King County Vashon Island Organics Processing Feasibility Study

Final Phase 2 Report

Contract No. 6122178

King County
Department of
Natural Resources and Parks
Solid Waste Division

Waste Prevention • Resource Recovery • Waste Disposal

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VASHON ISLAND ORGANICS PROCESSING FEASIBILITY STUDY
FINAL PHASE 2 REPORT

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Prepared by:

HDR

in association with
Matthew Cotton
O2Compost

Prepared for:

King County
Department of Natural Resources and Parks
Solid Waste Division
King Street Center, Suite 701
201 S. Jackson St.
Seattle, WA 98104-3855
206-296-296-4466 TTY Relay: 711
www.kingcounty.gov/solidwaste

Executive Summary

This organics processing feasibility study explores the potential of developing an on-island organics (food waste, green waste, brush, woody waste) composting facility (Facility) on Vashon Island in lieu of the current practice of hauling these materials off-island. The study previously concluded that there are ample quantities of material available to warrant such a facility, provided a number of issues are resolved that are beyond the scope of this effort. The HDR team estimated approximately 6,000 tons of material could be composted on-island at a lower cost than the current practice of hauling off-island.

This study evaluated several types of compost technologies in the Phase 1 report, and concluded there were two appropriate options for systems for the range of food waste likely to be received at the facility:

- a pipe-on-grade (also referred to as POG) positive air pressure static pile composting system, and
- a reversing aerated static pile (ASP) system with an in-floor aeration channel and a biofilter to capture and treat foul air.

These two technologies were described in the Phase 1 report as being appropriate for two ranges of food waste:

- An initial range of up to 10% food waste by weight, and
- An ultimate range of up to 34% food waste by weight.

An important note about this range of food waste is that King County (County) has historically collected relatively small quantities of brush/green waste at the Vashon Recycling & Transfer Station (VRTS). While the tons collected is increasing from year to year, it is assumed that the relatively high tip fee charged at the facility is a barrier to maximizing brush/green waste collection. The Phase 1 report described the importance of having enough brush/green waste to function as a bulking agent for the relatively wet, heavy food waste. Consequently, one of the key findings of the study is the need to attract an adequate quantity of brush/green waste such that the quantity of food waste is manageable within these ranges. If a composting facility is able to attract significant amounts of wet heavy food waste, it will also need significantly more brush/green waste for proper composting. This study does not explore how the feedstock material would be collected, but a lowered tip fee may be necessary for substantially increased organics collection.

Table ES-1 provides a summary of the total and annualized costs for two sizes of POG facility and the ultimate buildout of the ASP facility. The cost analysis concludes that the majority of the cost is to pay for the Facility operations. This value is dominated by cost of labor and operating equipment, which comprises two thirds of the cost. The study does not identify a preferable site for the Facility, so no land or site-specific improvement costs are included.

Table ES-1. Comparison of Total Costs of Facility Options

Cost Component	POG Initial	POG Ultimate	ASP Ultimate
Labor Cost	$241,075	$241,075	$216,834
Additional O&M Cost (Equipment, Utilities, 10% Contingency)	$257,930	$257,930	$328,220
Residuals Haul/Disposal	$10,175	$16,400	$16,400
Total Revenues	$(81,400)	$(131,000)	$(131,000)
Annualized Capital Cost (4%, 20 Years)	$150,000	$174,000	$202,000
Total Annual Cost	**$577,780**	**$558,405**	**$632,454**
Total Cost per Ton ($/ton)	**$142**	**$85**	**$97**

Notes:

1. The estimated 2021 cost to haul and process off-island is approximately $150 per ton for MSW going to Cedar Hills Regional Landfill and $215 per ton for green waste going to Cedar Grove Composting Facility.

As a way to evaluate environmental impacts as well as financial impacts, a greenhouse gas (GHG) analysis was performed comparing the current waste system operations to the proposed ultimate phase of a new composting facility. The analysis was performed using the U.S. EPA's Waste Reduction Model (WARM) and did not include a market study to evaluate how much compost is currently transported onto the island for sale, and how much that would likely be reduced once a market was established for the compost generated on-island. The WARM results show that the status quo option results in a greater reduction in GHG emissions than the proposed on-island composting option. Emissions from hauling the material off of the island are small compared to the emissions reduction from processing, both at the landfill and the compost facilities.

The favorable result for landfilling organics in the status quo is due to the carbon sequestration credits built into WARM; without carbon sequestration credits, the current waste system generates GHG emissions whereas the proposed composting facility would reduce GHG emissions. Table ES-2 shows the results from WARM, along with the related hauling emissions, and the emissions if landfill carbon sequestration credits are removed. Emissions are shown in metric tons of CO_2 equivalents ($MTCO_2E$). Hauling emissions from trucks are included in WARM. The emissions from the ferry transport of material are assumed to be negligible. The practice of counting carbon sequestration in landfills as reducing GHG emissions is not universal among waste management GHG models; both results are presented to inform but not advocate for either methodology. The WARM results are presented for informational and comparative purposes only, as there are many assumptions included in the model and this analysis.

Table ES-2. WARM Results (in MTCO$_2$E)

Scenario	Truck Hauling GHG Emissions	Processing GHG Emissions	Total GHG Emissions	GHG Emissions per Ton Feedstock	Estimated GHG Emissions - Without Carbon Sequestration	Estimated GHG Emissions per Ton Managed - Without Carbon Sequestration
Scenario 1 Status Quo	39	-1,200	-1,239	**-0.18**	1,511	**0.23**
Scenario 2 Ultimate Phase	0	-476	-476	**-0.07**	-476	**-0.07**

Note: The emission values represent net emissions, accounting for both direct and indirect emissions and credits associated with a given solid waste management option. Negative emissions indicate that a management scenario represents a net CO_2 sink.

