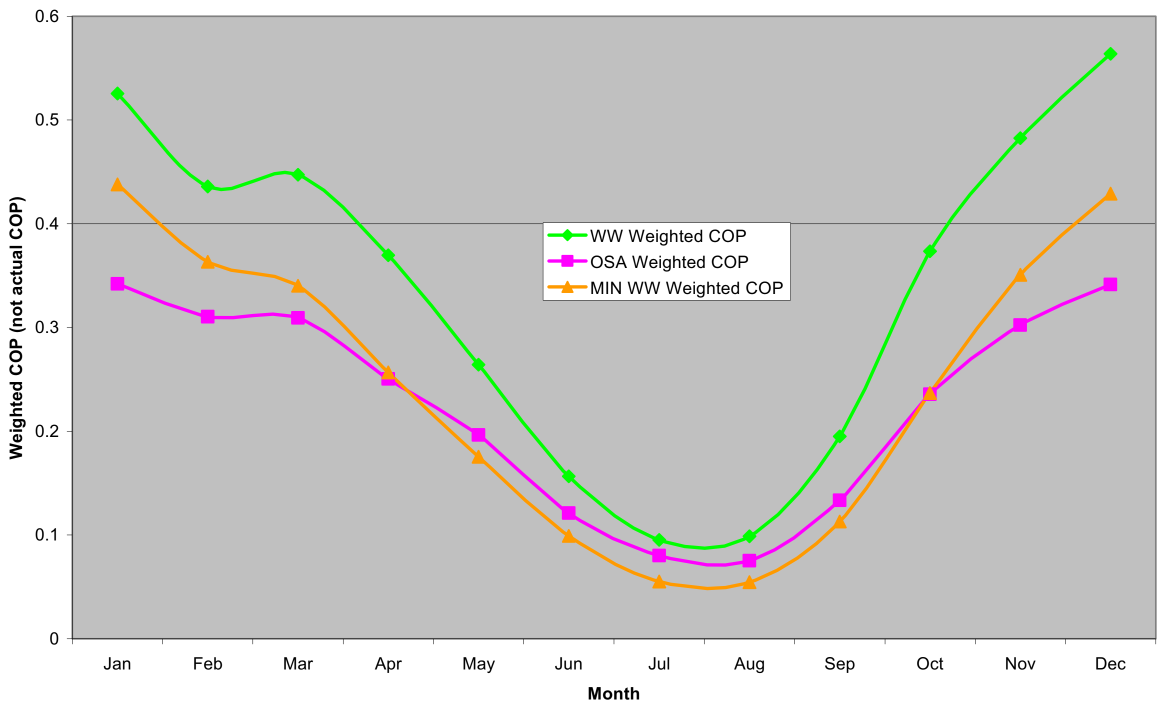
FIGURE 3
COPs of Heat Pumps With Various Heat Sources over an Average Year



This graph shows that the COP of heat pump running on wastewater as a heat source will be higher than the alternative throughout the entire year, most notably during the winter months. This means less energy, which must be paid for, need be applied to reach the same 55°C hot water temperature when using waste water as the heat source. The orange line in the above graph represents the minimum COP of a heat pump running on wastewater that has had the maximum amount of heat removed. As more heat pumps are installed, the waste water return temperatures will drop making it more difficult for pumps further down the line to extract heat. What this graph shows is that in the months where heating is critical, even wastewater at the minimum allowable temperature will yield a COP higher than that of outside air sources.

Figure 3 assumes that a constant load is being delivered at all times of the year this is applicable to facilities such as pools that require heating year round to avoid condensation problems. This is obviously not true for end-users such as space heating for offices and homes which are heated based on occupant comfort levels. In order to factor the demand fluctuation into the equation, a system of "weighting" the COP was developed. By combining the COP for a given month with the proportion of required heating for the same month, found as a percentage of total heating required in a year, a "weighted COP" is produced. **Figure 4** shows the weighted COP's for each month, and **Equation 1** shows the overall performance factor of using wastewater versus air as a heat source.

FIGURE 4
Weighted COPs to Reflect COP Combined With Usage Factor for Space Heating Over a Year



In graph above, the orange line represents a minimum weighted COP for the waste water supply. This is calculated in order to show that even at the minimum allowable waste water temperature, 10°C resulting in maximum lift, the weighted COP of the waste water heat pump is at or above that for air during the months that require heating. It should be noted that this analysis is only prudent for the heavy demand times for heating. It is unlikely that during the summer months, the wastewater stream would be taxed out to the minimum allowable temperature.

Equation 1 shows that the wastewater option performs at 140% of the efficiency seen in an outside air source. This is only a measure of the weighted COP's, it has no parameters of cost or payback, the data shows that you will surely have a more efficient system when dealing with wastewater as a heat source, but cost breakdowns must be done on a case by case basis as there are so many variables involved.

EQUATION 1
Efficiency Equation

Total WW Weighted COP		Total OSA Weighted COP		Overall Weighted Performance Factor
4.01	/	2.87	=	1.40

Conclusions

The data presented in this memo show that, in all areas of examination, the utilization of wastewater as a source for heat reclamation is preferable to the use of outside air. Effluent has been shown to have a higher average temperature year round. Also, the amount of available energy in the effluent shows that there is a vast potential for other uses outside of the specific treatment plants. When taken to an analysis of performance, it can be seen that a wastewater to supply water heat pump will be consistently more efficient year round and up to 1.5 times more efficient in the colder months when the need for heating is at its peak. For all these reasons it is suggested that wastewater be the heat source chosen over an outside air source for the Capital Regional District, British Columbia.

Technical Analysis of Available Heat Exchangers and Heat Pumps

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DATE:	October 27, 2008
PROJECT NUMBER:	352150.D1.36

Introduction

This is technical memorandum number eight in a series developed to inform the reader on various parts of the Capital Regional District sewage energy reclamation project. Thus far it has been established that there is a potential heat source in the wastewater flow and also that there is a need for that energy in buildings located near the main lines. Methods of extracting the heat have been suggested and minimum sizes for the systems have been covered. The purpose of this technical memorandum is to outline the technical specifications along with advantages and limitations of the various heat exchanger types and heat pumps.

Heat Exchanger Technologies

- Plate and frame heat exchanger

  The plate and frame heat exchanger is a widely used application for several reasons. The first is its ability to provide a large heat exchange area within a relatively compact space. Because the fluid is running through ripples in large sheets, and the sheets are thin and can be stacked you can have lots of heat exchanger area in the form of a box that can be added or subtracted from by simply adding plates. Another benefit, more specific to the particular task of heat reclamation from waste water is the ease of cleaning. The plates essentially hang on the frame and during a shut down period can be individually removed and cleaned then remounted. Even with the ease of cleaning this type of heat exchanger must be constructed with large passage areas due to the solids content of the wastewater. This option is available as a standard feature from manufacturers.

- Spiral heat exchanger

  The spiral type heat exchangers are manufactured by simultaneously rolling two strips of heat transfer element around a central core with spacers in between each strip. From the outside, it looks like a large can, but if you remove one cap you can see how the fluids are sent in opposite directions around the core, one incoming from the center and flowing spiral out and the other incoming from the perimeter and flow in a spiral towards the core. These exchangers can be dimensionally adjusted to have lots of heat exchange area either by increasing the overall diameter or height of the cylinder. This type of heat exchanger does not have the ability to be expanded for increased capacity. Once constructed the heat exchange area is fixed. Due to the construction this type of exchanger is exceptionally well suited for handling wastewater and wastewater sludge because of its capacity to pass solids. This style of exchanger is also very easily cleaned. The end plates are easily removed allowing direct access to the exchange surfaces for cleaning.

- Shell and tube heat exchanger
  The shell and tube style heat exchange is constructed by passing multiple parallel tubes through bulkheads in either end of a shell or tank. Tube side liquid passes through the tubes from one bulkhead to another. Bulkhead configurations can allow for multiple passes. The overall relative size of the exchanger is larger than the more compact plate and frame and spiral exchangers. It is difficult to construct these units as a true counter flow making it more difficult to achieve performance at the low differential temperatures anticipated for these systems. Tube cleaning of this style of exchanger is difficult due to the relatively long small diameter tubes.

- Other Heat Exchanger Types
  For this tech memo, the “other” category will represent all heat exchangers such as gravity film exchangers that have been examined and found incompatible for the processes in question due to limitations of capacity, performance or inability to handle solids content.

- Materials of Construction
  Regardless of the technology, the heat exchanger materials must be able to withstand the corrosive nature of the working medium. The raw wastewater and treated plant effluent can very aggressive against metals. The standard materials of constructions may be insufficient to resist the corrosive attack. In these heat exchanger applications it is assumed that the heat exchange surfaces be stainless steel or a similar material.

The heat exchanger technology recommended for this project is the large passage plate and frame type. The compact size, performance and ease of expandability and cleaning make it the preferred option. In addition these types of heat exchanges are available in suitable materials of construction as factory standard options.

Heat Pump Technologies

There are three basic types of heat pumps based upon the type of compressor technologies used. These are reciprocating, screw and centrifugal compressors.

- Reciprocating Compressor Heat Pumps
  The reciprocating style compressors for HVAC applications are typically small in size. They achieve a much lower performance than the other technologies and have the highest capital cost of installation per unit of capacity. The limited size and low

efficiency of these systems makes them economically unfeasible for the total heating capacity anticipated for this project.

- Screw Compressor Heat Pumps
  The screw style compressors for HVAC applications are usually a mid-range size. They typically can handle a much higher compressor ratio and therefore can operate across much higher lift temperatures. This makes the screw compressor much less sensitive to changes in operational temperatures. This style of compressor is also capable of capacity modulation even when operating at or near maximum temperature lift conditions. The overall efficiency of this style of compressor is surpassed only be the centrifugal style compressor.
- Centrifugal Compressor Heat Pumps
  Centrifugal compressor heat pumps for HVAC applications are usually the largest in size. This compressor technology relies on dynamic compression rather than positive displacement. This makes the centrifugal compressor much more sensitive to changes in operational temperatures. Due to the nature of this style of compressor it is least capable of capacity modulation especially when operating at or near maximum temperature lift conditions. The overall efficiency of this style of compressor is the highest.

The heat pump technology recommended for this project is screw style as the primary technology with centrifugal technology secondary for large installations and those with high baseline loads. It is recognized that these facilities will have to be constructed in a phased sequence. The small initial size and potential for large modulation requirements makes screw technology a requirement as least in the initial phases of the construction. As the facilities expand such that the newly added components represent a smaller portion of the overall capacity or where installations have a high baseline load a centrifugal machine may be added where it is allowed to operate continuously at full load with the required modulation taken up by a screw machine.

Viability of Using Raw Wastewater or Plant Effluent for Space Cooling

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PROJECT NUMBER: 352150.D1.36

Introduction

This is technical memo number nine in a series developed to inform the reader on various parts of the Capital Regional District wastewater energy reclamation project. This memo considers the viability of the incorporation of heat rejection for space cooling within the current heat recovery schemes.

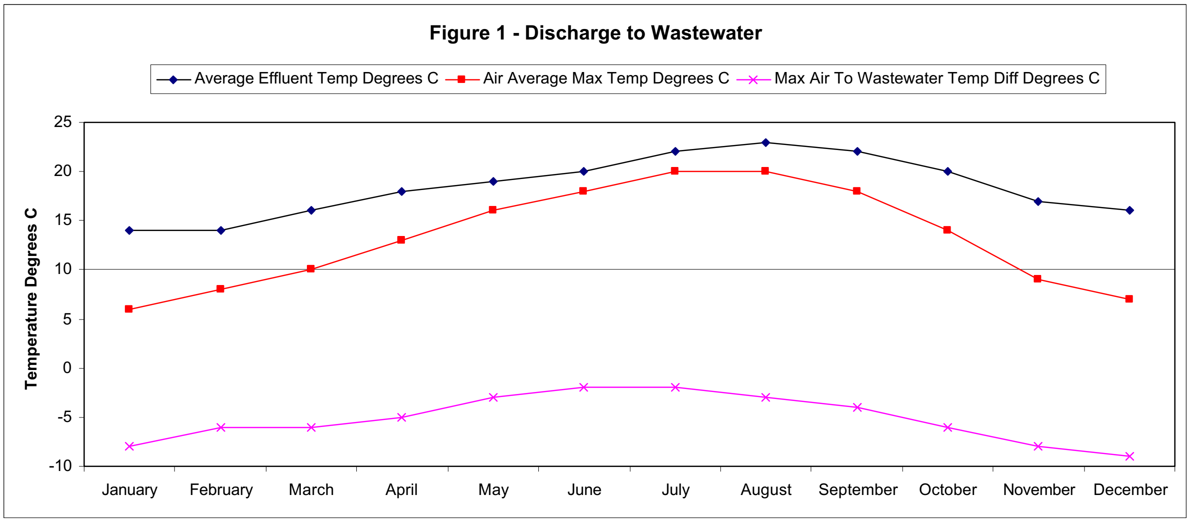
Background

The efficiency or COP (coefficient of performance) of a heat pump or chiller is a function of the lift temperature against which it is working. This temperature is the difference between the inlet temperature from the cold reservoir and the outlet temperature to the hot reservoir. In the case of cooling we will assume that the cold side is at a constant temperature. Therefore the COP is only dependent on the temperature of the hot reservoir. In our comparison we will look at a cooling system consisting of a chiller discharging heat directly to the ambient air (dry cooler) common for most small cooling applications, with a chiller discharging to wastewater and intermediate water loops connected to wastewater.

Rejection of Heat Directly to Wastewater

Since it is not technically viable for a system of this type to use the wastewater directly, we will consider the theoretical case where the rejection occurs to a water loop operating at the same temperature as the wastewater. Since most cooling demand occurs during the peak ambient temperature of the day, the temperature of the wastewater is compared to the temperature of the average daily maximum air temperature for each month. These results are shown in Figure 1. The negative differential indicates that the rejection of heat to the wastewater stream is less advantageous than rejection to the ambient air (reference 031-DP-6, *Heat Recovery*).

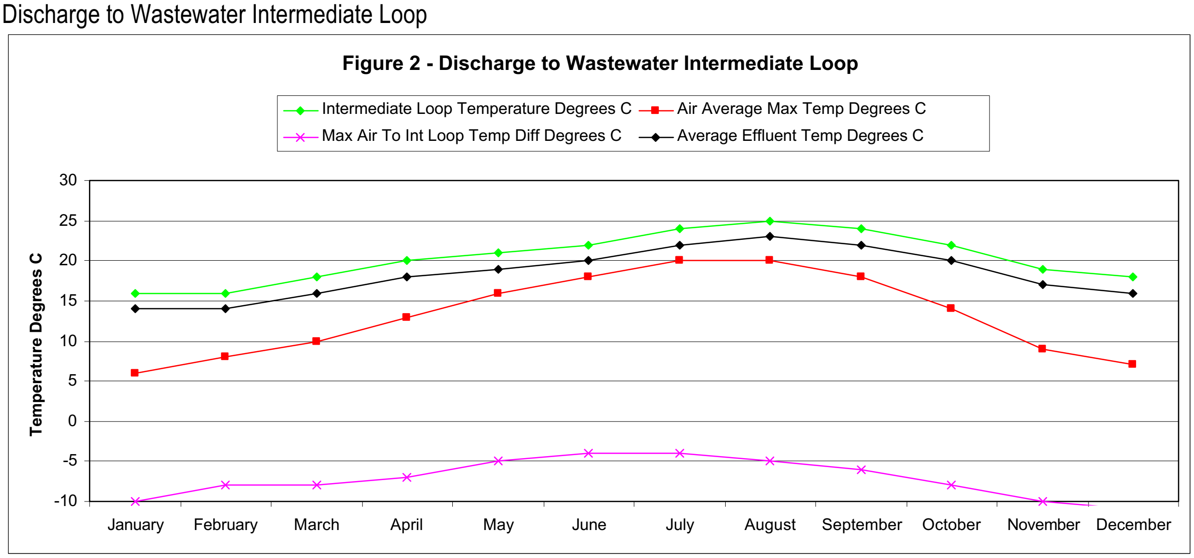
FIGURE 1
Discharge to Wastewater



Rejection of Heat to Wastewater Through an Intermediate Loop

We next consider the case where the rejection occurs to an intermediate water loop coupled to the wastewater through a heat exchanger. Since most cooling demand occurs during the peak ambient temperature of the day the temperature of the intermediate loop is compared to the temperature of the average daily maximum air temperature for each month. The loop temperature is assumed to be 2 degrees C above the wastewater temperature to allow for heat transfer to the wastewater. These results are shown in Figure 2. The negative differential indicates that the rejection of heat to the intermediate loop is less advantageous than rejection to the ambient air.

FIGURE 2
Discharge to Wastewater Intermediate Loop



Rejection of Heat to Intermediate Loop at Heat Pump Discharge

We next consider the case where the rejection occurs to an intermediate water loop at the discharge of a heat pump coupled to the wastewater through a heat exchanger. See Figure 3 for this system configuration. Since most cooling demand occurs during the peak ambient temperature of the day the temperature of the intermediate water loop at the heat pump discharge is compared to the temperature of the average daily maximum air temperature for each month. It is assumed that the magnitude of the cooling heat flow is less than the heating demand of the heat pump system. Therefore, the intermediate loop high temperature is assumed to be 2 degrees C below the wastewater temperature to allow for heat transfer from the wastewater to the heat pump. With the heat pump in operation the intermediate loop heat pump discharge temperature is assumed to be 5 degrees C below the intermediate loop high temperature. These results are shown in Figure 4. The positive differential values indicate that the rejection of heat to the intermediate loop is more advantageous than rejection to the ambient air.

FIGURE 3
System Configuration

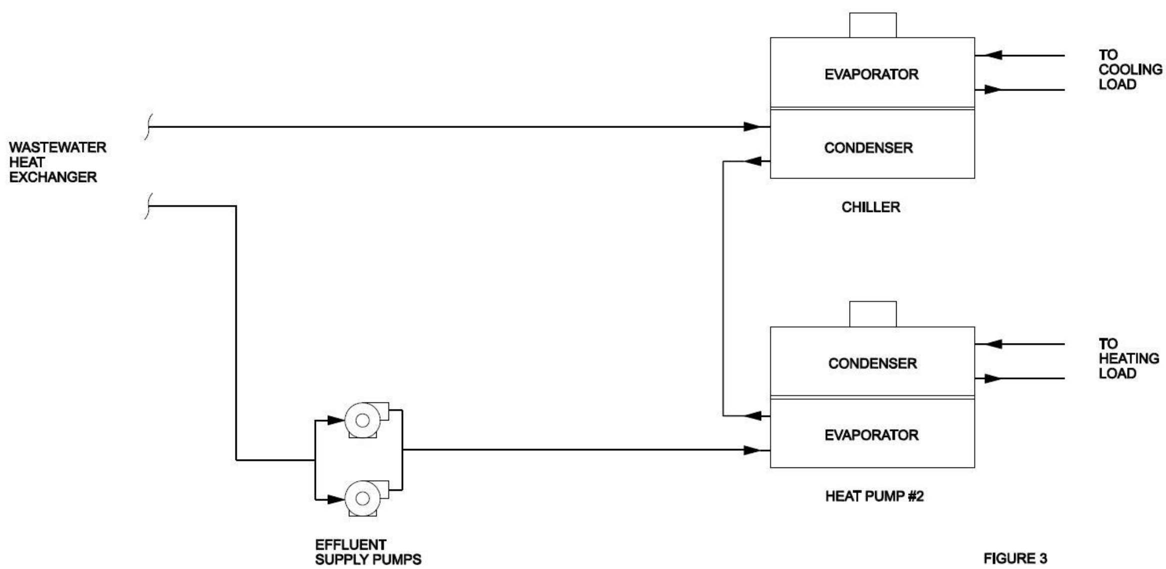
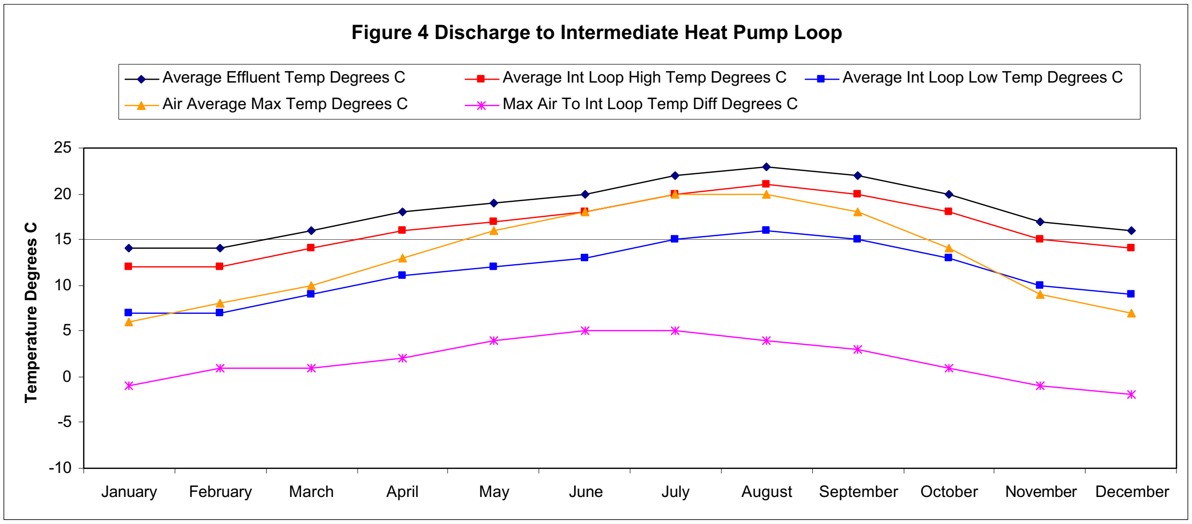
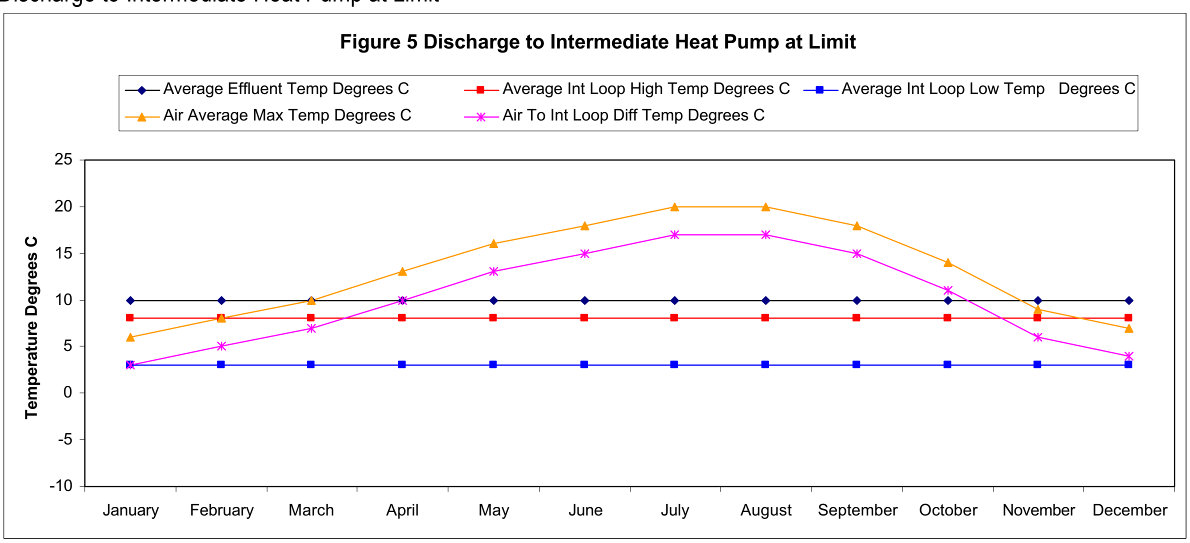


FIGURE 4
Discharge to Intermediate Heat Pump Loop



As the recovery of heat from the wastewater is increased its temperature is reduced. As this temperature is reduced the resulting intermediate loop temperatures are also reduced. This continues to increase the differential temperature up to the point of the limit temperature of 10 degrees C. The case of fully maximized heat recovery is shown in figure 5. The wastewater is assumed to be at the limit temperature of 10 degrees C continuously.

FIGURE 5
Discharge to Intermediate Heat Pump at Limit



Conclusion

The rejection of cooling heat to wastewater appears to be viable only when coupled with the operation of a heat recovery facility. Favorable results would be achieved only when the relative heat recovery demand is continually larger than the cooling demand. This is anticipated to occur only as the heat recovery facilities are fully developed or when very large demands or those with large summer baseline demands for heating such as a natatorium complex can be connected at the initial operation of the facility. Therefore cooling heat rejection would have to be considered on a case by case basis during the actual design of the individual facilities. For the purposes of the Triple Bottom Line analysis, cooling will not be included as an integrated resource available from wastewater.

Appendix B - Projecting Energy Demand for the Core Municipalities in 2020 and 2065

Technical Memo

Capital Regional District
Core Area Wastewater Management Program
Projecting Energy Demand for the Core Municipalities in 2020 and 2065

Prepared for: John Spencer
Prepared by: Rahul Ray MRM., David Harper PhD., Steve Young MEns.
October 24, 2008

Objective

The Capital Regional District (CRD) is implementing a wastewater management strategy that will involve wastewater conveyance, treatment, reuse, and disposal. Community leaders and members of the public have identified wastewater energy recovery as an important consideration in the planning, siting, and implementation of a wastewater management strategy.

In order to better understand the energy reuse opportunities that may exist in the CRD, the level of anticipated demand for energy needed to be estimated. WRG Westland Resource Group Inc. ("Westland") was tasked with projecting energy demand for the CRD study area in the 2020 and 2065 timeframes for the municipalities of Colwood, Esquimalt, Langford, Oak Bay, Saanich, Victoria, and View Royal (Map 1). Sufficient information was collected to allow the relative energy demand to be compared for different portions of the study area. At a later stage of the project, demand was compared with potential energy supply.

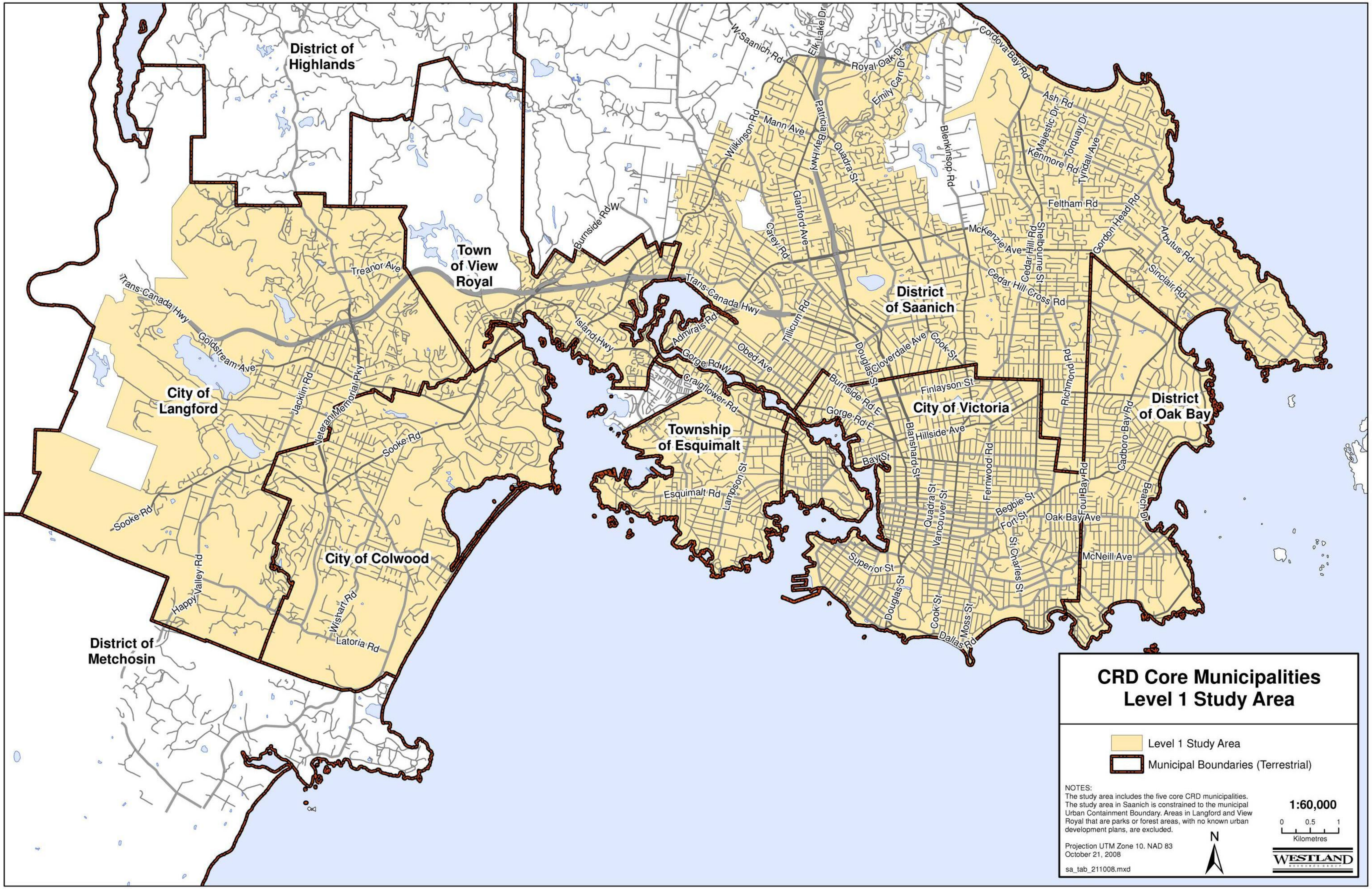
The Project estimated energy demand was projected for relatively large areas, not individual land parcels. Further effort would be needed to confirm energy demands for specific land parcels.

