APPENDIX C

Select Site Investigation Reports (Provided on CD)

APPENDIX C.2

Leachate System Flow Characterization (BHC Consultants, 2014)

BHC CONSULTANTS

TECHNICAL MEMORANDUM

Date: July 2, 2014
To: Jamey Barker, PE
From: BHC Consultants, LLC
CC: John Strunk, LHg
Subject: Vashon Island Landfill (VLF)
Leachate System Flow Characterization
Project No: E00102E08
Deliverable No. D.310.1.5

Objective

The primary objective of the analyses presented in this document is to provide a water balance and estimate of the relative contribution of leachate sources to the Vashon Island Closed Landfill (VLF) leachate lagoon. In addition, constituent loading will be evaluated and a mass balance completed as a check on the flow calculations. The results of these analyses will be used to evaluate options for minimizing leachate hauling from VLF.

Sources of Flow

There are four sources of inflow to the VLF leachate lagoon; the closed landfill, transfer station, toe collector, and direct precipitation into the leachate lagoon. The leachate conveyance system components and sampling locations at VLF are shown on Figure 1.

The closed landfill consists of both lined and unlined refuse areas. Both the lined and unlined portions of the landfill received a cover system that included a HDPE geomembrane layer. The use of a geomembrane reduces infiltration into the landfill cell thus minimizing leachate production. The closed landfill area is approximately ten acres. Perforated pipes collect the leachate and convey the flows to the leachate lagoon.

Flow from the transfer station is a composite of the drainage from the tipping floor (transfer station), wastewater from daily operations, and surface water runoff from the trailer storage area. The total transfer station flow is determined using two methods. Runoff from the trailer storage area is calculated based on the precipitation and affected area. Water meter data, recorded by King County Solid Waste Division (KCSWD), was used to estimate the volume of flow produced from the transfer station and associated wastewater flows.

The leachate toe collector is located at the south end of the landfill outside of the refuse cell to collect any potential leachate that may be present in this area. The toe collector drains to a pump station (PS-2) which pumps the flow to the gravity system that discharges to the leachate lagoon. As part of a 2011 rehabilitation project the depth of the pump station was reduced and a new lining system installed. These modifications were intended to reduce groundwater infiltration into the structure.

A major component of the total flow into the leachate lagoon is direct precipitation within the lagoon basin. This includes the surrounding area that drains to the lagoon. Based on topographical mapping the collection area for the leachate lagoon was determined to be approximately 24,500 square feet. This collection area includes the side slopes and portions of the gravel access road which are located over the lined area of the leachate lagoon. While this source of inflow contributes to the total volume of the lagoon it does not contribute significantly to the contaminant load in the leachate lagoon.

Flow Generation

To aid the evaluation of segregating leachate flows and reducing leachate haul volumes it is necessary to quantify the contribution of the each of the inflow sources. Using precipitation data, water meter data, and pump station flow data the total inflow to the leachate lagoon was calculated. This estimated inflow volume was then compared to the leachate haul volumes.

The calculated inflow for each year was compared with the corresponding leachate haul data for 2010 – 2012. While the total inflow from each source was combined to compare against the leachate haul data, a different calculation method was used for each source. A three year water balance was developed for the leachate system and is attached to this memorandum as Attachment 1.

Landfill Leachate
The contributing area of the VLF closed refuse areas is approximately ten acres. The volume of leachate produced from the closed landfill is estimated using local precipitation data. At Cedar Hills Regional landfill it was determined that the coefficient for leachate generation from a closed landfill area is 0.05 (i.e. 5% of precipitation) (HLA May 1991). Due to the similarity of the climate and design of the two closed landfills, this leachate generation rate based on precipitation is considered to be appropriate for VLF. The estimate assumes that 100% of the leachate is captured by the leachate system. Using the measured precipitation data, the closed landfill acreage, and the leachate generation coefficient it was possible to calculate an estimated leachate volume for the landfill from 2010 -2012.

Transfer Station
There are two sources of inflow to the leachate lagoon from the transfer station: flow generated from the transfer station activities; surface water runoff flow from the trailer storage area. Surface water runoff from the trailer storage area was calculated using local precipitation data and the surface area of the trailer storage area. Flow generated from the transfer station and associated operations activities is calculated from the water consumption at the transfer station. Wastewater flows generated through use of toilets and sinks are discharged to an on-site septic system. It is assumed that there is not a significant amount of irrigation at the transfer station and therefore, all water not sent to the septic system is discharged to the leachate system. Using this percentage an average daily discharge rate was developed using water meter data collected by KCSWD Operations Staff. The average daily production rate was then used to calculate the total inflow volume from this source over a three year period.

Leachate Toe Collector
A toe collector located at the southern extent of the VLF collects potential leachate seepage and conveys these flows to a pumping station (PS-2). The pump station discharges to the gravity leachate conveyance system that terminates at the leachate lagoon. Since all flow collected by the toe collector is conveyed to PS-2, the inflow volume from this source is equivalent to the total volume pumped from PS-2. The discharge volume from PS-2 is calculated using pump runtimes and the rated output of the pumps. PS-2 is a duplex station that utilizes submersible centrifugal pumps. A recent pump test determined the discharge rate for the pumps to be:

1. 342 gpm for pump 1
2. 376 gpm for pump 2

Using the pump run times and pump discharge rates provided by KCSWD an average daily production volume of 34 gpd was determined. This average value was then used to calculate the three year total inflow volume from the toe collector source. This estimate assumes that all water collected by the toe collector originates from the area between the landfill and the toe collector and does not include leachate from the landfill.

Direct Precipitation
The leachate lagoon receives inflow from direct precipitation into the lagoon. The volume of inflow is calculated using local precipitation data and the surface area of the leachate lagoon. The surface area of the lagoon includes all of the surrounding area that drains directly into the lagoon. Using aerial survey topography of the landfill it was determined that the surface area of the leachate lagoon and surrounding drainage area is approximately 24,500 square feet.

Source Inflow Volume
The volume of flow from leachate generation in the closed landfill and the direct precipitation on the leachate lagoon and trailer parking area are calculated directly from the precipitation totals for the three year period. However, the inflow from the transfer station and the leachate toe collector were calculated as daily averages based on flow measurements. These source inflow volumes are summarized in Table 1.

Table 1: Leachate Volume by Source[(1)]

Source	Average Daily Production	Three Year Volume, gal
Landfill Leachate	N/A	2,302,388
Direct Precipitation	N/A	2,589,921
Transfer Station	170 gpd	186,320
Trailer Parking Area	N/A	517,984
Leachate Toe Collector (PS-2)	34 gpd	37,264

Notes:
(1) See Attachment 1 – Water Balance for calculations.

Water Balance

To determine the relative proportions of the source inflows a water balance for the leachate system was developed. Inflow volumes for the three year period (2010 – 2012) were calculated for each of the sources and totaled. It was found that the majority of the flow is produced from direct precipitation on the leachate lagoon and from leachate generation in the closed landfill. These two sources generate approximately 87% of the leachate inflow to the lagoon (Table 2).

Table 2: Relative Proportion of Leachate Flow by Source

Source of Flow	Percentage of Leachate Flow
Landfill Leachate	41
Transfer Station	12
Leachate Toe Collector (PS-2)	1
Direct Precipitation	46

To complete the water balance it was necessary to determine the volume of leachate removed from the lagoon as well as the estimated volume removed from the lagoon due to evaporation. Historical leachate haul records were provided by KCSWD. Local pan evaporation data was obtained from the Desert Research Institute (DRI). The pan evaporation data provided a historical monthly average (64-year average) for inches of evaporation of 34.52 inches. A pan coefficient of 0.75 was applied to this value to account for open water evapotranspiration (McCuen 1998) producing an effective evaporation loss of 25.89 inches per year. The average annual evaporation loss was calculated and increased to account for a three year period. The leachate haul and evaporation loss volumes were then compared to the total inflow volumes from each source over the three year period. Table 3 summarizes the water balance calculations for the leachate system at VLF.