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1 INTRODUCTION

King County Solid Waste Division (KCSWD) retained HDR Inc. (HDR) to evaluate the feasibility of an on-island organics processing facility (Facility) on Vashon Island. KCSWD's primary objective is to explore alternatives to the current practice of hauling materials (by truck and ferry) to the Cedar Grove Compost facility (Cedar Grove) in order to minimize costs to ratepayers and environmental impacts. Further, the Vashon community represented by Zero Waste Vashon (ZWV) has sought to create a sustainable, resilient waste management system that would include a compost facility on-island. The overall study is the culmination of consideration of available organics feedstock, technologies, site layouts, siting considerations, options for ownership and operation, expected markets for finished compost and other products, and greenhouse gas (GHG) emissions related to the proposed Facility.

The scope of work is separated into two phases:

- Phase 1 Review and Explore Organics Processing Operations
- Phase 2 Expanded Analysis

This Phase 2 Report (Report) portion of the study summarizes the financial viability of implementing an on-island composting facility. Capital and operating cost estimates are provided for a range of feedstock as represented by the low and high quantities developed in the Phase 1 report. Also included is a discussion on how the on-island compost facility would influence the existing SWD operations in terms of avoided cost, freeing up capacity in transfer operations, and other considerations. In addition, this Report considers possible greenhouse gas impacts from the change in processing and transportation activities.

2 FINALIZED FEEDSTOCK MIXES

To develop a preliminary layout for the proposed Facility, the following feedstock is assumed available for composting in the Low Range or Initial Phase, which is also referred to as the lower range of food waste (specifically 10% by weight):

- 3,700 tons of yard waste, and
- 370 tons of residential and/or industrial, commercial, and institutional (IC&I) sourced food waste (approximately 10 percent of the available yard waste).

To develop a preliminary strategy and facility sizing for an upper or high range of food waste, also called the Ultimate Phase, the following assumptions were developed for available feedstock for composting:

- 3,700 tons of yard waste (consistent with the Initial Phase),
- 1,134 tons of food waste diverted from MSW received at VRTS per projections from KCSWD,
- 189 tons of yard waste diverted from MSW received at VRTS per projections from KCSWD,
- 536 tons from IC&I feedstock from on-island business participation per dialogue between ZWV and on-island businesses, and the NAICS analysis described in this Report,
- 1,000 tons from additional bulking material (e.g., wood chips) from additional on-island wood sources, and

- When combined, this feedstock represents up to 34% food waste by weight.

Please note this study does not assess the potential impacts on tonnage from the implementation of any collection program including adding a mandatory “third bin” for organics collection.

3 ESTIMATE OF COSTS

Cost estimates were developed to reflect a combined yard and food waste compost facility using two methods of operation:

- A pipe-on-grade (POG) system, and
- A forced aeration, reversing system

The POG positive air pressure system was modeled at the low range of food waste (Initial Phase) as well as the higher range of food waste (Ultimate Phase) to provide the County with options in terms of selecting an operating technology. The POG system was offered as a cost saving measure compared to the forced aeration reversing system in terms of their respective capital costs. The forced aeration reversing air system was only modeled at the higher range of food waste (Ultimate Phase).

Operations costs include the estimated cost of equipment, materials, and three to four personnel. The model reflects revenues of $40 per ton for compost from food and yard waste mixtures. This value is approximately half to one-third of the estimated revenue of compost from yard waste only, reflecting wholesale value of a compost that is likely not OMRI[1] certified due to the potential for contaminants like film plastics and broken glass to make it into the finished product. The food waste feedstock sources are assumed to deliver food waste with very low to no residues. Residues removed during processing were estimated to be no greater than approximately one percent of incoming tonnage. Landfill disposal costs are reportedly $150 per ton, which includes the County’s cost for hauling material off island, and were included for one percent of incoming material to be conservative. Residual disposal costs are developed from transfer station haul costs, and landfill disposal fees.

To offer a better understanding of the cost of the two systems, the POG system was also modeled at the same throughput rate as the ultimate throughput capacity. As described in the Phase 1 report, POG systems require more land area than reversing ASP systems. The POG system operating at the ultimate throughput capacity would require approximately 2.7 acres as compared to the 2 acres for lower, initial throughput rate. The impact of these costs is evident in the summary costs per ton on tables below.

3.1 CAPITAL COST

The capital cost estimate reflects a planning level analysis of the cost of a facility using unit prices applied to functional features of the facility. The capital costs reflect all weather surfaces (paved or concrete) for all composting, curing, and finished compost areas as well as waste receiving, roadways, rolling stock equipment maneuvering areas and fixed equipment screening areas. Fixed equipment such as blowers, logic controllers, and manifolds are all included in the capital cost. Power supply, blower fans, air manifolds, and biofilter with media (for the forced air system) are included in the capital cost. Rolling stock such as front-end loaders are included as

[1] OMRI is the Organic Materials Review Institute and certifies products for organic production and processing under the U.S. National Organic Program standards. OMRI certification is associated with higher market value.

a one-time purchase in the capital cost. The operation of equipment (fuel, maintenance, etc.) is included in the operations cost estimate. The capital cost includes site drainage and a lined pond to capture and contain site drainage. If the compost facility were to be located at the VRTS, the capital cost could benefit from a co-located facility at the county site including use of the entrance scale facility, existing utilities and offsite improvements, use of on-site roadways, etc.

The capital cost did not include the cost of land. This is partly due to two factors; one of the possible site locations could be a county-owned site, in which case there is not additional cost for land, or the cost of land is not known or too speculative to include in the estimate.

Capital costs include a 20% planning contingency plus 15% soft costs (consisting of design, construction management and permitting costs at 8%, 4% and 3% respectively).

The capital costs, including soft costs, are assumed to be amortized to an annual cost using a 20-year amortization period and assuming a 4% interest rate.

