Phase 1 – Cedar Falls And Vashon Island Landfills

CONTRACT NO. E00102E08

Vashon Island Landfill Work Plan

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VASHON ISLAND LANDFILL WORK PLAN

ENVIRONMENTAL INVESTIGATIONS, MONITORING, AND REMEDIATION SERVICES

Prepared for: King County Solid Waste Division

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1.0 INTRODUCTION

This Work Plan presents the details on field procedures for geophysical logging of existing wells, the installation of new groundwater monitoring wells, infrastructure upgrades, aquifer testing, and hydrostratigraphic interconnection evaluation at Vashon Island Closed Landfill (VLF). The groundwater investigation completed under this Work Plan will refine the existing site conceptual model, define the groundwater flow path and support the monitored natural attenuation assessment (Task 310.1.9) of Contract No. E00102E08 with Aspect Consulting, LLC (Aspect). The project location is presented on Figure 1, and the site layout is shown on Figure 2. This work plan covers:

- Pre-drilling activities which will include initial site visit, locating borings, utility locates, and surveying drilling locations;
- Geophysical logging of selected wells, including electromagnetic induction, natural gamma, and ground penetrating radar, to better understand subsurface correlations of water bearing units;
- Cc2 monitoring well (MW-33) drilling and installation just northeast of the leachate lagoon, completed at a depth of approximately 150 feet. MW-33 will evaluate South Slope refuse and landfill gas as potential upgradient contaminant sources to groundwater quality at MW-5D;
- Regional aquifer monitoring well (MW-34) drilling and installation, near MW-27, completed to a depth of approximately 250 feet. MW-34 will evaluate flow paths and groundwater mounding near MW-27;
- Infrastructure upgrades on site, including:
  - Decommissioning MW-5D, MW-5S, and MW-1;
  - MW-5D well replacement (MW-35) drilling and installation, completed to a depth of approximately 130 feet in the Cc2 water bearing unit;
  - Pump retrieval in MW-14, or well decommissioning and well replacement (MW-36) drilling if pump retrieval is not successful; and
  - Bollard installation around MW-13 and GP-1.
- Monitoring well development of new wells and select existing wells;
- Aquifer hydraulic conductivity testing of new and select existing wells to better understand contaminant transport at the site;
- Hydrostratigraphic interconnectedness evaluation of water bearing units at the site using pressure transducers deployed in selected wells; and
- Handling of investigative-derived waste.
2.0 PRE-DRILLING ACTIVITIES

Explorations locations will be field staked prior to field work with representatives from King County Solid Waste Division (KCSWD), Aspect, and the drilling contractor. The monitoring wells are scheduled to be installed in the first quarter 2015. A public and private utility locate will be conducted prior to drilling. Aspect will perform a site visit before field work starts to assess the drill site accessibility, stake the new well locations and evaluate the condition of the existing wells.

Prior to drilling and after Aspect’s site visit, KCSWD will survey the ground surface elevation of the planned boring locations. The ground surface elevations will be used during drilling and installation of the new monitoring to ensure that the target completion depths and water bearing zones are properly identified.

3.0 GEOPHYSICAL LOGGING

A downhole geophysical survey will be performed on selected existing monitoring wells to assist in stratigraphic correlation of hydrostratigraphic units and assist in the identification of water bearing zones. Aspect will subcontract services of a geophysical contractor to perform this survey using electromagnetic induction (EM) and natural gamma surveys. EM measures conductivity of the soils—finer-grained soils tend to have higher conductivity—and as such may be used to differentiate between silts and clays and coarser grained units. A natural gamma survey detects naturally occurring isotopes with a downhole tool. A common application is to delineate clay units, which typically contain potassium bearing minerals that emit gamma radiation. However, the natural gamma often does not show large responses in fine-grained overburden materials. The natural gamma will also respond to the bentonite grout in the hole. For monitoring wells, where the entire annulus has bentonite as part of the well seal, the natural gamma response will vary as the annulus dimension varies.

