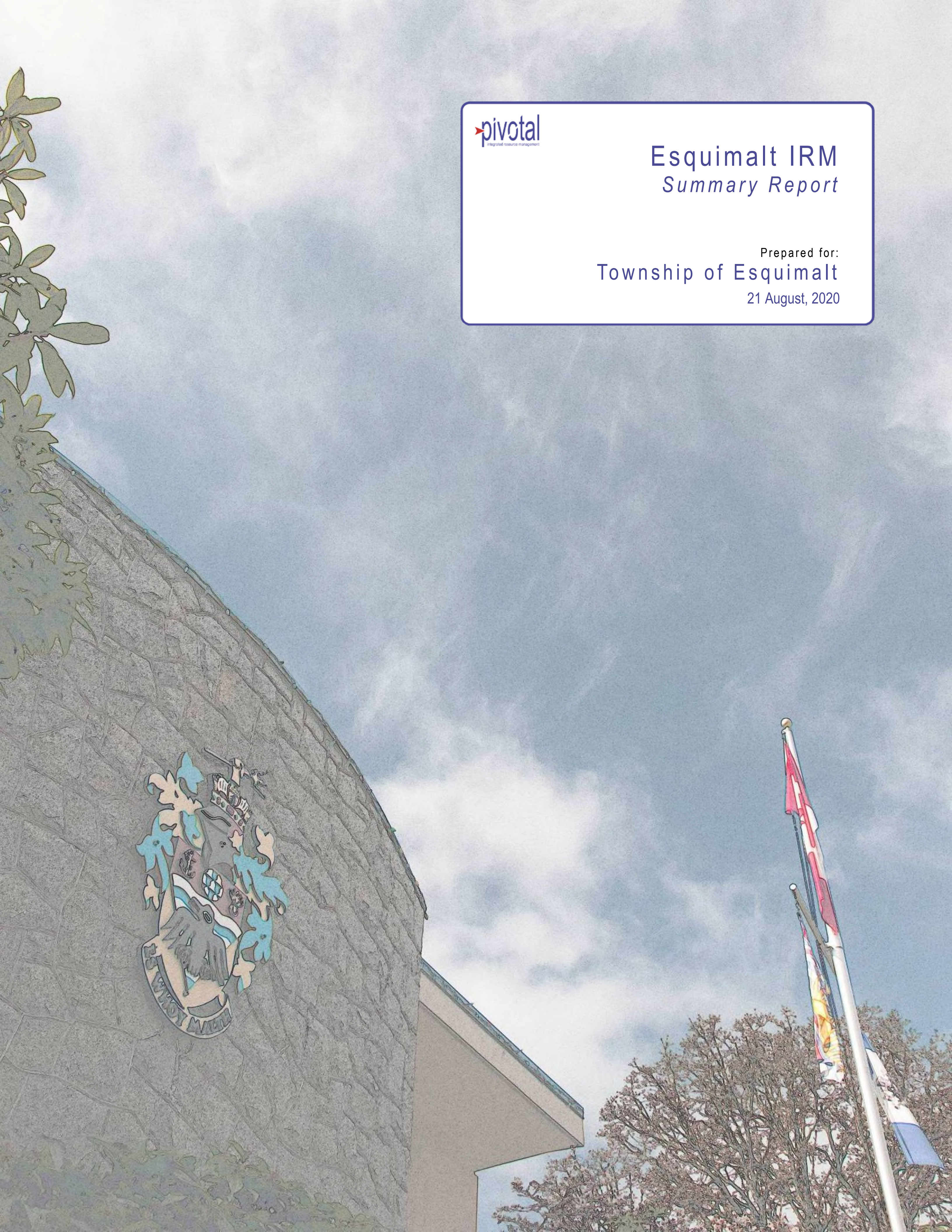
Esquimalt IRM
Summary Report

Prepared for:
Township of Esquimalt
21 August, 2020



Jeff Miller, Director of Engineering & Public Works
Township of Esquimalt
1229 Esquimalt Road
Esquimalt, BC,
V9A 3P1

21 August, 2020

Dear Mr. Miller

ESQUIMALT IRM - SUMMARY REPORT

We have pleasure in submitting a Summary of the IRM Technical Report provided to you on 29th July, 2020. This has been prepared to provide residents with a more concise understanding of IRM in Esquimalt, without having to absorb all of the complexities of the technical study. This and other material should assist with public engagement and we will be happy to answer any questions arising from this or the other materials.

Kindest regards,

Yours truly,

Graeme Bethell
President
Pivotal IRM Inc.

Chris Corps
CEO
Pivotal IRM Inc.

cc

Pivotal IRM Inc.,
4464 Markham Street,
Victoria,
British Columbia
Canada
V8Z 7X8

t: (250) 478 8820
e: info@pivotalirm.com
www.pivotalirm.com

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1 Executive Summary

1.1 Purpose & Scope of Work

The Township of Esquimalt commissioned a study of the potential to assess how and whether waste management can be improved and resources recovered with Integrated Resource Management (IRM), using gasification. The scope considered: (a) liquid waste and liquid waste energy; (b) energy from solid wastes collected by the Township and private haulers; and (c) yard and garden waste.

The study was mainly spurred by climate change and greenhouse gas emissions reduction, but also by concerns about the rising cost of waste management, planned regional landfill closure and an interest in moving towards more sustainable and beneficial approaches to waste management. Central to the scope is the Township's declaration of a Climate Emergency and commitment to becoming GHG neutral by 2050and eliminating corporate GHG emissions by 2030. To meet provincial requirements a number of technologies were compared and a key requirement to assess the financial impact of options.

1.2 Summary Findings

The study found that IRM has the potential to achieve or exceed environmental targets with a net reduction in taxpayer costs or possible taxpayer dividend. The main findings included:

General

- Dividend of up to ≈$360/door, net average, potentially $226m net over 30 years;
- Reduced trucking with no odour or noise, and simpler waste separation for residents with less garbage bins.