3.1.1 Compost Technologies for a Range of Food Waste Quantities

The capital cost for the compost technologies was modeled at two ranges of food waste as a percent by weight of the total throughput rates:

- The initial or lower range of food waste (up to approximately 10% by weight), and
- The ultimate or higher range of food waste (up to approximately 34% by weight)

HDR prepared three cost estimates to provide the County with additional insight about the likely range of capital and operating costs with varying feedstock composition and technologies to assist the County and ZWV when making decisions of which technology to employ. This consisted of the two discussed above (POG and ASP) plus an additional POG system operating at the higher food waste quantity rate. To accomplish this, HDR prepared an additional sizing analysis of the POG system and concluded the higher quantity throughput rate would necessitate approximately 2.7 acres for this technology and this feedstock quantity. HDR then used the areas from the POG system operating at the higher range of food waste (requiring 2.7 acres) in developing a cost estimate for the two throughput rates, as shown on **Table 1** below.

Table 1. Range of Potential Capital Costs

Component	POG Low Range	POG High Range	ASP High Range
Capital Improvements Cost	$1,368,825	$1,594,700	$1,847,900
Soft Cost (Design, CM, Permitting and Contingency)	$479,089	$558,100	$646,700
Total Capital Cost	**$1,848,000**	**$2,153,000**	**$2,495,000**

3.2 OPERATING COSTS

The cost of operations for the envisioned facilities is expected to be relatively similar for the two different technologies under the operating conditions that were modeled for this effort. Generally, the throughput rates are far lower than typical compost facilities that can benefit from any economies of scale. Consequently, the cost of operations (including the level of staff, rolling stock, etc.) remains essentially the same regardless of the technology. **Table 2** shows the expected equipment costs for the Facility, total and amortized. These apply to both types of technology and both throughput levels considered. Although not included in this study, there are several benefits to co-locating the compost facility at the VRTS including shared use of entrance facilities, staff, and rolling stock, and more efficient management of residuals.

Table 2. Composting Equipment for all Compost Facility Options Considered

Equipment	Unit Cost	Number	Total Cost
Front End Loader	$250,000	1	$250,000
Water Truck	$100,000	1	$100,000
Grinder/Shredder	$80,000	1	$80,000
Screen Compost Finish	$20,000	1	$20,000
Total			**$450,000**
Annualized for 10 Years at 4%			**$56,000**

3.2.1 Pipe-on-Grade Technology (Low Range and High Range of Food Waste)

The operating costs for the POG for both the low throughput rate and the ultimate rate are shown in the tables below. The staffing requirements of the POG system remain essentially the same regardless of the lower or higher throughput range due to the small quantity of material handled by these facilities.

Table 3. Equipment Operating Costs for Pipe-on-Grade

Equipment	O&M Costs	No.	Hours/Day	Subtotal
Water Truck	$8.00	1	2	$16
Front End Loader	$35.00	1	4	$140
Shredder	$45.00	1	2	$90
Screen 1	$10.00	1	2	$20
Blowers	$3.00	2	2	$144
Piping Beneath Piles	$2.00	8	2	$32
			Subtotal (per day)	**$442**
			Subtotal (Annual, 320 days/year)	**$141,440**
Replace on-grade piping every 5 years	$48,000	0.2	LS	$9,600
			ANNUAL EQUIPMENT OPERATING COST	**$151,040**

Table 4. Labor Costs for Pipe-on-Grade

	Cost w/o benefits ($/hr)	Cost w/ benefits ($/hr)	No.	hrs/day	Subtotal
Weekend Day Ops					
Benefits		135%			
Manager	$65.52	$88.45	0.5	0	$ -
Mechanic	$35.36	$47.74	0.5	2	$48
Heavy Equip Op weekends	$32.53	$43.92	1	8	$351
Laborer weekends	$26.90	$36.32	1	8	$291
		Subtotal Weekend Day	**3**		**$690**
		Subtotal Weekend Annual Costs	**104**		**$71,716**
Weekday Ops					
Manager	$65.52	$88.45	0.25	2	$44
Mechanic	$35.36	$47.74	0.5	2	$48
Heavy Equip Operator	$32.53	$43.92	1.2	4	$211
Laborer	$26.90	$36.32	1.2	8	$349
		Subtotal Weekday	**3**		**$651**
		Subtotal Weekday Annual Costs	**260**		**$169,359**
				TOTAL ANNUAL LABOR COSTS	**$241,075**

Table 5. Total O&M Costs for Pipe-on-Grade

	Subtotal
Equipment Operating Costs	$151,040
Labor Costs	$241,075
Miscellaneous Utilities	$58,817
Water	$2,708
Operating Contingency	$45,384
Total Annual Cost	**$499,005**

3.2.2 Reversing Aerated Static Pile Technology (Higher Range of Food Waste)

The annual operating costs for the reversing ASP system are detailed in the tables below.

Table 6. Equipment Operating Costs for Reversing ASP

Equipment	O&M Costs	No.	Hours/Day	Subtotal
Water Truck	$8.00	1	4	$32
Front End Loader	$35.00	1	2	$70
Shredder	$45.00	1	2	$90
Screen 1	$10.00	1	2	$20
Blowers	$3.00	4	24	$288
Piping Beneath Piles	$2.00	2	24	$96
			Subtotal (per day)	**$596**
			Subtotal (Annual, 320 days/year)	**$190,720**
Refresh Biofilter Every 2 Years	$80.00	78	CY	$3,109
			ANNUAL EQUIPMENT OPERATING COST	**$193,829**

Table 7. Labor Costs for Reversing ASP

	Cost w/o benefits ($/hr)	Cost w/ benefits ($/hr)	No.	hrs/day	Subtotal
Weekend Day Ops					
Benefits		135%			
Manager	$65.52	$88.45	0.5	0	$ -
Mechanic	$35.36	$47.74	0.5	2	$48
Heavy Equip Op weekends	$32.53	$43.92	1	8	$351
Laborer weekends	$26.90	$36.32	1	8	$291
		Subtotal Weekend Day	**3**		**$690**
		Subtotal Weekend Annual Costs	**104**		**$71,716**
Weekday Ops					
Manager	$65.52	$88.45	0.25	2	$44
Mechanic	$35.36	$47.74	0.5	2	$48
Heavy Equip Operator	$32.53	$43.92	1	4	$176
Laborer	$26.90	$36.32	1	8	$291
		Subtotal Weekday	**3**		**$558**
		Subtotal Weekday Annual Costs	**260**		**$145,117**
				TOTAL ANNUAL LABOR COSTS	**$216,834**

Table 8. Total O&M Costs for Reversing ASP

	Subtotal
Equipment Operating Costs	$193,829
Labor Costs	$216,834
Miscellaneous Utilities	$82,133
Water	$2,708
Operating Contingency	$49,550
Total Annual Cost	**$545,054**

3.3 SUMMARY OF COSTS

The overall system costs are generally driven by the cost of operations more so than the capital costs. This is true for either the POG or the forced air reversing system. Of the operations cost, the cost of labor is the most significant cost for the system. The following tables summarize the total annual costs for each of the three systems analyzed. As noted above, these costs do not reflect potential saving from colocation of the compost facility at the VRTS.