Table 3: Vashon Island Landfill Leachate System Water Balance

Source	Inflow Volume, gal	Outflow Volume, gal
Landfill Leachate	2,302,388	
Transfer Station/WW Flow	186,320	
Trailer Parking Area	517,984	
Leachate Toe Collector (PS-2)	37,264	
Direct Precipitation	2,589,921	
Evaporation		726,702
Leachate Haul Volume		4,845,000
Total	5,633,877	5,571,702

For the three year period it was found that the estimated volume into the leachate lagoon exceeded the estimated volume out by 62, 175 gallons. This volume is attributed to error in the estimation methods and the accuracy of the flow measurement techniques. The difference between the volumes equates to an error percentage of approximately 1%. The minimal difference between the effluent and influent volumes indicates that the leachate generation volumes by source are consistent with the overall leachate production at VLF.

The water balance was prepared using the best available data. However, it should be noted that there is a level of uncertainty in the water balance. Several of the major sources of flow are based on assumptions and empirically derived coefficients for which small differences in value can result in greatly increased or decreased flow volumes. In addition to the uncertainty of the inflow volumes there is some uncertainty in reported leachate haul volumes. The reported volumes are approximated based on truck count, but how much leachate is pumped into each tanker truck is not measured with a flow meter. Due to this method for quantifying and reporting leachate volume discharges the actual discharged volume may vary from what is recorded.

The three largest sources of uncertainty are the coefficient of leachate production from the closed landfill, measurement error, and applying an average evaporation value to a period that included two years with above average precipitation while ignoring the effects of aeration on evaporation.

Constituent Loading/Mass Balance

Concurrent with the leachate source inflow characterization, a study of the constituent loading, by source, for the leachate collection system was completed. In addition to providing a characterization of the source of loading for the leachate system, the study included collecting water quality sample data to evaluate alternative options for discharging the leachate so as to minimize the transmission of total suspended solids (TSS).

Water quality samples were collected from each of the sources of inflow to the leachate lagoon, except direct precipitation. The samples were analyzed for common leachate characteristics; conventionals, metals, and volatile constituents. The results of these analyses were then used to determine the constituent loading of the inflow to the leachate lagoon. However, only two sample events were completed. This number of sample events is too low for statistical accuracy.

Samples were also collected from the leachate lagoon. To aid in understanding the concentration levels of TSS in the leachate lagoon under differing operating conditions multiple samples were collected. The leachate lagoon samples included the following:

1. Collection from the lagoon surface after the aerators had been off for a minimum of one hour.
2. Collection from a depth of approximately 3-feet after the aerators had been off for a minimum of one hour.
3. Collection from the surface of the lagoon after the aeration system was operated for a minimum of 10 minutes.

4. Collection from a depth of approximately 3-feet after the aeration system was operated for a minimum of 10 minutes.

The results from the water quality sampling of the source flow and leachate lagoon were then used to calculate the constituent loading from the sources and within the lagoon. The loading analysis was then used to prepare a mass balance for the leachate system. These calculations and the mass balance are attached to this memorandum as Attachment 2.

It was found that the concentrations of magnesium, nitrogen, phosphorous, and sodium were lower in the leachate lagoon than the combined inflow concentrations. However, the concentrations of alkalinity, BOD, COD, TSS, copper, manganese, iron, and zinc were higher in the leachate lagoon. The concentrations of chloride and sodium in the inflow from the sources were found to be far greater than the concentrations in the lagoon. A review of the historical chloride and sodium concentrations generated from the inflow sources indicates that the concentrations match the range found during the sampling related to this study. In addition, the historical chloride and sodium concentrations from the leachate lagoon are also similar to the recent sample results. However, the number of sample events (two for this study) is too low for statistical accuracy. The small sample size and the assumptions used in calculating flows create some uncertainty in the results. Given this uncertainty, interpretation of the sample results indicating increased levels of sodium and chloride in the leachate lagoon relative to the inflow samples can not be made with confidence.

It was possible to determine the relative contributions of loading by source. This characterization of the leachate inflow provides an understanding of the source of individual constituents. For example, the majority of the phosphorous loading (88%) is from the transfer station, although flow volume from the transfer station accounts for only 13% of the total inflow volume. Table 4 provides a summary of the leachate loading by source for specific constituents common to leachate and wastewater. A summary of all detected analytes with concentrations is attached to this memorandum as Attachment 3.

Table 4: Relative Leachate Loading By Source										
Constituent	**Toe Collector (PS-2)**		**Leachate System**		**Transfer Station**		**Rainfall(2)**		**Total**	
	Percent of Total	Load, ppy(1)	Percent of Total	Load, ppy(1)	Percent of Total	Load, ppy(1)	Percent of Total	Load, ppy(1)	Percent of Total	Load, ppy(1)
Alkalinity	0.4%	5.09	90.4%	1,028.88	9.2%	104.62	0.0%	0	100.0%	1,138.59
BOD	0.0%	0.00	61.1%	4.64	38.9%	2.96	0.0%	0	100.0%	7.60
COD	0.2%	0.69	87.4%	264.18	12.3%	37.22	0.0%	0	100.0%	302.10
Chloride	0.0%	0.10	99.5%	1,993.39	0.5%	9.37	0.0%	0	100.0%	2,002.87
Copper, total	1.2%	0.00	74.7%	0.04	24.1%	0.01	0.0%	0	100.0%	0.05
Iron, total	16.6%	0.25	61.0%	0.94	22.3%	0.34	0.0%	0	100.0%	1.53
Magnesium, total	0.1%	0.45	98.9%	675.03	1.1%	7.32	0.0%	0	100.0%	682.80
Manganese, total	6.1%	0.01	92.2%	0.14	1.8%	0.00	0.0%	0	100.0%	0.15
Nitrate + Nitrite	0.0%	0.07	98.0%	428.78	2.0%	8.69	0.0%	0	100.0%	437.54
Phosphorous	0.0%	0.00	13.4%	0.14	86.6%	0.89	0.0%	0	100.0%	1.02
Sodium, total	0.0%	0.32	99.0%	1,317.72	1.0%	12.82	0.0%	0	100.0%	1,330.86
TSS	4.0%	0.97	88.7%	21.45	7.3%	1.76	0.0%	0	100.0%	24.19
Zinc, total	0.5%	0.00	87.3%	0.33	12.3%	0.05	0.0%	0	100.0%	0.38

Notes:
(1) ppy = pounds per year.
(2) Rainfall contains a small amount of chloride and other constituents.

A summary of the average TSS results from the samples taken from the inflow sources and in the leachate lagoon at the surface and at depth are included in Table 5. The summary of the sampling results indicates that the TSS concentrations in the lagoon are significantly greater than the inflow source concentrations. This is likely due to resuspension of sediment as a result of aeration. TSS concentrations in the lagoon should also be expected to increase as BOD is converted to solids. However, in this case there is a relatively low concentration of BOD in the inflow.

Table 5: TSS Concentrations By Source

Source	Aerated/Non-Aerated	Average TSS Conc. (mg/L)
Landfill Leachate	N/A	3.35
Transfer Station	N/A	0.90
Condensate Trap	N/A	4.75
Pump Station No. 2	N/A	9.40
Leachate Lagoon at Depth	Aerated	66.25
Leachate Lagoon at Surface	Aerated	73.00
Leachate Lagoon at Depth	Non-Aerated	63.50
Leachate Lagoon at Surface	Non-Aerated	52.50

It was found that there was a slight decrease in TSS concentration in the samples collected with the aerators turned off, particularly the surface collected samples. This indicates that there could be a benefit to setting the inlet to the discharge pipe at a higher elevation. As stated above the aerators were turned off for a minimum of an hour prior to sampling within the leachate lagoon. Given the resulting lower concentrations of TSS when the aerators had been off for an hour it may be beneficial to increase the non-aerated time prior to pumping. Reduced aeration may be possible due the low concentrations of BOD in the inflow sources and within the leachate lagoon.