Intangible

- European examples attract new business and enhance education, training, and eco-tourism, raising community profile and enhancing public pride;
- Broader economic stimulus & jobs with local re-investment and re-spending effect.

Environmental

- Exceed 2030 Corporate carbon reduction targets by ≈4½x and reduce community overall GHGs by ≈12%;
- Equivalent to removing ≈970 cars/year;
- ≈91% landfill diversion;
- Improved recycling;
- Generate clean energy to displace fossil fuels. Produce sterile fertilizer & sequester carbon;
- Simplest, most economic GHG reduction option available.

Challenges

- Statutory & regulatory compliance is likely and the community has the statutory empowerment to proceed, but this requires formal confirmation;
- Limited existing municipal capacity and experience raises risk, which can be managed but requires diligence to do so;
- While there are extensive systems using gasification (exceeding 1,000 years' combined operation and 90 plants) identified internationally, there are few examples in North America. Lack of identical example can be addressed by testing and guarantees.
- Systems can be guaranteed and externally funded to reduce taxpayer risk, but will lower financial outcomes;
- Finance is not confirmed, however it could be undertaken with limited capital and
- Community feedback is required under provincial process.

In summary the study concluded that an IRM approach using gasification is possible and has potential benefits, but as with any undertaking of this nature, will require commitment and management to address risks. Council and the community will thus wish to consider the cost/benefits but we believe the net advantages are sufficiently persuasive and the challenges are manageable, to merit proceeding further.

2 Background

2.1 What is IRM and Why Gasification

Integrated Resource Management (IRM) is an approach to managing water, energy and waste that aims to maximise their use and value as resources, in ways that reduce costs to homeowners, recover heat and other resources, reduce greenhouse gases (GHGs) and, other emissions and discharges. IRM mostly uses energy generation from waste residuals left over, after recycling.

IRM is a fully integrated life cycle assessment of ways that resources can be recovered from waste, to maximize the benefits to the environment and homeowners. This allows the community to compare financial and environmental impacts so that informed decisions can be made on the best direction for the community.

Choice of technology or technologies has a direct impact on yield and performance, viability and risk. Some technologies also cope with a wider range of materials. Choice of systems and integration is thus important.

Figure 1: Test gasifier, California

Composting, anaerobic digestion and similar approaches to waste disposal typically address some or all of the organic portion of the waste stream and are not complete, standalone solutions. Incineration, pyrolysis and gasification can address organics but also address a wider range of other wastes. Incineration creates pollution (toxins and smoke, which contains particulates) and thus requires appreciable equipment to handle this. Incineration doesn't scale easily to smaller applications such as Esquimalt needs and are not popular as a community solution. Pyrolysis and gasification both avoid burning and producing toxins and smoke, but with a typically similar cost to gasification, pyrolysis is less efficient, i.e. the technology typically with the highest yield, broadest adaptability and scalability, is gasification (Figure 1).

Internationally, gasification systems have over 1,000 years of combined operational experience, so are well proven, but not necessarily with examples handling wastes similarly to Esquimalt's needs. However combinations of testing, manufacturer yield guarantees and other approaches are considered acceptable to address this risk.

In short, gasification is a process where waste is heated to produce a syngas, which can be used to produce heating, cooling, biochar and other products. The syngas is considered "green" and the energy “renewable” because over 85% of Esquimalt's waste is biogenic, i.e. it comes from natural and organic sources, not fossil sources.

2.2 Context

To understand whether IRM makes sense we have to consider: how waste is currently managed in the region and what the wastes consist of; what the regulations are; how the community might grow – and how much waste there might be in the future.

Historical Background

Historically, waste has been landfilled because land was cheap, available and out of sight. Recently however, landfill emissions have raised concern – toxins seep into groundwater; Greenhouse Gas (GHG) emissions are rising; and there will be up to 50 years' of maintenance responsibilities once Hartland landfill closes, at taxpayer expense.

Spurred by rising costs, contamination and emissions, with land becoming more expensive and less available, and rising waste volumes as populations grow, increasing emphasis is being placed on diversion. Both older and new technologies are being considered to solve the problems.

Regulations

Provincial regulations allow municipalities to decide how to manage their wastes and the region is responsible to incorporate these into a regional plan. If Esquimalt decides its own waste plan, this would then be included in the regional plan. An example similar to this is Dockside Green, which has its own sewage treatment plant and recycling, which the regional plan was amended to allow for.

IRM can proceed providing it meets some regulatory requirements:

a) Recycling has to meet or exceed recycling thresholds set by the Ministry of the Environment and Climate Change Strategies' (MoE) 5R's guideline. Regional and local diversion and recycling meet this requirement;

b) Disposal level must be at or below 350 kg/capita/yr and the planned system must achieve at least 60% energy recovery yield while meeting emissions requirements. These criteria can be met;

c) CRD will need to amend the regional Solid Waste Management Plan (SWMP) to include an IRM energy recovery facility; and,

d) Community support is required.

In summary, an appropriately planned IRM plant has the ability to meet BC's regulatory structure and be permitted.

Liquid Waste

Liquid waste can be used to recover treated water and energy, however consideration of energy recovery from sewage has currently been deferred, largely because sewage flows are uncertain until the new treatment plant opens at McLoughlin Point. Recovery of water and energy from sludge has been deferred for the same reason, but should be feasible to phase in at a later date, once flows and availability are more certain.

Solid Waste

Currently wastes in the Capital Region are sent to a number of sites, not just to Hartland Landfill. These include sites in the Cowichan Valley, Nanaimo Regional District, Greater Vancouver and Washington State. Most of these centres are landfills but some recycle separated wastes such as food scraps, yard and garden wastes. Two recipients incinerate the wastes.