The objective of this technical memo is to outline the steps taken to develop estimates of energy demand for areas in the core municipalities in the 2020 and 2065 time frames, and to summarize results of the analysis. The tables identified in this document are located at the end of the memo.

Energy Demand Projections

The process developing 2020 and 2065 energy demand estimates for the core area involved three main phases, Information Collection, Floor Area Calculation, and Energy Demand Projection. The activities conducted in each of these phases, assumptions made, and the supporting tasks are described in the remainder of this report.

MAP 1
Level 1 Study Area



Phase 1: Information Collection

Intent. The intent of the Information Collection phase of the Project was to provide a better understanding of existing and planned land uses in the study area. The land use information collected during this phase supported the development of Floor Area Ratios (FARs) to which energy demand factors could be applied.

A FAR is a measure of development density, presented as the area of buildings relative to the size of the land parcel. If a 1,000 m^2 building is one story high, and covers an entire land parcel of 1,000 m^2, the parcel has a FAR of 1.0. If a building with a floor area of 250 m^2 is built on a 1,000 m^2parcel, the parcel has a FAR of 0.25. A four-story building with a 250 m^2 footprint n the same 1,000 m^2parcel, results in a FAR of 1.0.

The Westland Project team had collected land use information during a previous component of the CRD wastewater management strategy. This work involved discussions with planners and representatives from the City of Colwood, CRD, Department of National Defence (DND), District of Oak Bay, District of Saanich, Juan De Fuca Recreation Centre, Queen Alexandra Foundation, Royal Roads University, Town of View Royal, and the University of Victoria. The results of this earlier data collection were expanded and refined to support energy demand estimation.

Task 1. Gather Official Community Plans (OCPs), CRD Regional Growth Strategy (RGS), and zoning bylaws. An OCP builds on the input of community members, municipal staff, and consultants to create a broad strategy to direct growth, servicing, and development in a municipality. In the study area, the seven municipalities have OCPs to guide community growth. The Project team downloaded the most current versions of the OCPs at the time of data analysis from municipal websites. The acquired documents included:

- City of Colwood Draft OCP, April 17, 2008
- City of Langford Final Draft OCP, April 17, 2008
- City of Victoria, 1995, OCP map last updated September 26, 2005
- District of Saanich OCP, July 2008
- District of Oak Bay OCP, Consolidated to June 11, 2007
- Town of Esquimalt OCP, March 19, 2007
- Town of View Royal OCP, Consolidated to November, 2007

Information was requested from the Department of National Defense (DND). According to DND representatives, a Master Realty Asset Development Plan (MRADP) process has been initiated for DND lands, noting that a MRADP is similar to an Official Community Plan. The MRADP being developed is in the very early stages and is scheduled for completion and endorsement in May 2009. As a result, information on planned land uses on DND lands for this Project is limited.

The Westland team was familiar with the University of Victoria and the Royal Roads University Campus Plans through a previous phase of the CRD wastewater management strategy.

The CRD RGS was also reviewed for relevant information. According to the CRD RGS, "a regional growth strategy is an agreement, developed and approved by the member municipalities and the regional district in partnership, on social, economic and environmental goals and priority actions."

Digital OCP information in the form of shapefiles was requested from each of the municipalities. Geographic Information System (GIS) coverages were received from the District of Saanich and District of Oak Bay. Computer Aided Drawing (CAD) files were received from the City of Victoria, Town of Esquimalt, and Town of View Royal. Westland GIS staff digitized the OCP maps for the City of Colwood and City of Langford.

The digital OCP information gathered from municipalities presented information in a variety of ways. Some OCPs used parcels to designate their planning objectives, whereas others used neighbourhoods and less formalized boundaries. In developing a consolidated OCP layer, Westland applied municipal OCP information to parcel boundaries. This approach allowed the more commonly measured and understood Net Floor Area Ratios to be used in existing neighbourhoods, and Gross Floor Area to be used in undeveloped areas. Net Floor Area Ratios exclude roads, sidewalks, and other non-parcel features in the landscape, and Gross Floor Areas included these features.

With these processes and assumptions in place, Westland mapped the OCP designations for each of the seven municipalities.

Task 2. Plan review. Members of the Westland team reviewed the OCPs and the RGS to determine existing land uses and anticipated development patterns in each jurisdiction.

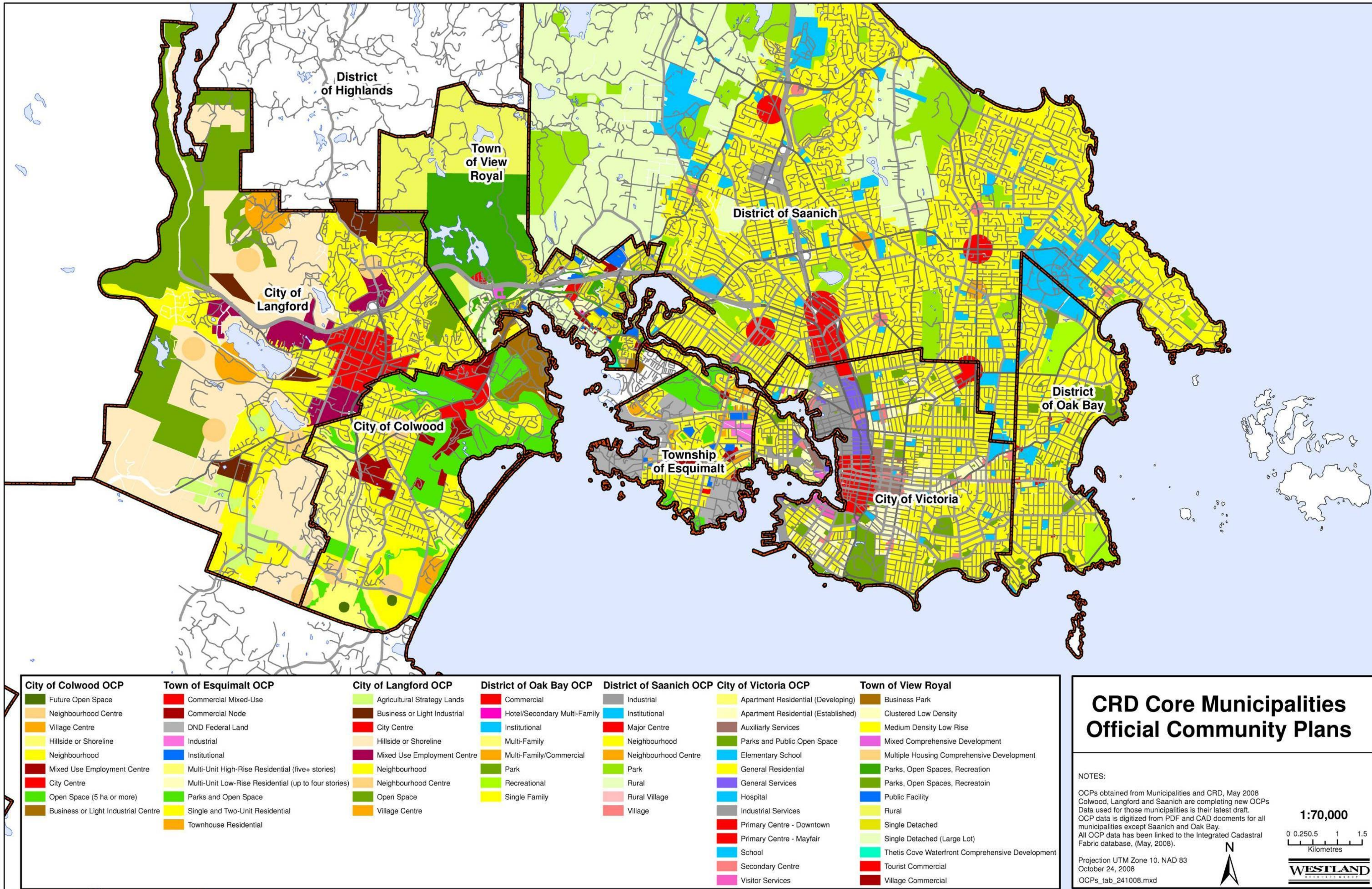
The team reviewed the land use designations that had been used by each of the seven core municipalities in their OCPs. The intent of each land use designation was noted, including the form and density of existing and expected development. The land use designation and description of each land use zone in the core municipalities was recorded (Table 1). In total, the seven core municipalities used 71 distinct land use categories in their OCPs (Map 2).

Some of the OCPs reviewed have been recently updated. The updated OCPs from Saanich, Esquimalt, Colwood, and Langford reflect the concept of nodal development, or focusing population growth, infrastructure development, and services in concentrated areas.

For this Project, FARs are used to estimate the building area that requires energy, either for heating or cooling. Where FAR data were available in the OCPs, the information was recorded for further use in energy calculations.

Task 3. Examine municipal land use bylaws. The zoning bylaws for the municipalities were examined to determine the kinds of activities permitted in relevant land use designations. Bylaws from some municipalities also defined maximum FARs.

MAP 2
Core Municipalities Official Community Plans



Task 4. Assessed typical residential dwelling sizes. Municipal bylaws provided some information on maximum FARs for detached residential dwellings, but FARs were generally unavailable for detached residential areas. To fill gaps these data gaps, current real estate information was gathered from the Multiple Listing Service (MLS). For each detached dwelling, the MLS listing provides the interior floor space and the land size. The interior floor space was divided by the parcel size to generate an FAR. For each municipality, Westland obtained the MLS listings for houses for sale at on May 15, 2008. FARs were calculated for the two lowest priced houses, two middle priced houses, and the two most expensive houses on the list. Overall, the average of the FARs for the median priced detached dwelling in each municipality was 0.31 (Table 2).

Phase 2: Floor Area Ratio Calculations

The intent of this study was to develop “broad brush” energy demand estimates across the study area in the 2020 and 2065 time frames. CH2M Hill project leaders sought land use designations that would allow energy demand comparisons throughout the study area using readily available and reliable data.

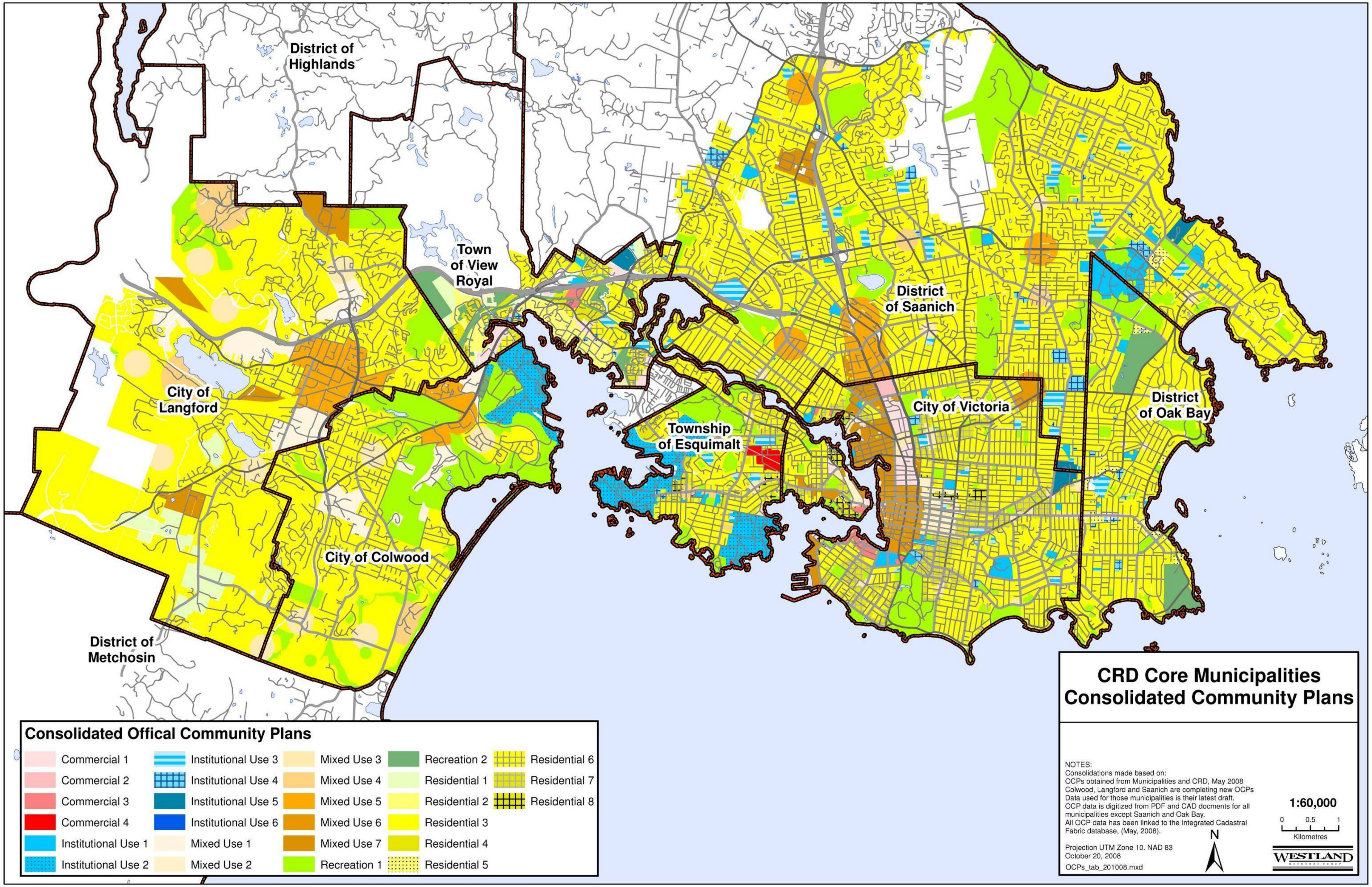
Task 5. Develop and apply uniform land use classifications for the study area. The project team agreed to use the land use designations in the seven Core Area OCPs as a basis for determining energy reuse opportunities. Using the process developed in previous tasks, Westland formulated 27 land use categories (Table 3). The 71 land use designations contained in the seven OCPs were reclassified into these 27 land use categories (Table 4) and (Map 3).

Task 6. Develop 2020 FARs. Based on information collected through the review of OCPs, zoning bylaws, ortho photos, and local experience, preliminary FARs were developed for each of the land use categories.

The Project team applied FARs to the 27 land use classifications. In some cases, the FARs were applicable in all parts of the study area. In other cases, however, the form, size, and development density of specific land use classifications differed from one municipality to another. For example, the “Residential 3” category was initially given a FAR of 0.31. After further examination, we found that residential FARs varied dramatically. Some municipalities experienced a trend toward larger houses on small lots, and thus a higher FAR. Other areas showed the opposite trend, with increasing lot sizes resulting in lower FARs. Additional land use FAR classes were developed to reflect these local conditions.

MAP 3

Consolidated Official Community Plans



Task 7. Review BC Assessment Authority data review. The BC Assessment Authority collects floor area information for some types of businesses. This information was used to confirm FARs and to fill data gaps. Partial information was obtained for the study area and FAR values were generated using parcel information. These FARs were compared with projected FARs, and in most cases found to have a high level of agreement.

Task 8. Review ortho photos. Orthophotos were reviewed to reliability of the land use designations in reflecting on-the-ground conditions. Building sizes and land parcel sizes were measured and the number of storeys recorded. FARs were generated and reviewed against the sample of FAR projections.

Task 9. Review population projections for 2015, 2045, and 2065. CRD staff provided population estimates for the 2015, 2045, and 2065 time periods (Table 5). Two projection scenarios were applied—one based on a low rate of population growth and one based on a higher growth rate.

Although the population growth rates and total population estimates differ between the two scenarios, both suggest dramatic population growth in the West Shore communities of View Royal, Colwood, and Langford. More modest growth is projected in 2020 and 2065 in Oak Bay, Esquimalt, Saanich, and Victoria.

Task 10. Develop FARs for 2065. The study team developed preliminary 2065 FARs by increasing 2020 FARs values to reflect expected population growth and the timing of new development.

Task 11. Conduct meetings with municipal planners and major institutional land holders. Telephone contact and then face-to-face meetings were held with planners from each of the seven core municipalities, and representatives from Royal Roads, University of Victoria, and Department of National Defence. Discussions with the following key informants occurred:

- Tracy Corbett, Manager, Regional Planning, CRD,
- Nigel Beatty, Director, Building and Planning, District of Oak Bay,
- Barbara Snyder, Director of Development Services, Township of Esquimalt,
- Mark Hornell, Manager, Community Planning Division, City of Victoria, and Steven Gauley, Senior Planner, City of Victoria,
- Matthew Baldwin, City Planner, City of Langford,
- Sharon Hvozdanski, Supervisor of Strategic Planning, District of Saanich,
- City of Colwood Development Review Committee Members, including John Munn, Michael Baxter, and Alan Haldenby,
- Neil Connelly, Director, Campus Planning and Sustainability, University of Victoria,

- Lindsay Chase, Town of View Royal, Director of Development Services,
- Marcel Gingras, Base Development Engineer, CFB Esquimalt,
- Greater Victoria Harbour Authority
- Discussions were also previously held with representatives from Royal Roads University during an earlier phase of the CRD wastewater treatment project. The meeting included discussion of the Royal Roads Campus Plan, development concepts, and existing land use designations.

In each of the discussions with the key informants, the Project team outlined the process that was used to develop the preliminary FARs for 2020 and 2065, including the translation of OCP and bylaw information, reclassification, and FAR development. Maps presented to meeting participants included:

- Land use classifications based on each municipality's OCP,
- Land use reclassification map, showing the 27 new land use classification for the entire study area,
- Preliminary 2020 FAR map,
- Preliminary 2065 FAR map.

Key outcomes of the discussions included:

- Confirmation of the assumptions that had been made with respect to the OCP designations,
- Review and confirmation of FARs that had been used in the representative's municipality for 2020 and 2065,
- Revision of map-based land use polygons reflecting expected growth in 2020 and 2065,
- Identification of potential development areas, and the expected density,
- Identification of areas that could experience re-development that is not reflected in OCPs or other development plans.

Task 12. Revise FAR estimates for 2020 and 2065 based on discussions with key informants. The discussions with key informants were useful in refining the 2020 and 2065 FARs for each municipality. At the conclusion of the discussions with key informants the 27 land use categories were further refined to reflect the local conditions of each municipality. For example, "Residential 3" was subdivided into "Oak Bay Residential 3", "Colwood Residential 3," and other Residential 3 categories for each municipality. At the conclusions of this stage, 90 land use categories had been defined (Table 6).

Discussion with planners identified areas that required further investigation and further refinement. The Westland team examined these areas and revised land use designations and FARs after reviewing plans and ortho photos. These refinements are included in FARs presented in Table 7, which is based on the GIS spreadsheet that supports Task 13.

Task 13. Preparation of 2020 and 2065 FAR maps: Maps of the FAR values revised through discussions with key informants were produced (Map 4 and Map 5).

Phase 3: Energy Demand Projection

Intent: The intent of this phase of the analysis was to develop energy demand values for the 90 land use designations that had been developed through Tasks 1 through 13.

Task 14. Develop energy demand values for specific land uses. Energy use values were provided by CH2M Hill for five building types:

- education,
- office,
- health care,
- retail trade, and
- residential.

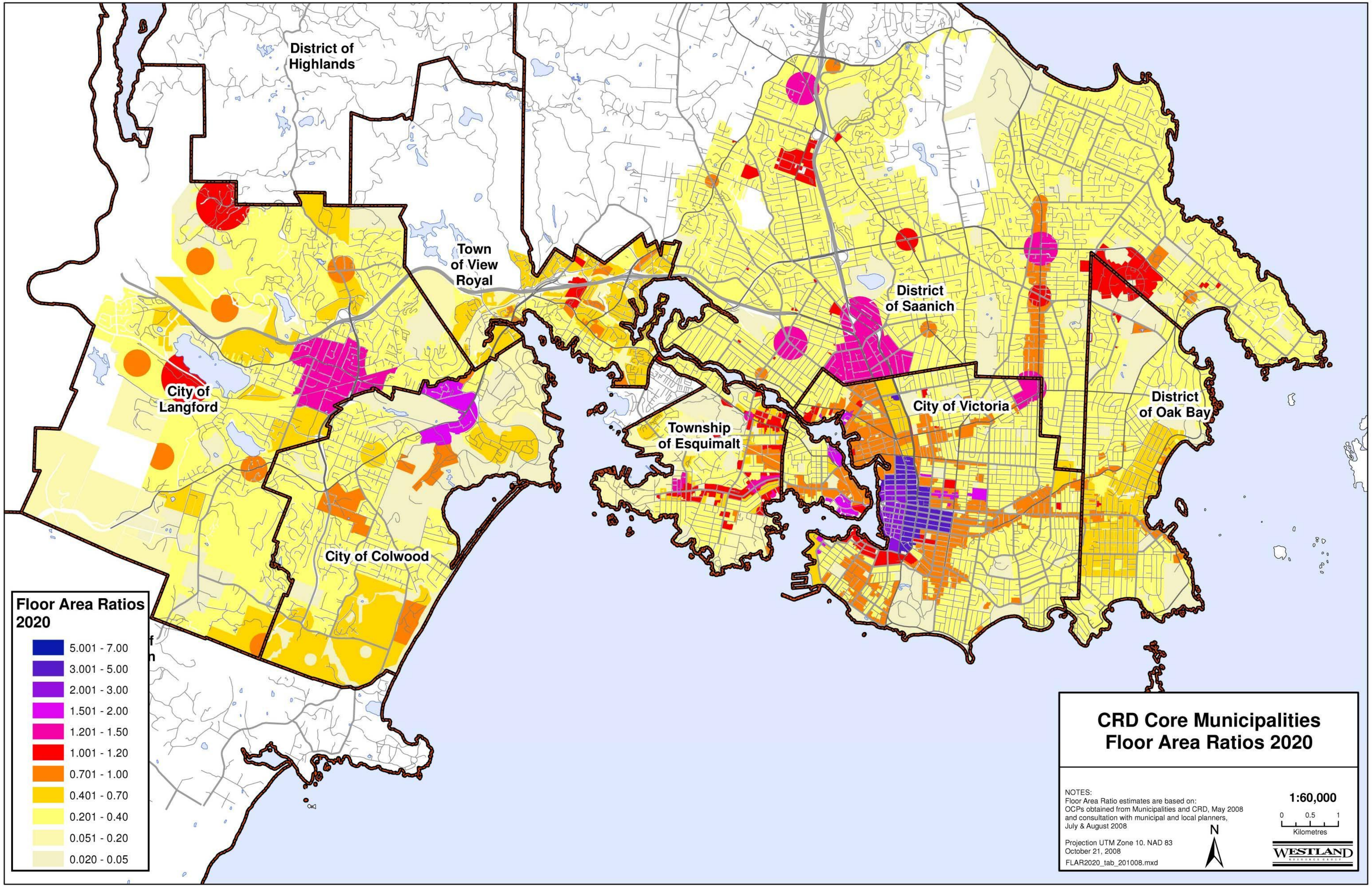
For each of these five land use types, energy demand values were provided for space heating, water heating, and space cooling, measured as megajoules per square metre per year ($MJ/m^2/yr$) (Table 7).

Table 15. Assign energy use values to land use designations. For each land use polygon, the energy FARs were multiplied by the energy demand factor. The calculated energy values were assigned to each of the land use designations identified in Task 12.
If the land uses in a specified area were uniform (e.g., residential), then a single energy value could be applied. For mixed use areas, the energy values reflect the proportional area of each land use in the polygon. For instance, if an area is 50% office and 50% residential, these proportions would be reflected in the calculation of energy demand.

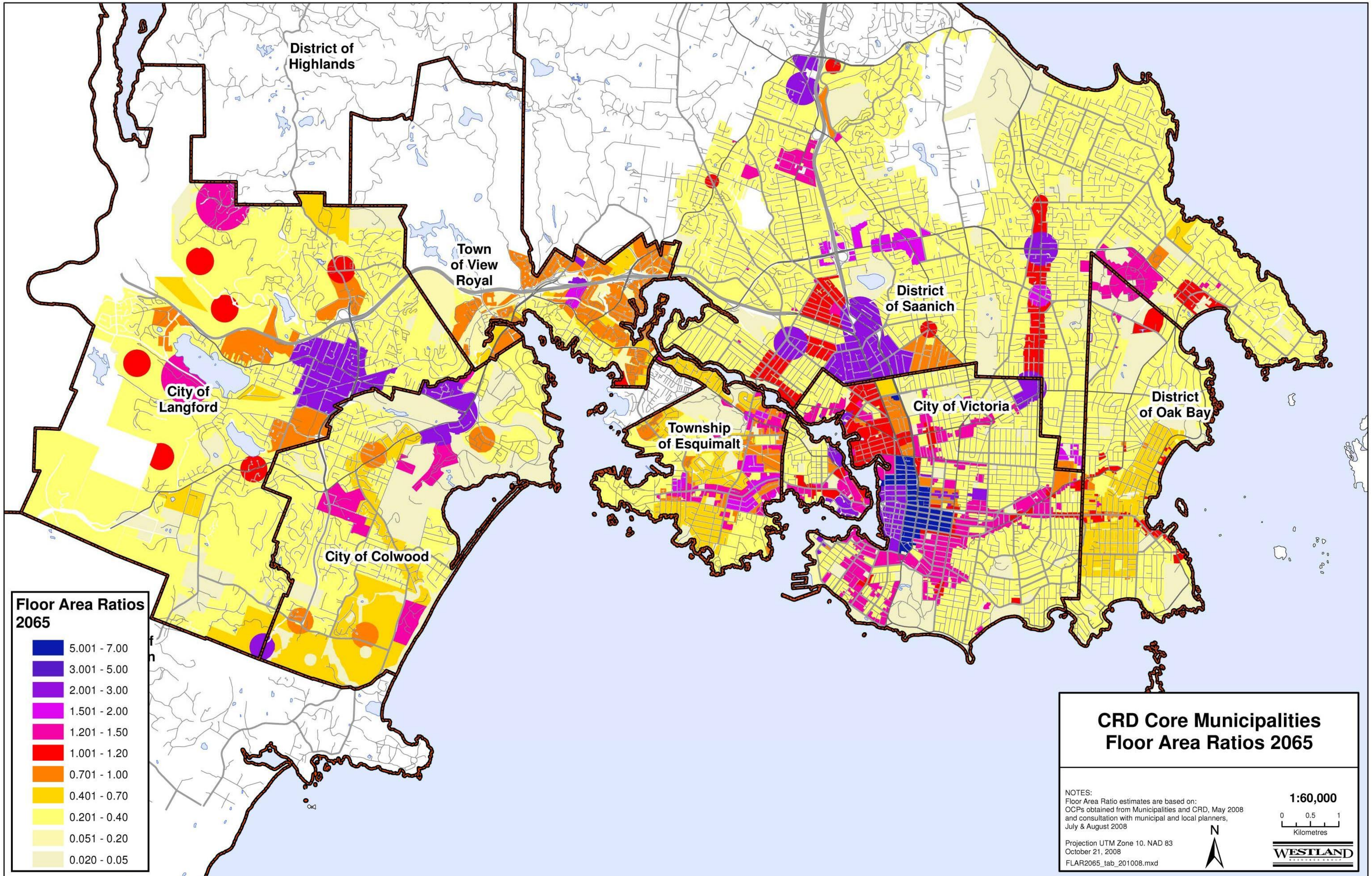
Table 16: Develop energy use map for 2020 and 2065. The energy demand values derived in Task 15 were mapped for the study area as GJ/ha/year (Map 6 and Map 7) and summarized in Table 8.