Results/Conclusions

The results of the leachate system water balance indicate that the estimated inflow agrees closely with the lagoon outfall records and estimated evaporation. Based on relative contributions (Table 2) from the four sources it is evident that the majority of flow is dependent on precipitation, with approximately 46% of the total inflow volume produced by direct precipitation onto the leachate lagoon.

The current method for discharging leachate from VLF is to haul the leachate to West Seattle or Cedar Hills Regional Landfill for discharge into the King County wastewater collection system. KCSWD is looking at options to reduce or eliminate the volume of leachate haul. Current options that are being investigated include; discharge to the Vashon Island wastewater treatment plant, and onsite treatment, including phytoremediation. However, due to the contribution percentages determined during the investigation into the source flow a third option to reduce leachate haul was identified. The third option is to cover the leachate lagoon to remove the direct precipitation inflow source.

As previously stated approximately 46% of the total inflow to the leachate system is generated by direct precipitation onto the leachate lagoon. This results in an annual volume of 700,000 – 1,000,000 gallons that must be transported off of Vashon Island for disposal. There is some benefit from this volume as it dilutes the concentrations of constituents in the leachate lagoon. However, estimated constituent concentrations without the dilution from the direct precipitation would not be great enough to preclude discharge to either the Vashon Island Treatment Plant or the King County wastewater collection system. Table 6 summarizes the average concentrations from the inflow sources as well as the diluted concentrations within the leachate lagoon and compares them to the discharge requirements at the Vashon WWTP and to the King County wastewater collection system. By removing or significantly reducing this inflow source the amount of leachate that must be hauled could be significantly reduced.

One element of this study was to evaluate potential options to reduce TSS concentrations in the leachate lagoon. One potentially beneficial option would be to significantly reduce the aeration within the leachate lagoon. The current aerators and operation were designed for an active landfill cell with high concentrations of BOD. Due to the low BOD concentrations contributed by the inflow sources and the low BOD concentrations in the lagoon the aeration requirements are relatively low. The results of the sampling within the leachate lagoon with the aerators off for only an hour showed that TSS concentrations are reduced. If aeration was reduced further the TSS concentrations would likely continue to reduce.

Another potential source that could be segregated is the inflow generated from the trailer storage area located adjacent to the transfer station. It may be possible to intercept this inflow source and convey it to the east water quality pond. However, due to the uncertainty of potential contamination from the trailers, this option was not pursued.

Table 6: Constituent Concentrations Compared to Discharge Limits				
Parameter	**VLF Source Average Concentration[(1)]**	**VLF Lagoon Average Concentration (Diluted)[(2)]**	**Vashon WWTP Limit[(3)]**	**West Seattle Limit[(4)]**
Arsenic, Total, mg/L	ND	ND	1	1
Cadmium, Total, mg/L	ND	ND	0.5	0.5
Chromium, Total, mg/L	ND	ND	2.75	2.75
Copper, Total, mg/L	0.02	0.01	3	3
Lead, Total, mg/L	ND	ND	2	2
Mercury, Total, mg/L	ND	ND	0.1	0.1
Nickel, Total, mg/L	0.052	ND	2.5	2.5
Silver, Total, mg/L	ND	ND	1	1
Zinc, Total, mg/L	0.1	0.04	5	5
Cyanide Amenable, mg/L	ND	ND	2	2
Nonpolar FOG, mg/L	4.1	2.2	100	100
Biological Oxygen Demand (BOD), mg/L	2.24	5.67	240	N/A
Total Suspended Solids (TSS), mg/L	18.4	63.8	240	N/A
pH	7.12	8.04	6 - 9	5 - 12
Daily Discharge Volume Limit, gal	N/A	N/A	14,000	54,405

Notes:

(1) Average concentration of combined inflow sources without precipitation dilution.
(2) Average concentration within leachate lagoon, including dilution via precipitation.
(3) Discharge limitations at the Vashon Island wastewater treatment plant.
(4) Discharge limitations at King County Sewer System in E. Marginal Way S., West Seattle.

The use of phytoremediation as a method for onsite treatment is an option currently being considered. Additional evaluations will need to be completed to determine the feasibility of this option.. However, providing a cover for the leachate lagoon may be relatively minor modification that would result in close to a 46% reduction in leachate haul. This option would require minimal changes to the operational procedures for the VLF leachate system, minimizing training requirements. The reduced volume and observed constituent concentrations suggest that the wastewater generated could be discharged at the Vashon Island wastewater treatment plant.

There are several options for eliminating the direct precipitation source from the leachate lagoon. These options would require either a cover to be installed over the lagoon or a leachate storage tank to be constructed to replace the lagoon. The cover for the lagoon could utilize either a floating or standing cover. However, the use of a floating cover would require the removal of the existing aeration system. Installing either cover option would significantly reduce the inflow volume, which would allow for a reduction in the capacity of the lagoon. A summary of the inflow reduction alternatives highlighting the components of each option are included below.

Floating Cover
A floating cover system could be installed over the existing lagoon or over a modified lagoon with reduced capacity. The leachate lagoon modifications would include the following components:

- Floating cover system constructed of HDPE or other corrosion resistant material.
- Replacement of existing floating aerators with aerators compatible with a floating cover system
- Reduce the capacity of the leachate lagoon (Optional).
    - As part of the construction to decrease the size of the lagoon a double liner with a leak detection layer may be required to be installed. The current leachate lagoon was installed prior to the requirement for a double liner and leak protection. However, modifications to the lagoon may result in the need to meet the requirements of WAC 173-350 and WAC 173-351. These requirements would need to be evaluated based on an additional study of the potential impacts of a leak in the leachate lagoon on groundwater.
    - A temporary bypass or storage tank would need to be utilized during construction.
- Install a separate aeration tank (similar size to a baker tank) to aerate leachate immediately prior to haul.

Standing Cover
Installation of a standing cover over the existing leachate lagoon footprint would be more feasible if the size of the lagoon was decreased. Major components of the modifications to the lagoon with a standing cover would include:

- Standing cover system over entire lagoon.
- Reduce the capacity of the leachate lagoon.
    - As part of the construction to decrease the size of the lagoon a double liner with a leak detection layer may be required to be installed. The current leachate lagoon was installed prior to the requirement for a double liner and leak

protection. However, modifications to the lagoon may result in the need to meet the requirements of WAC 173-350 and WAC 173-351. These requirements would need to be evaluated based on an additional study of the potential impacts of a leak in the leachate lagoon on groundwater.
    - A temporary bypass or storage tank would need to be utilized during construction.
- Existing floating aerators could continue to be utilized, if required.

Leachate Storage Tank

The reduced annual volume of leachate generated allows for the consideration of a storage tank as an alternative to the open lagoon. Use of a storage tank reduces the potential for vectors and utilizes a smaller footprint than a lagoon. However, the discharge pumping and piping facilities would require modifications to serve the storage tank. In addition, a site would need to be identified to locate this new permanent structure.

References Consulted

HLA (1991), Cedar Hills Regional Landfill Leachate Pretreatment Facilities Engineering Report, (HLA, May 1991)

McCuen, Richard H. (1998), Hydrologic Analysis and Design – Second Edition, Prentice Hall, Inc, Upper Saddle River, New Jersey 07458, ISBN 0-13-134958-9.