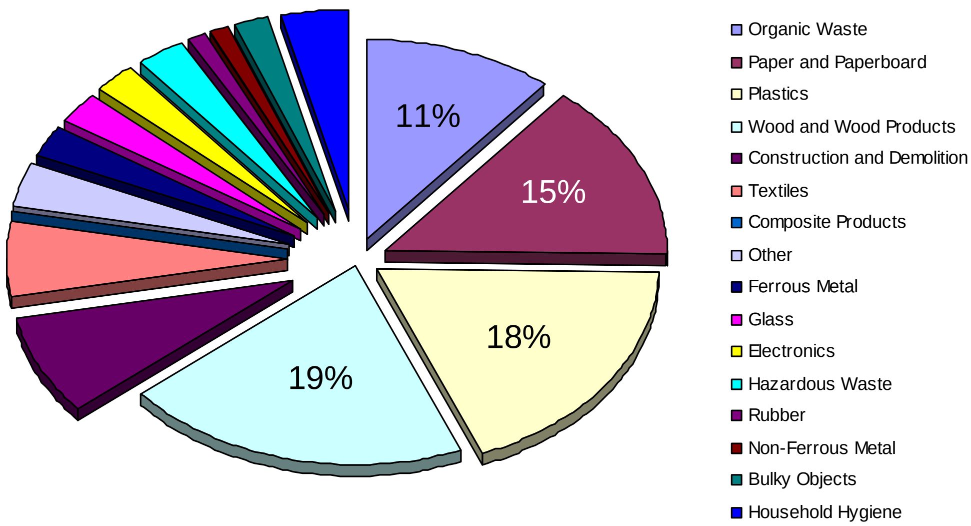

Figure 2: CRD 2016 Solid Wastes by Dry Weight

There has been an increasing effort to recycle and divert wastes from landfills. CRD's latest study (2016) shows that advances are being made, but almost half the organic wastes are still being landfilled, as are most other wastes, shown in Figure 2 (which excludes 'Blue Bin' recycling).

Because waste is often made of composite materials, it is difficult to separate the materials so they can be fully recycled. An example of this is coffee cups (which often mix paper with a plastic liner) or meat packaging (which mixes polystyrene and plastics with organics and paper).

The European Union provides contrast to understand both local progress and the potential for using waste, as the EU started with waste diversion and resource recovery since the early 1970s and is advanced. Figure 3 shows that the estimated current ≈43% diversion being achieved is low compared to most EU countries, but that up to 100% diversion has been achieved, largely by integrated (IRM) approaches using thermal conversion technologies. An example of this is in Gothenburg Sweden, [click here to see a short video] explaining this.

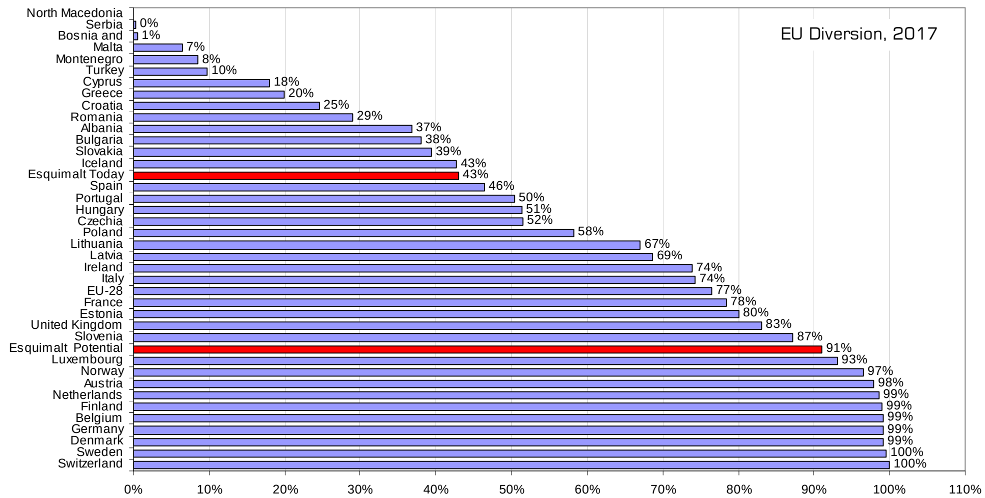

Figure 3: Diversion comparison, Esquimalt⇔EU

CRD has commenced public engagement for a new solid waste management plan so should Esquimalt decide to adopt IRM as its direction, it is timely for this to be included in the new regional plan.

Esquimalt's Waste Streams & Potential

The Township collects residential refuse (garbage) and kitchen (food) scraps largely from single family homes and small apartments, while private haulers collect the same from businesses and large apartment buildings. Yard and garden waste is dropped off at a recycling centre adjacent to the Public Works Yard on Canteen Road. This waste is currently transferred to Hartland landfill where some is sent for processing in the Lower Mainland and the remainder is landfilled (Figure 2).

Township of Esquimalt, 2019/2020	Tonnage		Moisture	Dry	
Yard & Garden	1,778	27%	40%	1,067	24%
Food waste	566	9%	60%	227	5%
Subtotal	2,344	36%	45%	1,293	29%
MSW	1,054	16%	25%	790	18%
Total	3,398	52%	39%	2,084	47%
Plus: private hauled wastes	3,100	48%	25%	2,325	53%
Total current estimated volume	6,498	100%		4,409	100%
Total current estimated volume, dry tonnes per day, public only				5.7dtpd	
Total current estimated volume, dry tonnes per day, combined				12.1dtpd	

Figure 4: Esquimalt Solid Waste Volumes

Figure 4 shows that in 2019/2020 the Township collected ≈3,400 tonnes of 'wet' waste, while private haulers collected ≈3,100 tonnes waste, i.e. a 50/50 split in collection. Wastes collected by the Township equate to ≈182kg/person, rising to ≈347 kg/person once private wastes are included, which meets provincial diversion guidelines to be able to consider energy recovery from waste.