MAP 4

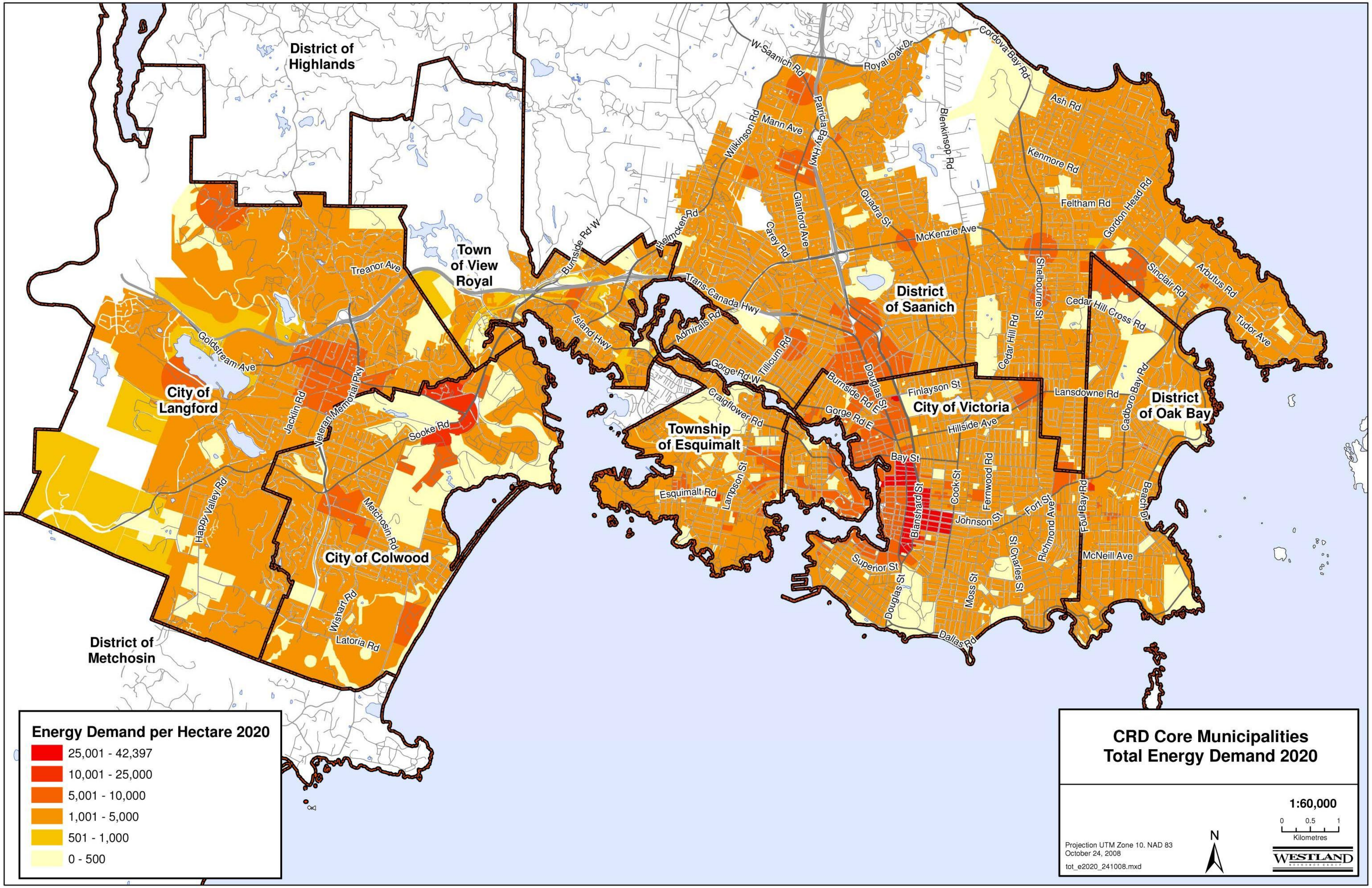
Floor Area Ratios 2020



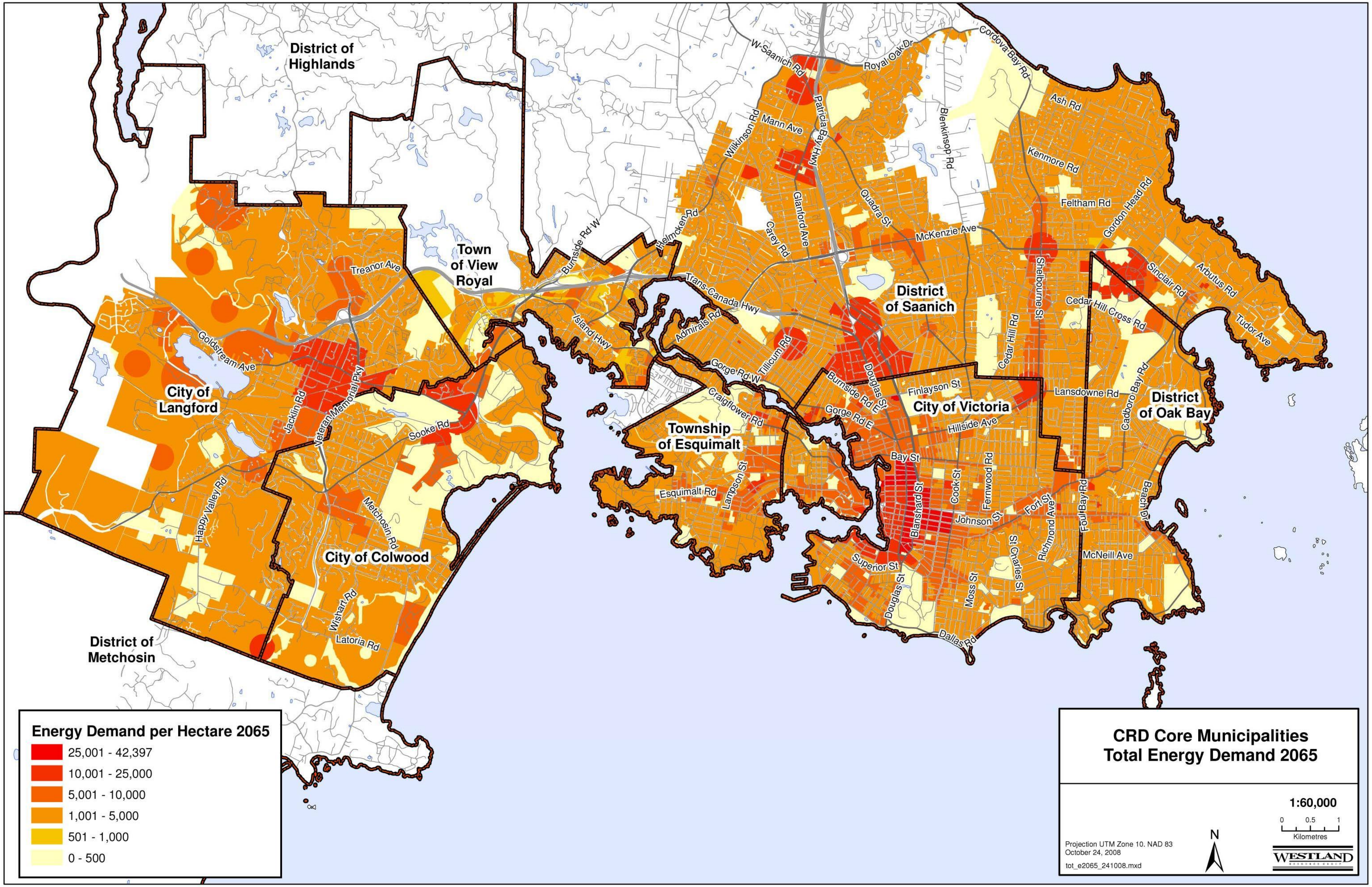
MAP 5
Floor Area Ratios 2065



MAP 6
Energy Demand 2020



MAP 7
Energy Demand 2065



Tables

TABLE 1
OCP Land Use Designations
Colwood OCP

Municipality	Designation	Note
Colwood	City centre	A major regional growth centre that supports a wide range of high density housing, including affordable and rental housing, major employment area for institutional, office, commercial, and light industrial uses.
Colwood	Village centre	Predominately residential precinct that supports a wide range of high and moderate density housing, including affordable and rental housing. A key location for shopping, services, amenities and others.
Colwood	Neighborhood centre	Predominantly residential precinct that supports a range of medium density housing, including affordable and rental housing. This area allows for residential and mixed-use commercial intensification of streets that connect centres and or are serviced by transit.
Colwood	Mixed-use employment centre	A predominantly workplace precinct that includes businesses of all types including commercial, accommodation, institutional, and light industrial. Schools, community facilities, and other institutional uses also define neighborhood centres
Colwood	Business or light industrial	Maintain a long-term supply of employment lands. Develop and maintain an inventory of commercial and industrial floor space and remaining capacity to ensure that an adequate supply of employment lands is maintained.
Colwood	Neighbourhood	Predominantly residential precinct that supports a range of medium density housing, including secondary suites. Allows for residential and mixed-use commercial intensification of streets that connect centres, and/or are served by transit. Retail serving local residents is encouraged along transportation corridors.
Colwood	Hillside or shoreline	Predominantly residential precinct that supports a range of low and medium density housing choices including secondary suites.
Colwood	Open Space and Future Open Space	Private and public linked open space of 5 ha or more

TABLE 1
OCP Land Use Designations
Colwood OCP

Municipality	Designation	Note
Colwood	City centre	A major regional growth centre that supports a wide range of high density housing, including affordable and rental housing, major employment area for institutional, office, commercial, and light industrial uses.
Colwood	Village centre	Predominately residential precinct that supports a wide range of high and moderate density housing, including affordable and rental housing. A key location for shopping, services, amenities and others.
Colwood	Neighborhood centre	Predominantly residential precinct that supports a range of medium density housing, including affordable and rental housing. This area allows for residential and mixed-use commercial intensification of streets that connect centres and or are serviced by transit.

TABLE 1 cont.
OCP Land Use Designations
Esquimalt OCP

Municipality	OCP Designation	Description
Esquimalt	Commercial mixed-use	Applies in four principal locations, with a predominance of this use along Esquimalt Road. A mix of commercial and multi-unit residential developments is encouraged.
Esquimalt	Commercial node	Concentrated commercial development.
Esquimalt	DND Federal land	Applies to those areas likely to be retained by the federal government for military and related purposes.
Esquimalt	Industrial	Applies to privately owned lands in the eastern area of the Township, bracketing the rail line and the oil storage facility at Victoria Harbour.
Esquimalt	Institutional	Applies in locations throughout Esquimalt's neighbourhoods, with predominance in the central areas of the Township. Include schools, civic facilities, and houses of worship.

TABLE 1 cont.
OCP Land Use Designations
Esquimalt OCP

Municipality	OCP Designation	Description
Esquimalt	Commercial mixed-use	Applies in four principal locations, with a predominance of this use along Esquimalt Road. A mix of commercial and multi-unit residential developments is encouraged.
Esquimalt	Commercial node	Concentrated commercial development.
Esquimalt	DND Federal land	Applies to those areas likely to be retained by the federal government for military and related purposes.
Esquimalt	Multi-Unit High Rise Residential (5+ stories)	Applies in specific areas, particularly in the Dockyards neighbourhood and along Esquimalt Road, adjacent to the boundary with Victoria.
Esquimalt	Multi-unit Low-Rise Residential (up to 4 stories)	Applies in specific areas, including properties along Esquimalt Road near Esquimalt Village and in the neighbourhoods adjacent to the boundary with Victoria.
Esquimalt	Parks and Open Space	Applies to publicly owned areas in all neighbourhoods of Esquimalt, as well as the privately owned Gorge Vale Golf Course.
Esquimalt	Single and Two-Unit Residential	Applies in contiguous areas throughout Esquimalt's neighbourhoods.
Esquimalt	Townhouse Residential	New buildings up to three storeys with a Floor Area Ratio of up to 0.70 may be acceptable provided the neighbours are consulted and the design responds effectively to both its site and surrounding land uses.

TABLE 1 cont.
OCP Land Use Designations
Saanich OCP

Municipality	Designation	Neighborhood	Intent
Saanich	Major Centre	Uptown, University, Royal Oak, Tillicum-Burnside, Hillside	To meet a broad range of community and regional commercial and service needs. Major centres are served by two or more bus routes, provide a range of multiple family housing options, and accommodate institutional uses such as a community centre or library.
Saanich	Neighborhood Centres	McKenzie-Quadra and Cedar Hill	Smaller in scale than a Major centre and provides a narrower range of commercial and service options, primarily focused on the needs of the immediate neighbourhood. A Neighbourhood centre is typically served by at least two bus routes and includes a range of multiple family housing.
Saanich	Village and smaller local nodes	Cadboro Bay, Cordova Bay, Broadmead, Four Corners, Feltham, Gorge, Strawberry Vale	Villages are small local nodes, with a historical basis, that meet local residents' basic commercial and service needs. They also provide a limited amount of multiple family housing, and are typically serviced by a single bus route.
Saanich	Rural Village	Prospect	Rural Village is a distinct type of local node that acknowledges the unique character of Rural Saanich. A Rural Village is meant to primarily serve the basic commercial needs of local residents. A Rural Village does not include multiple family housing.
Saanich	Institutional	Hospital, elementary schools, Churches and Knowledge Precincts	Includes major institutional uses such as Royal Jubilee Hospital, as well as smaller institutional uses including churches, schools, daycare centres, nursing homes, and community residential facilities.
Saanich	Industrial lands	Royal Oak Industrial Park and Douglas Street West Industrial Area	Industrial land uses comprise a significant part of Saanich's built environment and play an important role in our local economy. Next to the City of Victoria, Saanich has the second largest amount of industrial square footage in the region.
Saanich	Rural		Rural lands valued by Saanich residents and by those from outside the area for its natural beauty, diverse environments, high biological diversity, agricultural and well forested lands, and rural lifestyle.
Saanich	Neighbourhood		For the most part, Saanich neighbourhoods are low density, composed predominantly of single-family housing.

TABLE 1 cont.
OCP Land Use Designations
Saanich OCP

Municipality	Designation	Neighborhood	Intent
Saanich	Major Centre	Uptown, University, Royal Oak, Tillicum-Burnside, Hillside	To meet a broad range of community and regional commercial and service needs. Major centres are served by two or more bus routes, provide a range of multiple family housing options, and accommodate institutional uses such as a community centre or library.
Saanich	Neighborhood Centres	McKenzie-Quadra and Cedar Hill	Smaller in scale than a Major centre and provides a narrower range of commercial and service options, primarily focused on the needs of the immediate neighbourhood. A Neighbourhood centre is typically served by at least two bus routes and includes a range of multiple family housing.
Saanich	Village and smaller local nodes	Cadboro Bay, Cordova Bay, Broadmead, Four Corners, Feltham, Gorge, Strawberry Vale	Villages are small local nodes, with a historical basis, that meet local residents' basic commercial and service needs. They also provide a limited amount of multiple family housing, and are typically serviced by a single bus route.
Saanich	Park		Park lands

TABLE 1 cont.
OCP Land Use Designations
Langford OCP

Municipality	Designation	General Location	General Description
Langford	City centre	Downtown Langford	A major regional growth centre that supports a wide range of high density housing, including affordable and rental housing, a major employment area for institutional, office, commercial, and light industrial uses.
Langford	Village centre	Bear Mountain Village Centre, Westhills Village Centre	Predominately residential precinct that supports a wide range of high and moderate density housing, including affordable and rental housing. A key location for shopping, services, amenities and others.
Langford	Neighborhood centre	Various	Predominantly residential precinct that supports a range of medium density housing, including affordable and rental housing.
Langford	Mixed-use employment centre	West Shore Town Centre, Millstream Village, Goldstream Meadows, Trans	A predominantly workplace precinct that includes businesses of all types including commercial, light industrial, and institutional. Ideal location for creative or innovative infill housing.

TABLE 1 cont.
OCP Land Use Designations
Langford OCP

Municipality	Designation	General Location	General Description
Langford	City centre	Downtown Langford	A major regional growth centre that supports a wide range of high density housing, including affordable and rental housing, a major employment area for institutional, office, commercial, and light industrial uses.
Langford	Village centre	Bear Mountain Village Centre, Westhills Village Centre	Predominately residential precinct that supports a wide range of high and moderate density housing, including affordable and rental housing. A key location for shopping, services, amenities and others.
Langford	Neighborhood centre	Various	Predominantly residential precinct that supports a range of medium density housing, including affordable and rental housing.
		Canada Leigh Road	
Langford	Business or light industrial	Various	Predominantly business and light industrial precinct.
Langford	Neighborhood	Existing Settled Areas	Predominantly residential precinct that supports low and medium density housing choices including secondary suites.
Langford	Hillside or shoreline	Undeveloped or existing low intensity hillside or shoreline areas	Predominantly residential precinct that supports a range of clustered low, medium, and high density housing choices including secondary suites.
Langford	Open space		Public and private open spaces
Langford	Agricultural Lands Strategy		Lands currently held in the ALR

TABLE 1 cont.
OCP Land Use Designations
Oak Bay OCP

Municipality	OCP Designation	Description
Oak Bay	Single family	Single family dwellings
Oak Bay	Multi-family	Multi-family dwellings
Oak Bay	Multi-family/Commercial	Multi-family and commercial
Oak Bay	Commercial	Commercial
Oak Bay	Institutional	Institutional
Oak Bay	Recreational	Recreation focused lands, including golf courses

TABLE 1 cont.
OCP Land Use Designations
Oak Bay OCP

Municipality	OCP Designation	Description
Oak Bay	Single family	Single family dwellings
Oak Bay	Multi-family	Multi-family dwellings
Oak Bay	Multi-family/Commercial	Multi-family and commercial
Oak Bay	Park	Park lands
Oak Bay	Hotel/Secondary multi-family	Hotel or secondary multi-family option

TABLE 1 cont.
OCP Land Use Designations
View Royal OCP

Municipality	Land Use Category	OCP Designation	Description
View Royal	Residential A	Single detached	Single detached house
View Royal	Residential A (L)	Single detached (large lot)	Single detached housing or cluster low-density attached housing
View Royal	Residential B	Clustered low density	Single detached housing or cluster low-density attached housing
View Royal	Residential C	Medium density low rise	Medium density attached housing
View Royal	VC	Village Commercial	Village commercial development area, distinctive in character and accessible to pedestrian traffic
View Royal	TC	Tourist Commercial	Range of development types from park lands to high density accommodation
View Royal	BP	Business Park	Promote a range of commercial developments, and the rejuvenation and beautification of commercial areas, especially along the Island Highway from the Colwood boundary to the Six Mile Bridge.
View Royal	P	Parks, Open Space, Recreation	Open Space
View Royal	R	Rural	Rural lands
View Royal	PF	Public Facilities	Includes schools, hospitals, churches, and libraries
View Royal	MHCD	Multiple housing comprehensive	Medium density attached housing

TABLE 1 cont.
OCP Land Use Designations
View Royal OCP

Municipality	Land Use Category	OCP Designation	Description
View Royal	Residential A	Single detached	Single detached house
View Royal	Residential A (L)	Single detached (large lot)	Single detached housing or cluster low-density attached housing
View Royal	Residential B	Clustered low density development	Single detached housing or cluster low-density attached housing
View Royal	MCD	Mixed comprehensive development	Mixed commercial and residential
View Royal	TCWCD	Thetis Cove waterfront comprehensive development	Medium density attached and detached housing

TABLE 1 cont.
OCP Land Use Designations
Victoria OCP

Municipality	Structure Category	Area	Form	Uses
Victoria	Primary centres	Downtown	Downtown consists of a large number of independent structures, generally of high density, but of low to medium profile. However, buildings of high-rise form are a feature of Downtown, and will be permitted in appropriate locations. The policy area permits the highest density of development in the city.	Retail and related shop frontage commercial uses should predominate at street level but multi-level commercial developments are an important feature. Upper floors are used for offices, visitor accommodation, and apartments.
Victoria	Primary centres	Mayfair and Hillside	Regional shopping centres are planned developments on large property, under corporate ownership. The density is low.	The use range is limited, largely due to the policy of owners. Retail predominates, with few multi-story developments. Potential exists for a broader array of uses, institutional and residential justifying densities above 1:1.
Victoria	Secondary centres	Various	Generally, areas in this category are low to medium density, the floor space ratio generally not exceeding 1.5:1 And the developments are of a lower profile. Higher profile buildings with a floor space in excess of 1.5:1 may be developed where community objectives are advanced by the development (e.g. Humber Green).	Retail commercial uses predominate at street level, with limited personal services. Upper floor uses (e.g. residential, vary with specific locations a s defined in the Zoning Regulation Bylaw)
Victoria	General services	Various	Developments are generally of low to medium density and low profile and are usually situated on small to medium sized properties.	A wide range of uses is acceptable but in some instances, separation should be provided for in the application of the Zoning Regulation Bylaw. These are particularly appropriate for facilities that combine range of economic uses.
Victoria	Visitor services	Various	Buildings are generally low to medium density and low to mid-rise profile. However, on appropriate sites, high-rise and high-density buildings are acceptable in accordance with Zoning Regulation Bylaw.	The uses in these areas should be limited to visitor accommodation, associated services and transportation facilities. The waterfront in the vicinity of Montreal and Kingston Streets may be developed to a wider scope of development embracing visitor accommodation uses, together with a wide range of marine service uses. In all areas residential may also be permitted.
Victoria	Industrial services	Various	These areas are generally of low density and of low profile, but with provision for high-density mid-rise	While it is desirable to concentrate on industrial uses, others are acceptable provided they would not make

TABLE 1 cont.
OCP Land Use Designations
Victoria OCP

Municipality	Structure Category	Area	Form	Uses
Victoria	Primary centres	Downtown	Downtown consists of a large number of independent structures, generally of high density, but of low to medium profile. However, buildings of high-rise form are a feature of Downtown, and will be permitted in appropriate locations. The policy area permits the highest density of development in the city.	Retail and related shop frontage commercial uses should predominate at street level but multi-level commercial developments are an important feature. Upper floors are used for offices, visitor accommodation, and apartments.
Victoria	Primary centres	Mayfair and Hillside	Regional shopping centres are planned developments on large property, under corporate ownership. The density is low.	The use range is limited, largely due to the policy of owners. Retail predominates, with few multi-story developments. Potential exists for a broader array of uses, institutional and residential justifying densities above 1:1.
Victoria	Secondary centres	Various	Generally, areas in this category are low to medium density, the floor space ratio generally not exceeding 1.5:1 And the developments are of a lower profile. Higher profile buildings with a floor space in excess of 1.5:1 may be developed where community objectives are advanced by the development (e.g. Humber Green).	Retail commercial uses predominate at street level, with limited personal services. Upper floor uses (e.g. residential, vary with specific locations a s defined in the Zoning Regulation Bylaw)
			specialized structures. There is generally considerable space around buildings but more intensive development is acceptable.	redevelopment for industrial uses impractical. These would be in the wholesale and services commercial use categories.
Victoria	Auxiliary services	Various	The buildings generally will be of medium to high density, as provided under the regulations and application of the Zoning Regulation Bylaw. High-rise buildings will be permitted in appropriate locations, subject to design guidelines and policy plans for these sensitive, but important, areas of development.	As the predominant use of these areas is residential, only a limited range of retail, office, and personal service activities will be permitted.
Victoria	General Residential	Map 6	General residential areas are predominantly of detached, small structures on relatively small lots. Density and building height is low. Attached structures have become increasingly common and are acceptable in limited numbers and scale and in appropriate locations.	General residential areas are intended for residential use. While the traditional house is the predominant physical form, it can be occupied in a number of ways and this plan does not purport the flexibility of use of housing units. Suites, limited apartment units and special housing may be sited in General residential areas under the

TABLE 1 cont.
OCP Land Use Designations
Victoria OCP

Municipality	Structure Category	Area	Form	Uses
Victoria	Primary centres	Downtown	Downtown consists of a large number of independent structures, generally of high density, but of low to medium profile. However, buildings of high-rise form are a feature of Downtown, and will be permitted in appropriate locations. The policy area permits the highest density of development in the city.	Retail and related shop frontage commercial uses should predominate at street level but multi-level commercial developments are an important feature. Upper floors are used for offices, visitor accommodation, and apartments.
Victoria	Primary centres	Mayfair and Hillside	Regional shopping centres are planned developments on large property, under corporate ownership. The density is low.	The use range is limited, largely due to the policy of owners. Retail predominates, with few multi-story developments. Potential exists for a broader array of uses, institutional and residential justifying densities above 1:1.
Victoria	Secondary centres	Various	Generally, areas in this category are low to medium density, the floor space ratio generally not exceeding 1.5:1 And the developments are of a lower profile. Higher profile buildings with a floor space in excess of 1.5:1 may be developed where community objectives are advanced by the development (e.g. Humber Green).	Retail commercial uses predominate at street level, with limited personal services. Upper floor uses (e.g. residential, vary with specific locations a s defined in the Zoning Regulation Bylaw)
				specific control of the zoning regulation. These areas may also contain limited commercial and service developments to serve the neighborhood and in most zones home businesses are permitted.
Victoria	Apartment Residential (Established)	Map 6	Established Apartment residential districts are generally of medium density and of low to medium profile form. However, high-density high-rise structures have been permitted in a few appropriate locations.	Uses are limited to apartment residential uses and a few ancillary commercial uses. Home-based businesses are permitted.
Victoria	Apartment Residential (Developing)	Map 6	Generally, these developments will be of medium to high density and may be of high-rise form in designated locations.	While generally intended for apartment residential use, a significant economic content is in many of these areas.
Victoria	Parks and Open Space		Open spaces	Includes community lands such as cemeteries and parks

TABLE 1 cont.
OCP Land Use Designations
Victoria OCP

Municipality	Structure Category	Area	Form	Uses
Victoria	Primary centres	Downtown	Downtown consists of a large number of independent structures, generally of high density, but of low to medium profile. However, buildings of high-rise form are a feature of Downtown, and will be permitted in appropriate locations. The policy area permits the highest density of development in the city.	Retail and related shop frontage commercial uses should predominate at street level but multi-level commercial developments are an important feature. Upper floors are used for offices, visitor accommodation, and apartments.
Victoria	Primary centres	Mayfair and Hillside	Regional shopping centres are planned developments on large property, under corporate ownership. The density is low.	The use range is limited, largely due to the policy of owners. Retail predominates, with few multi-story developments. Potential exists for a broader array of uses, institutional and residential justifying densities above 1:1.
Victoria	Secondary centres	Various	Generally, areas in this category are low to medium density, the floor space ratio generally not exceeding 1.5:1 And the developments are of a lower profile. Higher profile buildings with a floor space in excess of 1.5:1 may be developed where community objectives are advanced by the development (e.g. Humber Green).	Retail commercial uses predominate at street level, with limited personal services. Upper floor uses (e.g. residential, vary with specific locations a s defined in the Zoning Regulation Bylaw)
Victoria	Schools	Various	Schools	Education
Victoria	Hospital	Various	Hospital	Medical services

TABLE 2

Detached dwelling FARs in the core municipalities, based on a sample of six detached dwellings per municipality on May 15, 2008

Municipality	Average Floor Area Ratio	Median Floor Area Ratio
View Royal	0.24	0.26
Langford	0.17	0.14
Oak Bay	0.13	0.17
Saanich	0.17	0.29
Esquimalt	0.41	0.56
Colwood	0.30	0.44
Victoria	0.42	0.30
	0.26	0.31

TABLE 3
Preliminary Land Use Classifications

Zone	Primary Building
Residential 1	Rural
Residential 2	Large lot detached residential
Residential 3	Medium lot detached dwelling
Residential 4	Townhouses or row houses
Residential 5	Low density multiple dwelling
Residential 6	Low rise apartments (approximately 4 storeys)
Residential 7	Medium rise apartments
Residential 8	High rise apartments
Commercial 1	Suburban strip
Commercial 2	Enclosed mall
Commercial 3	Tourist Commercial
Commercial 4	Industry
Mixed Use 1	Mixed Use Employment Centre
Mixed Use 2	Medium density mixed use centre
Mixed Use 3	Neighborhood Centre
Mixed Use 4	Village Centre
Mixed Use 5	City Centre
Mixed Use 6	Downtown Victoria
Mixed Use 7	Business or Light Industrial Centre
Institutional Use 1	Colleges and Universities
Institutional Use 2	Department of National Defence Lands
Institutional Use 3	Schools
Institutional Use 4	Other Institutional Use (mainly churches)
Institutional 5	Hospitals
Institutional 6	Cemeteries
Recreation 1	Natural Parks and Open Space
Recreation 2	Recreation facilities

TABLE 4
Reclassified land use designations

Municipality	OCP Classification	Zone	Description
City of Colwood	Mixed-Use Employment Centre	Mixed Use 1	Mixed Use Employment Centre
City of Colwood	Neighborhood Centre	Mixed Use 3	Neighborhood Centre
City of Colwood	Village Centre	Mixed Use 4	Village Centre
City of Colwood	City Centre	Mixed Use 5	City Centre
City of Colwood	Mixed-Use Employment Centre (Island Highway)	Commercial 1	Suburban Strip
City of Colwood	Open Space	Recreation 1	Natural Parks and Open Space
City of Colwood	Future Open Space	Recreation 1	Natural Parks and Open Space
City of Colwood	Neighbourhood and Hillside or Shoreline	Residential 3	Medium lot detached dwelling
City of Colwood	Department of National Defence Lands	Institutional Use 2	Department of National Defence Lands
City of Langford	Mixed-Use Employment Centre	Mixed Use 1	Mixed Use Employment Centre
City of Langford	Neighborhood Centre	Mixed Use 3	Neighborhood Centre
City of Langford	Village Centre	Mixed Use 4	Village Centre
City of Langford	City Centre	Mixed Use 5	City Centre
City of Langford	Business or Light Industrial	Mixed Use 7	Business or Light Industrial Centre
City of Langford	Open Space	Recreation 1	Natural Parks and Open Space
City of Langford	Agricultural Strategy Lands	Residential 1	Rural
City of Langford	Neighbourhood	Residential 3	Medium lot detached dwelling
City of Langford	Hillside or Shoreline	Residential 3	Medium lot detached dwelling
City of Victoria	General Services	Commercial 1	Suburban strip
City of Victoria	Primary Centre (Mayfair Mall)	Commercial 2	Enclosed mall
City of Victoria	Visitor Services	Commercial 3	Tourist Commercial
City of Victoria	Auxiliary Service	Mixed Use 2	Medium density mixed use centre
City of Victoria	Secondary Centre	Mixed Use 3	Neighborhood Centre
City of Victoria	Primary Centre (Hillside)	Mixed Use 5	City Centre
City of Victoria	Primary Centre (Downtown)	Mixed Use 6	Downtown Victoria
City of Victoria	Industrial Services	Commercial 4	Industry
City of Victoria	Parks and Public Open Space	Recreation 1	Natural Parks and Open Space
City of Victoria	General Residential	Residential 3	Medium lot detached dwelling