Attachment 1

Water Balance

Vashon Island Closed Landfill
Leachate System Water Balance

Three Year Period (2010 - 2012)

Source	Volume In, gal	Volume Out, gal	Perenct of Flow
Closed Landfill Cell	2,302,388		41%
Rainfall on Leachate Lagoon	2,589,921		46%
Transfer Station/WW Flow	186,320		3%
Trailer Parking Area	517,984		9%
Leachate Toe Drain	37,264		1%
Evaporation		726,702	Based on average pan evaporation of 34.52 inches per calendar year with 0.75 pan coefficient.
Discharge (West Seattle or CHRL)		4,845,000	
Total	**5,633,876**	**5,571,702**	62,175

Calendar Year 2010

Source	Volume In, gal	Volume Out, gal	
Closed Landfill Cell	838,738		
Rainfall on Leachate Lagoon	943,483		
Transfer Station/WW Flow	62,050		
Trailer Parking Area	188,697		
Leachate Toe Drain (PS-2)	12,410		
Evaporation		242,234	Based on average pan evaporation of 34.52 inches per calendar year with 0.75 pan coefficient.
Discharge (West Seattle or CHRL)		1,663,000	
Total	**2,045,377**	**1,905,234**	140,143 *Due to storage of november/december 2010 flows removed from lagoon in early 2011.

Calendar Year 2011

Source	Volume In, gal	Volume Out, gal	
Closed Landfill Cell	625,591		
Rainfall on Leachate Lagoon	703,718		
Transfer Station/WW Flow	62,050		
Trailer Parking Area	140,744		
Leachate Toe Drain (PS-2)	12,410		
Evaporation		242,234	Based on average pan evaporation of 34.52 inches per calendar year with 0.75 pan coefficient.
Discharge (West Seattle or CHRL)		1,297,000	
Total	**1,544,513**	**1,539,234**	5,279

Calendar Year 2012

Source	Volume In, gal	Volume Out, gal	
Closed Landfill Cell	838,059		
Rainfall on Leachate Lagoon	942,719		
Transfer Station/WW Flow	62,220		
Trailer Parking Area	188,544		
Leachate Toe Drain (PS-2)	12,410		
Evaporation		242,234	Based on average pan evaporation of 34.52 inches per calendar year with 0.75 pan coefficient.
Discharge (West Seattle or CHRL)		1,885,000	
Total	**2,043,952**	**2,127,234**	-83,282 *Due to excess storage from November/December 2011 removed from lagoon in Jan and Feb 2012.

3 - Year Total Influent Water Balance Calculations

Years 2010 - 2012

Assumptions:

Rainfall Total for all three years = 169.59 inches
For average leachate production in a closed area 5% of incident rainfall infiltrates final cover to become leachate.
Per Harding Lawson and Associates, a 5.91 peaking factor should be applied to average flow to obtain peak influent for closed areas.
Rainfall from Vashon Island Rain Gauge
Leachate Lagoon surface area is 24,500 SF (measured area from ceter of access road surronding lagoon)
Wastewater flows estimated from water usage measured at the Transfer Station Water Meter

Vashon Landfill Leachate production calculations

Value Description	Value (gal/acre)	Acres	Gallons
Leachate production of closed area	230,239	10	2,302,388

Formula for Value

$$5\% \times 169.59 \times \frac{1}{12}\frac{feet}{inches} \times 43{,}560\frac{ft^2}{acre} \times 7.48\frac{gal.}{ft^3}$$

Rainfall on Pre-Treatment Aeration Basin

	Gallons/SF	SF	Gallons
Rainfall in Leachate Lagoon	105.71	24,500	2,589,921

169.59 inches X 0.6233 gallons/in*SF X 15000 SF

Transfer Station wastewater production calculations

	Gallons
Wastewater from operations	186,320

= 170 gallons per day (water meter average day with discount for employee use directed to septic system) for three years (365+365+366)

	Gallons/SF	SF	Gallons
Wastewater from trailer parking	105.71	4,900	517,984

169.59 inches X 0.6233 gallons/in*SF X 4900 SF of trailer parking

Summary of Leachate/Wastewater Produced

Area	Average (gpd)	
Vashon LF Leachate	2,302,388	41%
Rain on Pre-Treatment Aeration Basin	2,589,921	46%
Transfer Station Sanitary wastewater	186,320	3%
Trailer Parking Area	517,984	9%
Total	**5,596,612**	

2010 Calendar Year Total Influent Water Balance Calculations

Year 2010

Assumptions:

Rainfall Total for calendar year 2010 = 61.78 inches
For average leachate production in a closed area 5% of incident rainfall infiltrates final cover to become leachate.
Rainfall from Vashon Island Rain Gauge
Leachate Lagoon surface area is 24,500 SF (measured area from ceter of access road surronding lagoon)
Wastewater flows estimated from water usage measured at the Transfer Station Water Meter

Vashon Landfill Leachate production calculations

Value Description	Value (gal/acre)	Acres	Gallons
Leachate production of closed area	83,874	10	838,738

Formula for Value

$$5\% \times 61.78 \times \frac{1}{12}\frac{feet}{inches} \times 43,560\frac{ft^2}{acre} \times 7.48\frac{gal.}{ft^3}$$

Rainfall on Pre-Treatment Aeration Basin

	Gallons/SF	SF	Gallons
Rainfall in Leachate Lagoon	38.51	24,500	943,483

61.78 inches X 0.6233 gallons/in*SF X 15000 SF

Transfer Station wastewater production calculations

	Gallons
Wastewater from operations	62,050

= 170 gallons per day (water meter average day with discount for employee use directed to septic system) for calendar year (3

	Gallons/SF	SF	Gallons
Wastewater from trailer parking	38.51	4,900	188,697

61.78 inches X 0.6233 gallons/in*SF X 4900 SF of trailer parking

Summary of Leachate/Wastewater Produced

Area	Average (gpd)
Vashon LF Leachate	838,738
Rain on Pre-Treatment Aeration Basin	943,483
Transfer Station Sanitary wastewater	62,050
Trailer Parking Area	188,697
Total	**2,032,967**

2011 Calendar Year Total Influent Water Balance Calculations

Year 2011

Assumptions:

Rainfall Total for calendar year 2011 = 46.08 inches
For average leachate production in a closed area 5% of incident rainfall infiltrates final cover to become leachate.
Rainfall from Vashon Island Rain Gauge
Leachate Lagoon surface area is 24,500 SF (measured area from ceter of access road surronding lagoon)
Wastewater flows estimated from water usage measured at the Transfer Station Water Meter

Vashon Landfill Leachate production calculations

Value Description	Value (gal/acre)	Acres	Gallons
Leachate production of closed area	62,559	10	625,591

Formula for Value

$$5\% \times 46.08 \times \frac{1}{12}\frac{feet}{inches} \times 43{,}560\frac{ft^2}{acre} \times 7.48\frac{gal.}{ft^3}$$

Rainfall on Pre-Treatment Aeration Basin

	Gallons/SF	SF	Gallons
Rainfall in Leachate Lagoon	28.72	24,500	703,718

46.08 inches X 0.6233 gallons/in*SF X 15000 SF

Transfer Station wastewater production calculations

	Gallons
Wastewater from operations	62,050

= 170 gallons per day (water meter average day with discount for employee use directed to septic system) for calendar year (3

	Gallons/SF	SF	Gallons
Wastewater from trailer parking	28.72	4,900	140,744

46.08 inches X 0.6233 gallons/in*SF X 4900 SF of trailer parking

Summary of Leachate/Wastewater Produced

Area	**Average (gpd)**
Vashon LF Leachate	625,591
Rain on Pre-Treatment Aeration Basin	703,718
Transfer Station Sanitary wastewater	62,050
Trailer Parking Area	140,744
Total	**1,532,103**