Table 9. Summary Total Costs of POG System at Initial Capacity

Component	Total Capital Cost	Annual Cost
Facility	$1,848,000	$150,000
O&M Costs		$499,005
Residuals Haul/Disposal		$10,175
Revenues		$(81,400)
Net Overall Cost	**$1,848,000**	**$577,780**

Table 10. Summary Total Costs of POG System at Ultimate Capacity

Component	Total Capital Cost	Annual Cost
Facility	$2,153,000	$174,000
O&M Costs		$499,005
Residuals Haul/Disposal		$16,400
Revenues		$(131,000)
Net Overall Cost	**$2,153,000**	**$558,405**

Table 11. Summary Total Costs of Reversing ASP at Ultimate Capacity

Component	Total Capital Cost	Annual Cost
Facility	$2,495,000	$202,000
O&M Costs		$545,054
Residuals Haul/Disposal		$16,400
Revenues		$(131,000)
Net Overall Cost	**$2,495,000**	**$632,454**

HDR compared annualized costs and revenues, including at the per ton level using the total tons processed through each of the three systems analyzed. The following table provides a summary of these costs. The cost per ton values at the bottom of the table indicate the cost of the POG system operating at the ultimate capacity (higher food waste valued) is the lowest cost of the three. However, for planning purposes all three are relatively similar. As noted above, the dominant cost of the system is the cost of operations which is controlled mostly by the cost of labor and operating equipment.

Table 12. Comparison of Total Costs of Facility Options

Cost Component	POG Initial	POG Ultimate	ASP Ultimate
Total O&M Cost	$499,005	$499,005	$545,054
Residuals Haul/Disposal	$10,175	$16,400	$16,400
Total Revenues	$(81,400)	$(131,000)	$(131,000)
Annualized Capital Cost (4%, 20 Years)	$150,000	$174,000	$202,000
Total Annual Cost	**$577,780**	**$558,405**	**$632,454**
Total Cost per Ton ($/ton)	**$142**	**$85**	**$97**

Notes:

1. The estimated 2021 cost to haul and process off-island is approximately $150 per ton for MSW going to Cedar Hills Regional Landfill and $215 per ton for green waste going to Cedar Grove Composting Facility.

4 GREENHOUSE GAS ANALYSIS

A GHG emissions model was prepared comparing the ultimate phase of the Facility to the status quo operations of diverting some organic material to an off-island composting facility and allowing the rest of recoverable organics to be disposed of at an off-island landfill. The U.S. EPA Waste Reduction Model (WARM), Version 15, was used to evaluate GHG emissions from landfill operations versus composting operations, and off-island processing versus on-island processing. There are limitations to WARM and to the assumptions made for both the status quo and the ultimate phase scenarios; therefore, results should be seen as illustrative of overall GHG potential emissions, for comparison purposes only. One such limitation relevant to this analysis is that the model does not offer a comparison of hauling emissions for ferry transport. Ferry transport emissions related to waste hauling were evaluated separately.

4.1 WARM

WARM was created by the U.S. EPA as a tool to help managers and policy makers understand and compare the emissions and offsets resulting from different materials management options (e.g., landfill disposal, composting, etc.) for materials commonly found in the waste stream. Only anthropogenic emissions are considered as GHG emissions in WARM. Biogenic emissions are considered to be carbon that was originally removed from the atmosphere through natural processes, like photosynthesis, and would eventually return to the atmosphere through a natural degradation process. Anthropogenic emissions result from human activities and are subject to human control, which are considered disruptive to the naturally occurring carbon cycles and balance.

Although the GHG emission results of WARM are presented as occurring in a discrete year, the results actually indicate the full life-cycle benefits of each waste management alternative, which may accrue over the long-term. The emissions shown for each scenario in WARM represent the estimate for net GHG emissions, which include gross manufacturing and production emissions, any increases in carbon stocks, and any avoided utility emissions. No scenario results in zero emissions, as there are emissions associated with manufacturing or producing the materials modeled and then processing them for reuse, conversion, or disposal.

4.2 FEEDSTOCK GENERAL ASSUMPTIONS

The GHG emissions model was developed based on comparing the current waste management practices (Scenario 1, Status Quo) to the waste management assumptions for the Ultimate Phase of the proposed Vashon Island compost facility (Scenario 2). These focus specifically on the management of 6,559 tons of organic waste produced annually on Vashon Island, broken out and managed as follows:

- 1,110 tons of yard waste, sent off-island to Cedar Grove for composting under the Status Quo, but which will be composted at the proposed Vashon Island compost facility.
- 1,134 tons of food waste, currently collected as part of MSW and transferred to CHRL via VRTS under the Status Quo, which will be diverted from MSW received at VRTS and composted at the proposed Vashon Island compost facility.
- 2,779 tons of yard waste, currently collected as part of MSW and transferred to CHRL via VRTS under the Status Quo, which are estimated to be composted at the proposed Vashon Island compost facility.
- 536 tons of IC&I food waste currently sent to disposal under the Status Quo, but which will be diverted at the generation source by participating on-island businesses and sent to the proposed Vashon Island compost facility.
- 1,000 tons of additional bulking material (e.g., wood chips) from additional on-island wood sources, which are assumed to be sent to disposal in the Status Quo but will be solicited for processing at the proposed Vashon Island compost facility.