TABLE 4
Reclassified land use designations

Municipality	OCP Classification	Zone	Description
City of Colwood	Mixed-Use Employment Centre	Mixed Use 1	Mixed Use Employment Centre
City of Colwood	Neighborhood Centre	Mixed Use 3	Neighborhood Centre
City of Victoria	Apartment Residential (Established)	Residential 7	Medium rise apartments
City of Victoria	Apartment Residential (Developing)	Residential 8	High rise apartments
City of Victoria	Schools	Institutional Use 3	Schools
City of Victoria	Other Institutional Use (mainly churches)	Institutional Use 4	Other Institutional Use (mainly churches)
City of Victoria	Hospitals	Institutional Use 5	Hospitals
City of Victoria	Cemeteries	Institutional Use 6	Cemeteries
District of Oak Bay	Commercial	Commercial 1	Suburban strip
District of Oak Bay	Institutional (Colleges and Universities)	Institutional Use 1	Colleges and Universities
District of Oak Bay	Multi-Family/Commercial	Mixed Use 3	Neighborhood Centre
District of Oak Bay	Park	Recreation 1	Natural Parks and Open Space
District of Oak Bay	Commercial Recreational Use	Recreation 2	Recreation facilities
District of Oak Bay	Single Family	Residential 3	Medium lot detached dwelling
District of Oak Bay	Single Family	Residential 3A	Large lot detached dwelling
District of Oak Bay	Multi-Family	Residential 5	Low density multiple dwelling
District of Oak Bay	Institutional (Schools)	Institutional Use 3	Schools
District of Oak Bay	Institutional (Other)	Institutional Use 4	Other Institutional Use
District of Saanich	Institutional Lands	Institutional Use 1	Colleges and Universities
District of Saanich	Rural Village	Mixed Use 2	Medium density mixed use centre
District of Saanich	Village	Mixed Use 3	Neighborhood Centre
District of Saanich	Neighbourhood Centre	Mixed Use 4	Village Centre

TABLE 4
Reclassified land use designations

Municipality	OCP Classification	Zone	Description
City of Colwood	Mixed-Use Employment Centre	Mixed Use 1	Mixed Use Employment Centre
City of Colwood	Neighborhood Centre	Mixed Use 3	Neighborhood Centre
District of Saanich	Major Centre	Mixed Use 5	City Centre
District of Saanich	Industrial Lands	Mixed Use 7	Business or Light Industrial Centre
District of Saanich	Parks	Recreation 1	Natural Parks and Open Space
District of Saanich	Rural Lands	Residential 1	Rural
District of Saanich	Neighbourhoods	Residential 3	Medium lot detached dwelling
District of Saanich	Colleges and Universities	Institutional Use 1	Colleges and Universities
District of Saanich	Schools	Institutional Use 3	Schools
District of Saanich	Other Institutional Use (mainly churches)	Institutional Use 4	Other Institutional Use (mainly churches)
District of Saanich	Institutional (QA)	Institutional Use 5	Hospital
District of Saanich	Cemeteries	Institutional Use 6	Cemeteries
Town of Esquimalt	Industrial	Commercial 4	Industry
Town of Esquimalt	Commercial Node	Mixed Use 3	Neighborhood Centre
Town of Esquimalt	Commercial Mixed Use	Mixed Use 4	Village Centre
Town of Esquimalt	Parks and Open Space	Recreation 1	Natural Parks and Open Space
Town of Esquimalt	Residential - Single and Two-Unit	Residential 3	Medium lot detached dwelling
Town of Esquimalt	Residential - Townhouse	Residential 4	Townhouses or row houses
Town of Esquimalt	Residential - Multi-Unit Low-Rise (up to 4 stories)	Residential 6	Low rise apartments
Town of Esquimalt	Residential - Multi-Unit High-Rise (5+ stories)	Residential 8	High rise apartments
Town of Esquimalt	Institutional (DND)	Institutional Use 2	Department of National Defence
Town of Esquimalt	Institutional (Schools)	Institutional Use 3	Schools

TABLE 4
Reclassified land use designations

Municipality	OCP Classification	Zone	Description
City of Colwood	Mixed-Use Employment Centre	Mixed Use 1	Mixed Use Employment Centre
City of Colwood	Neighborhood Centre	Mixed Use 3	Neighborhood Centre
Town of Esquimalt	Institutional (Other)	Institutional Use 4	Other Institutional Use
Town of View Royal	Schools	Institutional Use 3	Schools
Town of View Royal	Other Institutional Use (mainly churches)	Institutional Use 4	Other Institutional Use (mainly churches)
Town of View Royal	Hospitals	Institutional Use 5	Hospitals
Town of View Royal	Commercial - Village	Commercial 1	Suburban strip
Town of View Royal	Commercial - Business Park	Commercial 1	Suburban strip
Town of View Royal	Commercial - Tourist	Commercial 3	Tourist Commercial
Town of View Royal	Mixed Comprehensive Development	Mixed Use 2	Medium density mixed use centre
Town of View Royal	Thetis Cove Waterfront Comprehensive Development	Mixed Use 3	Neighborhood Centre
Town of View Royal	Parks, Open Spaces, Recreation	Recreation 2	Recreation facilities
Town of View Royal	Rural	Residential 1	Rural
Town of View Royal	Residential - Single Detached (Large Lot)	Residential 2	Large lot detached residential
Town of View Royal	Residential - Single Detached	Residential 3	Medium lot detached dwelling
Town of View Royal	Residential - Clustered Low Density	Residential 4	Townhouses or row houses
Town of View Royal	Multiple Housing Comprehensive Development	Residential 4	Townhouses or row houses
Town of View Royal	Residential - Medium Density Low Rise	Residential 6	Low rise apartments (approximately 4 storeys)
Town of View Royal	Residential-Small Lot	Residential 10	Small Lot Development

TABLE 5
CRD Population Grown Estimates

	Population 2006	Population 2015	Population 2045	Population 2065	Percent Change (2015-2065)
Population Growth Scenario 1					
Oak Bay	18,059	18,059	18,059	18,059	0.00%
Victoria	78,659	86,028	99,913	99,913	16.14%
Esquimalt	17,407	18,206	21,145	21,145	16.14%
Saanich	110,737	115,281	134,515	134,515	16.68%
View Royal	8,375	10,009	15,645	19,280	92.63%
Colwood	15,470	18,488	28,698	35,614	92.63%
Langford	22,229	26,566	41,524	51,174	92.63%
Highlands	2,230	2,546	3,979	4,904	92.62%
Totals	273,166	295,183	363,478	384,604	30.29%
Population Growth Scenario 2					
Oak Bay	18,059	18,222	18,777	19,175	5.23%
Victoria	78,659	86,028	99,913	102,032	18.60%
Esquimalt	17,407	18,206	21,145	21,593	18.60%
Saanich	110,737	115,281	134,515	137,368	19.16%
View Royal	8,375	10,009	15,645	19,280	92.63%
Colwood	15,470	18,488	28,698	39,506	113.68%
Langford	22,229	26,566	41,524	56,766	113.68%
Highlands	2,230	2,546	3,979	4,904	92.62%
Totals	273,166	295,346	364,196	400,624	35.65%

TABLE 6
Projected FARs for 2020 and 2065

Municipality	Zone	Description	Estimated 2020 Floor Area Ratio	Estimated 2065 Floor Area Ratio	Percentage Increase
City of Colwood	Mixed Use 1	Mixed Use Employment Centre	1.00	1.50	50%
City of Colwood	Mixed Use 3	Neighborhood Centre	0.60	0.75	25%
City of Colwood	Mixed Use 4	Village Centre	1.00	1.50	50%

TABLE 6
Projected FARs for 2020 and 2065

Municipality	Zone	Description	Estimated 2020 Floor Area Ratio	Estimated 2065 Floor Area Ratio	Percentage Increase
City of Colwood	Mixed Use 5	City Centre	2.00	3.00	50%
City of Colwood	Commercial 1	Suburban Strip	0.30	0.70	133%
City of Colwood	Recreation 1	Natural Parks and Open Space	0.02	0.02	0%
City of Colwood	Residential 3	Medium lot detached dwelling	0.45	0.60	33%
City of Colwood	Institutional Use 2	Department of National Defence Lands	0.20	0.40	100%
City of Langford	Mixed Use 1	Mixed Use Employment Centre	0.70	1.00	43%
City of Langford	Mixed Use 3	Neighborhood Centre	0.80	1.20	50%
City of Langford	Mixed Use 4	Village Centre	1.20	1.50	25%
City of Langford	Mixed Use 5	City Centre	1.50	2.5	67%
City of Langford	Mixed Use 7	Business or Light Industrial Centre	0.50	0.63	25%
City of Langford	Recreation 1	Natural Parks and Open Space	0.02	0.02	0%
City of Langford	Residential 1	Rural	0.07	0.11	50%
City of Langford	Residential 3	Medium lot detached dwelling	0.45	0.60	33%
City of Langford	Residential 3	Medium lot detached dwelling	0.18	0.28	57%
City of Victoria	Commercial 1	Suburban strip	0.70	0.81	15%
City of Victoria	Commercial 2	Enclosed mall	0.60	0.69	15%
City of Victoria	Commercial 3	Tourist Commercial	1.20	1.44	20%
City of Victoria	Mixed Use 2	Medium density mixed use centre	0.75	0.94	25%
City of Victoria	Mixed Use 3	Neighborhood Centre	0.90	1.13	25%
City of Victoria	Mixed Use 5	City Centre	1.50	3.00	100%
City of Victoria	Mixed Use 6	Downtown Victoria	5.00	7.00	40%
City of Victoria	Mixed Use 7	Business or Light Industrial Centre	0.80	1.20	50%
City of Victoria	Mixed Use 8	Old Town	3.00	4.5	50%
City of Victoria	Commercial 4	Industry	1.00	1.25	25%
City of Victoria	Recreation 1	Natural Parks and Open Space	0.02	0.02	0%

TABLE 6
Projected FARs for 2020 and 2065

Municipality	Zone	Description	Estimated 2020 Floor Area Ratio	Estimated 2065 Floor Area Ratio	Percentage Increase
City of Victoria	Residential 3	Medium lot detached dwelling	0.31	0.36	17%
City of Victoria	Residential 7	Medium rise apartments	1.00	1.50	50%
City of Victoria	Residential 8	High rise apartments	2.00	2.35	17%
City of Victoria	Institutional Use 1	Public Institutions	1.2	1.5	25%
City of Victoria	Institutional Use 3	Schools	0.30	0.35	17%
City of Victoria	Institutional Use 4	Other Institutional Use (mainly churches)	0.30	0.35	17%
City of Victoria	Institutional Use 5	Hospitals	0.60	0.75	25%
City of Victoria	Institutional Use 6	Cemeteries	0.02	0.02	0%
District of Oak Bay	Commercial 1	Suburban strip	0.70	0.81	15%
District of Oak Bay	Institutional Use 1	Colleges and Universities	1.20	1.50	25%
District of Oak Bay	Mixed Use 3	Neighborhood Centre	0.80	1.00	25%
District of Oak Bay	Recreation 1	Natural Parks and Open Space	0.02	0.02	0%
District of Oak Bay	Recreation 2	Recreation facilities	0.10	0.10	0%
District of Oak Bay	Residential 3	Medium lot detached dwelling	0.40	0.48	20%
District of Oak Bay	Residential 3A	Large lot detached dwelling	0.30	0.36	20%
District of Oak Bay	Residential 5	Low density multiple dwelling	0.90	1.2	33%
District of Oak Bay	Institutional Use 3	Schools	0.35	0.39	10%
District of Oak Bay	Institutional Use 4	Other Institutional Use	0.30	0.33	10%
District of Saanich	Mixed Use 2	Medium density mixed use centre	0.80	1.00	25%
District of Saanich	Mixed Use 3	Neighborhood Centre	0.90	1.13	25%
District of Saanich	Mixed Use 4	Village Centre	1.20	1.80	50%
District of Saanich	Mixed Use 5	City Centre	1.50	3.00	100%
District of Saanich	Mixed Use 7	Business or Light Industrial Centre	1.20	1.50	25%
District of Saanich	Recreation 1	Natural Parks and Open Space	0.05	0.05	0%
District of Saanich	Residential 1	Rural	0.07	0.08	18%

TABLE 6
Projected FARs for 2020 and 2065

Municipality	Zone	Description	Estimated 2020 Floor Area Ratio	Estimated 2065 Floor Area Ratio	Percentage Increase
District of Saanich	Residential 3	Medium lot detached dwelling	0.31	0.37	18%
District of Saanich	Residential 5	Low density multiple dwelling	0.72	0.86	20%
District of Saanich	Residential 6	Low rise apartments	1.15	1.35	17%
District of Saanich	Institutional Use 1	Colleges and Universities	1.20	1.50	25%
District of Saanich	Institutional Use 3	Schools	0.30	0.35	18%
District of Saanich	Institutional Use 4	Other Institutional Use (mainly churches)	0.30	0.38	25%
District of Saanich	Institutional Use 5	Hospital	0.40	0.50	25%
District of Saanich	Institutional Use 6	Cemeteries	0.02	0.02	0%
Town of Esquimalt	Commercial 4	Industry	0.80	1.00	25%
Town of Esquimalt	Mixed Use 3	Neighborhood Centre	1.50	2.00	33%
Town of Esquimalt	Mixed Use 4	Village Centre	1.20	1.5	25%
Town of Esquimalt	Recreation 1	Natural Parks and Open Space	0.02	0.02	0%
Town of Esquimalt	Residential 3	Medium lot detached dwelling	0.35	0.41	17%
Town of Esquimalt	Residential 4	Townhouses or row houses	0.60	0.70	17%
Town of Esquimalt	Residential 6	Low rise apartments	1.15	2.0	74%
Town of Esquimalt	Residential 8	High rise apartments	1.50	2.00	33%
Town of Esquimalt	Institutional Use 2	Department of National Defence	0.20	0.24	20%
Town of Esquimalt	Institutional Use 3	Schools	0.30	0.35	17%
Town of Esquimalt	Institutional Use 4	Other Institutional Use	0.30	0.35	17%
Town of View Royal	Institutional Use 1	Public Facilities	1.2	2.3	93%
Town of View Royal	Institutional Use 3	Schools	0.30	0.48	17%
Town of View Royal	Institutional Use 4	Other Institutional Use (mainly churches)	0.30	0.48	17%
Town of View Royal	Institutional Use 5	Hospitals	0.40	0.64	59%
Town of View Royal	Commercial 1	Suburban strip	0.45	0.70	56%
Town of View Royal	Commercial 1	Suburban strip	0.45	0.70	56%
Town of View Royal	Commercial 3	Tourist Commercial	0.30	0.36	20%

TABLE 6
Projected FARs for 2020 and 2065

Municipality	Zone	Description	Estimated 2020 Floor Area Ratio	Estimated 2065 Floor Area Ratio	Percentage Increase
Town of View Royal	Mixed Use 2	Medium density mixed use centre	0.75	0.94	25%
Town of View Royal	Mixed Use 3	Neighborhood Centre	0.90	1.13	25%
Town of View Royal	Mixed Use 4	Village Centre	1.2	1.8	50%
Town of View Royal	Recreation 1	Parks and Open Space	0.02	0.02	0%
Town of View Royal	Recreation 2	Recreation facilities	0.10	0.10	0%
Town of View Royal	Residential 1	Rural	0.07	0.11	59%
Town of View Royal	Residential 2	Large lot detached residential	0.30	0.36	20%
Town of View Royal	Residential 3	Medium lot detached dwelling	0.45	0.72	59%
Town of View Royal	Residential 4	Townhouses or row houses	0.60	0.80	33%
Town of View Royal	Residential 4	Townhouses or row houses	0.60	0.80	33%
Town of View Royal	Residential 6	Low rise apartments (approximately 4 storeys)	0.80	1.00	25%

TABLE 7
Energy Values

Use Type	Educational		Offices		Health Care		Retail Trade		Residential	
Basis Year	2005	2020/2065	2005	2020/2065	2005	2020/2065	2005	2020/2065	2005	2020/2065
Space Heating MJ/m^2/year	701.518	540.284	605.627	464.945	882.689	679.658	736.161	566.964	327.107	280.516
Water Heating MJ/m^2/year	112.951	97.460	98.585	85.743	203.385	175.490	118.529	102.273	160.451	133.610
Space Cooling MJ/m^2/year	54.557	55.970	51.828	57.340	71.428	73.283	53.325	54.706	3.065	4.403

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
COLWOOD Recreation 1	0.020	200	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
COLWOOD Commercial 1	0.300	3000	Suburban Strip	100% Retail Trade	1700.892	306.819	164.118	**2171.829**
COLWOOD Institutional Use 2	0.200	2000	Department of National Defence Lands	100% Office	929.890	171.486	114.680	**1216.056**
COLWOOD Institutional Use 2	0.250	2500	Department of National Defence Lands	100% Office	1162.363	214.358	143.350	**1520.070**
COLWOOD Mixed Use 1	1.000	10000	Mixed Use Employment Centre	60% Office, 30% Retail Trade, 10% Education	5030.846	918.737	564.128	**6513.711**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
COLWOOD Mixed Use 3	0.600	6000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	2205.107	779.265	129.692	**3114.064**
COLWOOD Mixed Use 3	0.600	6000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	2205.107	779.265	129.692	**3114.064**
COLWOOD Mixed Use 4	1.000	10000	Village Centre	60% Residential, 30% Retail, 10% Education	3924.272	1205.938	246.509	**5376.718**
COLWOOD Mixed Use 5	2.000	20000	City Centre	40% Residential, 25% Office, 25% Retail, 10% Health Care	8762.989	2359.939	742.023	**11864.951**
COLWOOD Recreation 1	0.020	200	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
COLWOOD Residential 3	0.400	4000	Medium lot detached dwelling	100% Residential	1122.064	534.439	17.614	**1674.117**
COLWOOD Residential 3	0.450	4500	Medium lot detached dwelling	100% Residential	1262.322	601.244	19.815	**1883.382**
ESQUIMALT Commercial 4	0.800	8000	Industry	100% Retail Trade	4535.712	818.184	437.648	**5791.544**
ESQUIMALT Institutional Use 1	1.200	12000	Colleges and Universities	100% Education	6483.404	1169.517	671.644	**8324.564**
ESQUIMALT Institutional Use 2	0.200	2000	Department of National Defence	100% Office	929.890	171.486	114.680	**1216.056**
ESQUIMALT Institutional Use 3	0.300	3000	Schools	100% Education	1620.850936	292.379	167.911	**2081.141**
ESQUIMALT Institutional Use 4	0.300	3000	Other Institutional Use	100% Education	1620.851	292.379	167.911	**2081.141**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
ESQUIMALT Mixed Use 3	1.500	15000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	5512.769	1948.162	324.229	**7785.160**
ESQUIMALT Mixed Use 4	1.200	12000	Village Centre	60% Residential, 30% Retail, 10% Education	4709.126	1447.125	295.811	**6452.062**
ESQUIMALT Recreation 1	0.020	200	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
ESQUIMALT Recreation 1	1.500	15000	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
ESQUIMALT Residential 3	0.350	3500	Medium lot detached dwelling	100% Residential	981.806	467.634	15.412	**1464.852**
ESQUIMALT Residential 4	0.600	6000	Townhouses or row houses	100% Residential	1683.096	801.659	26.421	**2511.176**
ESQUIMALT Residential 6	1.150	11500	Low rise apartments	100% Residential	3225.934	1536.513	50.639	**4813.087**
ESQUIMALT Residential 8	1.500	15000	High rise apartments	100% Residential	4207.740	2004.148	66.051	**6277.939**
LANGFORD Mixed Use 1	0.700	7000	Mixed Use Employment Centre	60% Office, 30% Retail Trade, 10% Education	3521.592	643.116	394.890	**4559.597**
LANGFORD Mixed Use 3	0.800	8000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	2940.143	1039.020	172.922	**4152.086**
LANGFORD Mixed Use 4	1.200	12000	Village Centre	60% Residential, 30% Retail, 10% Education	4709.126	1447.125	295.811	**6452.062**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
LANGFORD Mixed Use 5	1.500	15000	City Centre	40% Residential, 25% Office, 25% Retail, 10% Health Care	6572.242	1769.954	556.518	**8898.713**
LANGFORD Mixed Use 7	0.500	5000	Business or Light Industrial Centre	100% Retail Trade	2834.820	511.365	273.530	**3619.715**
LANGFORD Recreation 1	0.020	200	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
LANGFORD Residential 1	0.070	700	Rural	100% Residential	196.361	93.527	3.082	**292.970**
LANGFORD Residential 3	0.400	4000	Medium lot detached dwelling	100% Residential	1122.064	534.439	17.614	**1674.117**
LANGFORD Residential 3	0.180	1800	Medium lot detached dwelling	100% Residential	504.929	240.498	7.926	**753.353**
LANGFORD Residential 3	0.450	4500	Medium lot detached dwelling	100% Residential	1262.322	601.244	19.815	**1883.382**
OAK BAY Commercial 1	0.700	7000	Suburban strip	100% Retail Trade	3968.748	715.911	382.942	**5067.601**
OAK BAY Institutional Use 1	1.200	12000	Colleges and Universities	100% Education	6483.404	1169.517	671.644	**8324.564**
OAK BAY Institutional Use 3	0.300	3000	Schools	100% Education	1620.851	292.379	167.911	**2081.141**
OAK BAY Institutional Use 3	0.350	3500	Schools	100% Education	1890.993	341.109	195.896	**2427.998**
OAK BAY Institutional Use 4	0.300	3000	Other Institutional Use	100% Education	1620.851	292.379	167.911	**2081.141**
OAK BAY Mixed Use 3	0.800	8000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	2940.143	1039.020	172.922	**4152.086**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
OAK BAY Recreation 1	0.020	200	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
OAK BAY Recreation 2	0.100	1000	Recreation facilities	100% Education	540.284	97.460	55.970	**693.714**
OAK BAY Residential 3	0.300	3000	Large lot detached dwelling	100% Residential	841.548	1603.318	13.210	**2458.076**
OAK BAY Residential 3A	0.450	4500	Medium lot detached dwelling	100% Residential	1262.322	601.244	19.815	**1883.382**
OAK BAY Residential 5	0.900	9000	Low density multiple dwelling	100% Residential	2524.644	1202.489	39.631	**3766.763**
SAANICH HARTLAND	0.020	200	Saanich Hartland	100% Retail Trade	113.393	20.455	10.941	**144.789**
SAANICH Institutional Use 1	1.200	12000	Colleges and Universities	100% Education	6483.404	1169.517	671.644	**8324.564**
SAANICH Institutional Use 3	0.300	3000	Schools	100% Education	1620.851	292.379	167.911	**2081.141**
SAANICH Institutional Use 3	0.350	3500	Schools	100% Education	1890.993	341.109	195.896	**2427.998**
SAANICH Institutional Use 4	0.300	3000	Other Institutional Use (mainly churches)	100% Education	1620.851	292.379	167.911	**2081.141**
SAANICH Institutional Use 5	0.400	4000	Queen Alexandra Hospital	100% Health Care	2718.632	701.960	293.132	**3713.724**
SAANICH Institutional Use 6	0.020	200	Cemeteries	0%	0.000	0.000	0.000	**0.000**
SAANICH Mixed Use 2	0.800	8000	Medium density mixed use centre	50% Office, 50% Retail Trade	4127.636	752.064	448.184	**5327.884**
SAANICH Mixed Use 3	0.900	9000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	3307.661	1168.897	194.538	**4671.096**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
SAANICH Mixed Use 4	1.200	12000	Village Centre	60% Residential, 30% Retail, 10% Education	4709.126	1447.125	295.811	**6452.062**
SAANICH Mixed Use 5	1.500	15000	City Centre	40% Residential, 25% Office, 25% Retail, 10% Health Care	6572.242	1769.954	556.518	**8898.713**
SAANICH Mixed Use 7	1.200	12000	Business or Light Industrial Centre	100% Retail Trade	6803.568	1227.276	656.472	**8687.316**
SAANICH Recreation 1	0.800	8000	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
SAANICH Residential 1	0.020	200	Rural	100% Residential	56.103	26.722	0.881	**83.706**
SAANICH Residential 1	0.070	700	Rural	100% Residential	196.361	93.527	3.082	**292.970**
SAANICH Residential 3	0.020	200	Medium lot detached dwelling	100% Residential	56.103	26.722	0.881	**83.706**
SAANICH Residential 3	0.310	3100	Medium lot detached dwelling	100% Residential	869.600	414.191	13.651	**1297.441**
SAANICH Residential 5	0.720	7200	Low density multiple dwelling	100% Residential	2019.715	961.991	31.705	**3013.411**
SAANICH Residential 6	1.150	11500	Low rise apartments	100% Residential	3225.934	1536.513	50.639	**4813.087**
VICTORIA Commercial 1	0.700	7000	Suburban strip	100% Retail Trade	3968.748	715.911	382.942	**5067.601**
VICTORIA Commercial 1	0.900	9000	Suburban strip	100% Retail Trade	5102.676	920.457	492.354	**6515.487**
VICTORIA Commercial 2	0.600	6000	Enclosed mall	100% Retail Trade	3401.784	613.638	328.236	**4343.658**
VICTORIA Commercial 3	1.200	12000	Tourist Commercial	100% Retail Trade	6803.568	1227.276	656.472	**8687.316**
VICTORIA Commercial 4	1.000	10000	Industry	100% Retail Trade	5669.640	1022.730	547.060	**7239.430**
VICTORIA Institutional Use 1	1.200	12000	Public institutions	100% Education	6483.404	1169.517	671.644	**8324.564**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
VICTORIA Institutional Use 3	0.300	3000	Schools	100% Education	1620.851	292.379	167.911	**2081.141**
VICTORIA Institutional Use 4	0.300	3000	Other Institutional Use (mainly churches)	100% Education	1620.851	292.379	167.911	**2081.141**
VICTORIA Institutional Use 5	0.600	6000	Hospitals	100% Health Care	4077.948	1052.940	439.698	**5570.586**
VICTORIA Mixed Use 2	0.750	7500	Medium density mixed use centre	50% Office, 50% Retail Trade	3869.659	705.060	420.173	**4994.891**
VICTORIA Mixed Use 2	0.900	9000	Medium density mixed use centre	50% Office, 50% Retail Trade	4643.591	846.072	504.207	**5993.870**
VICTORIA Mixed Use 3	0.900	9000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	3307.661	1168.897	194.538	**4671.096**
VICTORIA Mixed Use 5	1.500	15000	Major Centre	75% Residential, 25% Retail Trade	5281.920	1886.635	254.686	**7423.241**
VICTORIA Mixed Use 6	5.000	50000	Downtown Victoria	25% Residential, 45% Office, 25% Retail, 5% Health Care	22753.908	5316.478	2212.225	**30282.611**
VICTORIA Mixed Use 7	0.500	5000	Business or Light Industrial Centre	100% Retail Trade	2834.820	511.365	273.530	**3619.715**
VICTORIA Mixed Use 7	0.800	8000	Business or Light Industrial Centre	100% Retail Trade	4535.712	818.184	437.648	**5791.544**
VICTORIA Mixed Use 8	3.000	30000	Old Town	50% Office, 30% Retail, 20% Residential	6974.401	1286.202	860.117	**9120.721**
VICTORIA Recreation 1	0.020	200	Natural Parks and Open Space	0%	0.000	0.000	0.000	**0.000**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
VICTORIA Residential 3	0.310	3100	Medium lot detached dwelling	100% Residential	869.600	414.191	13.651	**1297.441**
VICTORIA Residential 7	1.000	10000	Medium rise apartments	100% Residential	2805.160	1336.099	44.034	**4185.293**
VICTORIA Residential 8	2.000	20000	High rise apartments	100% Residential	5610.320	2672.197	88.068	**8370.585**
VIEW ROYAL Commercial 1	0.450	4500	Suburban strip	100% Retail Trade	2551.338	460.229	246.177	**3257.744**
VIEW ROYAL Commercial 3	0.300	3000	Tourist Commercial	100% Retail Trade	1700.892	306.819	164.118	**2171.829**
VIEW ROYAL Institutional 4	0.300	3000	Other Institutional Use (mainly churches)	100% Education	1620.851	292.379	167.911	**2081.141**
VIEW ROYAL Institutional Use 1	1.200	12000	Public facilities	100% Education	6483.404	1169.517	671.644	**8324.564**
VIEW ROYAL Institutional Use 3	0.300	3000	Schools	100% Education	1620.851	292.379	167.911	**2081.141**
VIEW ROYAL Institutional Use 5	0.400	4000	Hospitals	100% Health Care	2718.632	701.960	293.132	**3713.724**
VIEW ROYAL Mixed Use 2	0.750	7500	Medium density mixed use centre	50% Office, 50% Retail Trade	3869.659	705.060	420.173	**4994.891**
VIEW ROYAL Mixed Use 3	0.900	9000	Neighborhood Centre	70% Residential, 10% Retail, 10% Office, 10% Health Care	3307.661	1168.897	194.538	**4671.096**
VIEW ROYAL Mixed Use 4	1.200	12000	Village Centre	60% Residential, 30% Retail, 10% Education	4709.126	1447.125	295.811	**6452.062**
VIEW ROYAL Recreation 1	0.020	200	Parks and Open Space	0%	0.000	0.000	0.000	**0.000**
VIEW ROYAL Recreation 2	0.100	1000	Recreation facilities	100% Education	540.284	97.460	55.970	**693.714**
VIEW ROYAL Residential 1	0.070	700	Rural	100% Residential	196.361	93.527	3.082	**292.970**

TABLE 8
Energy Use

2020 Land Use Zone	FAR 2020	Built Area (M^2/ha)	Description	Basis for Energy Demand Calculation	2020 Space Heating (GJ/ha/yr)	2020 Water Heating (GJ/ha/yr)	2020 Space Cooling (GJ/ha/yr)	2020 Total (GJ/ha/yr)
VIEW ROYAL Residential 10	0.650	6500	Small Lot Development	100% Residential	1823.354	868.464	28.622	**2720.440**
VIEW ROYAL Residential 2	0.300	3000	Large lot detached residential	100% Residential	841.548	400.830	13.210	**1255.588**
VIEW ROYAL Residential 3	0.450	4500	Medium lot detached dwelling	100% Residential	1262.322	601.244	19.815	**1883.382**
VIEW ROYAL Residential 4	0.600	6000	Townhouses or row houses	100% Residential	1683.096	801.659	26.421	**2511.176**
VIEW ROYAL Residential 6	0.800	8000	Low rise apartments (approximately 4 storeys)	100% Residential	2244.128	1068.879	35.227	**3348.234**
COLWOOD Recreation 2	0.200	2000	Recreation facilities	100% Education	561.032	267.220	8.807	**837.059**
ESQUIMALT Recreation 2	0.400	4000	Recreation facilities	100% Education	1122.064	534.439	17.614	**1674.117**
OAK BAY Recreation 3	0.650	6500	Recreation facilities	100% Education	1823.354	868.464	28.622	**2720.440**

Appendix C - Heat Energy Recovery from the CRD Wastewater System

Technical Memo

Capital Regional District
Core Area Wastewater Management Program
Secondary Treatment Program Development – Distributed Treatment Task 036

Heat Energy Recovery from the CRD Sanitary Sewer System
October 24, 2008

Prepared by: Mike Homenuke, P.Eng., Wayne Wong, M.A.Sc., Chris Johnston, P.Eng., Kerr Wood Leidal Associates Ltd.