2012 Calendar Year Total Influent Water Balance Calculations

Year 2012

Assumptions:

Rainfall Total for calendar year 2012 = 61.73 inches
For average leachate production in a closed area 5% of incident rainfall infiltrates final cover to become leachate.
Rainfall from Vashon Island Rain Gauge
Leachate Lagoon surface area is 24,500 SF (measured area from ceter of access road surronding lagoon)
Wastewater flows estimated from water usage measured at the Transfer Station Water Meter

Vashon Landfill Leachate production calculations

Value Description	Value (gal/acre)	Acres	Gallons
Leachate production of closed area	83,806	10	838,059

Formula for Value

$$5\% \times 61.73 \times \frac{1}{12}\frac{feet}{inches} \times 43{,}560\frac{ft^2}{acre} \times 7.48\frac{gal.}{ft^3}$$

Rainfall on Pre-Treatment Aeration Basin

	Gallons/SF	SF	Gallons
Rainfall in Leachate Lagoon	38.48	24,500	942,719

61.73 inches X 0.6233 gallons/in*SF X 15000 SF

Transfer Station wastewater production calculations

	Gallons
Wastewater from operations	62,220

= 170 gallons per day (water meter average day with discount for employee use directed to septic system) for calendar year (3

	Gallons/SF	SF	Gallons
Wastewater from trailer parking	38.48	4,900	188,544

61.73 inches X 0.6233 gallons/in*SF X 4900 SF of trailer parking

Summary of Leachate/Wastewater Produced

Area	Average (gpd)
Vashon LF Leachate	838,059
Rain on Pre-Treatment Aeration Basin	942,719
Transfer Station Sanitary wastewater	62,220
Trailer Parking Area	188,544
Total	**2,031,542**

Vashon Island Closed Landfill
Rainfall Data

Annual Data

Year	Average daily	Max Day	Total
2010	0.1693	3.38	61.78
2011	0.1262	2.61	46.08
2012	0.1687	3.29	61.73
2013*	0.1222	1.5	14.54

*Partial year (Jan - April

Monthly Data

Month	Year	Average	Total
January	2010	0.311	9.63
	2011	0.180	5.57
	2012	0.265	8.2
	2013	0.131	4.06
February	2010	0.176	4.92
	2011	0.181	5.07
	2012	0.150	4.35
	2013	0.100	2.8
March	2010	0.147	4.56
	2011	0.305	9.47
	2012	0.325	10.06
	2013	0.122	3.79
April	2010	0.141	4.23
	2011	0.125	3.76
	2012	0.096	2.87
	2013	0.134	3.89
May	2010	0.129	4
	2011	0.106	3.29
	2012	0.082	2.55
June	2010	0.081	2.44
	2011	0.045	1.36
	2012	0.091	2.72
July	2010	0.011	0.34
	2011	0.028	0.88
	2012	0.050	1.55
August	2010	0.020	0.62
	2011	0.003	0.08
	2012	0.000	0
September	2010	0.169	5.06
	2011	0.058	1.74
	2012	0.001	0.02
October	2010	0.211	6.53
	2011	0.130	4.04
	2012	0.263	8.15
November	2010	0.219	6.56
	2011	0.256	7.68
	2012	0.392	11.77
December	2010	0.416	12.89
	2011	0.101	3.14
	2012	0.306	9.49

Washington State Pan Evaporation Data

	Period of Record	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	
BELLINGHAM	1948-1985	0	0	0	2.75	4.59	5.35	6.28	5.56	3.34	1.22	0	0	29.09	
BELLINGHAM	1985-2005	0	0	0	0	3.77	4.69	5.31	4.5	2.65	1.39	0	0	22.31	
BUMPING Lake	1931-1967	0	0	0	0	4.01	4.13	5.58	4.63	3.19	2.34	0	0	23.88	
CONNELL	1960-2003	0	0	0	5.43	8.35	9.89	11.9	10.77	6.88	3	0	0	56.22	
ELTOPIA	1954-1973	0	0	3.23	5.46	6.61	7.73	9.36	7.56	4.93	2.45	0.83	0	48.16	
ELTOPIA	1974-2005	0	0	0	4.44	6.1	7.05	8.07	7.04	4.44	2.06	0.62	0	39.82	
LAKE Kachess	1931-1977	0	0	0	2.37	3.78	4.82	6.12	5.12	3.2	0	0	0	25.41	
LIND	1931-2005	0	0	0	5.35	8.02	9.4	12.02	10.44	6.87	2.59	0	0	54.69	
MOSES Lake	1943-1979	0	0	0	5.51	7.5	8.78	10.29	8.1	5.53	2.79	0	0	48.5	
OROVILLE	1960-1970	0	0	0	4.49	5.82	6.36	7.42	6.22	4.28	1.99	0	0	36.58	
OTHELLO	1941-2002	0	0	0	5.4	7.6	9	10.77	9.14	6.12	2.92	0	0	50.95	
PROSSER	1931-2005	0	0	2.49	4.86	6.57	7.5	8.61	7.09	4.73	2.48	0.8	0.69	45.82	
PUYALLUP	1931-1995	0	0.71	1.58	2.46	3.97	4.63	5.61	4.97	2.92	1.28	0.61	0	28.74	
QUINCY	1941-2005	0	0	0	5.76	8.05	9	10.2	8.52	5.52	2.6	0	0	49.65	
RIMROCK	1947-1977	0	0	0	0	5.35	7.08	15.41	6.71	3.7	1.63	0	0	39.88	
SEATTLE	1941-1960	0.61	0.82	1.8	3.26	4.64	5.12	6.7	5.19	3.49	1.62	0.74	0.53	34.52	25.89
SPOKANE	1889-2005	0	0	0	4.66	7.27	8.57	11.28	10.22	6.41	0	0	0	48.41	
WALLA	1931-1962	0	0	0	4.79	6.26	7.61	9.72	7.95	4.78	2.58	0	0	43.69	
WENATCHEE	1950-1997	0	0	0	4.74	6.87	7.87	9.38	7.83	4.19	0	0	0	40.88	
WHITMAN	1962-2005	0	0	0	4.58	6.58	8.17	10.34	9.08	5.52	2.84	0	0	47.11	
WIND	1901-1977	0	0	0	2.91	4.19	4.64	6.15	4.97	3.31	1.62	0	0	27.79	
YAKIMA	1946-2005	0	0	0	5.27	7.62	8.71	10.42	9.29	5.9	0	0	0	47.21	

Source: Desert Reasarch institute

Attachment 2

Mass Balance

Vashon Island Closed Landfill
Leachate System Mass Balance
Three Year (2010 - 2012) Period