Figure 5: Biochar

Energy recovered by the IRM plant would be supplied to the Township's municipal centre and the biochar produced (Figure 5), it is typically used as a sterile soil supplement because it retains fertilizers and water, while sequestering carbon. It can also be used as an air or water filter for buildings, swimming pools and fish tanks. This is a considerable benefit in reducing GHGs while supporting environmental restoration, and is an appreciable potential revenue contributor.

Community Growth

Figure 6 shows that Esquimalt has grown at ≈0.3% per annum in the long term whereas the region as a whole grew at an average of ≈1% per annum. However between 2005-2016, Esquimalt grew at ≈1.0%, which is representative of the region.

	Population					
Community	**1991**	**1996**	**2001**	**2006**	**2011**	**2016**
Central Saanich	13,684	14,611	15,348	15,745	15,936	16,814
Colwood	13,468	13,848	13,745	14,687	16,093	16,859
CRD	299,550	317,989	325,754	345,164	359,991	383,360
CRD Core (CALWMP)	239,138	250,487	256,227	271,654	283,977	303,542
Esquimalt	16,192	16,151	16,127	16,840	16,209	17,655
Highlands	1,094	1,423	1,674	1,903	2,120	2,225
Indian reserves	3,214	3,806	4,667	4,670	5,282	5,244
Langford	15,642	17,484	18,840	22,459	29,228	35,342
Metchosin	4,232	4,709	4,857	4,795	4,803	4,708
North Saanich	9,645	10,411	10,436	10,823	11,089	11,249
Oak Bay	17,815	17,865	17,798	17,908	18,015	18,094
Saanich	95,583	101,388	103,654	108,265	109,752	114,148
Sidney	10,082	10,701	10,929	11,315	11,178	11,672
Sooke			8,735	9,704	11,435	13,001
Victoria	71,228	73,504	74,125	78,057	80,017	85,792
View Royal	5,996	6,441	7,271	8,768	9,381	10,408

Source: CRD &Statistics Canada

Figure 6: CRD Demographics, 1991-2016

The Township anticipates that the community may reach buildout over the next 10+ years, and reach a maximum of ≈25,000 population, which is considered practical for projecting waste volumes.

The combined waste volumes indicate that a 15 tonne per day plant would be needed at the start but will expand to ≈25 tonne per day at buildout. The plant's expansion can be phased and expanded in stages to meet population growth. Phasing reduces initial cost, however, some additional capacity will be needed to address maintenance downtime.

Climate Change Esquimalt Council has declared a Climate Emergency, to elevate the importance of initiatives that will reduce carbon. The Township's Corporate annual balance is 1,005 tCO_2e and the emissions for the entire community are 37,644 tCO_2e, according to provincial inventories. As a main objective of IRM is to reduce GHGs, this is a key part of the assessment.

3 IRM Assessment

3.1 Options

Previous Technology Reviews

Resource recovery technologies were reviewed by CRD during Core Area Liquid Waste Management planning and by CRD's IRM Task Force. The focus of these studies was primarily on wastewater aligned technologies, and the main focus was not on integration of waste streams, even though CRD's IRM Task Force and Technical Oversight Panel noted that IRM could be beneficial. Advanced Gasification was put forward by West Shore Innovation Days, and CRD noted that IRM has the potential to impact every aspect of solid waste management in the region, but it has yet to progress.

Main Technology Options

Anaerobic digestion is an accepted technology selected by the region for sewage sludge treatment (Figure 7), although this could extend to organics processing (≈11% of the region's wastes, per Figure 2). Other options such as biofuels could handle more, but would need several systems to cover available wastes and the technology is not well advanced. It would also not be easy to locate plants in Esquimalt.

Figure 7: Planned Digester, Hartland Landfill

Figure 8: Advanced Gasifier USA

A technology supported during prior reviews is Advanced Gasification (an ex maple is shown in Figure 8), which can handle a broader range of wastes, including compound wastes. Digestion and gasification were thus compared using CRD's assessment for the proposed digester at Hartland Landfill, shown in Figure 9, adjusted to equate plant size. This shows Advanced Gasification is financially preferable, potentially yielding a dividend whereas digestion is expected to require continuing taxpayer support.

Aspect	Anaerobic digestion	Advanced Gasification
Feedstock suitability	≈11% of volume Organics only	≈75% of volume Most solid wastes
Recovered, saleable resources	Biogas for heating/RNG	Heating, cooling, biochar
Capital cost per tonne processed, life cycle	≈-$232 per tonne	≈-$91 per tonne
Operating cost per tonne processed, annual	-$3.0m/yr	-$1.6m/yr
Total net life cycle cost/revenue, undiscounted, current $$, after debt	≈-$2,154 per tonne	≈+$122 per tonne
Annual tCO2e reduction	Not assessed by CRD	≈8,500 tCO2e
Life cycle CO2e reduction	Not assessed by CRD	≈425,000 tCO2e

Figure 9: Technology Comparison

Waste Options

As noted previously, Esquimalt's wastes are collected by the Township and private companies, raising the question of whether to size a plant to process purely the Township's collected wastes, or all wastes. While it would be possible to process more wastes than purely Esquimalt's, we evaluated the impacts of these two main options : (a) Figure 10 summarizes the net annual tCO_2e GHG reduction and tCO_2e sequestration; and, (b) Figure 11 shows the dividend per home. These indicate both a financial and environmental benefit in handling all the wastes generated in Esquimalt, not just the Township-collected wastes.