Objective

The Capital Regional District (CRD) is implementing a wastewater management strategy that will involve wastewater conveyance, treatment, reuse and disposal. Alternatives for wastewater treatment options and preliminary sizing of liquid and solids treatment facilities have been discussed in previous discussion papers. Potential locations for placement of new facilities have also been identified.

The objective of this discussion paper is to present the methodology used to determine recoverable heat energy supply from the CRD and municipal sanitary sewer systems. Energy recovered through anaerobic digestion of biosolids is not included in this document.

Energy Recovery from Municipal Wastewater

Energy recovery from municipal wastewater is an emerging application that to date has not seen widespread implementation. Traditionally, heat energy from wastewater has not been considered as an energy source, and has been discharged in the effluent into the receiving environment. With the increased focus on developing alternative and more sustainable energy sources, there is an emerging interest in extracting heat from wastewater either as a primary energy source or to supplement existing energy sources.

The basic process by which heat energy can be extracted from wastewater is the heat exchange between the wastewater and a carrier fluid, that is at different temperatures and separated by a physical barrier, that allows heat to conduct from the wastewater source to the lower temperature carrier fluid. Heat exchangers and heat pumps are technologies that can be used for wastewater heat energy extraction.

A heat exchanger is generally considered to be a passive system, where heat energy is transferred from a high energy source fluid to a carrier fluid by conduction. A heat pump operates by using electrical energy to convert the energy available in the source into a higher temperature in the carrier fluid.

Heat extraction could occur at any point along the wastewater collection system (from raw wastewater) or treatment system (from treated effluent), but the amount of heat extracted would be dependent on the influent and effluent temperatures of the wastewater.

Raw Wastewater

While it is uncommon, the technology exists to recover heat energy directly from raw wastewater using heat exchangers. There are several installations in Europe that use in-pipe heat exchanger technology to extract heat directly from the sewer.

For raw wastewater applications, the heat exchanger could be installed either within the sewer (heat exchange by conduction of heat directly through contact with sewage) or in the trench around the sewer pipe (heat exchange by conduction of heat through the wetted surface of the sewer pipe). The benefit of installing heat exchangers within the sewer is that there is improved heat transfer but there is the increased risk of fouling and corrosion. Heat exchangers outside the sewer have a markedly lower risk of fouling and corrosion, but the drawback is that there is a significant decrease in heat transfer efficiency through the wetted surface of the sewer pipe wall.

Treated Effluent

Heat extraction from treated effluent is a promising option since effluent is significantly lower in biochemical oxygen demand and total suspended solids compared to raw wastewater. From the perspective of energy content, there are minimal heat energy gains or losses within a wastewater treatment plant as the wastewater travels through various unit operations and processes. Thus, the extraction of heat energy from the treated effluent would be beneficial in that the energy content remains essentially unchanged but the potential for fouling and corrosion that would occur using raw wastewater is much less using treated effluent.

An example of heat extraction from treated effluent can be found at Whistler BC. A District Energy System (DES) using heat from treated effluent as the primary heat source is being implemented in the Resort Municipality of Whistler at the Whistler Athletes' Village for the 2010 Winter Olympic and Paralympic Games. The DES at the Athletes' Village is a dual-pipe, closed-loop, ambient temperature system, with a minimum loop temperature of 10 ^{o}C extracted from the wastewater effluent. The minimum return temperature is 5 ^{o}C once heat energy has been extracted at the individual buildings connected to the loop. The heat energy demand is estimated to be up to 11,000 MWh per year for an almost 100,000 square metre development. The Whistler Athletes' Village DES has been designed to deliver 99.8% of the annual heat energy demand from wastewater effluent, with gas-fired boilers available to provide a secondary energy source as backup.

Heat Energy Supply in CRD Sewers

Unit Rate of Heat Energy Recovery

The amount of heat recovered from raw wastewater and treated effluent depends on the amount of heat available in the sewer, and is dependent on parameters such as wastewater temperature, flow rate, and heat transfer efficiency, and specific heat capacity. The estimated maximum theoretical unit heat exchange rate of wastewater (liquid stream) is 33,500 kJ/m^3 at 14 ^oC, assuming that the minimum exit temperature of the wastewater source in the heat exchanger is 6 ^oC. This is based on a unit heat energy of wastewater of 4,187 kJ/m^3/^oC[1]. This is considered representative of heat extraction from a treated effluent stream. Extraction from a raw wastewater stream is expected to have a higher outlet temperature due to the potential for fouling of heat exchange surfaces.

Of particular consideration in the extraction of heat energy is from where the energy is extracted. Heat energy extracted from the raw wastewater stream must be done in such a way that ensures that wastewater entering a WWTP does not drop below 10^oC to ensure treatment processes are not compromised. Further, because the exit temperature of the wastewater or treated effluent from the heat exchanger is assumed to be a minimum of 6^oC, any upstream extraction of heat will impact extraction at downstream locations. Hence, any proposed facilities that are intended only for use as heat extraction will need to have consideration for this effect.

Regional Sewer Hydraulic Modelling

KWL has developed sewer hydraulic models for the District of Saanich (HYDRA) and the CRD trunk sewer system (XP-SWMM).

The Saanich model was developed as an all-pipe model using the District's GIS database. Average dry weather flows are available for individual pipe segments for existing (2005) conditions, but no future flow scenarios have been developed.

The CRD model is a skeletonized trunk model, and has each trunk sewer system discretized into 15-20 modelling segments, which represent approximately 500 individual pipe sections. Flow scenarios are available at 15-year increments from 2005 through to 2065, with a range of return-period I&I loading conditions. These scenarios are based on Official Community Plans (OCPs) from the Core Area municipalities. Discussion Paper #033-DP-2 details the development of this information. The most recent population projections were used to estimate flows from Langford and Colwood, which are detailed in Discussion paper #056-DP-1.

The sewer modelling results have been loaded into a GIS dataset based on the CRD's current GIS sewer database. Pipes over 450 mm dia. were considered to be suitable for usage in this study. This includes a number of municipally-owned pipes, within Saanich as

[1] Discussion Paper 031-DP-6, *Heat Recovery*, June 11, 2008, p. 9

well all of the other Core Area municipalities. In order to estimate flows for the different systems in existing and future scenarios, the following three methods were utilized:

1. If modelled flows were available for a given pipe and scenario (CRD and 2005 Saanich), these were used first;
2. If modelled flows were available for a previous scenario (future Saanich), the flow was linearly scaled based on the incremental increase in flow at the downstream CRD connection point, as determined from the CRD model; and
3. If no modelled flows were available, the branch sewer was broken into subcatchments and flow scaled linearly by upstream tributary area from the downstream CRD connection point, as determined from the CRD model.

The resulting dataset has flow estimates in 920 segments of sewer mains, which provide the basis for a regional sewer heat energy model.

Estimation of Heat Energy in Wastewater

Heat energy in wastewater is estimated based on Average Dry Weather Flow (ADWF), and estimated according to the following equation:

$$HES\,(GJ/d) = ADWF\,(m^3/d) \times UHER_{ww}\,(kJ/m^3)$$

where,

HES = Heat Energy Supply

$UHER_{ww}$ = Unit Heat Exchange Rate @ 14°C= 33,500 kJ/m^3

Heat energy was estimated for each pipe segment over 450 mm dia. in the sewer modelling database, assuming that heat energy would be extracted from treated effluent at a WWTP. Heat supply in any given pipe ranges from 6 GJ/d at the upper reaches in 2008 to 3,600 GJ/d at Macaulay Point by 2065. This is shown on Figures 1-3 for the 2005, 2020 and 2065 scenarios.

Supply Proximity Analysis

Demand Opportunities

The Project Team identified 39 potential heat supply opportunities based on land use, proximity to sewerage infrastructure and existing boilers. These opportunities have been used in the following analysis.

Methodology

A spatial analysis was conducted to quantify heat energy supply to the opportunities within a range of distances. The maximum heat energy supply within 500 m, 1000 m , 1500 m and

FIGURE 1
2005 Sewer Heat Energy Supply Potential

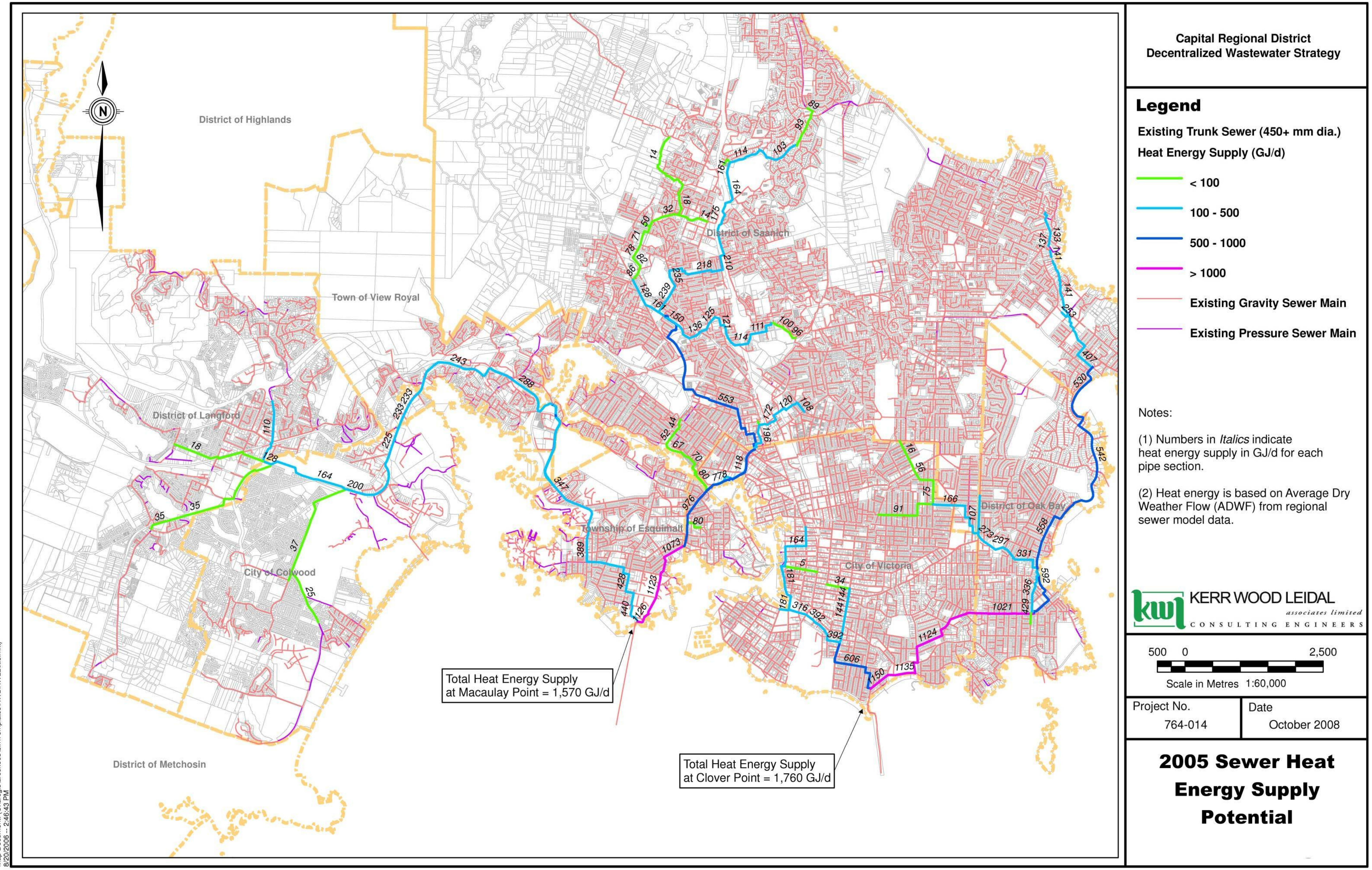


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FIGURE 2
2020 Sewer Heat Energy Supply Potential

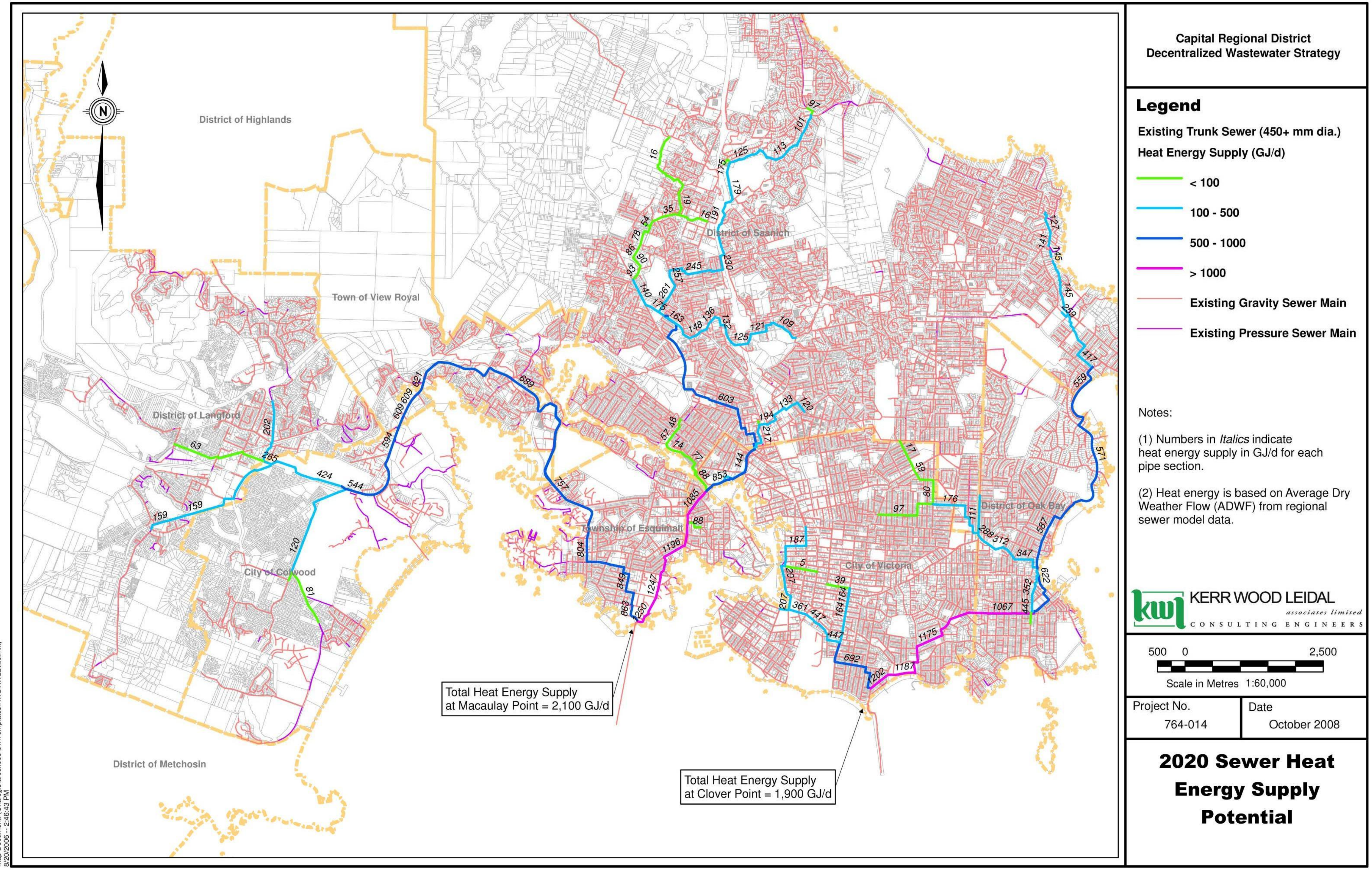

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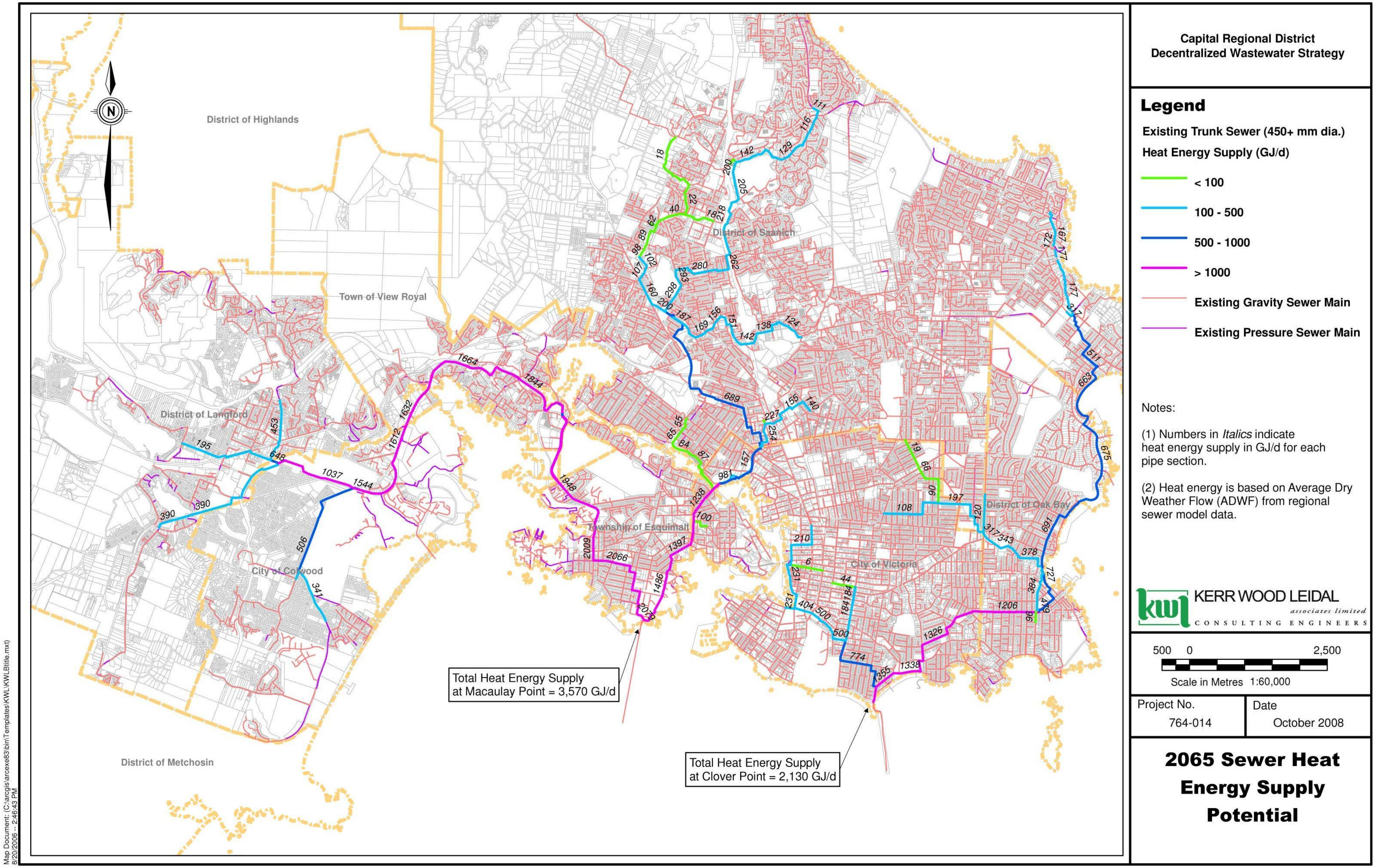
FIGURE 3
2065 Sewer Heat Energy Supply Potential



5000 m radii from the geographic centroid of each opportunity were tabulated for each development scenario. By normalizing the supply by distance and summing these values for each distance tranche, it is possible to rate the opportunities in terms of heat energy supply. The maximum radius of 5000 m is sufficient for identification of energy supply for all opportunities.

This analysis was conducted as a 'base-case' situation, wherein no diversions to potential WWTP locations have been considered. Re-routing flows to potential WWTP sites would result in significant changes to the findings of this analysis.

The following sections discuss the results of the analysis, and Table 1 shows the results of the spatial analysis.

Discussion of Analysis Results

Opportunities that currently have the best proximity to heat sources are located along the lower reaches of the NWTN and NET/ECI. In particular, Opportunity #13 (Esquimalt Centre) is well situated between the NWTN and NWTW. Other noteworthy opportunities proximal to heat supplies include , #4 (East of Downtown), #36 (Oak Bay Marina) and #10 (Douglas Road Corridor).

Most of the opportunities in the Western Communities showed minimal potential in the 2005 scenario due to the limited extent of sewerage servicing in Langford and Colwood. A number of opportunities showed no potential inside the 1500 m radius.

Through 2020, the same opportunities that were identified for 2005 have the best distance-adjusted supply, however a number of opportunities in the Langford/Colwood centre areas increase in rank.

By 2065 the opportunities in the Langford/Colwood centre areas become some of the best in terms of distance-adjusted supply of heat energy. This is a result of the considerable growth predicted for the Western Communities. Key opportunities in the Western Communities at the 2065 scenario include #15 (View Royal Town Centre), #16 (Colwood Corners), #17 (Royal Roads) and #18 (Langford City Centre).

This analysis has indicated that from a distance to supply perspective, most of the best opportunities are located upstream of the existing outfall locations. These locations however may not necessarily represent the best demand opportunities or a suitable location for a WWTP. A number of options will be developed that involve diverting flows to a range of potential WWTP locations and the results of this analysis are expected to change. However, the opportunities identified in this analysis represent those where heat energy can be supplied from the trunk sewer system at a comparatively lower cost due to the proximity to supply.

TABLE 1
Heat Energy Supply at Various Distances from Opportunities

Opportunities		2005 Heat Energy Supply at Distance (GJ/d)				2020 Heat Energy Supply at Distance (GJ/d)				2065 Heat Energy Supply at Distance (GJ/d)				Distance-Normalized Heat Supply (GJ/d/m)				
No.	Name	500 m	1000 m	1500 m	5000 m	500 m	1000 m	1500 m	5000 m	500 m	1000 m	1500 m	5000 m	2005	2020	2065	% Change 2005-2020	% Change 2020-2065
1	James Bay	0	392	606	1,756	0	448	692	1,894	0	500	774	2,128	1.1	1.3	1.4	12%	12%
2	Old Town	181	392	606	1,756	207	448	692	1,894	231	500	774	2,128	1.5	1.7	1.9	13%	12%
3	Downtown Victoria	165	392	606	1,756	187	448	692	1,894	210	500	774	2,128	1.5	1.7	1.9	13%	12%
4	Fairfield	**606**	**606**	**1,756**	**1,756**	**692**	**692**	**1,894**	**1,894**	774	774	2,128	2,128	**3.3**	**3.7**	4.2	11%	12%
5	Hillside	0	76	166	1,756	0	80	177	1,894	0	89	197	2,128	0.5	0.6	0.6	7%	12%
6	Shellbourne and MacKenzie	0	0	0	895	0	0	0	996	0	0	0	1,137	0.2	0.2	0.2	11%	14%
7	University of Victoria	0	0	530	1,022	0	0	559	1,067	0	0	663	1,206	0.6	0.6	0.7	5%	17%
8	Royal Oak	161	175	189	553	175	191	206	603	201	218	235	689	0.7	0.8	0.9	9%	14%
9	Lower Mackenzie	100	110	121	1,072	109	121	133	1,196	125	138	151	1,949	0.6	0.7	0.9	10%	32%
10	Douglas Corridor	**553**	**778**	**778**	**1,127**	**603**	**853**	**853**	**1,250**	689	982	982	2,079	**2.6**	**2.9**	3.4	9%	19%
11	Rock Bay/West Douglas	0	778	975	1,756	0	853	1,084	1,894	0	982	1,238	2,128	1.8	2.0	2.2	10%	14%
12	Esquimalt Harbour	0	181	1,072	1,756	0	207	1,196	1,894	0	231	1,398	2,128	1.2	1.4	1.6	11%	15%
13	Esquimalt Centre	**1,072**	**1,123**	**1,127**	**1,756**	**1,196**	**1,247**	**1,250**	**1,894**	**2,066**	**2,079**	**2,079**	**2,128**	**4.4**	**4.9**	**8.0**	11%	65%
14	Tillicum Mall	553	553	895	1,127	603	603	996	1,250	689	689	1,137	2,079	2.5	2.7	3.2	10%	19%
15	View Royal Town Centre	243	287	553	1,072	620	689	757	1,196	**1,665**	**1,844**	**1,949**	**2,066**	1.4	2.7	**6.9**	97%	157%
16	Colwood Corners	225	234	243	553	594	608	620	849	**1,611**	**1,633**	**1,665**	**2,066**	1.0	2.4	**6.4**	149%	168%
17	Royal Roads	201	225	225	553	545	594	594	849	**1,544**	**1,611**	**1,611**	**2,066**	0.9	2.2	**6.2**	154%	175%
18	Langford City Centre	129	163	163	287	264	424	424	689	647	1,038	1,038	1,844	0.6	1.4	3.4	134%	147%
19	Colwood Employment Centre	0	37	37	243	0	121	159	620	0	506	506	1,665	0.1	0.4	1.2	218%	235%
20	Royal Bay	0	0	25	225	0	0	81	594	0	0	341	1,611	0.1	0.2	0.5	180%	218%
21	Olympic View	0	0	0	201	0	0	0	545	0	0	0	1,544	0.0	0.1	0.3	172%	183%
22	Glen Lake Neighborhood Centre	36	36	36	234	159	159	159	608	389	389	389	1,633	0.2	0.7	1.8	296%	148%
23	Westhills Tower 1	0	0	36	201	0	0	159	545	0	0	389	1,544	0.1	0.2	0.6	236%	164%
24	Westhills Main	0	0	17	201	0	0	62	545	0	0	194	1,544	0.1	0.2	0.4	192%	191%
25	Westhills Tower 2	0	0	0	163	0	0	0	424	0	0	0	1,038	0.0	0.1	0.2	159%	145%
26	Bear Mountain Expansion 1	0	0	17	243	0	0	62	620	0	0	194	1,665	0.1	0.2	0.5	176%	179%
27	Bear Mountain Expansion 2	0	0	0	201	0	0	0	545	0	0	0	1,544	0.0	0.1	0.3	172%	183%
28	Bear Mountain Main	0	0	0	163	0	0	0	424	0	0	0	1,038	0.0	0.1	0.2	159%	145%
29	Langford North Millstream	0	0	110	287	0	0	202	689	0	0	453	1,844	0.1	0.3	0.7	108%	146%
30	Camosun College	0	15	78	553	0	16	85	757	0	17	98	1,949	0.2	0.2	0.5	26%	111%
31	Fort Street	0	0	1,124	1,756	0	0	1,176	1,894	0	0	1,326	2,128	1.1	1.2	1.3	6%	13%
32	DND West Esquimalt	0	0	428	1,127	0	0	849	1,250	0	0	2,066	2,079	0.5	0.8	1.8	60%	120%
33	Jubillee Hospital	274	331	558	1,756	288	347	587	1,894	316	379	692	2,128	1.6	1.7	1.9	6%	12%
34	Victoria General Hospital	0	287	553	1,072	0	689	757	1,196	0	1,844	1,949	2,066	0.9	1.4	3.6	65%	148%
35	Spectrum High School	0	553	553	1,127	0	603	603	1,250	0	689	689	2,079	1.1	1.3	1.6	9%	25%
36	Oak Bay Marina area	**592**	**1,022**	**1,022**	**1,756**	**622**	**1,067**	**1,067**	**1,894**	727	1,206	1,206	2,128	**3.2**	**3.4**	3.9	5%	14%
37	Oak Bay High School-Cadboro Bay Road	331	592	592	1,756	347	622	622	1,894	379	727	727	2,128	2.0	2.1	2.4	5%	14%
38	Queen Alexandra	407	407	530	592	417	417	559	622	510	510	663	727	1.7	1.7	2.1	3%	21%
39	Vanalman	189	235	243	975	206	256	264	1,084	235	294	303	1,949	1.0	1.1	1.4	9%	28%

Notes:
(1) Distances are radial from centroid of opportunity polygon, and do not necessarily represent the actual distance from the opportunity to a sewer main.
(2) Heat energy supply is based on 25,000 kJ/m3/d of Average Dry Weather Flow.
(3) Heat energy supply is the maximum available within the stated distance.
(4) Values in **BOLD** denote top 4 opportunities in each scenario.