WARM allows the input of food waste in the following categories:

- Food Waste (non-meat)
    - Grains 16%, Fruits and Vegetables 61%, Dairy Products 22%
- Food Waste (meat only)
    - Beef 46%, Poultry 54%
- Individual Materials
    - Beef
    - Poultry
    - Grains
    - Bread
    - Fruits and Vegetables

  - Dairy Products
- Food Waste
  - Beef 9%, Poultry 11%, Grains 13%, Fruits and Vegetables 49%, Dairy Products 18%

Because detailed information is not available at this time, all food waste and IC&I materials were input to WARM in the Food Waste category. WARM assumes that the Food Waste comprises the individual food waste materials in proportions that match those found in the U.S. Department of Agriculture (USDA) Economic Research Service (ERS) Food Availability (per Capita) Data System (2010). There is currently no differentiation in WARM between the composition of residential and commercial food waste.

WARM allows the input of yard waste in the following categories:

- Yard Trimmings
  - 50% grass, 25% leaves, and 25% tree and brush trimmings from residential, institutional, and commercial sources.
- Individual Materials
  - Grass
  - Leaves
  - Branches
- Mixed Organics
  - 53% food waste and 47% yard waste

The WARM analyses performed assume that yard waste is modeled under the Yard Trimmings category, and bulking material is modeled under the Branches category.

4.3 PROCESSING GENERAL ASSUMPTIONS

4.3.1 Landfill

All waste material generated on Vashon and sent to disposal is taken to Cedar Hills Regional Landfill (CHRL). CHRL is located in an area receiving approximately 57 inches of rain per year. For the purposes of modeling landfill gas generation, the “wet” designation in WARM (receiving greater than 40 inches of precipitation annually) was chosen. Since landfill disposal creates an anaerobic environment that generates methane (CH_4) that would not have been generated without human intervention, WARM counts this as anthropogenic GHG emissions. CHRL recovers landfill gas for energy and King County’s engineers estimate a 98 percent landfill gas recovery rate. There are varying options available in WARM for the level of landfill gas collection and use. This WARM analysis assumes that the landfill has a landfill gas recovery system with “California regulatory collection” operating efficiency (the most efficient WARM option, not limited to use in California),[2] and that the gas is recovered for energy. The electricity GHG emissions that are avoided by using landfill gas to energy are based on WARM’s regional

[2] WARM assumes the following landfill gas collection efficiency percentages for landfills with “California regulatory collection” systems - in Year 0: 0 percent; Year 1: 50%; Years 2-7: 80 percent; Years 8 to 1 year before final cover: 85 percent; Final cover: 90 percent.

marginal electricity grid mix emissions for Washington. Carbon dioxide (CO_2) in the landfill gas is not counted as it is considered biogenic.

The WARM model also accounts for the energy used by mobile equipment at the landfill to compress the MSW and obtain and place cover materials. In addition, WARM assumes a level of anthropogenic carbon storage in the landfill. The effect this has on the WARM results is discussed in more detail in Section 4.6.1.

4.3.2 Composting

Currently, organic material that is generated on Vashon Island and sent to commercial composting is processed at Cedar Grove's compost facility near Maple Valley, Washington. It is assumed that the operations of both the Cedar Grove facility and the proposed Vashon Island compost facility will be similar in terms of GHG emission generation, and that those emissions are adequately modeled using the composting assumptions built into WARM.

WARM assumes composting occurs in a central compost facility utilizing the windrow operating method; adjustments cannot be made for type of compost processing technology. Composting generates anthropogenic GHG emissions from the mechanical turning of compost piles. Fugitive CH_4 and N_2O emissions generated from decomposition during composting are considered anthropogenic emissions. CO_2 generated from decomposition during composting is considered biogenic. Composting is assumed to result in anthropogenic carbon storage, or carbon sink, from the application of compost to agricultural soils. The model is based on an application rate of 20 short tons of compost per acre.[3]

It is assumed that all finished compost produced will be used on the island.

4.4 VEHICLE TRANSPORT GENERAL ASSUMPTIONS

WARM is limited to evaluating GHG emissions from truck hauling only and allows input of the distances from the curb to the landfill, combustor, material recovery facility, composting facility, and anaerobic digester. For the WARM inputs for the Vashon Island model, the location of the "curb" is assumed to be the VRTS. Therefore, the hauling distance is assumed to be zero for organics in Scenario 2, as organics will be processed on the island. For Scenario 1, the one-way truck hauling distances are assumed to be 35 miles to the Cedar Grove Composting Facility for organics, and 36 miles to Cedar Hills Regional Landfill for MSW. Both distances include 8 miles driving from the transfer station to the Vashon Ferry Terminal, plus the driving distance from the Fauntleroy Ferry Terminal to the final destination facility (typical route is 27 miles for compost and 28 miles for MSW). WARM requires the hauling distance to be input as a one-way distance but takes round-trip emissions into account.

Emissions were not estimated for the status quo transportation of compost onto Vashon Island. Information on the quantity, quality, and origin of purchased compost is not readily available. Furthermore, it is currently unclear how much of compost currently purchased from off-island sources would be displaced by compost from the proposed facility. This information could be estimated in the future through a market study or similar analysis and may show additional expected reductions in GHG emissions.

[3] US EPA Office of Resource Conservation and Recovery. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), Management Practices Chapters. November 2020. Available at https://www.epa.gov/sites/production/files/2020-12/documents/warm_management_practices_v15_10-29-2020.pdf. Accessed April 2021.