Borehole ground penetrating radar (GPR) will also be run on a trial basis to see if it is capable of differentiating between finer- and coarser-grained materials. The trial will include one, 200-foot, 4-inch diameter monitoring well, and one, 200-foot, 2-inch diameter monitoring well.

Up to 6 monitoring wells (average depth 200 feet) will be logged for EM and natural gamma (Figure 3). If the GPR trial shows that fine and coarse grained materials can be differentiated, up to 4 additional existing monitoring wells will be surveyed using this method. In addition to the 6 existing monitoring wells, up to three new monitoring wells installed in this investigation will also be surveyed for the full downhole geophysical survey suite (EM, natural gamma, and GPR).

A list of wells proposed for geophysical testing are summarized in Table 1. Existing wells MW-7, MW-19 and MW-27 will be tested using geophysics prior to drilling new wells. Selected new and additional existing wells will be tested using geophysics after drilling after the new wells are installed and developed.

Data obtained from these surveys will be used to update the hydrostratigraphic model and may provide data useful for determining completion zone of the new VLF Regional Aquifer monitoring well (MW-34).
4.0 CC2 MONITORING WELL (MW-33)

4.1 Purpose

The new monitoring well installed into the Cc2 hydrostratigraphic unit will be used to evaluate contaminant sources in the vicinity of the South Slope for observed downgradient impacts in MW-5D. The new well, MW-33, will evaluate South Slope refuse and landfill gas as potential sources for the contamination in MW-5D. The well will also serve to confirm the absence of glacial till in this area as is currently understood by the hydrostratigraphic conceptual model. The new well will be drilled on the Vashon Island Landfill property, just northeast of the leachate lagoon, and is expected to be no more than 150 feet deep. Since the well may penetrate refuse, the well will be completed using a temporary 10-inch diameter conductor casing installed through the refuse zone, as specified in WAC 173-160-241 (2) (a). The temporary casing will insure that landfill refuse and leachate if encountered will not be dragged downward into native deposits and that a competent surface seal is formed through the landfill material.

4.2 Drilling and Installation Procedures

The monitoring well will be installed using rotosonic drilling techniques as described in Appendix B – Section B.2.1 of the Environmental Review, Investigation and Evaluation Technical Memorandum – Vashon Island Closed Landfill (Aspect, 2012).

The monitoring well will be advanced using a dual casing rotosonic drilling system that allows the collection of continuous core soil samples. During drilling, soil samples for soil classification and field screening will be collected continuously at 5- to 20-foot intervals using a 4.75-inch-diameter inner core barrel and an 8-inch diameter outer casing.

When water is encountered in the borehole, the driller will be instructed to stop drilling and sufficient time will be allowed for the water level to reach near-static or static conditions. The water level will be measured through the drill string and referenced to the surveyed ground-surface elevation. The depth to groundwater will be measured with a down-hole water-level indicator to the nearest 0.01 feet. Water-level measurements will be taken at the start and the end of each work day.

If heaving sand conditions are encountered below the water table, drilling techniques may be altered to reduce heave. These techniques may include adding water to the boring to maintain a positive pressure head within the inside diameter of the casing to counteract the hydrostatic pressure of the aquifer. Water used for drilling activities will be provided by KCSWD from an on-site potable water source at the transfer station. If KCSWD is not able to provide potable water, the contractor will have potable water available.

Soil samples and cuttings will be field-screened for the presence of volatile organic vapors using a MiniRae 3000 photoionization detector (PID). The PID is designed to detect and measure volatile organic compound (VOC) vapors in air, but it does not detect methane. The VOC concentrations will be used to monitor worker health and safety during drilling and to indicate if VOCs appear to be present in the soil encountered during drilling (measurements will indicate a potential for contamination that may be investigated further). In addition, a LandTec GEM 2000 landfill gas meter will be used to monitor methane, carbon dioxide, and
oxygen concentrations during drilling. Methane measurements will be taken from the top of the drill casing after each sample run, and periodic ambient air measurements will be recorded as part of the Health and Safety monitoring. In the case of elevated levels of methane, drilling will cease and a brush fan, provided by the driller, will be used to clear the immediate area of dangerous gasses. Drilling will resume after mitigation plans approved by Aspect’s Health and Safety officer are put into place to ensure safe drilling operations. See the Health and Safety Plan for more details (Appendix D).