Constituent	**Source Loading**										**Loading in Discharge from Leachate Lagoon, pounds**			
	Toe Collector		Leachate System		Transfer Station		Rainfall		Total		Non-Aerated Depth	Non-Aerated Surface	Aerated Depth	Aerated Surface
	Percent of Total	Load, ppy	Percent of Total	Load, ppy	Percent of Total	Load, ppy	Percent of Total	Load, ppy	Percent of Total	Load, ppy	Load, ppy	Load, ppy	Load, ppy	Load, ppy
Alkalinity	0.4%	5.09	90.4%	1,028.88	9.2%	104.62	0.0%	0	100.0%	1,138.59	1,231.14	1,272.92	1,238.55	1,278.98
BOD	0.0%	0.00	61.1%	4.64	38.9%	2.96	0.0%	0	100.0%	7.60	80.19	72.64	74.12	78.64
COD	0.2%	0.69	87.4%	264.18	12.3%	37.22	0.0%	0	100.0%	302.10	625.34	642.86	654.99	664.42
Chloride	0.0%	0.10	99.5%	1,993.39	0.5%	9.37	0.0%	0	100.0%	2,002.87	231.81	233.16	231.81	231.81
Copper, total	1.2%	0.00	74.7%	0.04	24.1%	0.01	0.0%	0	100.0%	0.05	0.15	0.13	0.14	0.15
Iron, total	16.6%	0.25	61.0%	0.94	22.3%	0.34	0.0%	0	100.0%	1.53	37.94	34.57	38.68	43.19
Magnesium, total	0.1%	0.45	98.9%	675.03	1.1%	7.32	0.0%	0	100.0%	682.80	122.91	120.15	122.91	123.18
Manganese, total	6.1%	0.01	92.2%	0.14	1.8%	0.00	0.0%	0	100.0%	0.15	6.84	6.14	7.12	7.92
Total Nitrogen	0.0%	0.07	98.0%	428.78	2.0%	8.69	0.0%	0	100.0%	437.54	16.72	16.53	16.52	16.62
Phosphorous	0.0%	0.00	13.4%	0.14	86.6%	0.89	0.0%	0	100.0%	1.02	0.00	0.00	0.00	0.00
Sodium, total	0.0%	0.32	99.0%	1,317.72	1.0%	12.82	0.0%	0	100.0%	1,330.86	179.92	177.22	179.92	179.92
TSS	4.0%	0.97	88.7%	21.45	7.3%	1.76	0.0%	0	100.0%	24.19	707.55	855.80	892.86	983.83
Zinc, total	0.5%	0.00	87.3%	0.33	12.3%	0.05	0.0%	0	100.0%	0.38	0.47	0.51	0.52	0.58

ppy = pounds per year

Vashon Island Closed Landfill
Leachate System Source Loading

Constiuent Loading at Pump Station No. 2

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	49.1	37,264	15.269
BOD	0	37,264	0.000
COD	6.7	37,264	2.083
Chloride	1	37,264	0.311
Copper, total	0.0055	37,264	0.002
Iron, total	2.46	37,264	0.765
Magnesium, total	4.34	37,264	1.350
Manganese, total	0.0876	37,264	0.027
Total Nitrogen	0.672	37,264	0.209
Phosphorous	0	37,264	0.000
Sodium, total	3.09	37,264	0.961
TSS	9.4	37,264	2.923
Zinc, total	0.017	37,264	0.005

Constiuent Loading from Transfer Station

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	53.400	704,304	313.854
BOD	1.510	704,304	8.875
COD	19.000	704,304	111.671
Chloride	4.785	704,304	28.123
Copper, total	0.006	704,304	0.034
Iron, total	0.175	704,304	1.029
Magnesium, total	3.735	704,304	21.952
Manganese, total	0.001	704,304	0.008
Total Nitrogen	4.435	704,304	26.066
Phosphorous	0.453	704,304	2.662
Sodium, total	6.545	704,304	38.468
TSS	0.900	704,304	5.290
Zinc, total	0.024	704,304	0.140

Constiuent Loading from Landfill

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	160.65	2,302,388	3086.637
BOD	0.73	2,302,388	13.930
COD	41.25	2,302,388	792.554
Chloride	311.25	2,302,388	5980.179
Copper, total	0.01	2,302,388	0.107
Iron, total	0.15	2,302,388	2.810
Magnesium, total	105.40	2,302,388	2025.095
Manganese, total	0.02	2,302,388	0.413
Total Nitrogen	66.95	2,302,388	1286.339
Phosphorous	0.02	2,302,388	0.410
Sodium, total	205.75	2,302,388	3953.162
TSS	3.35	2,302,388	64.365
Zinc, total	0.05	2,302,388	0.997

Constiuent Loading in Discharge from Non-Aerated Leachate Lagoon (Surface)

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	94.45	4,845,000	3818.758
BOD	5.39	4,845,000	217.926
COD	47.7	4,845,000	1928.584
Chloride	17.3	4,845,000	699.465
Copper, total	0.0094	4,845,000	0.380
Iron, total	2.565	4,845,000	103.707
Magnesium, total	8.915	4,845,000	360.447
Manganese, total	0.4555	4,845,000	18.417
Total Nitrogen	1.2265	4,845,000	49.589
Phosphorous	0	4,845,000	0.000
Sodium, total	13.15	4,845,000	531.675
TSS	63.5	4,845,000	2567.402
Zinc, total	0.0382	4,845,000	1.544

Constiuent Loading in Discharge from Non-Aerated Leachate Lagoon (At Depth)

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	91.35	4,845,000	3693.420
BOD	5.95	4,845,000	240.568
COD	46.4	4,845,000	1876.023
Chloride	17.2	4,845,000	695.422
Copper, total	0.011	4,845,000	0.445
Iron, total	2.815	4,845,000	113.815
Magnesium, total	9.12	4,845,000	368.736
Manganese, total	0.5075	4,845,000	20.519
Total Nitrogen	1.2405	4,845,000	50.155
Phosphorous	0	4,845,000	0.000
Sodium, total	13.35	4,845,000	539.761
TSS	52.5	4,845,000	2122.655
Zinc, total	0.0347	4,845,000	1.403

Constiuent Loading in Discharge from Aerated Leachate Lagoon (Surface)

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	94.9	4,845,000	3836.952
BOD	5.835	4,845,000	235.918
COD	49.3	4,845,000	1993.274
Chloride	17.2	4,845,000	695.422
Copper, total	0.0115	4,845,000	0.465
Iron, total	3.205	4,845,000	129.583
Magnesium, total	9.14	4,845,000	369.544
Manganese, total	0.5875	4,845,000	23.754
Total Nitrogen	1.233	4,845,000	49.852
Phosphorous	0	4,845,000	0.000
Sodium, total	13.35	4,845,000	539.761
TSS	73	4,845,000	2951.501
Zinc, total	0.04285	4,845,000	1.732

Constiuent Loading in Discharge from Aerated Leachate Lagoon (At Depth)

Constituent	Concentration, mg/L	Flow Volume, gal	Load, lb
Alkalinity	91.9	4,845,000	3715.657
BOD	5.5	4,845,000	222.373
COD	48.6	4,845,000	1964.972
Chloride	17.2	4,845,000	695.422
Copper, total	0.01025	4,845,000	0.414
Iron, total	2.87	4,845,000	116.038
Magnesium, total	9.12	4,845,000	368.736
Manganese, total	0.528	4,845,000	21.348
Total Nitrogen	1.2255	4,845,000	49.549
Phosphorous	0	4,845,000	0.000
Sodium, total	13.35	4,845,000	539.761
TSS	66.25	4,845,000	2678.589
Zinc, total	0.0388	4,845,000	1.569