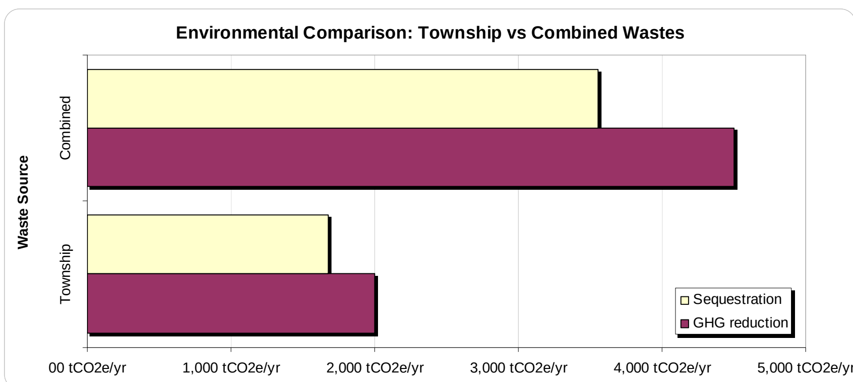

Figure 10: Environmental Waste Comparison

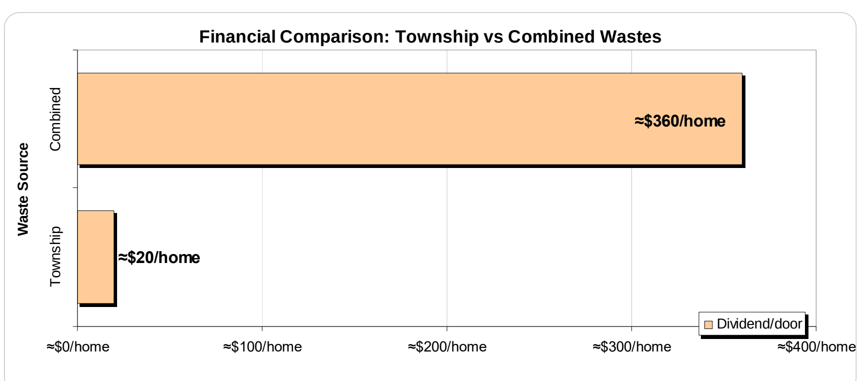

Figure 11: Financial Waste Comparison

Notably Figure 11 shows that as the community grows and the plant reaches capacity, the dividend could be up to ≈$360 per home, net. While this is likely to be used to pay for other services and avoid higher taxes, it is indicative of the likely benefit to taxpayers, net of the investment needed for building the plant.

Energy & Resource Recovery

Because a significant part of an IRM philosophy is maximising reuse of recovered energy and resources, plants need to be located close to energy consumers.

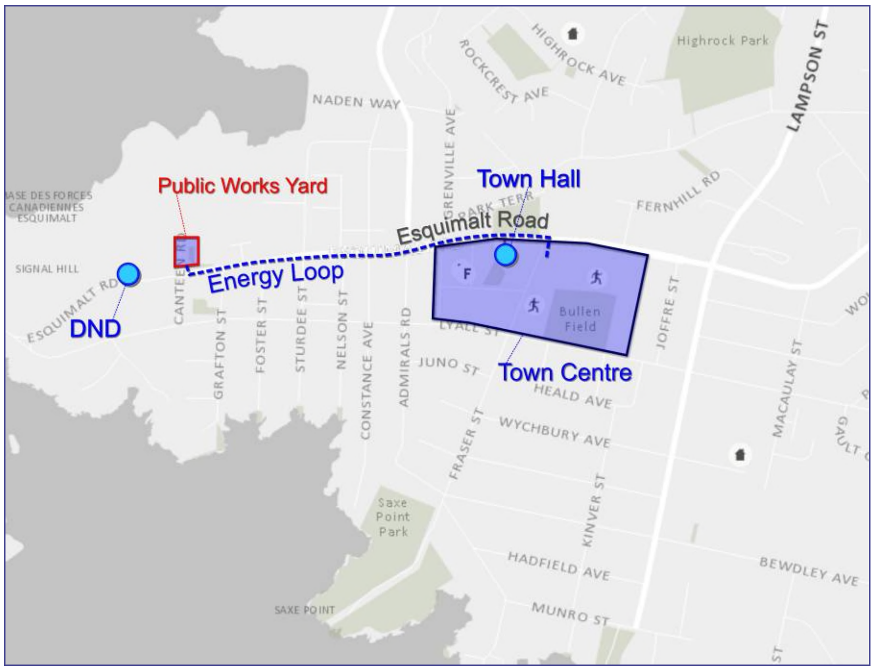

Figure 12: IRM Site and energy Users

Figure 12 shows an IRM plant could be located at the current Public Works site on Canteen Road, with a District Energy System connecting with Esquimalt's core. The loop would be buried along municipal streets with service connections to buildings who would be supplied with both heating and cooling. This was assessed for the Township in a 2013 study by Kerr Wood Leidal which identified ample consumers for energy. Should the project proceed, we recommend this be updated as part of an integrated Net Zero study for the core, to further reduce GHGs and lower energy costs in Esquimalt.

While other sites may exist and be feasible, the Public Works Site is well located to distribute energy recovered from waste and is owned by the Township. This site is preferred and has been assumed for modelling.

Site & Traffic

The Public Works Yard (Figure 13) is a recommended choice for the plant, located at the intersection of Esquimalt and Canteen Roads. This is well situated to minimize the cost of supplying recovered energy to Esquimalt's core, using a ≈1km energy loop, or to other potential major consumers.

Phasing and the ability to expand the plant has been considered and it likely that projected growth can be accommodated. The site is currently used for parking, which would be relocated within the site if alternative parking is unavailable.

Figure 13: Public Works Yard

We do not expect any noticeable or significant change in traffic caused by the plant. We estimate up to three trucks per day would supply waste. These are already circulating in the community so would not generate new traffic, but instead of going to Hartland, would go to the plant. There may be at most 3-5 additional employee cars visit the site during the day. The traffic impact is thus expected to be negligible and as this would reduce traffic going to Hartland, trucking costs would be expected to be lower, as would GHG emissions.