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O:\0700-0799\764-014\400-Work\Opportunities\[Opportunities_HeatSupply_20081024.xls]Table1

Summary of Findings

The key findings of this document include:

- Heat energy present in wastewater can be extracted using a number of methods including passive (heat exchangers) and active (heat pump) technologies.
- Technologies currently exist to extract heat energy from treated effluent at a WWTP, or using in-line heat exchange for raw wastewater. Treated effluent heat extraction is expected to have fewer operational problems than that of raw wastewater, primarily due to corrosion and fouling.
- The estimated design rate of heat energy extraction from wastewater assumed for this study is 33,500 kJ/m^3, assuming an inlet temperature of 14ºC and an outlet temperature of 6ºC. This is representative of the use of treated effluent at a WWTP.
- Heat extraction from a raw wastewater stream is expected to result in a higher outlet temperature than would be from a WWTP, and therefore less heat energy would be extracted per unit wastewater volume.
- A key consideration for heat extraction from raw wastewater is the exit temperature, as this can affect wastewater treatment and downstream heat recovery.
- Sanitary sewer hydraulic models are available for the CRD trunk sewer system and the District of Saanich's municipal sewer system. These models provide estimates of ADWF that are suitable for estimating potential heat energy supply at 2005, 2020 and 2065.
- Pipes greater than 450 mm diameter are considered suitable for heat extraction. This formed the basis for development of a GIS-based sewer heat energy supply model, with heat estimates for 920 individual pipe segments.
- 39 demand opportunities identified by the Project Team were used in a spatial analysis to determine the maximum heat energy supply available at 500 m, 1000 m, 1500 m and 5000 m radii.
- From 2005 through 2020 the opportunities with the best supply outlook are located along the lower reaches of the NWTN and ECI/NET.
- By 2065 the opportunities along the NWTW show the most potential in terms of new supply.

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Appendix D - Resource Recovery Evaluation Methodology, Performance Ratings, and Results

Capital Regional District

Core Area Wastewater Management Program
Program Development Phase

Resource Recovery - Evaluation Methodology, Performance Ratings, and Results

Prepared by: Dan Speicher, John Spencer
Previous Issue: None
Issued: November 7, 2008

1 Introduction

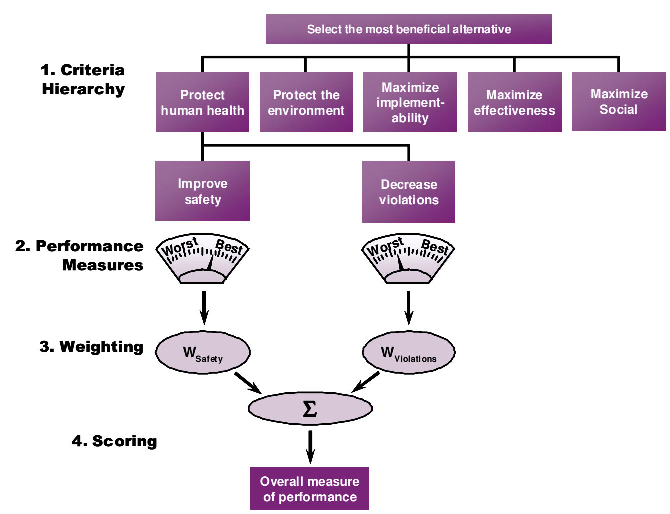
This document is a technical memorandum designed to capture the details of the evaluation of the 39 Energy Recovery Areas.

2 Evaluation of Energy Recovery Opportunity Areas

2.1 Evaluation Methodology

Resource recovery has been incorporated into the mix of selecting the preferred distributed treatment wastewater system by identifying resource recovery opportunity areas within the study area and evaluating the relative performance of those areas and screening the opportunity areas with the multi-objective alternative analysis (MOAA) methodology. Exhibit 1 summarizes this methodology. It begins with the establishment of a Criteria Hierarchy. This hierarchy includes the range of criteria that reflect the spectrum of characteristics of performance.

EXHIBIT 1
Multi-Objective Alternative Analysis



The next key part of the MOAA is formulating performance measures against which the alternatives are assessed. The performance measures could be qualitative (e.g., 4 = high recovery of available heat), or quantitative (e.g., 95% of heat recovery).

With the criteria hierarchy and performance measures in place, the next MOAA step is weighting the relative importance of each criterion. This weighting reflects the values of the CRD. Finally, the alternatives are scored using the performance measures and weightings. All measures and weights are normalized to a 0-1 scale and a weighted average of scores and weights is calculated, resulting in a relative performance score for each alternative.

This methodology is designed to reflect the incorporate the resources recovery element into the overall distributed treatment system process. Specifically, this methodology serves as a screening tool for focusing on the more valuable (more efficient energy transfer and more effective water reuse) resource recovery opportunity areas in the subsequent steps of creating the preferred distributed wastewater treatment system.

2.2 Criteria Hierarchy

The criteria hierarchy is a reflection of the spectrum of characteristics of performance important to the decision makers. This set of criteria was created by the technical team as a reflection of the Provincial direction, the CRD mission, and the data pertinent to the performance of the resource recovery areas. This set of criteria is designed to be a first step in the assessment of performance of energy recovery areas and the screening of the energy recovery opportunity areas.

Performance measures for these criteria were created to reflect the reasonably available data. Much of the data lent to quantitative performance measurements. In other cases, a qualitative assessment was more appropriate to reflect performance.

Nine criteria and associated performance measures were generated as part of this analysis

1. Supply of source heat
2. Amount of heat demand
3. Boiler availability as a percentage of heat demand
4. Demand Development Timing
5. Number of parties involved
6. Treatment and Energy recovery potential
7. Reuse production (assume reuse potential only if have a treatment plant or energy recovery facility)
8. Suitability of reuse demand
9. Combined environmental considerations

Each criterion is described below.

1. Supply of Source Heat

One of the most basic elements of resource recovery is the supply of source heat within the wastewater system. Because of the physical location of the 39 EROAs, the supply of the source heat varies. The higher the supply of source heat the better the opportunity for taking advantage of that source heat; and therefore, the better the performance of the EROA. The performance measurement for this criterion is the estimated giga-joules of heat available in the system per day within 500 meters of the centroid point of the EROA.

2. Amount of recoverable heat demand

In order to better understand the energy reuse opportunities that may exist in the CRD, the level of anticipated demand for energy needed to be estimated. The process of developing 2020 and 2065 energy demand estimates for the core area involved three main phases, Information Collection, Floor Area Calculation, and Energy Demand Projection. The calculations produced heat demand in terms of giga-joules per hectare per day for each EROA. Detailed steps for this calculation are found in Appendix B—Projecting Energy Demand for the Core Municipalities in 2020 and 2065. For the performance ratings, the 2020 estimates of heat demand that could use recoverable energy were estimated. This calculation was based upon the total heat demand and an adjustment factor that estimated the total energy demand that could be served with recovered energy. Table 1 presents the view of the likely use of recovered energy in the 39 Energy Opportunity Areas. Points considered in assigning values included:

a. 2020 is only 4-8 years after the wastewater facilities begin to be built, so there will not be much opportunity for retrofitting existing developments. Hence, 2020 values in the eastern core are generally low.

b. Some West Shore developments (Olympic View, Westhills expansion) will not be built out until the 2020-2065 period, so they have a substantial growth in adoption in 2065.

c. Some areas (Spectrum School, Vic General Hospital) are "all or nothing" areas, with one major energy user.

d. In large areas, even 15% or 20% represents substantial use of recovered energy.

e. In Royal Bay, Olympic View, and Westhills, development is new and can be built to use recovered energy, so the 2065 values are high.

f. In areas with boilers, the replacement schedule will influence the adoption rate.

TABLE 1
Percentage of Total Energy Demand from Recovered Sources in 2020 per EROA

Opportunity Area #	Opportunity Ares Name	% of total energy demand from recovered sources	
		2020	**2065**
1	James Bay	15	30
2	Old Town	10	30
3	Downtown Victoria	15	45
4	Fairfield	15	25
5	Hillside	15	25
6	Shelbourne and McKenzie	15	25
7	University of Victoria	10	30
8	Royal Oak	15	30
9	Lower McKenzie	15	30
10	Douglas Corridor	15	35
11	Rock Bay/West Douglas	15	35

TABLE 1
Percentage of Total Energy Demand from Recovered Sources in 2020 per EROA

Opportunity Area #	Opportunity Ares Name	% of total energy demand from recovered sources	
		2020	**2065**
12	Vic West	15	35
13	Esquimalt Centre	15	35
14	Tillicum Mall	25	35
15	View Royal Town Centre	15	45
16	Colwood Corners	35	45
17	Royal Roads	35	45
18	Langford City Centre	25	35
19	Colwood Employment Centre	25	45
20	Royal Bay	35	45
21	Olympic View	45	55
22	Glen Lake Neighborhood Centre	25	35
23	Westhills Tower 1	20	55
24	Westhills Main	35	55
25	Westhills Tower 2	20	55
26	Bear Mountain Expansion 1	20	30
27	Bear Mountain Expansion 2	20	30
28	Bear Mountain Main	25	35
29	Langford North Millstream	25	35
30	Camosun College	-	-
31	Fort Street	15	30
32	DND West Esquimalt	10	35
33	Jubilee Hospital	20	35
34	Victoria General Hospital	25	35
35	Spectrum High School	35	35
36	Oak Bay Marina area	10	30
37	Oak Bay High School-Cadboro Bay Road	15	30
38	Queen Alexandra	20	45
39	Vanalman	10	35

3. Current boiler availability as a percentage of 2020 heat demand

Having a heat demand is an important element, but having the opportunity to use the heat supply to meet heat demand requires the use of boilers. Boilers are of three different classes: hot water, low-pressure steam and high-pressure steam. Of these, only hot water boilers are compatible with a liquid heat exchange district energy system that would be applied to this energy recovery. As such, boiler inventories for this analysis only included hot water boilers. This boiler inventory is characterized in Appendix E - Utilization of Recovered Heat Energy from Municipal Wastewater.

The more boiler capacity there is currently within an EROA, the better the opportunity to use the heat supply of the wastewater system and the less likely the use of recovered heat supply would have to rely on future development. This criterion reflects the percentage of boiler demand as a percentage of total heat demand with the EROA. The higher the better.

4. Demand Development Timing

The timing of development is another rating of the relative performance of the EROAs. Those EROAs with potential or planned development within a 'sweet-spot' time-frame would maximize the use of heat supply. The performance measure was constructed to reflect this sweet-spot.

1- Low existing demand, all growth later than 2020

2- Low existing demand, moderate growth after 2010 OR moderate existing demand, slow growth after 2010

3- Moderate existing demand, moderate growth after 2010

4- Low existing demand, rapid growth after 2010

The performance ratings for the EROAs were performed by the technical team with reference to land use maps and interaction with many owners throughout the CRD.

5. Number of parties involved

Application of heat exchangers to use the heat supply from the wastewater system involves working with owners of existing properties and owners of future developments. The more owners there are within an EROA, the lower the probability of successfully applying heat exchange technology. More players simply add more complexity to the application. The fewer the owners, the higher the probability of success.

1 – More than 10 owners

2 – 6 to 10 owners

3 – 2 to 5 owners

4 – One owner

6. Treatment and Energy recovery potential

The greatest potential for energy recovery lies with the use of effluent from a treatment plant. Removal of heat from the effluent has limitations. However, a heat exchange upstream from a treatment plant, on the other hand, has an additional limitation of heat removal from the raw wastewater. Too much heat removal from the raw wastewater jeopardizes the treatment conditions at the plant. Secondly, the closer the treatment plant to the energy demand the higher the efficiency and effectiveness in transferring that energy. These two conditions point to a realization that EROAs very close to a treatment plant present the best energy recovery potential. This criterion is captured in a binary performance scale.

1 = Yes, a treatment plant within 500 meters

0 = No, no treatment plant within 500 meters

If a treatment plant is logical and possible within 500 meters, the EROA received a rating of 1. The location of logical and possible treatment plants was created by the technical team for this analysis. The collection areas, the nodal points, and the reasonable locations for treatment facilities were all passed through the professional judgement filter of the technical team. These plant locations are an assumption that is carried through this first analysis, and applied specifically to this criterion and the next criterion, Reuse Production.

7. Reuse production

Water reuse is a benefit that can be derived from treated wastewater. We have incorporated water reuse wherever an efficient and effective energy recovery opportunity exists so those together - reuse and energy recovery - make use of treatment facilities. Therefore, the location of potential treatment facilities and/or energy recovery facilities is the driving factor determining the potential reuse production.

For this assessment, the designated possible distributed wastewater treatment and energy recovery sites were used again. The constructed performance scale was the following:

1 = No Class A treatment,

2 = Secondary treatment and Class A Water 1km-2km,

3 = Secondary Treatment works between 500m-1km,

4 = Secondary Treatment and Class A <500m distance

The distance refers to how close the EROA is to the treatment facility. The closer the treatment facility, the better the reuse production performance of the EROA.

8. Suitability of reuse demand

The gradual change in land-uses and public acceptance of reclaimed water in both interior and outside uses should be expected and therefore should be taken into account so that the resulting distributed system enables this change. With this in mind, it is appropriate to consider the performance of the EROAs relative to possible water reuse implementation.

There are many potential water reuse applications in the CRD study area. These uses range from higher volume irrigation to lower volume industrial and residential application. The best opportunities lie with outdoor irrigation of landscaping, golf-courses and other large open spaces (playfields, large lawns and boulevards, and parks). Industrial uses, commercial uses, and water reuse in other built structures were not examined. This criterion was created to reflect the potential for the best water reuse opportunities within the EROAs. Using the current land uses mapping and site verification; the [technical team] reviewed each EROA and judged the potential opportunity for water reuse with this performance scale:

0 – No water demand

1 – Many small, seasonal water users

2 – Moderately sized, seasonal users

3 – Large sized, seasonal users

4 – Large sized, non-seasonally dependent users

Table 2 showcases the possible water resource opportunities for the 39 recovery areas. From this information the rating of performance was derived.

TABLE 2
Preliminary Water Reuse Opportunities

Area	Area Name	Preliminary Water Reuse Opportunities
1	James Bay	Limited, but large area includes two dispersed playfields and lawn of Legislature
2	Old Town	Very limited in immediate vicinity
3	Downtown Victoria	Very limited
4	East of Downtown Victoria	Some, polygon is adjacent to Beacon Hill Park
5	Hillside Mall-South Shelbourne	Some, but polygon adjacent to a school field and 500m from the Cedar Hill Golf Course
6	Shelbourne and Mackenzie	Limited, but polygon adjacent to school fields
7	University of Victoria	Yes, lawns and playfields
8	Royal Oak	Yes, but limited to two school fields and highway boulevard
9	Lower Mackenzie	Limited, but polygon adjacent to school fields
10	North Douglas Corridor-Town and Country Mall	Some, includes walkways, park, highway boulevards
11	Gorge-Rock Bay	Limited
12	Vic West	Some, includes walkways, park, sports fields
13	Esquimalt Centre	Limited
14	Burnside-Tillicum	Some, including sports fields
15	View Royal Town Centre	Limited in polygon, but approximately 600m from new golf course
16	Colwood Corners	Limited in polygon, but adjacent to Royal Colwood Golf and Country Club
17	Royal Roads	Yes, lawns, playfields, and gardens
18	Langford City Centre	Yes, adjacent to Royal Colwood Golf and Country Club. Polygon also includes fields and opportunities for redevelopment in a large area
19	Colwood Employment Centre	Some, depending on form of development that occurs in and around polygon (e.g. Royal Bay, Royal Roads)

TABLE 2
Preliminary Water Reuse Opportunities

Area	Area Name	Preliminary Water Reuse Opportunities
20	Royal Bay	Yes, potential for new, large residential community
21	Olympic View	Yes, development adjacent to a golf course
22	Glen Lake Neighborhood Centre	Limited
23	Westhills Tower 1	Some, depending on form of development that occurs
24	Westhills Main	Some, depending on form of development that occurs
25	Westhills Tower 2	Some, depending on form of development that occurs
26	Bear Mountain Expansion 1	Yes, development in close proximity to a golf course
27	Bear Mountain Expansion 2	Yes, development adjacent to a golf course
28	Bear Mountain Main	Yes, development adjacent to a golf course
29	Langford North Millstream	Limited
30	Camosun College	Yes, horticultural school, and associated infrastructure
31	Fort Street	Some, includes walkways, park, sports fields
32	DND West Esquimalt	Some, includes military operational areas
33	Jubilee Hospital	Some, includes open fields and playfields
34	Victoria General Hospital	Some, approximately 900m from a new golf course
35	Spectrum High School	Yes, some open space and play fields
36	Oak Bay Marina area	Limited
37	Oak Bay High School-Cadboro Bay Road	Some, includes, and adjacent to, five dispersed play fields
38	Queen Alexandra hospital	Yes, includes open fields and playfields
39	Vanalman	Limited

9. Combined environmental considerations

Placing heat recovery facilities and infrastructure in EROAs will effect the environment. Each area has unique attributes and constraints that make them more or less suitable for siting a heat recovery facility. The criterion was incorporated to analyze the range of influences that siting heat recovery facilities would have on the local environment within the 39 EROAs, and potential effects of the environment on a heat recovery facility.

Four disciplines are considered in the environmental analysis.

A. Geotechnical conditions

B. Land use compatibility

C. Ecological conditions

D. Heritage and archaeology

Each discipline lead generated mapped information for the study area that describes suitability for facility siting. The performance scale used for each discipline was a constructed scale of 1 through 3, where sites that scored 3 were considered suitable for siting a wastewater heat recovery facility or infrastructure, 2 moderately suitable and, sites scoring 1 were considered less suitable or unsuitable.

The digital information collected for each discipline was overlaid with the EROAs. Each EROA was then visually assessed and scored in terms of archaeological, ecological, geological, and land use suitability. A single score was calculated for each of the four disciplines using the pertinent data. The combination of the four disciplines scoring produced an overarching environmental analysis performance rating for each EROA.

The more detailed review of this environmental analysis method is found in Appendix F, Energy Recovery Opportunity Areas – Environmental Analysis. As with all of the screening analysis, the environmental analysis was undertaken as a broad analysis and is not intended to identify specific sites suitable for locating a wastewater heat recovery facility.

2.3 EROAs Evaluation

Each EROA was rated relative to the performance criteria. Table 3 summarizes the performance of the 39 EROAs.

TABLE 3
Performance Ratings for EROAs

		1	2	3	4	5	6	7	8	9
		Quantitative	Quantitative	Quantitative	Qualitative	Qualitative	Qualitative	Based upon Quantitative Data	Qualitative	Qualitative
		Supply of source heat in 2020	Amount of recoverable heat demand in 2020	2008 current boiler recoverable heat demand as a % of 2020 total heat demand	Demand Development Timing	Number of parties involved	Treatment and Energy recovery potential	Reuse production (assume reuse potential only if have a treatment plant or energy recovery facility)	Suitability of reuse demand	Combined environmental considerations
		Quantitative	Quantitative	Quantitative	1-4 constructed scale	1-4 constructed scale	Yes or No	1-4 constructed scale	0-4 constructed scale	1-3 constructed scale
Site Number	**Site Description**	Gj/d within 500m	Gj/ha/d (distance is not known)	% (indicator of cost and future development)	1- Low existing demand, all growth later than 2020 2- Low existing demand, moderate growth after 2010 OR Moderate existing demand, slow growth after 2010 3- Moderate existing demand, moderate growth after 2010 4- Low existing demand, rapid growth after 2010	1- More than 10 owners 2- 6 to 10 owners 3- 2 to 5 owners 4- One owner	1- Yes - treatment plant within 500 M 0- No - no treatment plant	1= No Class A treatment, 2=Secondary treatment and Class A Water 1km-2km, 3=Secondary Treatment works between 500m-1km, 4 = Secondary Treatment and Class A <500m distance	0 - No water demand 1- Many small, seasonal water users 2- Moderately sized, seasonal users 3- Large sized, seasonal users 4- Large sized, non-seasonally dependent users	1- Substantial environmental concerns 2- Moderate environmental concerns 3- Few or no environmental concerns
1	**James Bay and Legislative District**	75	3.5	531%	2	1	1	4	1	2
2	**Old Town**	110	4.8	761%	2	1	0	2	0	1
3	**Downtown Victoria**	100	25.2	177%	3	1	1	2	1	2
4	**Fairfield**	369	4.6	553%	2	1	0	2	1	2
5	**Hillside Mall-South Shelbourne**	0	5.5	41%	3	1	0	0	1	3
6	**Shelbourne and McKenzie**	0	5.8	73%	3	1	0	0	1	3
7	**University of Victoria (Saanich)**	0	5.1	177%	3	4	0	3	3	2
8	**Royal Oak**	98	5.7	0%	2	2	0	0	2	3
9	**Quadra-McKenzie**	61	3.2	138%	2	1	0	0	1	3
10	**North Douglas Corridor-Town and Country Mall**	532	7.2	60%	3	1	1	4	1	3
11	**Gorge-Rock Bay**	0	4.6	156%	3	1	1	4	1	3
12	**Vic West**	0	4.9	65%	3	1	0	2	1	1

TABLE 3
Performance Ratings for EROAs

		1	2	3	4	5	6	7	8	9
		Quantitative	Quantitative	Quantitative	Qualitative	Qualitative	Qualitative	Based upon Quantitative Data	Qualitative	Qualitative
		Supply of source heat in 2020	Amount of recoverable heat demand in 2020	2008 current boiler recoverable heat demand as a % of 2020 total heat demand	Demand Development Timing	Number of parties involved	Treatment and Energy recovery potential	Reuse production (assume reuse potential only if have a treatment plant or energy recovery facility)	Suitability of reuse demand	Combined environmental considerations
13	**Esquimalt Centre**	732	3.9	218%	3	1	1	3	1	2
14	**Burnside-Tillicum**	378	12.6	15%	2	2	0	2	2	3
15	**View Royal Town Centre**	32	4.9	0%	4	3	0	2	2	3
16	**Colwood Corners**	111	23.6	9%	4	3	1	3	2	2
17	**Royal Roads**	111	8.5	61%	2	4	0	2	2	1
18	**Langford City Centre**	26	14.6	2%	3	1	1	4	2	3
19	**Colwood Employment Centre**	0	9.5	0%	4	3	0	0	2	2
20	**Royal Bay**	0	5.2	0%	4	4	1	4	3	2
21	**Olympic View**	0	10.2	0%	1	4	0	0	3	2
22	**Glen Lake Neighborhood Centre**	16	6.3	0%	2	1	0	2	1	2
23	**Westhills Tower 1**	0	5.1	0%	1	4	1	4	2	2
24	**Westhills Main**	0	14.9	0%	4	4	0	3	3	1
25	**Westhills Tower 2**	0	5.1	0%	1	4	0	2	2	2
26	**Bear Mountain Expansion 1**	0	5.1	0%	2	1	0	3	2	1
27	**Bear Mountain Expansion 2**	0	5.0	0%	2	1	0	2	3	1
28	**Bear Mountain Main**	0	10.6	5%	3	1	0	0	3	2
29	**Langford North Millstream**	0	6.3	0%	2	1	0	2	1	3
30	**Camosun College**	0	0.0	0%	0	0	0	0	0	1
31	**Upper Fort Street**	0	4.2	407%	2	1	0	0	2	2
32	**DND West Esquimalt**	0	0.6	6273%	2	4	0	3	1	2
33	**Jubilee Hospital**	146	3.8	62%	2	1	0	2	2	1
34	**Victoria General Hospital**	0	2.3	1233%	2	2	0	0	1	2

TABLE 3
Performance Ratings for EROAs

		1	2	3	4	5	6	7	8	9
		Quantitative	Quantitative	Quantitative	Qualitative	Qualitative	Qualitative	Based upon Quantitative Data	Qualitative	Qualitative
		Supply of source heat in 2020	Amount of recoverable heat demand in 2020	2008 current boiler recoverable heat demand as a % of 2020 total heat demand	Demand Development Timing	Number of parties involved	Treatment and Energy recovery potential	Reuse production (assume reuse potential only if have a treatment plant or energy recovery facility)	Suitability of reuse demand	Combined environmental considerations
35	**Spectrum High School**	0	7.5	113%	1	4	0	0	2	1
36	**Oak Bay Marina area**	225	1.7	1170%	2	1	1	4	1	1
37	**Oak Bay High School-Cadboro Bay Road**	178	2.9	503%	2	1	0	2	2	2
38	**Queen Alexandra**	207	3.3	224%	2	4	1	4	2	1
39	**Vanalman**	115	4.3	124%	3	1	0	0	1	2

The product of this analysis is a weighted calculation of the relative performance of the 39 EROAs. For this screening effort, the assumption was that each of the nine criteria are of equal weight.

The rank order results are presented in Table 4.

TABLE 4
Performance Scores of EROAs

Rank	EROAs	Relative Performance Score
1	16. Colwood	0.64
2	20. Royal Bay	0.63
3	10. N. Doug. Corr.	0.60
4	18. Langford City	0.59
5	13. Esquimalt Ctr.	0.53
6	23. Westhills T-1	0.51
7	38. Queen Alex.	0.51
8	3. Down. Vic.	0.50
9	11. Gorge-Rock	0.50
10	24. Westhills Main	0.48
11	7. U of V (Saanich)	0.47
12	14. Burnside-Tillicum	0.47
13	15. View Royal	0.46
14	32. DND West Esq.	0.46
15	1. James Bay	0.43
16	36. Oak Bay Marina	0.40
17	19. Colwood Emp. Ctr.	0.37
18	17. Royal Rds.	0.35
19	21. Olympic View	0.35
20	25. Westhills T-2	0.35
21	8. Royal Oak	0.34
22	4. East of Down Vic.	0.32
23	28. Bear Mtn. Main	0.32
24	37. Oak Bay HS	0.32
25	29. Langford N. Mill.	0.31
26	6. Shell. & Mac.	0.29

TABLE 4
Performance Scores of EROAs

Rank	EROAs	Relative Performance Score
27	5. Hillside-S. Shell.	0.28
28	27. Bear Mtn. 2	0.27
29	9. Lower Mac.	0.26
30	22. Glen Lake	0.26
31	26. Bear Mtn. 1	0.26
32	33. Jubilee Hospital	0.25
33	35. Spectrum HS	0.25
34	31. Upper Fort St.	0.24
35	34. Victoria Gen. Hos.	0.24
36	39. Vanalman	0.24
37	12. Vic West	0.23
38	2. Old Town	0.19
39	30. Camosun	0.00

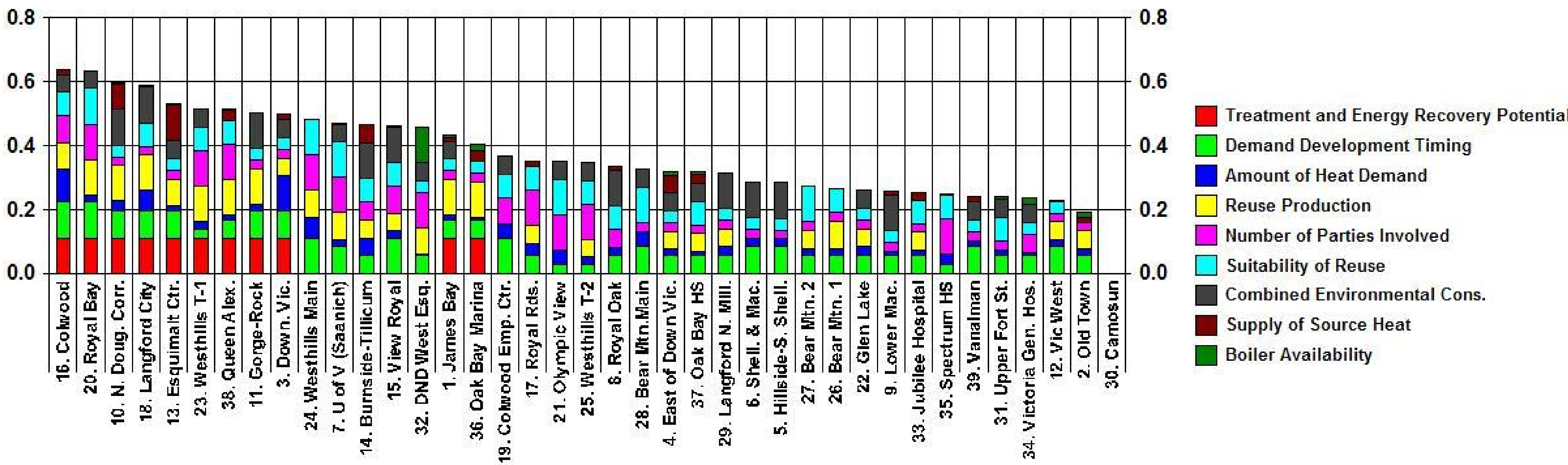
Exhibit 2 shows a powerful means to display this information. This graphic lists the 39 EROAs from best to worst performing from left to right. It is in the same rank order as found in Table 000. The colored bars represent the total performance score of each EROA (e.g., the 0.64 performance score of Colwood Corner, the top performing resource recovery opportunity area, is displayed as a point just above the 0.6 demarcation on the y-axis). The different colors of the bar represent the individual contribution of performance from each of the nine criteria. The size of the individual colored bars showcase the contribution an individual EROA received from that criterion—the larger the colored segment, the better the performance of the EROA on that criterion. For example, Colwood Corners performed well on 'Treatment and Energy Recovery Potential' and therefore received a contribution as showcased by the red segment. A number of other EROAs also performed well and in 'Treatment and Energy Recovery Potential' and received the same contribution as Colwood Corners.

This graph also shows the relative value or importance an individual criterion has on the performance score. The legend presents the most influential criterion at the top with decreasing influence towards the bottom. The results suggest that 'Treatment and Energy Recovery Potential' has the single largest contribution to differentiating the 39 EROAs. On the other hand, 'Supply of Source Heat' and 'Boiler Availability' have the least influence. Some EROAs receive contribution from these two criteria (the colored segment representing these two criteria show up in some EROAs performance bar), but they provide very little differentiation among the 39 EROA options.