Attachment 3

Detected Analytes

Vashon Island Closed Landfill
Summary of Detected Analytes

Sample Source	Date	Sample Code	COND (F)	PH (F)	TEMP	ACETONE	ALKALINITY, TOTAL (AS CACO3)	ALUMINUM, Dissolved	ALUMINUM, Total	AMMONIA AS N	BARIUM, Dissolved	BARIUM, Total	BIOLOGICAL OXYGEN DEMAND - 5 DAY	CALCIUM, Dissolved	CALCIUM, Total	CHEMICAL OXYGEN DEMAND	CHLORIDE	CHROMIUM, Total	COBALT, Dissolved	COBALT, Total	COLIFORMS, FECAL
			umhos/cm	pH units	deg c	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	cfu/100ml
Leachate System	1/9/2013	LVB-130109M	1400	7.28	13.5	< 4 U	99.6	< 0.02 U	< 0.02 U	< 0.01 U	0.0283	0.0385	< 2 U	94.8	121	28.4	209	< 0.005 U	< 0.003 U	< 0.003 U	< 1 U
Leachate System	2/7/2013	LVB-130207M	2350	7.19	11.4	< 4 U	127	< 0.02 U	< 0.02 U	0.0697	0.0456	0.0544	< 2 U	157	182	46.3	324	< 0.005 U	< 0.003 U	< 0.003 U	< 1 U
Leachate System	3/5/2013	LVB-130305-	1600	7.31	10.5		130	< 0.02 U	< 0.02 U	< 0.01 U	0.0506	0.0521	2.9	177	179	38.1	328	< 0.005 U	< 0.003 U	0.0033 T	< 1 U
Transfer Station	3/5/2013	LVBE130305-	190	7	8.5		57.7	< 0.02 U	0.13 T	0.232	0.00862	0.00968	3.02 L	28.8	28.7	18 T	6.64	< 0.005 U	< 0.003 U	< 0.003 U	2
Condensate Trap	3/5/2013	LVCT130305-	370	7.03	12.6		195	< 0.02 U	< 0.02 U	< 0.01 U	0.0182	0.0185	< 2 U	79.1	80	7 T	16.6	< 0.005 U	< 0.003 U	< 0.003 U	
Pump Station No. 2	3/5/2013	LVPS2130305	115	6.26	9.8	< 4 U	49.1	0.963	1.67	0.513	0.0203	0.0245	< 2 U	11.4	11.7	6.7 T	1	< 0.005 U	< 0.003 U	< 0.003 U	< 1 U
LS-PA-D[1]	3/5/2013	LVPA130305D	230	7.36	7.3	< 4 U	93.2	< 0.02 U	1.33	< 0.01 U	0.00765	0.0206	4.16	35.6	39.8	43.5	17.6	< 0.005 U	< 0.003 U	< 0.003 U	7
LS-PA-S[2]	3/5/2013	LVPA130305S	285	8.28	7.8	< 4 U	93.3	< 0.02 U	1.53	< 0.01 U	0.00786	0.0223	4.67	35.9	40.1	45.5	17.2	< 0.005 U	< 0.003 U	< 0.003 U	7
LS-PN-D[3]	3/5/2013	LVPN130305D	280	7.74	6.9	< 4 U	93.8	< 0.02 U	1.43	< 0.01 U	0.00793	0.0214	5.39 L	35.4	40.1	44.2	17.4	< 0.005 U	< 0.003 U	< 0.003 U	6
LS-PN-S[4]	3/5/2013	LVPN130305S	285	7.55	7.9	4.26	93	< 0.02 U	1.19	< 0.01 U	0.00771	0.0187	4.1	35.6	38.1	43.3	17.5	< 0.005 U	< 0.003 U	< 0.003 U	9
Leachate System	4/2/2013	LVB-130402-	5100	7.53	10.3																
Transfer Station	4/2/2013	LVBE130402-	1300	7.68	10.4	< 4 U	286	< 0.02 U	0.23 T	< 0.01 U	0.0858	0.0807	< 2 U	244	226	52.2	384	0.0079 T	0.0045 T	0.0034 T	< 1 U
Condensate Trap	4/2/2013	LVCT130402-	3350	7.59	13.5	< 4 U	49.1	< 0.02 U	< 0.02 U	< 0.01 U	0.00741	0.0077	< 2 U	23.6	23.3	20 T	2.93	< 0.005 U	< 0.003 U	< 0.003 U	
Pump Station No. 2	4/2/2013	LVPS2130402-	115	6.38	10.5	4.08	129	< 0.02 U	0.24 T	< 0.01 U	0.0229	0.0264		68.2	70.1	30.5	12.7	< 0.005 U	< 0.003 U	< 0.003 U	
LS-PA-D[1]	4/2/2013	LVPA130402D	280	8.37	12.8	< 4 U	90.6	< 0.02 U	1.21	< 0.01 U	0.00804	0.0209	6.84	35.2	39.8	53.7	16.8	< 0.005 U	< 0.003 U	< 0.003 U	1
LS-PA-S[2]	4/2/2013	LVPA130402S	280	8.43	11.2	4.01	96.5	< 0.02 U	1.39	< 0.01 U	0.00821	0.0227	7	36.1	40.6	53.1	17.2	< 0.005 U	< 0.003 U	< 0.003 U	1
LS-PN-D[3]	4/2/2013	LVPN130402D	280	8.27	11	< 4 U	88.9	< 0.02 U	1.09	< 0.01 U	0.00831	0.0195	6.51	35.7	39.4	48.6	17	< 0.005 U	< 0.003 U	< 0.003 U	< 1 U
LS-PN-S[4]	4/2/2013	LVPN130402S	275	8.34	10.7	< 4 U	95.9	< 0.02 U	1.16	< 0.01 U	0.00855	0.02	6.68	36.4	38.9	52.1	17.1	< 0.005 U	< 0.003 U	< 0.003 U	1

1. Leachate lagoon at depth, aerated
2. Leachate lagoon at surface, aerated
3. Leachate lagoon at depth, non-aerated
4. Leachate lagoon at surface, non-aerated