Pertinent geologic and hydrogeologic subsurface conditions and PID and methane readings will be recorded on a monitoring well boring log.

Soil samples will be collected from the inner split barrel during sonic drilling, which provides a near-continuous core. The sonic core will be carefully extruded from the inner core barrel into a plastic wrap at ground surface to preserve sample moisture content, and laid out onto the sample collection and logging area. The plastic wrap will be cut open and the resulting core segment logged under the discretion of Aspect’s geologist on site. Sample descriptions will be made in general accordance with ASTM Method D-2488, Standard Practice for Description and Identification of Soils (Visual/Manual Procedure). All information pertaining to the borings will be recorded on field boring logs. The core will be subsampled at 5-foot intervals and at lithologic changes and placed in chip trays for archiving. Cores and associated plastic will be disposed of after the geologic log is finalized and Department of Health or Department of Ecology representatives have been given an opportunity to review the core. Core samples and chip trays will be photographed. Soil cuttings will be stored in dedicated drums, as is described in the Investigative-Derived Waste Section below. If groundwater is encountered in the Cc1 unit during drilling, drilling will stop and a grab sample will be collected with a bailer to measure field parameters (including specific conductance, temperature, dissolved oxygen, pH, and oxidation-reduction potential). These field parameters will be used to identify leachate impact on groundwater in the Cc1 unit. Groundwater quality field parameters will also be collected and measured from deeper units Cc2, Cc3, and the Regional aquifer only if potable water is not used during drilling.

Based on the current hydrostratigraphic conceptual model, the proposed Cc2 monitoring well is expected to be completed to a depth of no greater than 150 feet below ground surface. To avoid drag down of landfill material and leachate if encountered, a 10-inch outer diameter steel conductor casing will be installed during drilling to a depth greater than the bottom of the refuse and seated in native soil. The conductor casing will be sealed with bentonite slurry or bentonite chips before drilling proceeds through the casing to final total depth. If a bentonite slurry is used, it will be installed using a tremie pipe.

To ensure that MW-33 is completed in the Cc2 unit, Aspect has reviewed boring logs, groundwater flow maps, and a cross-section produced from the RockWorks Subsurface model created by KCSWD. MW-33 is ideally located for it to be completed in the Cc2 unit directly upgradient of the most impacted groundwater quality results (from MW-5D). During drilling, an experienced Aspect hydrogeologist will be on site collecting soil samples, logging core, measuring water levels, and interpreting stratigraphy. These interpretations will be based on the site conceptual model, and will be compared to the MW-5D boring log.
Aspect’s lead hydrogeologist and field hydrogeologist will be in close communication to ensure that accurate stratigraphic interpretations are made.

The well will be completed with a 4-inch diameter Schedule 40 PVC well casing, a 0.020-slot PVC screen, a 10x20 Colorado Silica Sand filter pack, and a steel above ground stickup monument with a hinged lid – in accordance with King County Solid Waste specifications (Figure 6). The screened interval will be 10 to 15 feet long, targeting the upper portion of the Cc2 aquifer to monitor water level variations at the top of the Cc2 unit. Overdrilled sections greater than 3 feet will be backfilled with bentonite chips. Overdrilled sections less than 3 feet will be allowed to collapse or will be backfilled with pea gravel, unless a distinct aquitard is penetrated, in which case the boring will be backfilled with bentonite pellets. An approximate 3-foot bentonite seal will be placed above the Colorado Silica Sand, and the remainder of the annular space will be backfilled with either bentonite pellets or high-solids bentonite grout to about 8 feet below ground surface. If highly permeable material is encountered near the 3-foot seal zone, the bentonite chip seal will be extended to prevent high-solids bentonite grout from short circuiting through the formation and influencing the well screen. If hydrated bentonite chips are used in lieu of bentonite grout or slurry, the chips will be placed to fill the annular space around the monitoring well casing to within approximately 2 to 3 feet below ground surface. During placement of the chips, they will be continuously sounded to ensure bridging is not occurring. Water used for hydrating chips or for mixing bentonite grout will be from a potable source.