4.5 FERRY TRANSPORT GENERAL ASSUMPTIONS

Trucks hauling MSW and organics off the island for processing use the Southworth-Vashon Island Ferry, which travels 3.4 miles between the Vashon Island North-End Ferry Terminal and the Fauntleroy Ferry Terminal. The ferries are part of the Washington State Ferries agency under the Washington State Department of Transportation (WSDOT), and so run on a regular schedule which is not affected by the presence (or lack thereof) of trucks hauling MSW or organics. There are currently approximately two dozen Fauntleroy/Vashon ferry trips leaving from each terminal every weekday. These routes are primarily served by the MV Kittitas and the MV Issaquah, both Issaquah class auto/passenger ferries running on B10 diesel fuel, and capable of carrying 1200 passengers and 124 vehicles, with a displacement (weight) of 3,310 long tons.[4]

The exact waste hauling schedules are unknown, but based on historical annual tons and estimated payloads provided by King County, it is assumed that approximately 1 to 2 transfer trucks, hauling approximately 20 tons of MSW, and 1 to 2 trucks hauling approximately 3 to 5 tons of yard waste, are traveling from the island each weekday on average. Scenario 2 would reduce the quantity enough to eliminate the need for one of those transfer trucks every other day, and potentially eliminate the need for all the yard waste trucks.

Each ferry is only allowed to take on 42.5 tons of waste hauling vehicles, which is the approximate weight of one fully loaded MSW transfer truck. This maximum weight of 42.5 tons is approximately 1 percent of the weight of the ferry as listed by WSDOT (equivalent to 3,707 tons); less than 1 percent if the truck is empty or a smaller yard waste hauling truck. Therefore, adding the weight of the truck is unlikely to cause a significant reduction in fuel efficiency for the ferry. And because the ferries run on schedules, reducing the number of truck trips on the ferries will not cause any reduction in the number of trips the ferries take. This means that any reduction in ferry GHG emissions that could be attributed to reducing the number of trucks needing passage each year would be negligible, and therefore are not included in this analysis.

4.6 GHG RESULTS

The scenarios were modeled in WARM according to the assumptions detailed in previous sections. The results are shown below in **Table 13**. The full WARM results are included in Appendix 2. The results show a greater reduction in GHG emissions per ton for Scenario 1, the status quo, than from Scenario 2, the on-island Ultimate Phase compost facility.

[4] Ferry details available through https://wsdot.wa.gov/ferries/vesselwatch/Vessels.aspx. Accessed April 2021.

Table 13. WARM Results (in $MTCO_2E$)

Scenario	Annual Throughput Landfilled (tons/year)	Annual Throughput Composted (tons/year)	Truck Hauling GHG Emissions ($MTCO_2E$)	Processing GHG Emissions ($MTCO_2E$)	Total GHG Emissions ($MTCO_2E$)	GHG Emissions per Ton Feedstock ($MTCO_2E$)
Scenario 1 Status Quo	5,449	1,110	39	-1,200	-1,239	**-0.18**
Scenario 2 Ultimate Phase	0	6,559	0	-476	-476	**-0.07**

Notes:

1. The emission values represent net emissions, accounting for both direct and indirect emissions and credits associated with a given solid waste management option. Negative emissions indicate that a management scenario represents a net CO_2 sink.

2. The transportation emissions included represent round-trip distances from the VRTS to the anticipated solid waste management option location (CHRL or Cedar Grove Composting), plus emissions from mobile equipment used in the waste management practice (landfilling or composting).

3. The landfill scenario assumes a "California regulatory collection" landfill gas capture efficiency and that the gas is recovered for energy. The landfilling avoided electricity GHG emissions are based on WARM's regional marginal electricity grid mix emissions for Washington.

4.6.1 Carbon Sequestration in WARM

WARM assumes a level of anthropogenic carbon storage, created when carbon-based materials do not decompose in the anaerobic environment of the landfill and therefore are removed from the global carbon cycle, avoiding the biogenic GHG emitted during natural decomposition. The inclusion of carbon storage in landfills follows the approach outlined by the Intergovernmental Panel on Climate Change,[5] but does differentiate WARM from some other life cycle emissions accounting models that estimate biogenic carbon storage separately and do not include it as an emissions credit. HDR does not object to or recommend one approach over the other; rather, the subject of carbon sequestration credit is discussed simply for informational purposes. It may seem counterintuitive for landfilling to result in more environmental benefit than composting. However, the use of WARM in this case reveals landfilling is the environmentally superior option to composting in regard to GHG emissions.

WARM assumes that for every wet ton of food waste buried in the landfill, 0.09 metric tons of CO2 equivalents (MTCO2E) will stay sequestered as carbon in the landfill. For every wet ton of yard trimmings and branches buried in the landfill, WARM assumes that 0.54 MTCO2E and 1.06 MTCO2E, respectively, will stay sequestered as carbon in the landfill.[6] As a sensitivity analysis, HDR has performed a separate calculation to determine how much of the GHG emissions in the WARM results were due to WARM's estimation of carbon sequestration in the

[5] USEPA. "Landfill Carbon Storage in WARM." October 27, 2010. Available at <www.epa.gov/sites/production/files/2016-03/documents/landfill-carbon-storage-in-warm10-28-10.pdf>.

[6] US EPA Office of Resource Conservation and Recovery. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), Organics Materials Chapters. November 2020. Available at https://www.epa.gov/sites/production/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf. Accessed April 2021.

landfill. Using the WARM values for carbon sequestration for each material type and the quantities of each material input to the model, a total value for landfill carbon storage was extracted from the WARM model results.

Table 14 shows the final results from WARM, both with and without the credits for carbon storage in the landfill. Allowing WARM to consider carbon storage results in emissions of -0.18 $MTCO_2E$ per ton of waste managed at the landfill. When landfill carbon storage credits are removed from the WARM results, the landfilling result is 0.23 $MTCO_2E$ per ton of waste. The GHG emissions of the new compost facility calculated by WARM remains -0.07 $MTCO_2E$ per ton of waste managed.

It is evident that the decision to include or exclude carbon sequestration credit greatly impacts which scenario looks more beneficial from a GHG standpoint.