Conclusion

IRM technologies have recently been extensively researched by CRD and we have referenced assessments of over 90 MSW gasifiers operating in total, with the equivalent of over 1,000 years of use. MoE regulations needing to be satisfied and our review indicates the technology should comply with the Ministry's requirements. Advanced gasification addresses the largest portion of the waste streams and is less expensive and more efficient, as well as being more compatible to recovering energy in Esquimalt, which has site limitations restricting effective use of other alternatives. We conclude that although the Township directed an assessment based on gasification, that Advanced Gasification is the best option for Esquimalt's needs, assumed to be located at the Public Works Yard with a ≈1km District Energy System supplying the core to recapture and reuse green energy.

3.2 System & Approach

To ensure odours from waste are controlled, the plant will have a negative pressure feedstock processing and storage centre, where garbage is unloaded behind closed doors and air is filtered to eliminate odours. Large recyclable and inert materials will be removed and recycled, then the waste will be processed in a chipper/shredder, blended, dried to ≈20% moisture ratio, cooled and stored, ready for gasification (Figure 14).

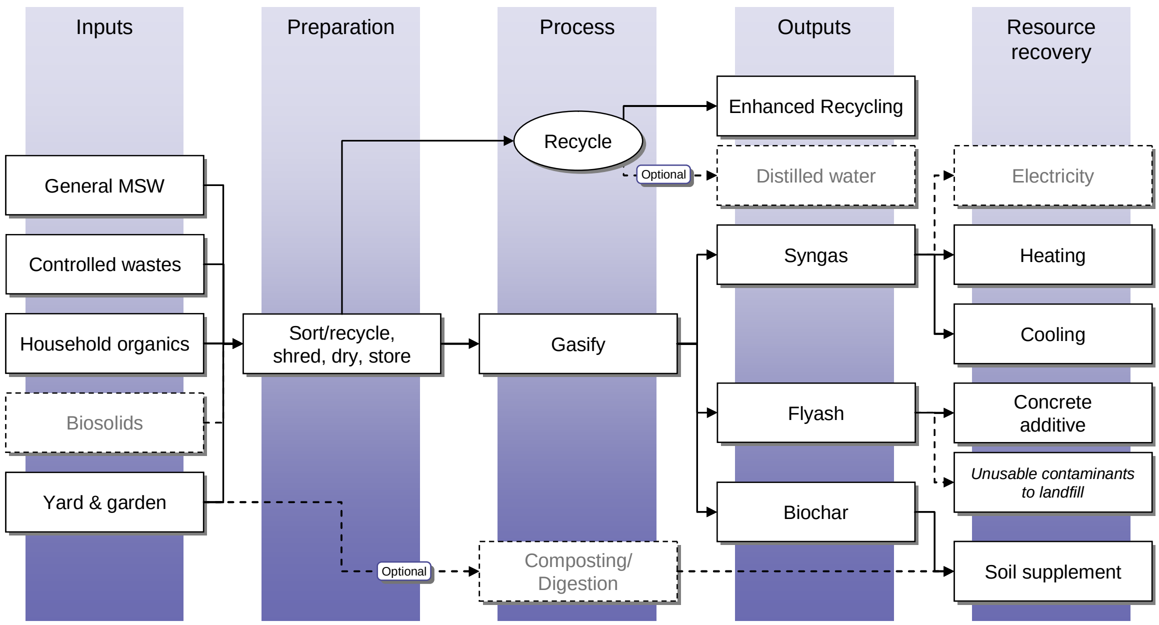

Figure 14: Gasification General Process

Gasifiers vary widely and in the IRM Technical Report provided to the Township we identified the Advanced RotoGasifier manufactured by TSI, Lynnwood, WA, as the preferred technology, due to its track record and robust feedstock handling. Working with a specific technology and manufacturer improves costing and performance information for the business case.

3.3 Analysis

Pivotal uses a proprietary computer model to assess IRM projects, developed with input from sector experts. The model combines both environmental and financial aspects to calculate the full net life cycle, using financial and environmental standards. The model is used to run scenarios, each of which has 105 cash flows, plus GHG projections over 150 years (to assess GHG life cycle).

Scenario	Growth	(a) Township	(b) Combined
1 Minimum	0.3%/yr	≈3,800 t	≈7,200 t
2 Moderate	1.0%/yr	≈4,700 t	≈9,000 t
3 High	1.7%/yr	≈5,900 t	≈11,300 t

Figure 15: Scenario Summary

Because population and waste growth is uncertain, we assessed scenarios with population growth of 0.3%, 1% and 1.7% per annum, comparing the results given either (a) just using the waste collected by the Township; or, (b) Combined Township and broader community wastes.

Figure 15 shows the main scenarios run, with the base models for each of these assuming a publicly-owned project.

The method of procurement and delivery is not yet determined, and because factors such as risk and investment can vary, we also ran initial private partnership estimates for each of the six scenarios shown in Figure 15, for a total of twelve scenarios. The private sector models have been provided separately but in summary, we anticipate probable private sector interest only in the combined waste scenario, subject to how the contracts are structured.

Because growth (in both population and waste) is not predictable, a "just-in-time" approach was devised using multiple smaller gasifier units so the plant can be expanded as and when needed. This avoids incurring capital cost for a population that might never happen, but also avoids today's taxpayers having to fund anything that is not absolutely necessary based on what we know today.

Figure 16 summarizes the main indicators for the "moderate" growth curve, for both the "Township only" waste collected, and the "Combined" wastes for the whole community. The combined waste scenario, highlighted in green, is recommended.