After monitoring well installation, the drilling site will be restored to its original condition to the extent feasible, and the driller will install bollards as specified by WAC 173-160. The borings will be flagged and identified for later surveying by KCSWD. Before moving to a new drilling location, the driller will decontaminate drilling equipment at a designated decontamination pad.

Daily reports and landfill gas monitoring logs will be generated to document activity performed each day with email updates prepared and submitted to KCSWD. Soil boring and monitoring well installation logs will be prepared for each monitoring well documenting the geologic and groundwater conditions and well installation details.
5.0 REGIONAL AQUIFER MONITORING WELL (MW-34)

5.1 Purpose

The new monitoring well for the VLF Regional Aquifer will be used to help define flow paths in the regional aquifer, including determining vertical hydraulic and chemical gradients in the aquifer. The new monitoring well, MW-34, located outside of the western landfill refuse boundary, will help evaluate the apparent groundwater mound at MW-27, as well as refine the hydrostratigraphy and hydraulic relationship between the Cc3 hydrostratigraphic unit and the Regional Aquifer.

5.2 Installation Procedures

The monitoring well MW-34 will be drilled and completed in the same manner as the Cc2 well MW-33, described above but without the 10-inch diameter conductor casing. Based on the current hydrostratigraphic conceptual model, the proposed regional aquifer monitoring well is expected to be completed to a depth of approximately 250 feet below ground surface. The completion interval for MW-34 will be in the regional aquifer, and will be based upon geophysical survey results from MW-27, evaluations of the continuous sonic core samples, and water levels obtained during drilling.

6.0 INFRASTRUCTURE UPGRADES

6.1 Well Decommissioning

Wells MW-1 and MW-5S/5D are scheduled for decommissioning. MW-1 is damaged and has been a dry well, not yielding a groundwater sample for several years. MW-5S and MW-5D are part of a multi-completion well in the same 8-inch diameter borehole with two monitoring well casings and one gas probe. The well completion log for MW-5S, which was drilled in 1986, indicates that the well has no seal other than in the upper 3 feet, and therefore has, effectively, an approximate 80-foot long filter pack. MW-5S would not meet current monitoring well standards. Furthermore, KCSWD has indicated that MW-5D has sediment accumulation and iron staining issues.

A licensed driller will be subcontracted to decommission wells MW-1 and MW-5S/5D in accordance with WAC 173-160 by overdrilling using rotosonic methods and sealing the borehole with a bentonite slurry by tremie and/or by placement of bentonite chips. The drilling contractor will also drill and install a new monitoring well to replace MW-5D.

6.2 MW-5D Replacement Well (MW-35)

MW-35 is a replacement well for MW-5D, and will be drilled near the original location of MW-5D using 8-inch diameter rotosonic methods and constructed using 4-inch diameter PVC well casing and screen. The well is expected to be drilled to a depth of 130 feet, and will be completed and developed in the Cc2 unit, in
the same manner as the Cc2 well MW-33, as described above, but without the 10-inch diameter conductor casing. MW-35 may be drilled prior to the decommissioning MW-5D.

6.3 MW-14 Pump Retrieval or Well Replacement (MW-36)

MW-14 has become altered and the pump is stuck above the screen. A driller will be subcontracted to provide a pump truck and “fishing” equipment to retrieve the pump. Pump retrieval efforts will be limited to a one-day level of effort. If retrieval efforts are successful, KCSWD will perform a camera survey of the well to confirm well integrity. If the well screen and casing is deemed useable and undamaged, Aspect will make a recommendation for a suitable replacement pump.