Table 14. WARM Results Considering Carbon Sequestration (in $MTCO_2E$)

Scenario	WARM Estimated GHG Emissions	Estimated GHG Emissions per Ton Managed	WARM Estimated GHG Emissions from Carbon Sequestration	Estimated GHG Emissions - Without Carbon Sequestration	Estimated GHG Emissions per Ton Managed - Without Carbon Sequestration
Scenario 1 Status Quo	-1,200	**-0.18**	-2,711	1,511	**0.23**
Scenario 2 Ultimate Phase	-476	**-0.07**	0	-476	**-0.07**

Notes:

1. The emission values represent net emissions, accounting for both direct and indirect emissions and credits associated with a given solid waste management option. Negative emissions indicate that a management scenario represents a net CO_2 sink.

2. The transportation emissions included represent round-trip distances from the VRTS to the anticipated solid waste management option location (CHRL or Cedar Grove Composting), plus emissions from mobile equipment used in the waste management practice (landfilling or composting).

3. The landfill scenario assumes a "California regulatory collection" landfill gas capture efficiency and that the gas is recovered for energy. The landfilling avoided electricity GHG emissions are based on WARM's regional marginal electricity grid mix emissions for Washington.

4. The potential carbon storage associated with landfilling is included as a credit by WARM, but is not included in some life cycle GHG evaluations conducted internationally. The credit amount calculated by WARM was determined and subtracted.

5 FINDINGS AND RECOMMENDATIONS/NEXT STEPS

Given that the estimated cost of all three systems analyzed is less than the current cost to haul materials off island, and the GHG emissions of composting on-island are expected to be similar to the current waste management system (or greatly reduced if carbon sequestration credits are not counted), HDR finds that the County should explore the possibility of developing an on-island compost facility at Vashon Island. HDR recognizes that developing an on-island compost facility requires a significant capital investment to process a relatively small quantity of material. However, the benefits of such a facility are shown to outweigh the cost of this system, particularly if the quantities on-island reach the higher levels.

Some of the key issues the County should consider as a part of their decision-making process include:

- The cost of this system is dominated by the cost of operations which is driven mostly by the cost of labor and operating equipment. The labor rates are based on the labor rates of King County employees. The County may wish to explore ways of reducing the cost of the system by contracting for the facility operations from the private sector. The County would construct and own the facility but would contract for its operation, using performance metrics for the operator to comply with in order to meet environmental and good-neighbor standards. Another possibility within this concept is to solicit for on-island composting services. This practice is common elsewhere and may provide the County with a remedy that does not obligate the County to develop, construct and operate the facility.
- The possibility exists that the quantity of food waste arriving at the facility is more than should be processed given the relatively small quantity of green waste, brush and other materials that are needed as a bulking material for the food waste. Consequently, the County should explore the possibility of lowering the tip fee for green waste, brush and untreated wood, so as to attract these materials to the site for this necessary function. Please see the discussion about Port Townsend in the Phase 1 report for how they successfully accomplished attracting bulking material to their biosolids compost facility.
- Although HDR concluded an on-island compost facility is financially preferred to off-hauling these materials, securing the appropriate location for the facility will likely be one of the most challenging aspects of developing an on-island compost facility. Community support will be needed, particularly if the site is in close proximity to sensitive receptors. The County should undertake a site selection process that includes exploration of non-county owned land that has agricultural or industrial zoning as a way of securing both the necessary land for the compost facility but also areas for buffer zones to mitigate off-site influences.

Appendix 1 Capital Cost Estimates

POG Low Range Food Waste (Initial)

Pipe on Grade ASP Composting
Scenario 1 (at 10% food waste)

Parameters				
Green Waste (tons/yr)			3,700	
Food Waste (tons/yr)			370	
Total (tons/yr)			4,070	
Processing days per year			312	
Total (tons/day, based on 286 processing days/yr)			13	
Capital Cost				
Capital Improvement	**Unit cost**	**Units**	**Quantity**	**Cost**
Unloading/Receiving Area	$8	SF	5,245	$41,960
Grinding Area	$8	SF	3,750	$30,000
Compost Pad	$8	SF	12,000	$96,000
Pipe pull area	$8	SF	12,000	$96,000
Aerated Bed Compost Pad				
Bio Filter		SF	0	--
Compost Curing Pad	$8	SF	9,600	$76,800
Finished Compost Screening Area	$8	SF	7,500	$60,000
Storage Pad	$8	SF	7,444	$59,552
Maintenance Shop, Tool Storage Area	$50	SF	3,170	$158,500
Traffic Lanes for Operations	$8	SF	22,079	$176,634
Retention Pond	$12	SF	10,172	$122,068
Excavation & Embankment	$5	CY	6,886	$34,430
Drainage System	$3	SF	92,961	$278,882
Aerated System head walls	$950	CY	0	$0
Power supply and distribution	$50,000	LS	1	$50,000
Compost Fans	$15,000	EA	2	$30,000
Manifold Piping	$400	LF	120	$48,000
Blower Control system	$10,000	EA	1	$10,000
Subtotal Capital and Equipment				**$1,368,825**
Design		8%		$109,506
CM		4%		$54,753
Permitting		3%		$41,065
Contingency		20%		$273,765
Total Capital Cost with Contingency				**$1,848,000**
Capital Cost per ton of annual throughput				**$454.05**
Revenues and Avoided Cost				
Sale of Compost	$40	tons	2,035	$81,400
Subtotal Revenue				**$81,400**

Residuals Haul/Disposal				
Refuse and Rejects (assumed to be 1% of processed tons)	$250	tons	41	$10,175
Annual O&M Costs				
Labor				$241,075
Equipment Operations and Maintenance				$151,040
Utilities & Water				$61,525
Operating Contingency		10%		$45,364
Total O&M Cost				**$499,005**
O&M Cost per Ton ($/ton)				**$122.61**
Total Costs				
Total O&M Cost				**$499,005**
Residuals haul/disposal				**$10,175**
Total Revenues				**-$81,400**
Annualized Capital Cost (4%, 20 yrs)				**$150,000**
Total Annual Cost				**$577,780**
Total Cost per Ton ($/ton)				**$141.96**

POG High Range Food Waste (Ultimate)

Pipe on Grade ASP Composting (at ultimate throughput rate)