	Township	Combined
Scenario	2a	2b
Population growth %	1.0%	1.0%
Total capex	$17.3m	$21.3m
Annual O&M	-$1.5m	-$1.7m
Waste volume	4,670 t/yr	8,930 t/yr
Life cycle profit/loss	$47m	$226m
Simple payback	≈14yrs	≈6yrs
Taxpayer dividend/subsidy/yr, 1st 10 yr avg	≈$0/home	≈$360/home
Total mwt, life cycle	249,000 mWht	528,000 mWht
Total GJ, life cycle	897,900 GJ	1,901,700 GJ
Life cycle biochar, tonnes	17,100 t	36,300 t
Life cycle tCO2e redn/increase	101,185 tCO2e	223,139 tCO2e
Life cycle vehicles less/more	13,200 cars	29,100 cars
Life cycle sequestered carbon, tCO2e	50,330 tCO2e	106,594 tCO2e
Life cycle landfill diversion, tonnes	140,100 t	267,900 t

Figure 16: IRM Analysis Summary

- Although both 2a and 2b are viable, 2a will only become viable as it approaches projected capacity and will likely require taxpayer support up to that point (≈18 yrs), whereas 2b is anticipated to be viable from the start of operations. Note also that each model has external savings (e.g. meeting corporate emissions targets, landfill diversion benefits and other savings), not fully accounted for in Figure 16.

- Both Township and combined waste options have heat recovery and CO_2e benefits, with 2b being much superior over the 30 year projection period.

- We estimate Option 2b has the potential to reduce the entire community's GHG emissions by ≈12%, and reduce the 2030 target by ≈30%. The potential for carbon sequestration, at no extra cost, is important given alternatives and the Township's declaration of a Climate Emergency. Few options exist able to essentially extract carbon from the atmosphere by ≈3,600 tCO_2e annually, at no cost.

- The major resources recovered are heating, cooling, and biochar with primary revenues from biochar, tipping fees and energy sales. The most sensitive of these is biochar sales, however most of the revenues can be pre-contracted and the value confirmed prior to committing to the project, to limit risk.

- Landfill diversion is achieved under all options and are desirable given rising costs and limited capacity at Hartland Landfill. IRM is expected to divert ≈9,020 tonnes per year from the landfill – and if adopted across the region, would extend the existing landfill's life to 2186 (166 yrs).

- At buildout, a plant addressing the combined Township and other community wastes is estimated to potentially yield a "rebate" to taxpayers in the order of ≈$360/home. Few other waste management options exist with the potential to yield a rebate to taxpayers.

3.3.1 Risk

A basic risk assessment and scenario testing was undertaken to identify the main issues that could affect a decision on whether to proceed further.

All waste treatment systems have technology risk – the potential for the systems to fail or underperform. Usually these are handled by technology guarantees, and is true for the gasifier, the manufacturer is willing to guarantee the system and its design performance at the yield in the business case. Steps to address this are relatively simple and require laboratory and physical testing of actual sample wastes. A demonstration test with local wastes was successfully undertaken in 2017, shown in Figure 17, proving the system works with similar wastes to those found in Esquimalt.

Figure 17: Demonstration Test of Local Waste

Projection risk – the likelihood that population and waste grows to meet predictions – has been managed by adopting a "just-in-time" phased system design and pricing. While this adds cost in the long term, it reduces it initially and means that projection risk is reduced if not eliminated.

Any project of this scale involves contract and construction risks. These are normally handled through fixed price contracting, bonding, warranties, guarantees and other mechanisms. This risk will be monitored through construction and procurement can be structured to address and manage this risk.

Should the Township decide to pursue a combined waste strategy addressing all of the community's wastes, contracts will need to be put in place with haulers. We confirmed there is interest in this, thus reducing this risk and although it cannot be completely eliminated during the 30 year plant life, strategies exist to manage it in the long term. This helps mitigate volume and contract risk.

Revenues in the model have been relatively conservatively determined, for example we have excluded the possibility of selling electricity so BC Hydro revenue has been ignored. Aspects such as tipping fees and carbon credits have also not been aggressively determined. The model is more sensitive to biochar revenues so work was undertaken to confirm this aspect, and a rate of US$2,000/tonne applied whereas retail rates for biochar are currently sold for US$5,000/tonne. This is an item for early risk management, which can be achieved through sample testing and pre-contracting. A more detailed comment on this item has been provided but the system is not ultimately reliant on biochar revenues and can exceed breakeven without this.

In terms of operational risk, budgets have been assumed based on experience with other plants, and the systems themselves are not pressurized, so do not require certified boiler engineering professionals. Training and shift staffing have been assumed with standard allowances for maintenance, so we do not currently identify this risk as especially sensitive.

In conclusion, while there are risk concerns with this system, the same is true with other systems and the risks are considered manageable, with most capable of being mitigated in whole or part before final commitment to construct. Feedstock supplies, construction and technology performance, guarantees and revenue contracts can be managed before proceeding and we have not identified risks that cannot be managed or are sufficiently significant to reject proceeding at this stage.

3.4 Next Steps

We expect further consideration will be needed depending on the Township's review of the study’s findings. Should Council decide to proceed further, we recommend establishing an advisory committee and taking a measured approach to mitigate risks and safeguard project and taxpayer value.

The next steps would be to concurrently confirm the IRM approach meets MoE requirements and has their support; partner with CRD to amend the Solid Waste Management Plan to include a waste to energy IRM project for Esquimalt; and confirm regulatory and development approval processes. Then undertake essential laboratory testing of the waste as well as run a physical test of the waste mixture to confirm suitability.

With these in hand, the next major decision would be to decide whether to proceed with a Detailed Development and Implementation Feasibility Assessment with a proposed Implementation Plan. The procurement model would be decided and the financials would be updated as new information is provided. The Township would then be in a position for one final decision on whether to proceed to development or not.

4 What IRM Means For Residents

This summary is mainly intended to inform residents and to aid with community engagement, so technical terms have been minimized, but a separate Technical Report has been prepared with greater detail and is available for those with an interest in the technical aspects. In that context, the following provides a simplified summary based on the recommended option – which addresses all of the wastes generated in the entire Township.