This graph is also particularly helpful in displaying the relative performance of the options. The gradual decrease in relative performance shows that there is no obvious break point between the higher performing EROAs and the lower performing EROAs. The only exception is Camosun. That option should be removed from consideration.

The results of this ranking can be used to focus the selection of EROAs in terms of the potential to maximize energy recovery and water reuse. The distributed wastewater treatment system creation can then optimize the use of energy recovery and water reuse.

EXHIBIT 2
Contributions by Criteria



Appendix E - Utilization of Recovered Heat Energy from Municipal Wastewater

Technical Memo

Capital Regional District
Core Area Wastewater Management Program
Secondary Treatment Program Development – Distributed Treatment Task 036

Utilization of Recovered Heat Energy from Municipal Wastewater
October 31, 2008

Prepared by: Mike Homenuke, P.Eng., Wayne Wong, M.A.Sc., Chris Johnston, P.Eng., Kerr Wood Leidal Associates Ltd.

Objective

The Capital Regional District (CRD) is implementing a wastewater management strategy that will involve wastewater conveyance, treatment, reuse and disposal. Alternatives for wastewater treatment options and preliminary sizing of liquid and solids treatment facilities have been discussed in previous discussion papers. Potential locations for placement of new facilities have also been identified.

The objective of this technical memo is to present the methodology used to determine potential demand opportunities for heat energy recovered from the municipal wastewater system in the CRD. This document has been developed in concert with the "*Heat Energy Recovery from the CRD Sanitary Sewer System*" memo produced by KWL in October 2008.

Utilization of Recovered Wastewater Heat Energy

Heat energy from wastewater is proposed to be recovered using heat exchangers or heat pumps that transfer energy from either raw wastewater or treated effluent to a closed-loop pipe system that distributes heat to end users. This system typically has a dual-pipe configuration in which one pipe carries heated fluid from the heat source to the destination buildings, while the other pipe returns the same (cooled) fluid back to the heat source. Depending upon the type of carrier fluid and heat exchange equipment used, the temperature of the closed-loop system may vary.

A (passive) heat exchanger system uses conduction to transfer the heat energy of the wastewater to the carrier fluid, and results in the carrier fluid temperature being similar to that of the heat source. A heat pump system uses electrical energy in concert with compressible fluids to transfer the source energy to a higher temperature carrier fluid.

In a District Energy System (DES) arrangement, heat pumps in buildings would typically transfer the heat energy from the closed-loop system to either a forced-air or radiant floor heating system to distribute heat throughout the building. Boiler systems and water heaters can also use the heat energy to offset electrical or combustion energy requirements.

Design Considerations

Wastewater has a finite amount of heat energy available for recovery. The technical memo "*Heat Energy Recovery from the CRD Sanitary Sewer System*"[3] states that the assumed influent wastewater temperature for the CRD system is 14ºC, and a minimum exit temperature of 6ºC. Using a passive heat exchange to an aqueous carrier fluid, the resulting maximum carrier fluid temperature would be close to 14ºC. A heat pump system using a refrigerant-type carrier may boost the temperature significantly higher. In either case, the energy recovered is considered to be 'low-grade' heat (reference 031-DP-6, *Heat Recovery*).

The primary consideration in selecting a configuration to transport the heat energy is that energy losses between the heat source and end user will increase with temperature and distance. It is anticipated that consumption of heat energy will occur at some distance away from the heat source[4]. Further, because the total amount of heat available is limited, little is to be gained by using a heat pump for extraction of the heat energy. Hence, a lower-temperature carrier fluid is preferable in order to maximize the amount of recovered heat energy consumed by end users.

There remains one drawback to low-grade heat, which is that this system is incompatible with steam boiler systems. This is a result of the building-side heat pump only being able to boost the temperature from a low-grade heat source to a maximum of approximately 60ºC. This is approximately the same output temperature that a hot water boiler would provide. A high- or low-pressure steam boiler system requires a much higher-grade heat source, which cannot be provided by a heat pump.[5]As discussed in the following sections, most boilers in the Core Area are hot water; therefore the impact of this situation is minimal.

Heat Energy Demand Opportunities

Potential utilization of the heat energy that can be recovered from the wastewater stream can be considered in a number of ways:

- On-site use, e.g. wastewater treatment plant needs;
- Early opportunities such as existing boilers;
- Institutional opportunities including universities, hospitals and government buildings; and
- New development that can integrate recovered heat energy into design.

In general, existing buildings with boilers are the only locations where utilization of recovered heat is expected to be feasible, as these buildings are already fitted with hot water distribution systems. Single-family residential areas, for instance would not represent feasible opportunities because of low density and high individual retrofit costs. New residential and commercial developments that incorporate DES into design represent the bulk of future opportunities.

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[3] Kerr Wood Leidal Associates Ltd. Technical Memo for Discussion Paper 036-DP-1. October 24, 2008.

[4] Ibid. Table 1.

[5] CH2M HILL, Wastewater Heat Recovery – Options for Effluent Heat Recovery at Treatment Plants Technical Memo #3.

Existing Boilers

Existing boiler locations, unit types and capacity (in m^2 heat exchanger area) were supplied by the BC Safety Authority (BCSA) in February 2008. In order to estimate design boiler capacity (DBC) in terms of heat energy, a unit heating rate of 5 boiler hp/sq. ft. was determined from industry data. This converts to 1.82 $GJ/m^2/d$, which was multiplied with the heat exchanger area to estimate DBC. Boilers on a Design Heating Day (DHD) do not operate at peak capacity, and a peaking factor is required to relate boiler capacity to DHD demand and average annual demand (AAD).

Boilers are classified in three types in the BCSA database: hot water, low-pressure steam and high-pressure steam. Of these, only hot water boilers are compatible with the low-grade heat supplied through the proposed DES, and as such, boiler inventories reported in this document only include hot water boilers.

CH2M[6] provided a number of peaking factors for determination of DHD heat demands:

DBC/AAD = 3.09

DHD/AAD = 2.81

DHD/DBC = 0.91

The composite DHD/ DBC factor was used to estimate DHD demand from the BCSA database. This is an estimate of the total heat demand for a given building based on the boiler capacity. In practice, a heat pump will be used to offset the heat energy normally generated with a boiler. Because of the additional electrical energy provided through a heat pump, the peaking factor for comparing heat supply against DHD demand is reduced. The ratio provided by CH2M was a DHD/AAD of 2.50 (DHD/DBC = 0.81).

In total there are 971 boilers listed in the BCSA database, of which 894 are hot water boilers. The steam boilers are generally located on larger institutional properties, such as the universities, hospitals or military bases. The hot water boilers are estimated to have a combined DHD demand of 27,650 GJ/d, and an AAD of 3,591,000 GJ/a. Figure 1 shows the locations of all hot water boilers in the Core Area.

Future Opportunities

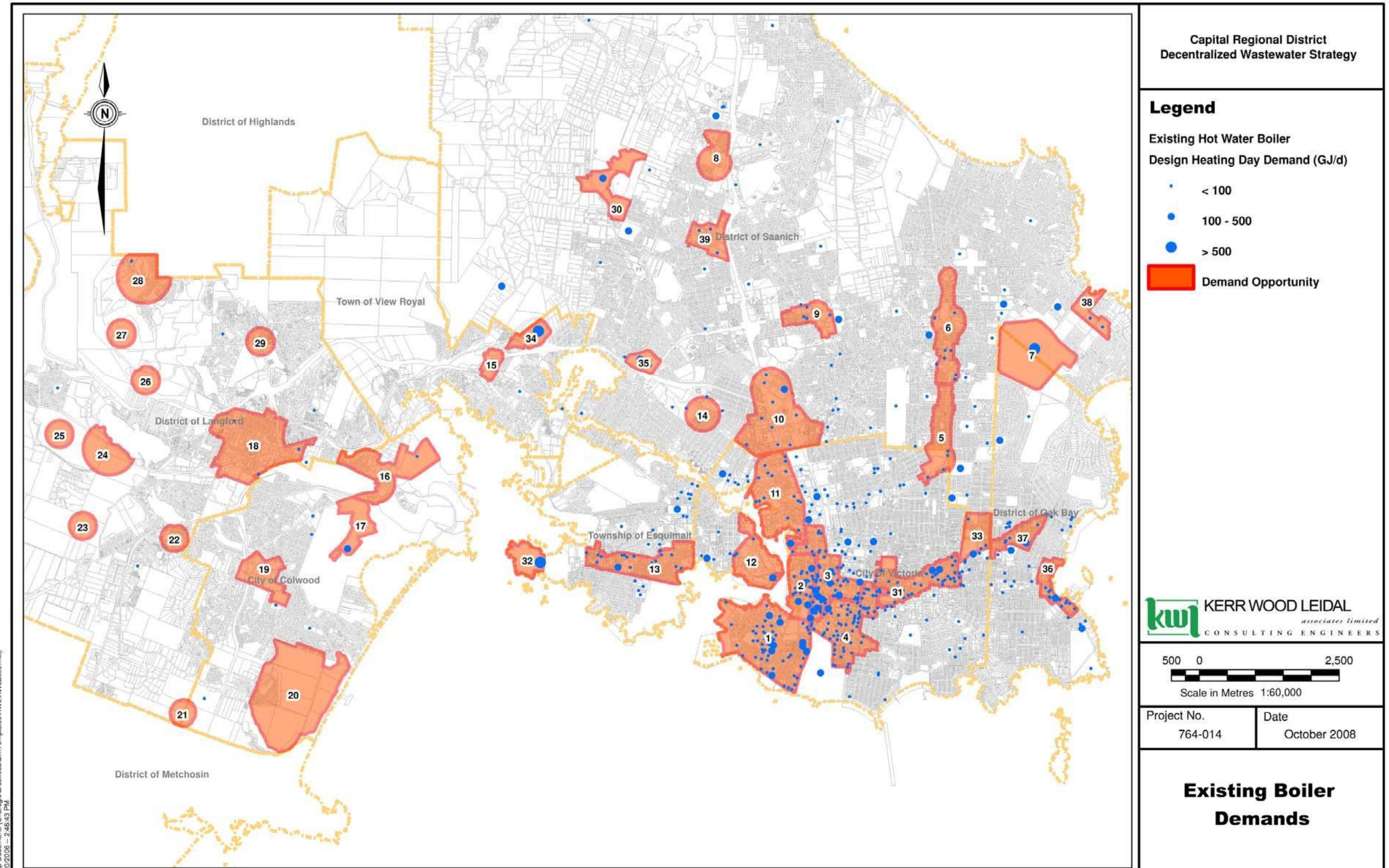
The Project Team identified 39 energy opportunities based on existing and future land use, as well as proximity to trunk sewer infrastructure and existing boilers. For each opportunity, the future average annual heat energy demands in 2020 and 2065 were estimated by Westlands Resource Group.

Future opportunities are assumed to have a direct transfer of heat energy from the building heat pump into forced-air, and radiant heating systems. As indicated above, the DHD/AAD ratio of 2.50 was assumed.

Within the 39 opportunities identified by the Project Team, the total DHD boiler demand has been estimated at approximately 18,500 GJ/d, which accounts for two-thirds of the total Core Area boiler capacity. Table 1 lists existing boiler demands and Table 2 lists future

[6] Personal communication October 15, 2008, Neal Forrester, P.E., CH2M

EXHIBIT 1
Existing Boiler Demands



demands for each opportunity. Potential demands increase to 94,000 GJ/d and 140,000 GJ/d by 2020 and 2065, respectively.

The greatest concentrations of existing boiler demands are in the following opportunities:

- Downtown (#3)
- James Bay (#1)
- Fairfield/East of Downtown (#4)
- Old Town (#2)
- DND West Esquimalt (#32)
- University of Victoria (#7)

These represent locations that exceed 1,000 GJ/d in potential demand for heat recovered from wastewater. At the 2020 and 2065 development levels, the number of opportunities exceeding 1,000 GJ/d increases to 23 and 26, respectively. These opportunities are located throughout the Core Area. Table 3 summarizes the demands for recovered heat energy at each development scenario.

Supply-Demand Analysis

With available heat supplies having been determined as per the "*Heat Energy Recovery from the CRD Sanitary Sewer System*" memo, a supply-demand comparison can be made at the 2005/2008 (existing), 2020 and 2065 development scenarios. This analysis at its current state however, would not account for potential WWTP locations, which are to be addressed in a subsequent discussion paper. The end-of-pipe recoverable heat supply ranges from approximately 3,000 GJ/d in 2005 to 5,500 GJ/d by 2065.

The opportunities that have demands exceeding 1,000 GJ/d represent locations where the heat recovered from a small-to-medium-sized WWTP could be fully utilized. Based on the number of opportunities that exceed this amount at the 2020 and 2065 development levels, there are a large number of locations that would potentially support resource recovery. Overall, the projected demand exceeds the available recovered energy supply by a factor of ~20:1 and ~30:1 by 2020 and 2065 respectively.

At the existing development scenario, only WWTPs in the Inner Harbour and UVic areas are anticipated to have enough adjacent demand to fully utilize recovered heat energy. Total demands exceed supply for these areas by a ratio of approximately ~3:1 in 2005/2008.

Summary of Findings

The key findings of this document include:

- Heat energy recovered from the wastewater stream is assumed to be distributed to buildings through a closed-loop district energy system, and transferred to individual buildings using a heat pump.
- District energy piping systems are assumed to use a low-temperature (~14ºC) aqueous carrier fluid.

TABLE 1
Summary of Existing (2008) Boiler Capacity and Demands in Opportunity Areas

Opportunities No.	Name	Existing Design Boiler Capacity (GJ/d)	Existing Design Heating Day Demand (GJ/d)	Existing Average Annual Demand (GJ/yr)	Estimated Demand for Recovered Heat (GJ/d)
		(1)	(2) = (1) x 2.91/3.09	(3) = (1) / 3.09 x 365	(4) = (2) x 2.50/2.91
1	James Bay	3,309	3,010	390,847	2,586
2	Old Town	1,667	1,514	196,927	1,301
3	Downtown Victoria	3,133	2,850	369,783	2,448
4	Fairfield	2,295	2,090	270,890	1,796
5	Hillside	137	125	16,124	107
6	Shellbourne and MacKenzie	305	275	35,903	236
7	University of Victoria	1,323	1,203	156,293	1,034
8	Royal Oak	0	0	0	0
9	Lower Mackenzie	159	144	18,704	124
10	Douglas Corridor	560	510	66,216	438
11	Rock Bay/West Douglas	781	712	92,445	612
12	Esquimalt Harbour	204	185	24,079	159
13	Esquimalt Centre	699	637	82,557	547
14	Tillicum Mall	55	50	6,450	43
15	View Royal Town Centre	0	0	0	0
16	Colwood Corners	109	99	12,899	85
17	Royal Roads	162	147	19,134	126
18	Langford City Centre	57	52	6,665	45
19	Colwood Employment Centre	0	0	0	0
20	Royal Bay	0	0	0	0
21	Olympic View	0	0	0	0
22	Glen Lake Neighborhood Centre	0	0	0	0
23	Westhills Tower 1	0	0	0	0
24	Westhills Main	0	0	0	0
25	Westhills Tower 2	0	0	0	0
26	Bear Mountain Expansion 1	0	0	0	0
27	Bear Mountain Expansion 2	0	0	0	0
28	Bear Mountain Main	36	33	4,300	28
29	Langford North Millstream	0	0	0	0
30	Camosun College	302	275	35,687	236
31	Fort Street	1,258	1,141	148,346	980
32	DND West Esquimalt	1,432	1,303	169,192	1,119
33	Jubillee Hospital	88	80	10,320	69
34	Victoria General Hospital	728	662	85,994	569
35	Spectrum High School	167	152	19,779	131
36	Oak Bay Marina area	535	485	63,208	417
37	Oak Bay High School-Cadboro Bay Road	454	411	53,532	353
38	Queen Alexandra	215	195	25,368	168
39	Vanalman	204	185	24,078	159
Total		**20,374**	**18,525**	**2,405,720**	**15,915**

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O:\0700-0799\764-014\400-Work\BoilerData\[OpportunityBoilerSummary_20081029.xls]Table1BoilerMemo

TABLE 2
Summary of Future Demands in Opportunity Areas

Opportunities No.	Name	2020 Average Annual Demand (GJ/yr)	2020 Design Heat Day Demand (GJ/d)	2020 Estimated Demand for Recovered Heat (GJ/d)	2065 Average Annual Demand (GJ/yr)	2065 Design Heat Day Demand (GJ/d)	2065 Estimated Demand for Recovered Heat (GJ/d)
		(1)	(2) = (1)/365 x 2.91	(3) = (1)/365 x 2.5	(4)	(5) = (4)/365 x 2.91	(6) = (5)/365 x 2.5
1	James Bay	612,913	4,887	4,198	786,979	6,274	5,390
2	Old Town	322,919	2,575	2,212	484,342	3,861	3,317
3	Downtown Victoria	1,743,868	13,903	11,944	2,441,393	19,464	16,722
4	Fairfield	408,550	3,257	2,798	576,158	4,593	3,946
5	Hillside	325,579	2,596	2,230	546,604	4,358	3,744
6	Shellbourne and MacKenzie	419,556	3,345	2,874	696,817	5,555	4,773
7	University of Victoria	1,101,045	8,778	7,541	1,147,491	9,148	7,860
8	Royal Oak	222,663	1,775	1,525	559,281	4,459	3,831
9	Lower Mackenzie	113,438	904	777	336,204	2,680	2,303
10	Douglas Corridor	1,014,731	8,090	6,950	2,029,567	16,181	13,901
11	Rock Bay/West Douglas	492,333	3,925	3,372	699,230	5,575	4,789
12	Esquimalt Harbour	309,382	2,467	2,119	398,974	3,181	2,733
13	Esquimalt Centre	316,191	2,521	2,166	461,445	3,679	3,161
14	Tillicum Mall	213,007	1,698	1,459	426,035	3,397	2,918
15	View Royal Town Centre	66,164	528	453	99,246	791	680
16	Colwood Corners	610,034	4,864	4,178	922,485	7,355	6,318
17	Royal Roads	346,983	2,766	2,377	512,073	4,083	3,507
18	Langford City Centre	1,122,443	8,949	7,688	1,870,817	14,915	12,814
19	Colwood Employment Centre	283,588	2,261	1,942	411,625	3,282	2,819
20	Royal Bay	563,925	4,496	3,863	775,467	6,182	5,311
21	Olympic View	67,572	539	463	269,688	2,150	1,847
22	Glen Lake Neighborhood Centre	71,343	569	489	107,006	853	733
23	Westhills Tower 1	85,841	684	588	128,752	1,026	882
24	Westhills Main	360,638	2,875	2,470	450,797	3,594	3,088
25	Westhills Tower 2	87,010	694	596	130,505	1,040	894
26	Bear Mountain Expansion 1	83,316	664	571	124,966	996	856
27	Bear Mountain Expansion 2	89,761	716	615	134,633	1,073	922
28	Bear Mountain Main	426,888	3,403	2,924	533,610	4,254	3,655
29	Langford North Millstream	71,686	572	491	107,521	857	736
30	Camosun College	745,278	5,942	5,105	931,563	7,427	6,381
31	Fort Street	302,827	2,414	2,074	423,981	3,380	2,904
32	DND West Esquimalt	33,678	269	231	40,408	322	277
33	Jubillee Hospital	104,960	837	719	208,577	1,663	1,429
34	Victoria General Hospital	34,835	278	239	47,889	382	328
35	Spectrum High School	62,727	500	430	74,012	590	507
36	Oak Bay Marina area	67,283	536	461	80,004	638	548
37	Oak Bay High School-Cadboro Bay Road	88,367	705	605	86,437	689	592
38	Queen Alexandra	70,771	564	485	106,816	852	732
39	Vanalman	242,245	1,931	1,659	302,711	2,413	2,073
Total		**13,706,340**	**109,275**	**93,879**	**20,472,108**	**163,216**	**140,220**

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TABLE 3
Summary of Estimated Demand for Recovered Heat

Opportunities		Estimated Demand for Recovered Heat (GJ/d)		
No.	**Name**	**2005**	**2020**	**2065**
1	James Bay	2,586	4,198	5,390
2	Old Town	1,301	2,212	3,317
3	Downtown Victoria	2,448	11,944	16,722
4	Fairfield	1,796	2,798	3,946
5	Hillside	107	2,230	3,744
6	Shellbourne and MacKenzie	236	2,874	4,773
7	University of Victoria	1,034	7,541	7,860
8	Royal Oak	0	1,525	3,831
9	Lower Mackenzie	124	777	2,303
10	Douglas Corridor	438	6,950	13,901
11	Rock Bay/West Douglas	612	3,372	4,789
12	Esquimalt Harbour	159	2,119	2,733
13	Esquimalt Centre	547	2,166	3,161
14	Tillicum Mall	43	1,459	2,918
15	View Royal Town Centre	0	453	680
16	Colwood Corners	85	4,178	6,318
17	Royal Roads	126	2,377	3,507
18	Langford City Centre	45	7,688	12,814
19	Colwood Employment Centre	0	1,942	2,819
20	Royal Bay	0	3,863	5,311
21	Olympic View	0	463	1,847
22	Glen Lake Neighborhood Centre	0	489	733
23	Westhills Tower 1	0	588	882
24	Westhills Main	0	2,470	3,088
25	Westhills Tower 2	0	596	894
26	Bear Mountain Expansion 1	0	571	856
27	Bear Mountain Expansion 2	0	615	922
28	Bear Mountain Main	28	2,924	3,655
29	Langford North Millstream	0	491	736
30	Camosun College	236	5,105	6,381
31	Fort Street	980	2,074	2,904
32	DND West Esquimalt	1,119	231	277
33	Jubillee Hospital	69	719	1,429
34	Victoria General Hospital	569	239	328
35	Spectrum High School	131	430	507
36	Oak Bay Marina area	417	461	548
37	Oak Bay High School-Cadboro Bay Road	353	605	592
38	Queen Alexandra	168	485	732
39	Vanalman	159	1,659	2,073
No. of Opportunities Exceeding 1,000 GJ/d		6	23	26

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- Low-grade heat is considered to be compatible only with hot water boiler systems; therefore steam boilers have been ignored in this study when considering existing (2008) opportunities.
- New residential and commercial developments are assumed to incorporate compatibility into their designs for future opportunities.
- Design boiler capacity can be related to demand for recovered heat at a ratio of 1:0.81 (demand/capacity).
- Average annual energy demand can be related to demand for recovered heat at a ratio of 1:2.50.
- A small number of opportunities located in the Inner Harbour and UVic areas could support usage of heat recovered from WWTPs in 2005/2008. These opportunities represent demand exceeding supply at a ratio of approximately 3:1.
- By 2020 and 2065 a wide range of opportunities that can support usage of recovered heat are anticipated. These opportunities are located throughout the Core Area, and in total have demand exceeding supply by ratios of 20-30:1.

References

- Kerr Wood Leidal Associates Ltd. Technical Memo for Discussion Paper 036-DP-1. October 24, 2008.
- Neal Forrester, P.E., CH2M. Personal communication (email). October 15, 2008,

Appendix F - Energy Recovery Opportunity Areas - Environmental Analysis

Technical Memo

Capital Regional District
Core Area Wastewater Management Program
Energy Recovery Opportunity Areas – Environmental Analysis

Prepared for: John Spencer
Prepared by: Rahul Ray MRM, David Harper PhD., Steve Young MEns.
October 23, 2008

Objective

The Capital Regional District (CRD) is implementing an integrated wastewater management strategy that will involve recovering heat from wastewater or treated effluent. This has been recognised as an important aspect of the overall management strategy. Discussion Paper 1 identified the locations of 39 areas within the Level 1 Study Area that, due to high energy demand and the presence of water heating systems, are suitable areas for siting a heat recovery facility. These areas are described as Energy Recovery Opportunity Areas (EROAs) and illustrated in Map 1.

Placing heat recovery facilities and infrastructure in EROAs will effect the environment. Each IRM area has unique attributes and constraints that make them more or less suitable for siting a heat recovery facility. The objective of this report is to describe the work that was done to record and analyze the range of influences that siting heat recovery facilities would have on the local environment of the EROAs, and potential effects of the environment on a heat recovery facility. The results are presented in a table that evaluates the areas in terms of their overall environmental suitability for locating a heat recovery facility.

The study was undertaken as a broad analysis and is not intended to identify specific sites suitable for locating a wastewater heat recovery facility.

Environmental Categories

Four fields of environmental science were studied to provide information on specific topics of interest, ecology, geology, archaeology and land use. Each discipline, the lead author and their data sources are described in Table 1.

MAP 1
Resource Recovery Areas

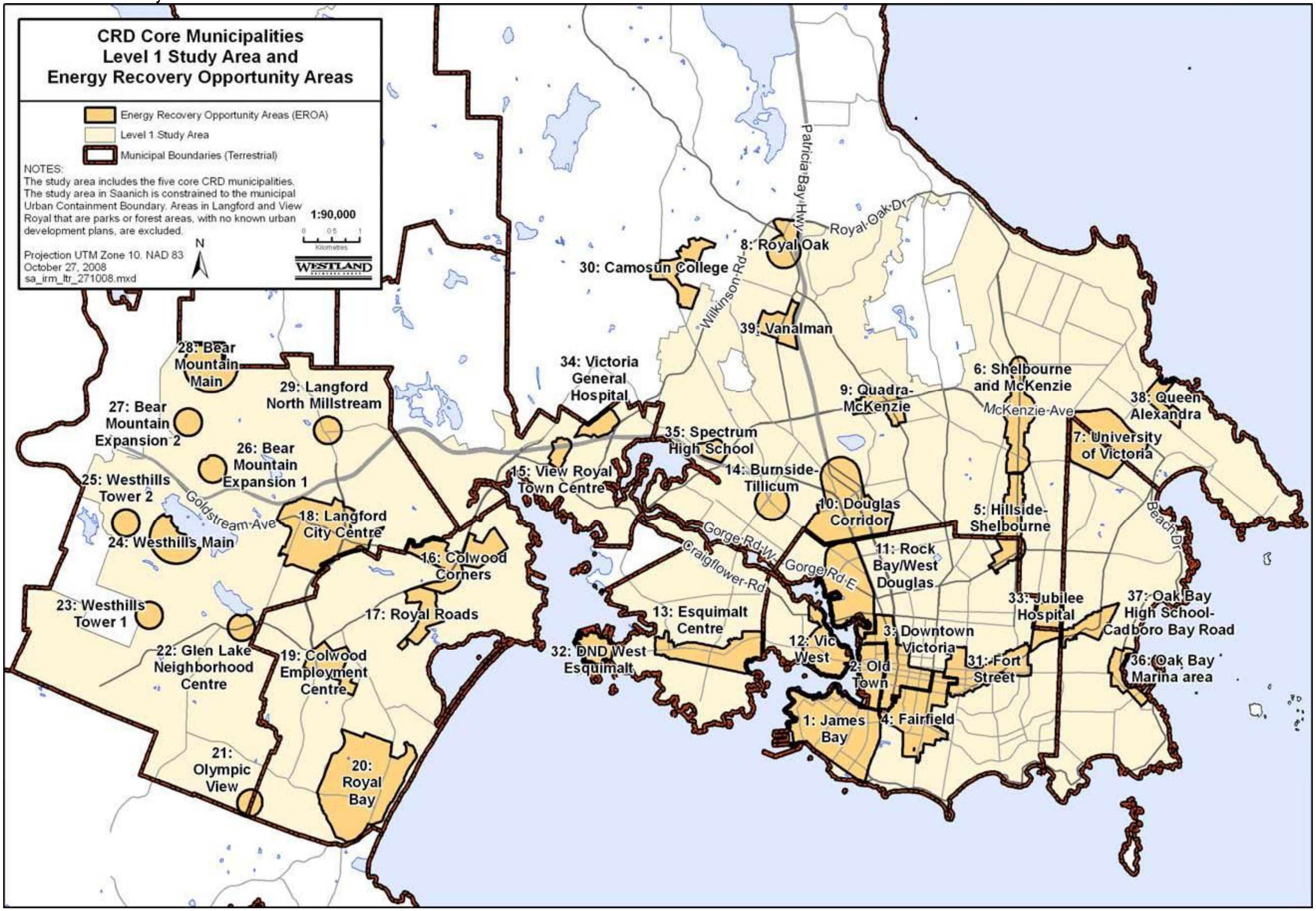


TABLE 1
Environmental Disciplines

Category	Discipline Lead	Affiliation	Data Sources
Archaeology and heritage	Bjorn Simonsen Thomas Munson	Bastion Group & Westland	Millenium Group Archaeological Potential Mapping (2008) District of Saanich and Town of Oak Bay Heritage Registers (2008) BC Provincial Government Archaeology Branch Sites Register (2008) Known archaeological sites and previously disturbed areas.
Ecology	Carmen Holschuh	Westland	BC Conservation Data Centre, Sensitive Ecosystem Inventory, (2004), BC CRD Orthophotos, (2007)
Geological information: Slope stability Site specific construction conditions	Chris Ryzuk	Chris Ryzuk & Associates Ltd	BC Geological Survey: Patrick A. Monahan, P. Geo.1, and Victor M. Levson, P. Geo. (2000): Composite Relative Earthquake Hazard Map of Greater Victoria Relative Amplification of Ground Motion Hazard Map of Greater Victoria Relative Liquefaction Hazard Map of Greater Victoria Seismic Slope Stability Map of Greater Victoria Quaternary Geological Map of Greater Victoria
Slope steepness	Steve Young	Westland	CRD Digital Elevation Model, (2007)
Land use compatibility	David Harper Rahul Ray	Westland	Consolidated OCP information (see Westland Energy Demand Technical Memo 24/10/08) BC CRD Orthophotos, (2007)

Phase 1: Information Collection

Each discipline lead generated mapped information for the study area that describes suitability for facility siting using a scale of 1 through 3, where sites that scored 3 were considered suitable for siting a wastewater heat recovery facility or infrastructure, 2 moderately suitable and, sites scoring 1 were considered less suitable or unsuitable.