Vashon Island Closed Landfill
Summary of Detected Analytes

Sample Source	Date	Sample Code	COLIFORMS, TOTAL	COPPER, Dissolved	COPPER, Total	FLUORIDE	IRON, Dissolved	IRON, Total	MAGNESIUM, Dissolved	MAGNESIUM, Total	MANGANESE, Dissolved	MANGANESE, Total	NICKEL, Dissolved	NICKEL, Total	NITRATE + NITRITE AS N	PHOSPHORUS, SOLUBLE REACTIVE	POTASSIUM, Dissolved	POTASSIUM, Total	SODIUM, Dissolved	SODIUM, Total
			cfu/100ml	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Leachate System	1/9/2013	LVB-130109M	20	< 0.002 U	0.0044 T	0.13 T	< 0.01 U	< 0.01 U	54.7	70.6	0.0057 T	0.0439	0.0255	0.0356	44.1	0.0264	15.4	20.5	108	142
Leachate System	2/7/2013	LVB-130207M	< 1 U	0.005 T	0.0056 T	0.17 T	0.22 T	< 0.01 U	92.1	107	0.0205	< 0.001 U	0.0456	0.0535	66.2	0.021 T	26.8	28.5	185	217
Leachate System	3/5/2013	LVB-130305-	5	0.0052 T	0.005 T	< 0.1 U	< 0.01 U	0.051 T	106	107	< 0.001 U	0.0023 T	0.0512	0.0523	71.5	0.017 T	30.8	30.1	211	212
Transfer Station	3/5/2013	LVBE130305-	29	< 0.002 U	0.0054 T	< 0.1 U	0.07 T	0.24 T	3.3	3.35	< 0.001 U	0.0027 T	< 0.01 U	< 0.01 U	3.57	0.432	5.33	5.32	7.63	7.64
Condensate Trap	3/5/2013	LVCT130305-		< 0.002 U	< 0.002 U	0.1 T	< 0.01 U	< 0.01 U	10.9	11.1	< 0.001 U	< 0.001 U	< 0.01 U	< 0.01 U	0.205	0.12	10.6	10.6	10.2	10.3
Pump Station No. 2	3/5/2013	LVPS2130305	< 1 U	< 0.002 U	0.0055 T	0.13 T	1.81	2.46	4.12	4.34	0.0822	0.0876	< 0.01 U	< 0.01 U	0.672	< 0.01 U	1.48	1.53	3.01	3.09
LS-PA-D[1]	3/5/2013	LVPA130305D	52	< 0.002 U	0.0095 T	0.13 T	< 0.01 U	2.96	8.34	9.17	< 0.001 U	0.5	< 0.01 U	< 0.01 U	1.61	< 0.01 U	3.15	3.36	12.8	13.4
LS-PA-S[2]	3/5/2013	LVPA130305S	34	< 0.002 U	0.012 T	< 0.1 U	< 0.01 U	3.3	8.41	9.11	< 0.001 U	0.562	< 0.01 U	< 0.01 U	1.62	< 0.01 U	3.19	3.47	12.8	13.1
LS-PN-D[3]	3/5/2013	LVPN130305D	50	< 0.002 U	0.011 T	< 0.1 U	< 0.01 U	3.18	8.31	9.12	< 0.001 U	0.545	< 0.01 U	< 0.01 U	1.64	< 0.01 U	3.13	3.35	12.7	13.2
LS-PN-S[4]	3/5/2013	LVPN130305S	44	< 0.002 U	0.0093 T	0.18 T	< 0.01 U	2.57	8.28	8.85	< 0.001 U	0.421	< 0.01 U	< 0.01 U	1.61	< 0.01 U	3.13	3.35	12.7	13
Leachate System	4/2/2013	LVB-130402-																		
Transfer Station	4/2/2013	LVBE130402-	< 1 U	0.0047 T	0.0072 T	0.14 T	< 0.01 U	0.534	149	137	0.0036 T	0.0398	0.0706	0.0669	86	0.021 T	36.7	33.8	271	252
Condensate Trap	4/2/2013	LVCT130402-		0.0061 T	0.0063 T	< 0.1 U	< 0.01 U	0.11 T	4.12	4.12	0.0042 T	< 0.001 U	< 0.01 U	< 0.01 U	5.3	0.474	3.57	3.45	5.34	5.45
Pump Station No. 2	4/2/2013	LVPS2130402-		< 0.002 U	< 0.002 U	0.11 T	< 0.01 U	0.754	8.68	9	0.073	0.0869	< 0.01 U	< 0.01 U	0.183	0.0382	9.03	8.82	8.25	8.6
LS-PA-D[1]	4/2/2013	LVPA130402D	< 1 CU	< 0.002 U	0.011 T	< 0.1 U	< 0.01 U	2.78	8.33	9.07	< 0.001 U	0.556	< 0.01 U	< 0.01 U	0.841	< 0.01 U	3.15	3.54	12.9	13.3
LS-PA-S[2]	4/2/2013	LVPA130402S	< 1 CU	< 0.002 U	0.011 T	0.11 T	< 0.01 U	3.11	8.46	9.17	< 0.001 U	0.613	< 0.01 U	< 0.01 U	0.846	< 0.01 U	3.23	3.58	13.2	13.6
LS-PN-D[3]	4/2/2013	LVPN130402D	9	< 0.002 U	0.011 T	0.18 T	< 0.01 U	2.45	8.4	9.12	< 0.001 U	0.47	< 0.01 U	< 0.01 U	0.841	< 0.01 U	3.24	3.52	12.9	13.5
LS-PN-S[4]	4/2/2013	LVPN130402S	2 C	< 0.002 U	0.0095 T	< 0.1 U	< 0.01 U	2.56	8.5	8.98	0.0039 T	0.49	< 0.01 U	< 0.01 U	0.843	< 0.01 U	3.22	3.49	13.3	13.3

1. Leachate lagoon at depth, aerated
2. Leachate lagoon at surface, aerated
3. Leachate lagoon at depth, non-aerated
4. Leachate lagoon at surface, non-aerated

Vashon Island Closed Landfill
Summary of Detected Analytes

Sample Source	Date	Sample Code	SPECIFIC CONDUCTANCE	STYRENE	SULFATE	SULFIDE, TOTAL	TOTAL DISSOLVED SOLIDS	TOTAL FATS, OILS & GREASE	TOTAL KJELDAHL NITROGEN	TOTAL ORGANIC CARBON	TOTAL SUSPENDED SOLIDS	TOTAL VOLATILE SOLIDS	TRICHLOROFLUORO METHANE	VOLATILE SUSPENDED SOLIDS	ZINC, Dissolved	ZINC, Total
			umhos/cm	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
Leachate System	1/9/2013	LVB-130109M	1890	< 0.2 U	336	< 0.01 U		< 2 U	0.668	11.7	1.2	334	< 0.2 U	1	0.012 T	0.0285
Leachate System	2/7/2013	LVB-130207M	2600	< 0.2 U	526	< 0.01 U		< 2 U	1.3	16.1	< 1 U	630	< 0.2 U	1.4 T	0.022 T	0.019 T
Leachate System	3/5/2013	LVB-130305-	2670		531	< 0.01 U	1970	4.9 BT	1.15	14.5	< 1 U	696		< 1 U	0.021 T	0.049
Transfer Station	3/5/2013	LVBE130305-	238		28.7	0.022 T	161	3.3 BT	1.38	6.22	1.8	59.4		1.6	0.019 T	0.022 T
Condensate Trap	3/5/2013	LVCT130305-	542		60.3	< 0.01 U	331		0.481		1.5	69.6		< 1 U	< 0.004 U	< 0.004 U
Pump Station No. 2	3/5/2013	LVPS2130305	116	< 0.2 U	3.25	< 0.01 U	93.5	2.2 BT	0.735	3.4	9.4	33.1	0.23 T	8	0.0079 T	0.017 T
LS-PA-D[1]	3/5/2013	LVPA130305D	329	< 0.2 U	33.5	< 0.01 U	197	2.1 BT	2.09	10.4	57	81	< 0.2 U	32	< 0.004 U	0.0396
LS-PA-S[2]	3/5/2013	LVPA130305S	327	< 0.2 U	34.4	< 0.01 U	189	2.6 BT	2.17	12.2	78	95.6	< 0.2 U	52	0.013 T	0.0438
LS-PN-D[3]	3/5/2013	LVPN130305D	327	< 0.2 U	33.3	< 0.01 U	187	2.2 BT	2.07	16.9	66	93.7	< 0.2 U	32	< 0.004 U	0.0439
LS-PN-S[4]	3/5/2013	LVPN130305S	327	< 0.2 U	33.5	< 0.01 U	200	2 BT	1.91	18.2	42	77.4	< 0.2 U	19	< 0.004 U	0.0339
Leachate System	4/2/2013	LVB-130402-														
Transfer Station	4/2/2013	LVBE130402-	3410	< 0.2 U	630	0.011 T	2540	< 2 U	1.55	20.6	12.2	862	< 0.2 U	3.8	0.0352	0.111
Condensate Trap	4/2/2013	LVCT130402-	198	< 0.2 U	15.3	< 0.01 U	148	< 2 U	0.685	8.72	< 1 U	60.8	< 0.2 U	< 1 U	0.013 T	0.0257
Pump Station No. 2	4/2/2013	LVPS2130402-	471	< 0.2 U	78.6	< 0.01 U	316		0.721	9.4 T	8	59	< 0.2 U	3.6	< 0.004 U	0.011 T
LS-PA-D[1]	4/2/2013	LVPA130402D	322	< 0.2 U	32	< 0.01 U	195	< 2 U	2.39	19.5	75.5	79.4	< 0.2 U	36.5	< 0.004 U	0.038
LS-PA-S[2]	4/2/2013	LVPA130402S	324	< 0.2 U	32.7	< 0.01 U	185	< 2 U	2.4	9.95	68	77.1	< 0.2 U	28	< 0.004 U	0.0419
LS-PN-D[3]	4/2/2013	LVPN130402D	321	< 0.2 U	31.7	< 0.01 U	189	< 2 U	2.28	11.7	61	69.9	< 0.2 U	29	< 0.004 U	0.0325
LS-PN-S[4]	4/2/2013	LVPN130402S	323	< 0.2 U	31.9	< 0.01 U	183	< 2 U	2.37	11.2	63	80.2	< 0.2 U	21	< 0.004 U	0.0355

1. Leachate lagoon at depth, aerated
2. Leachate lagoon at surface, aerated
3. Leachate lagoon at depth, non-aerated
4. Leachate lagoon at surface, non-aerated