Perspective	Comment
Homeowners	Residents currently separate kitchen scraps and other wastes but this is expected to reduce to Blue Box items and a single combined garbage can. The facility has the potential to limit homeowner costs, or may provide a small tax rebate to residents. No additional garbage trucks are expected to be needed. The garbage trucks are already circulating within the community and we anticipate up to ≈3 trucks per day will visit the site. Because the facility is sealed, there will be no odours. the gasifier system has low level noise from the chamber rotation, it is not expected to be an issue and below allowable limits.
Financial	The facility is expected to cost ≈$15m initially, expanding to ≈$21m over time (±15%), with eventual operating and maintenance costs of ≈$1.7m annually. There may be up to $226 million net revenues, over the life of the project. This is equal to a homeowner dividend (or rebate) of ≈$360 per home per year, potentially with more beyond the first 30 years of operation. Grant and funding programs are likely to be available but have not been assumed. Homeowner costs can be reduced or eliminated using outsource contracting, however this is likely to reduce potential dividends and may affect resource recovery and GHG reduction. The maximum benefits are likely to be obtained by the community owning the project.

Perspective	Comment
Environmental	The plant is expected to divert up to ≈9,000 tonnes of waste annually from Hartland Landfill. If IRM is adopted across CRD, the current landfill capacity is estimated to be extendable to 2186 at no extra taxpayer cost. GHGs are estimated to be reduced by up to ≈4,500 tCO_2e annually, equivalent to ≈12% of the entire community's carbon footprint. This is ≈31% of the 2030 community GHG reduction target and would eliminate the corporate carbon footprint. The plant is anticipated to remove ≈107,000 tCO_2e from the atmosphere using biochar, which is usable as a sterile soil supplement and sequesters carbon.
Resource recovery	Recovered resources contribute to revenue generation and carbon reduction. The recommended option is anticipated to recover ≈17,600 MWh of heat annually, which displaces using natural gas and oil. This can also be used for cooling, thus supplementing or replacing air conditioning systems. The plant is anticipated to produce ≈1,210 tonnes of biochar, usable as a fossil-free sterile soil supplement, which equates to ≈3,550tCO_2e GHG reduction per annum. As BC Hydro is not currently purchasing clean energy, electrical energy generation has not been assumed. This can be added later if feasible, as the plant complies with clean energy guidelines. Water and other resources could also be recovered but this has not initially been assumed as this would reduce viability. It can be added later if feasible.
Technology	The design assumes multiple gasifier units operating 24/7/365, expandable to cope with increasing waste volumes over time, as the community grows. The recommended plant location is the Public Works Yard, located at the junction of Esquimalt and Canteen Roads, which is owned by the Township.
Governance	As proposed the facility will be owned and operated by the Township with options to outsource operations to a qualified operator. Alternatively the facility can be financed and operated under a concession or similar contract where Esquimalt shares in the revenue potential but risk is reduced. Unless taxpayers fund landfill expansion, Hartland Landfill is scheduled to close between 2045 and 2048. Expansion would

Perspective	Comment
	increase GHGs and require both taxpayer investment and long term taxpayer support, and would not contribute to landfill diversion or GHG reduction objectives. It would also conflict with provincial and federal objectives, programmes and regulations. The carbon dioxide reduction and sequestration potential is considered the most significant single opportunity for the Township to achieve its 2030 and 2050 carbon reduction goals.
Intangible benefits	There is potential for intangible benefits that stimulate economic development, as shown by examples in Europe. This attracts like-minded businesses, enhances education, training, eco-tourism and investment. Experience elsewhere is that residents increase active participation in quantifiable climate change action, generating community involvement and pride.

Appendix 1: Team & Limiting Conditions

Study Team & Acknowledgements

This report was prepared by Graeme Bethell, M.Sc., QEP, a pollution prevention, utility management and gasification specialist; Chris Corps, B.Sc., a Land Economist specialising in complex business cases, feasibility and viability assessments for sustainable land development and energy projects; with technical assistance and input from James Pratt, RPP, a public consultation specialist; Michael Wolinetz, a greenhouse gas quantitative and assessment specialist; and Albert Bicol, P. Eng., an international energy systems and sustainable energy master planning and development specialist. Information on gasification yield, performance, testing and pricing was kindly provided by Dr. Matt Summers, P.Eng, of West Biofuels Inc. in California and by staff at TSI Inc., of Washington State, including VP Andrew Johnson and Matt Hoffman P.Eng. Their contributions are gratefully acknowledged.

The authors acknowledge that the Township of Esquimalt exists on unceded Lekwungen lands, home of the peoples now known as the Esquimalt and Songhees Nations.

We are grateful to the Township of Esquimalt for providing information for the report and guidance on options, and waste haulers active in the region for assessing wastes in Esquimalt and information on different waste types. Lastly we are grateful for kind assistance of system manufacturers and providers for their help assessing how to optimize systems and in pricing options.

Assumptions & Limiting Conditions

The information in this document was compiled for the purpose of providing a preliminary assessment of the potential for implementing IRM of waste streams generated in the Township of Esquimalt using gasification. The authors have prepared this document at the request of the Township, solely for this purpose.

Information in this report from which conclusions have been derived has been provided by the Township and third parties. While reasonable skill, care and diligence have been exercised to assess the information acquired during the preparation of this report, no guarantees or warranties are made concerning the accuracy or completeness of this information, although the information provided by others is represented to be accurate by the suppliers. This document, the information it contains, and the basis on which it relies and factors associated with implementation of resource recovery from gasification are subject to changes which are beyond the control of the authors.

IRM requires an inter-disciplinary approach. As a result, components of the document were prepared by professionals in one field who are not qualified in the other fields of study. While diligence has been applied to the assessment, the scope of this report did not allow for full inter-disciplinary cross-verification of all components.

This report includes screening-level estimates which should not be relied upon for design or other purposes without verification, for example through detailed feasibility studies and especially as recommended by the authors. The authors do not accept responsibility for the use of this report for any purpose other than that stated above and do not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This report is intended to provide a preliminary assessment to meet the purposes of this study and cannot be applied to other jurisdictions or applications without conversion, analysis and confirmation with the authors. Any use by any entity or client, consultants, sub-consultants or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

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