If pump retrieval efforts are unsuccessful, or if the well screen or casing is damaged to the point of rendering the well unusable, the well will be decommissioned and a replacement well will be drilled. The well will be decommissioned in accordance with WAC 173-160 by overdrilling (stuck pump in casing will preclude backfilling with bentonite) and sealing the borehole with a bentonite slurry using tremie and/or bentonite chips. A replacement well, MW-36, will be drilled using rotosonic methods and completed with a 4-inch diameter well casing. The well will be drilled to a comparable depth to MW-14, approximately 180 feet of drilling. The well will be completed and developed in the Cc3 unit, in the same manner as the Cc2 well MW-33, as described above, but without the 10-inch diameter conductor casing.

6.4 Bollard Installation

MW-13 and GP-1 require bollard installation to comply with WAC 173-160. Three bollards will be installed around each of these locations.
7.0 MONITORING WELL DEVELOPMENT

The drilling subcontractor will develop all newly drilled wells and wells selected for hydraulic conductivity testing (Table 2) as described in Appendix B – Section B.4 of the Environmental Review, Investigation and Evaluation Technical Memorandum – Vashon Island Closed Landfill (Aspect, 2012). Well development will include surging, bailing, and pumping with a submersible pump. Wells will be surged with a tight-fitting surge block having a 2-foot stroke. The surge block will be periodically removed and sediment removed from the well using a bailer. When the well has sufficiently low sand production as judged by the Aspect field representative, the submersible pump will be installed to complete development. Turbidity, temperature, specific conductance, and pH will be monitored throughout development. Development will continue until field parameters have stabilized and the turbidity is low (less than 50 NTUs) or has stabilized.

8.0 AQUIFER HYDRAULIC TESTING

8.1 Purpose

Groundwater flow velocities are a required component of contaminant transport evaluations as well as a required reporting element under WAC-173-351. Groundwater velocities using current hydraulic conductivity estimates provide very slow travel time estimates for the Cc2 unit (a mean value of about 0.002 feet/day), which is inconsistent with water quality impacts observed at the West Hill Side springs, (i.e. the travel time is on the order of 500 years, and the earliest waste placement was about 100 years ago). Slug tests (both rising head and falling head) will be performed to obtain hydraulic conductivity data for use in computing groundwater flow velocities required under WAC Chapter 173-351-410 and for use in future engineering control evaluations.

A subset of nine existing wells completed in Cc1, Cc2, and the VLF Regional Aquifer have been selected for hydraulic testing (Figure 4, Table 2). Some of these wells have been tested before, and these new tests will confirm previous hydraulic conductivity estimates. A hydrogeologist from Aspect will be on-site to conduct the slug tests. In addition to the 10 existing wells, newly drilled wells MW-33, MW-34, MW-35, and MW-36 (if installed) will also be slug tested. Prior to slug testing, wells will be redeveloped as is described above in the Monitoring Well Development section.

8.2 Slug Testing Procedures

Slug testing procedures are described in Appendix B – Section B.5.1 of the 300.2 memorandum (Aspect, 2012).

A slug test produces a change in water level within a well and measures the rate of return to the static water level (SWL). This rate of water level change in the well is used to compute the hydraulic conductivity of the water bearing zone. There are two common ways to induce a change in water level for slug tests: 1) using a slug bar – a solid cylinder of known volume – to displace water in a well; and 2) using a pneumatic slug test device, which changes water level by inducing a change in pressure in the well above SWL.
Pneumatic slug tests do not work on wells with partially saturated screened intervals, which is anticipated (Table 2), so a slug bar will be used on these wells. To test the results for dependency on hydraulic head, two slug bars of different lengths (ergo, different displacement volumes) will be used at each well. The slug bars will both be an inch (or less) in diameter to allow passage of the transducer cable in the smallest diameter wells (2 inch diameter). To test for repeatability, two slug tests will be performed with each bar. Two-inch diameter slugs may be utilized in the 4-inch diameter wells.