Parameters				
Green Waste (tons/yr)			4,889	
Food Waste (tons/yr)			1,662	
Total (tons/yr)			6,551	
Processing days per year			312	
Total (tons/day, based on 286 processing days/yr)			21	
Capital Cost				
Capital Improvement	**Unit cost**	**Units**	**Quantity**	**Cost (To Nearest $100)**
Unloading/Receiving Area	$8	SF	5,336	$42,700
Grinding Area	$8	SF	3,750	$30,000
Compost Pad	$8	SF	16,800	$134,400
Pipe pull area	$8		16,800	$134,400
Aerated Bed Compost Pad		SF	0	$0
Bio Filter		SF	0	$0
Compost Curing Pad	$8	SF	14,400	$115,200
Finished Compost Screening Area	$8	SF	7,500	$60,000
Storage Pad	$8	SF	7,444	$59,600
Maintenance Shop, Tool Storage Area	$50	SF	3,170	$158,500
Traffic Lanes for Operations	$8	SF	22,079	$176,600
Retention Pond	$12	SF	10,172	$122,100
Excavation & Embankment	$5	CY	8,643	$43,200
Drainage System	$3	SF	116,675	$350,000
Aerated System head walls	$950	CY	0	$0
Power supply and distribution	$50,000	LS	1	$50,000
Compost Fans	$30,000	EA	2	$60,000
Manifold Piping	$400	LF	120	$48,000
Blower Control system	$10,000	EA	1	$10,000
Subtotal Capital and Equipment				**$1,594,700**
Design		8%		$127,600
CM		4%		$63,800
Permitting		3%		$47,800
Contingency		20%		$318,900
Total Capital Cost with Contingency				**$2,153,000**
Capital Cost per ton of annual throughput				**$328.65**
Revenues and Avoided Cost				
Sale of Compost	$40	tons	3,276	$131,000
Subtotal Revenue				**$131,000**
Residuals Haul/Disposal				
Refuse and Rejects (assumed to be 1% of processed tons)	$250	tons	66	$16,400

Annual O&M Costs				
Labor				$241,075
Equipment Operations and Maintenance				$151,040
Utilities & Water				$61,525
Operating Contingency		10%		$45,364
Total O&M Cost				**$499,005**
O&M Cost per Ton ($/ton)				**$76.17**
Total Costs				
Total O&M Cost				**$499,005**
Residuals haul/disposal				**$16,400**
Total Revenues				**-$131,200**
Annualized Capital Cost (4%, 20 yrs)				**$174,000**
Total Annual Cost				**$558,405**
Total Cost per Ton ($/ton)				**$85.24**

Reversing Aerated Static Pile Technology (Higher Range of Food Waste)

Reversing ASP Composting Scenario 2

Parameters				
Green Waste (tons/yr)			4,889	
Food Waste (tons/yr)			1,662	
Total (tons/yr)			6,551	
Processing days per year			312	
Total (tons/day, based on 286 processing days/yr)			21	
Capital Cost				
Capital Improvement	**Unit cost**	**Units**	**Quantity**	**Cost (To Nearest $100)**
Unloading/Receiving Area	$8	SF	7,647	$61,200
Grinding Area	$8	SF	5,000	$40,000
Compost Pad	$8	SF		$0
Pipe pull area	$8			$0
Aerated Bed Compost Pad	$35	SF	6,825	$238,900
Bio Filter	$60	SF	1,049	$63,000
Compost Curing Pad	$35	SF	6,825	$238,900
Finished Compost Screening Area	$8	SF	7,500	$60,000
Storage Pad	$8	SF	9,107	$72,900
Maintenance Shop, Tool Storage Area	$50	SF	3,170	$158,500
Traffic Lanes for Operations	$8	SF	21,714	$173,700
Retention Pond	$12	SF	9,979	$119,800
Excavation & Embankment	$5	CY	5,860	$29,300
Drainage System	$3	SF	79,111	$237,300
Aerated System head walls	$950	CY	89	$84,400
Power supply and distribution	$50,000	LS	1	$50,000
Compost Fans	$30,000	EA	4	$120,000
Manifold Piping	$400	LF	150	$60,000
Blower Control system	$40,000	EA	1	$40,000
Subtotal Capital and Equipment				**$1,847,900**
Design		8%		$147,800
CM		4%		$73,900
Permitting		3%		$55,400
Contingency		20%		$369,600
Total Capital Cost with Contingency				**$2,495,000**
Capital Cost per ton of annual throughput				**$380.86**
Revenues and Avoided Cost				
Sale of Compost	$40	tons	3,276	$131,000
Subtotal Revenue				**$131,000**
Residuals Haul/Disposal				
Refuse and Rejects (assumed to be 1% of processed tons)	$250	tons	66	$16,400

Annual O&M Costs				
Labor				$216,834
Equipment Operations and Maintenance				$193,829
Utilities & Water				$84,841
Operating Contingency		10%		$49,550
Total O&M Cost				**$545,054**
O&M Cost per Ton ($/ton)				**$83.20**
Total Costs				
Total O&M Cost				**$545,054**
Residuals haul/disposal				**$16,400**
Total Revenues				**-$131,000**
Annualized Capital Cost (4%, 20 yrs)				**$202,000**
Total Annual Cost				**$632,454**
Total Cost per Ton ($/ton)				**$96.54**

Appendix 2 WARM Results

Scenario 1: Status Quo

GHG Emissions from Baseline Waste Management ($MTCO_2E$): (1,199.93)

Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Food Waste	NA	1,670.00	-	-	-	491.50
Yard Trimmings	NA	2,779.00	-	1,110.00	-	(885.58)
Branches	NA	1,000.00	-	-	-	(805.84)

Scenario 2: Ultimate Phase

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (476.43)

Material	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Food Waste	-	NA	-	-	1,670.00	-	(198.51)
Yard Trimmings	NA	NA	-	-	3,889.00	-	(221.07)
Branches	NA	NA	-	-	1,000.00	-	(56.84)

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

a) For explanation of methodology, see the EPA WARM Documentation:

Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)
-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits of waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.