Suitability Mapping. The following maps summarize the information collected for each discipline.

Map 2: CRD Core Municipalities, EROAs, Archaeological Suitability

Map 3: CRD Core Municipalities, EROAs, Ecological Suitability

Map 4: CRD Core Municipalities, EROAs, Geotechnical Constraints

Map 5: CRD Core Municipalities, EROAs, Slope Stability

Map 6: CRD Core Municipalities, EROAs, Slope Steepness

Map 7: CRD Core Municipalities, EROAs, Land Use Compatibility

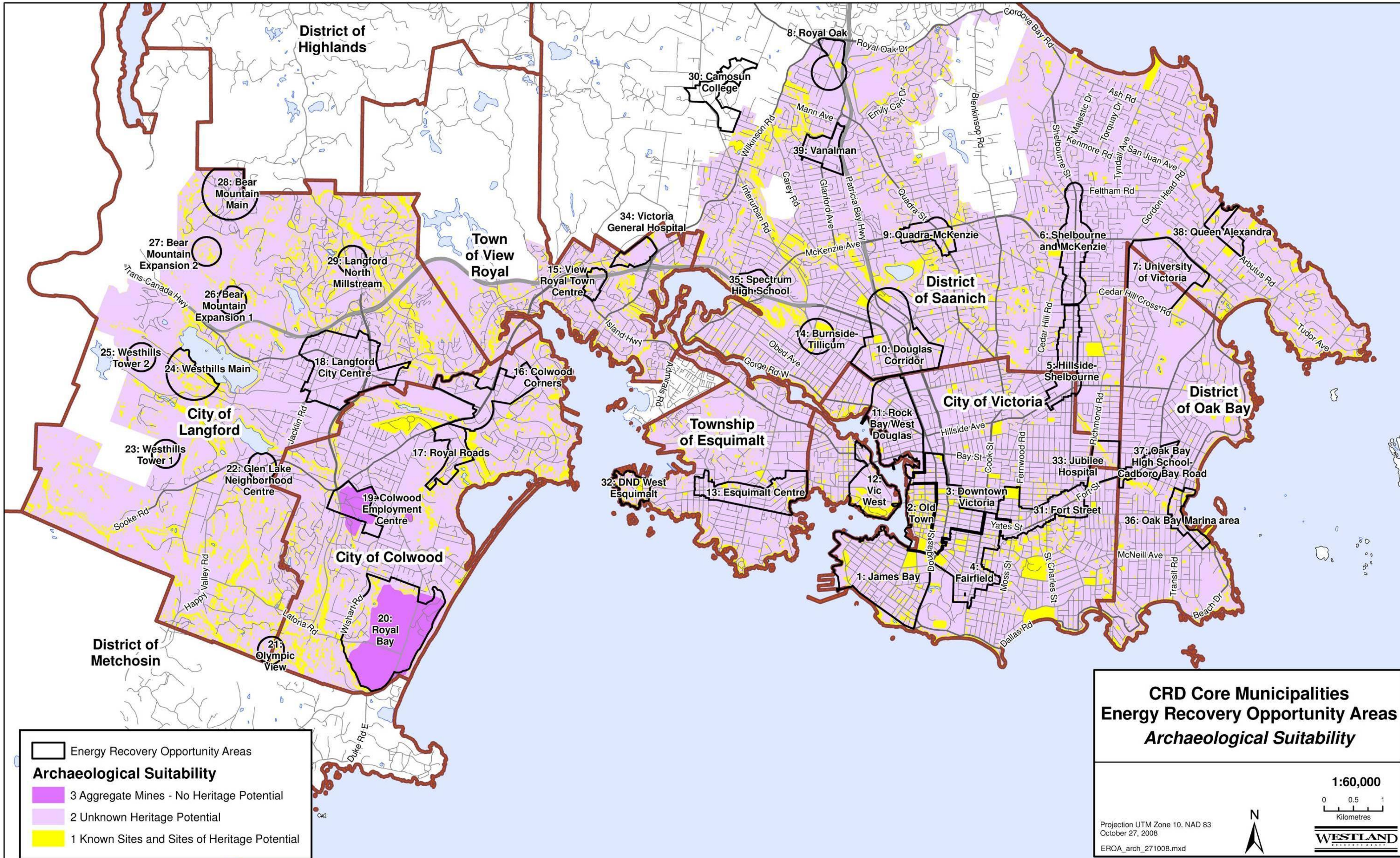
Phase 2: Data Analysis and Summary

The digital information collected for each discipline was overlaid with the EROAs. Each EROA was then visually assessed and scored in terms of archaeological, ecological, geological, and land use suitability. A single geology score was calculated by combining the ratings for slope steepness, slope stability and soil conditions. Table 2 summarizes the scores generated for all disciplines.

The ecology, geology, heritage and land use results in Table 2 were further summarized to provide one score for each EROA that describes the overall environmental suitability of the area, the 'Combined Environmental Considerations" column in Table 2. Totaling the ecology, geology, heritage, and land use scores and then assigning a score of 1 through 3 based on their summed value produced the summary scores. This score provides a relative ranking of the sites in terms of environmental suitability.

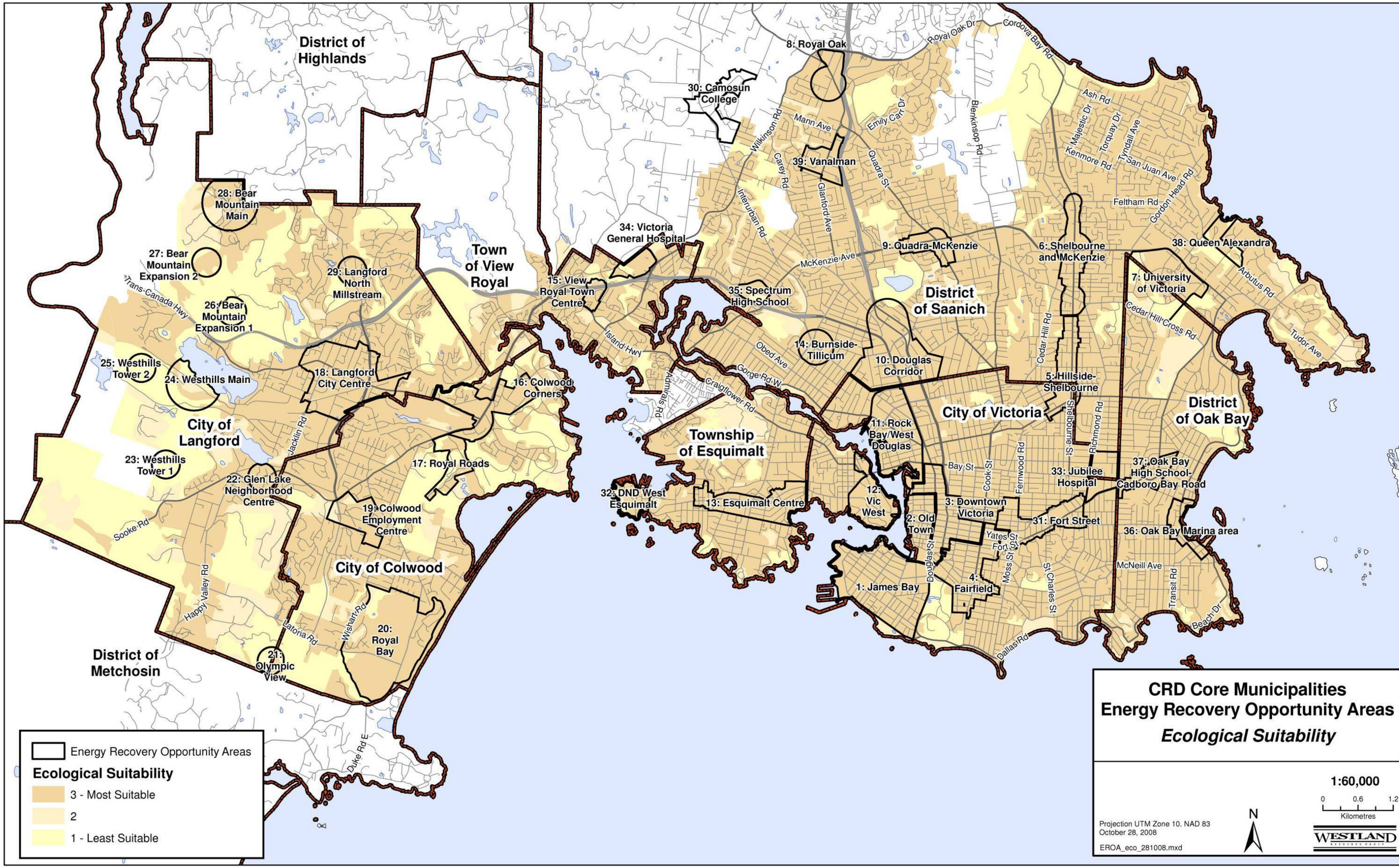
MAP 2

CRD Core Municipalities, EROAs, Archaeological Suitability



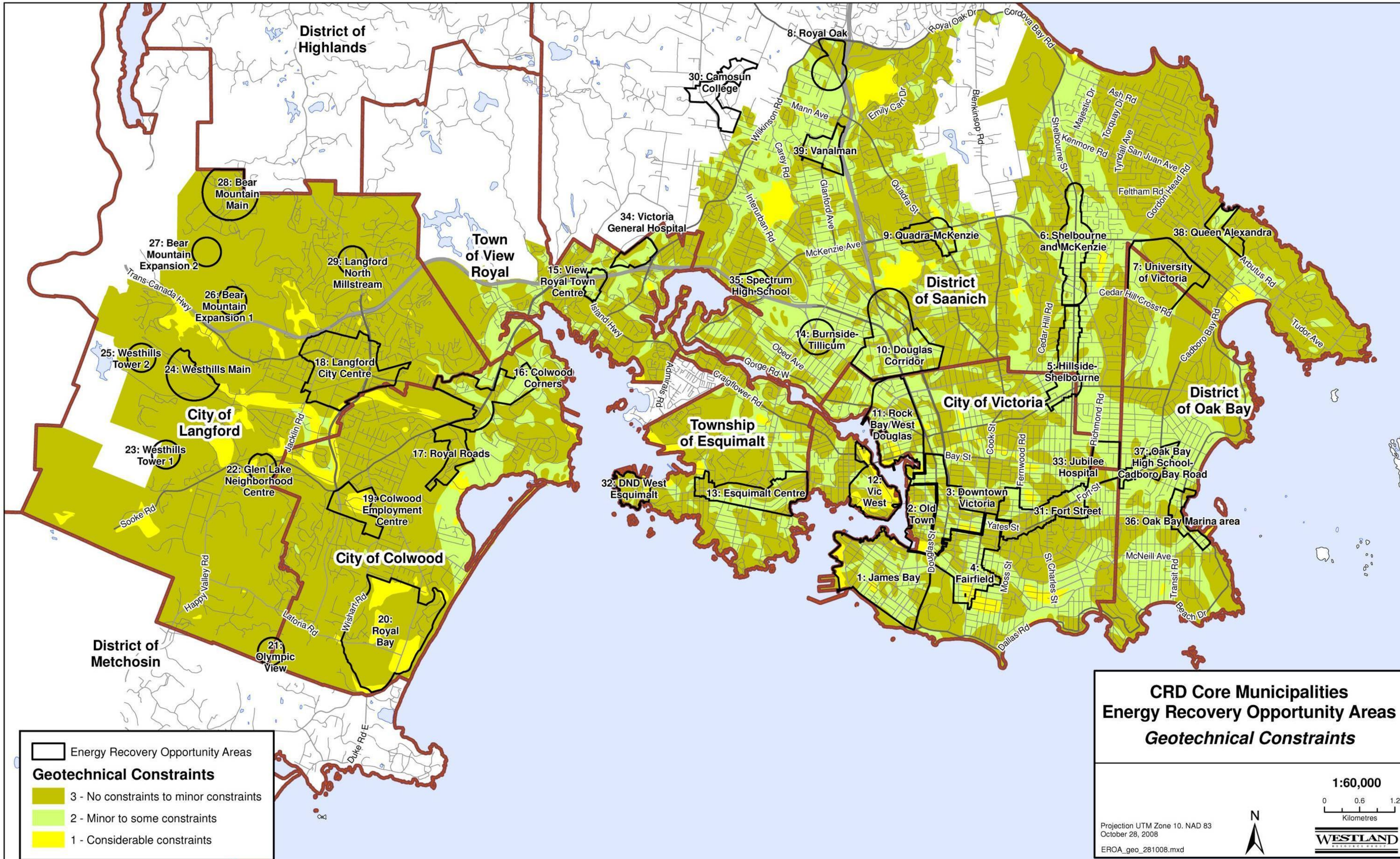
MAP 3

CRD Core Municipalities, EROAs, Ecological Suitability

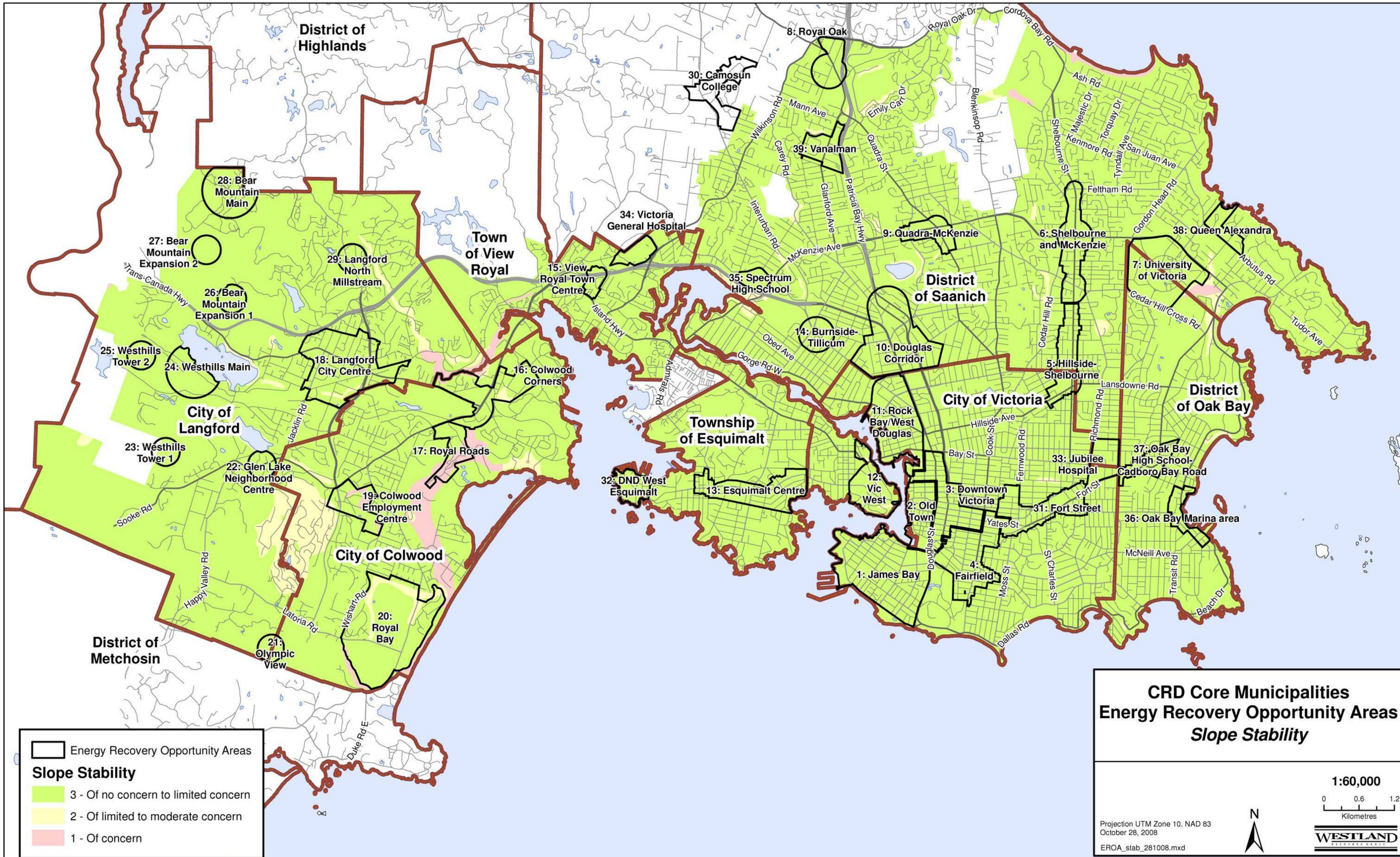


MAP 4

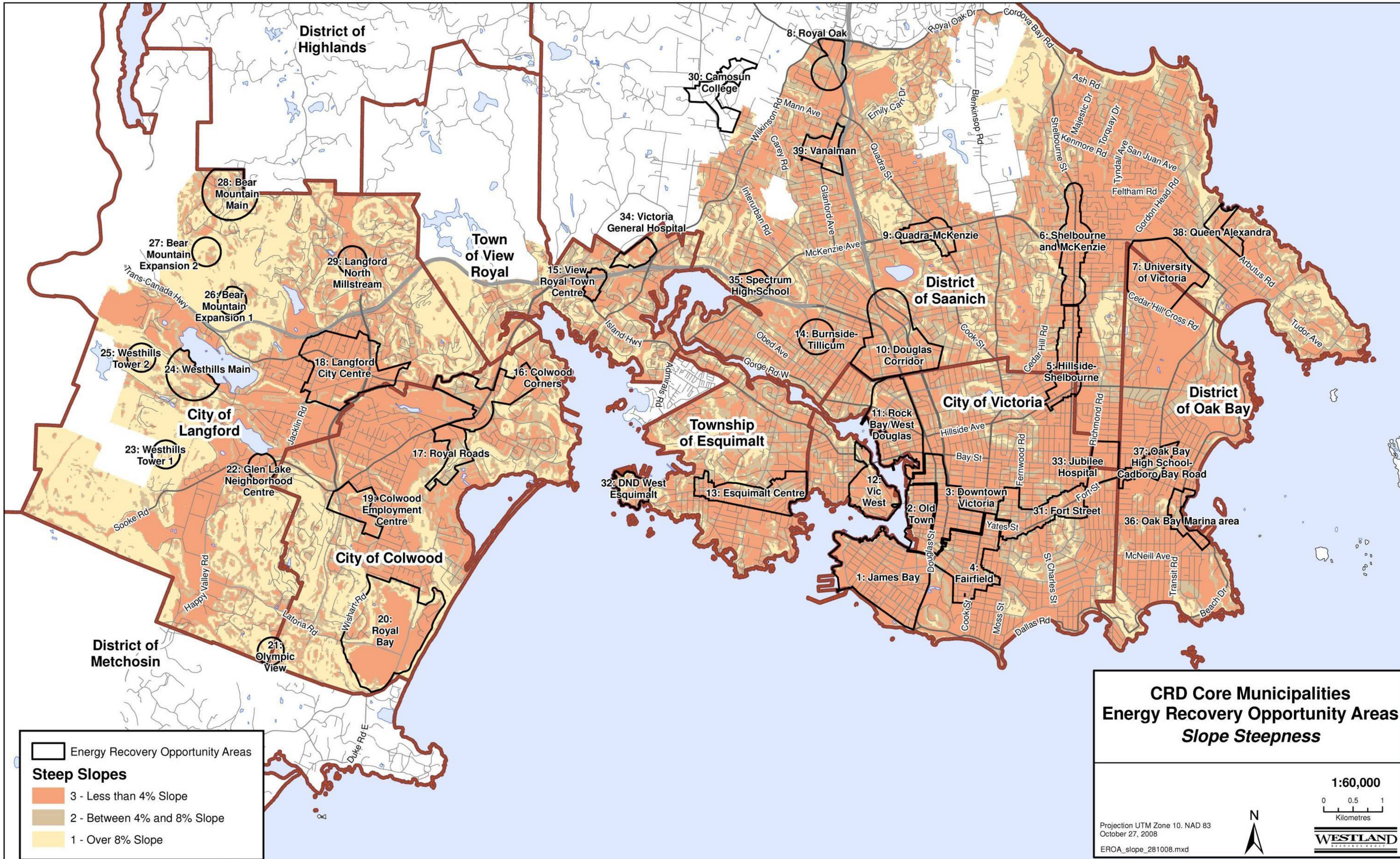
CRD Core Municipalities, EROAs, Geotechnical Constraints



MAP 5
CRD Core Municipalities, EROAs, Slope Stability



MAP 6
CRD Core Municipalities, EROAs, Slope Steepness



MAP 7
CRD Core Municipalities, EROAs, Land Use Compatibility

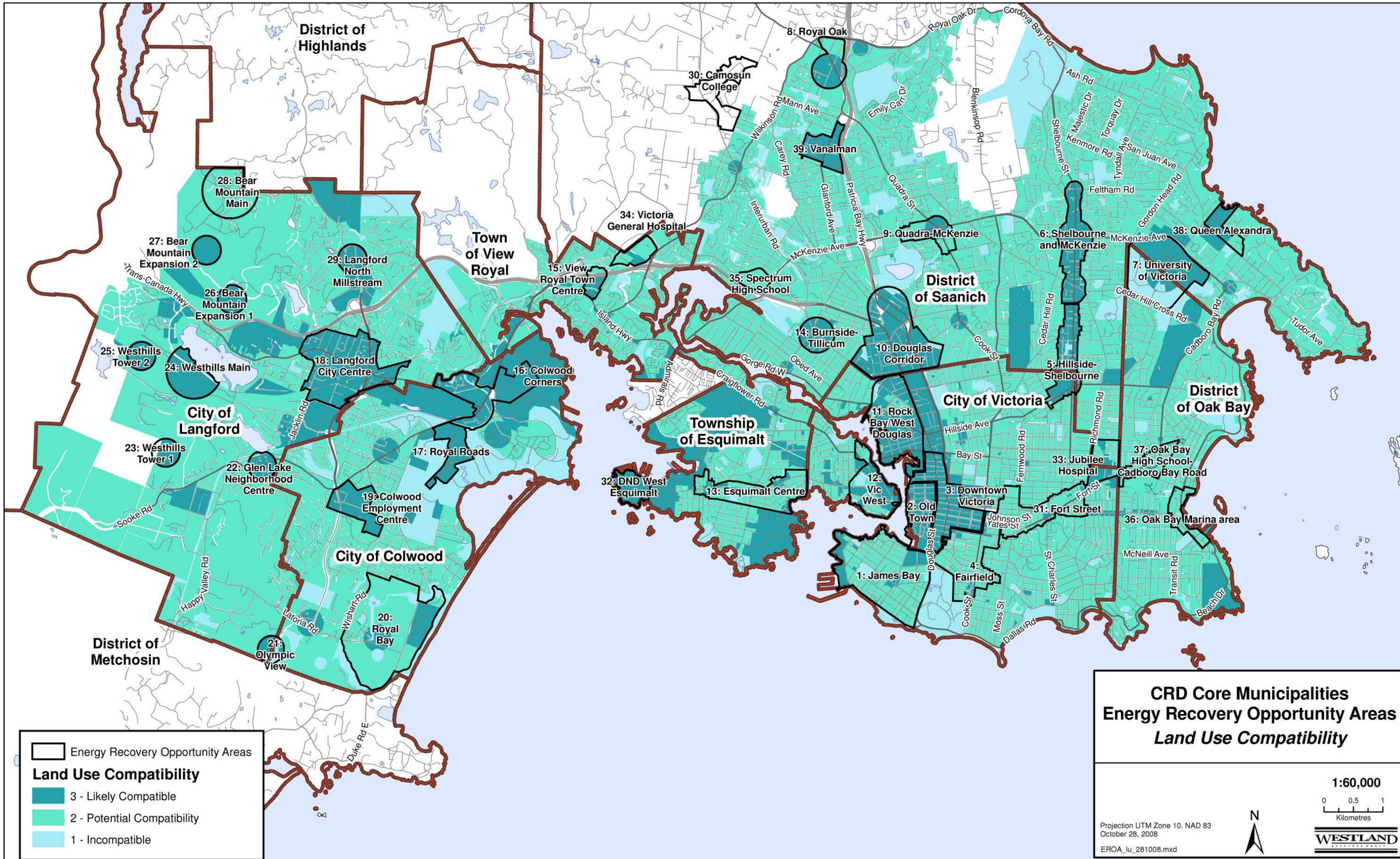


TABLE 2

IRM Environmental Suitability Summary Scores

Site Number	Site Description	Geotechnical conditions 1- Considerable constraints 2- Minor to some constraints 3- No constraints to minor constraints	Land use compatibility 1- Substantial land use compatibility concerns 2- Moderate land use compatibility concerns 3- Few or no land use compatibility concerns	Ecological conditions 1- Substantial ecological concerns 2- Moderate ecological concerns 3- Few or no ecological concerns	Heritage and archaeology 1- Substantial likelihood of encountering heritage or archaeological features 2- Moderate likelihood of encountering heritage or archaeological features 3- Low likelihood of encountering heritage or archaeological features	Combined environmental considerations 1- Substantial environmental concerns 2- Moderate environmental concerns 3- Few or no environmental concerns
1	James Bay and Legislative District	3	2	3	2	2
2	Old Town	3	2	3	1	1
3	Downtown Victoria	3	3	3	2	2
4	Fairfield	3	2	3	2	2
5	Hillside Mall-South Shelbourne	3	3	3	3	3
6	Shelbourne and McKenzie	3	3	3	3	3
7	University of Victoria (Saanich)	3	3	2	3	2
8	Royal Oak	3	3	3	3	3
9	Quadra-McKenzie	3	3	3	3	3
10	North Douglas Corridor-Town and Country Mall	3	3	3	3	3
11	Gorge-Rock Bay	3	3	3	3	3
12	Vic West	2	3	2	2	1
13	Esquimalt Centre	2	3	3	3	2

TABLE 2
IRM Environmental Suitability Summary Scores

Site Number	Site Description	Geotechnical conditions 1- Considerable constraints 2- Minor to some constraints 3- No constraints to minor constraints	Land use compatibility 1- Substantial land use compatibility concerns 2- Moderate land use compatibility concerns 3- Few or no land use compatibility concerns	Ecological conditions 1- Substantial ecological concerns 2- Moderate ecological concerns 3- Few or no ecological concerns	Heritage and archaeology 1- Substantial likelihood of encountering heritage or archaeological features 2- Moderate likelihood of encountering heritage or archaeological features 3- Low likelihood of encountering heritage or archaeological features	Combined environmental considerations 1- Substantial environmental concerns 2- Moderate environmental concerns 3- Few or no environmental concerns
14	Burnside-Tillicum	3	3	3	3	3
15	View Royal Town Centre	3	3	3	3	3
16	Colwood Corners	2	3	2	3	2
17	Royal Roads	2	2	1	1	1
18	Langford City Centre	3	3	3	3	3
19	Colwood Employment Centre	2	3	2	3	2
20	Royal Bay	2	3	3	3	2
21	Olympic View	2	3	2	3	2
22	Glen Lake Neighborhood Centre	3	3	2	3	2
23	Westhills Tower 1	2	3	2	3	2
24	Westhills Main	2	3	2	2	1
25	Westhills Tower 2	2	3	2	3	2
26	Bear Mountain Expansion 1	2	3	2	2	1
27	Bear Mountain Expansion 2	2	3	2	2	1

TABLE 2
IRM Environmental Suitability Summary Scores

Site Number	Site Description	Geotechnical conditions 1- Considerable constraints 2- Minor to some constraints 3- No constraints to minor constraints	Land use compatibility 1- Substantial land use compatibility concerns 2- Moderate land use compatibility concerns 3- Few or no land use compatibility concerns	Ecological conditions 1- Substantial ecological concerns 2- Moderate ecological concerns 3- Few or no ecological concerns	Heritage and archaeology 1- Substantial likelihood of encountering heritage or archaeological features 2- Moderate likelihood of encountering heritage or archaeological features 3- Low likelihood of encountering heritage or archaeological features	Combined environmental considerations 1- Substantial environmental concerns 2- Moderate environmental concerns 3- Few or no environmental concerns
28	Bear Mountain Main	2	3	3	3	2
29	Langford North Millstream	3	3	3	3	3
30	Camosun College		3	3	3	1
31	Upper Fort Street	3	2	3	2	2
32	DND West Esquimalt	3	2	3	2	2
33	Jubilee Hospital	3	2	2	2	1
34	Victoria General Hospital	2	2	3	3	2
35	Spectrum High School	2	2	2	3	1
36	Oak Bay Marina area	3	2	2	2	1
37	Oak Bay High School-Cadboro Bay Road	3	2	3	3	2
38	Queen Alexandra	3	2	2	2	1
39	Vanalman	2	3	3	3	2

Conclusions

Due to the small size of heat recovery facilities and their associated infrastructure, environmental effects are not generally substantial. It is not surprising therefore, that energy recovery facilities are identified as either a compatible or moderately compatible in a large portion of the study area. Some exceptions include the Old Town and Royal Roads areas, which were identified as having heritage and ecological values that affect their suitability for siting a facility. The EROAs most suitable from an environmental perspective were Hillside Mall-South Shelbourne, Shelbourne and Mackenzie, Royal Oak, Quadra-Mackenzie, North Douglas Corridor, Gorge-Rock Bay, Burnside-Tillicum, View Royal Town Centre, Langford City Centre and Langford North Millstream.

This analysis examined broad areas and a more detailed assessment could identify sites that are suitable for facility siting in areas with relatively low ratings. Conversely generally highly ranked areas would probably have some unsuitable sites.