The water level in the well will be measured using a vented pressure transducer (5 or 15 psi range) and collected electronically on a data logger set to a nearly continuous time interval (1 second or less). Manually collected water level measurements, taken periodically throughout the test with a water level indicator, will be used to confirm results collected from the pressure transducer. Prior to the testing the pressure transducer will be installed in the well at a depth twice the length of the longer slug bar below the initial SWL to avoid contact with the slug bars. Once the transducer is in place and the data logger is programmed, the slug bar will be lowered on a line until it is just above the water – as evidenced by change in monitored pressure reading when the bottom of the slug bar enters water, or by a level indicator lowered with the slug. The rope will then be marked at the top of the casing and at one and one half the length of the slug bar above the top of casing.

For the falling head test (slug in test), the slug bar will be dropped into the groundwater so that it is fully submerged (lowered to the second mark on the rope). This insertion should be done quickly, and with care not to disturb the pressure transducer, but not so quickly as to cause water to splash inside the well. The water level will rapidly rise in the well, and then slowly fall over time to meet the initial SWL. The pressure will be monitored to confirm initial displacement was relatively instantaneous compared to the response. When the pressure indicates that water levels have recovered 80% (for low hydraulic conductivity formations) to 95% (for high hydraulic conductivity formations) of the initial displacement, the test is concluded at which time the water level will be confirmed manually.

At the completion of the falling head test, a rising head test (slug out test) occurs. Once the water level has returned to near static condition, the slug bar will be raised completely out of the water. This will be done quickly, and without disturbing the pressure transducer. Water in the well will rapidly fall and then rise over time to meet the initial SWL. The pressure will be monitored to confirm initial displacement was relatively instantaneous compared to the response. When pressure indicates that water levels have recovered 80% (for low hydraulic conductivity formations) to 95% (for high hydraulic conductivity formations) of the initial displacement, the test is concluded, at which time the water level will be confirmed manually.

8.3 Slug Testing Analysis

The recovery data of the slug tests will be used to estimate the hydraulic conductivity of the formation adjacent to the screened interval of each monitoring well through the comparison of theoretical models. Possible models include Hvorslev, 1951; Cooper et al., 1967; Bouwer and Rice, 1976; or Dagan, 1978. The appropriate model for each well will be determined after data is plotted and inspected. The use of a curve-matching computer software program may be utilized for effective analysis.
9.0 HYDROSTRATIGRAPHIC INTERCONNECTEDNESS EVALUATION

Hydraulic connection between water-bearing units will be evaluated through the installation of pressure transducers to obtain a new continuous record of water level changes between wells. The timing, magnitude, and spatial distribution of water level responses will be used to evaluate preferential flow paths and interconnection between hydrostratigraphic units. Up to 10 pressure transducers will be installed in selected wells. Figure 5 shows the wells chosen for transducers, and Table 3 shows well completion information necessary for transducer installation. Locations were chosen based on possible correlations in water quality and water level data, suggesting cross connection between aquifers. Locations focus on the south end of the facility where greatest groundwater quality impacts have been observed. Transducers will be installed in winter 2015, and removed in summer 2015. The transducers will be downloaded on an approximately monthly basis. Aspect will coordinate installation and downloading of the transducers with KCSWD personnel to avoid conflicts with the monitoring and sampling of the wells.

Prior to deploying, all equipment will be decontaminated using a three-point wash consisting of a non-phosphate detergent (Liquinox) scrub, potable water rinse, and distilled water rinse. Some wells will require removal of the sampling pumps prior to deployment of the transducers. In instances where the pumps are required to remain out of the wells, the pump and ancillary tubing will be appropriately bagged, labelled and stored until reinstallation following the data collection. If KCSWD needs to sample wells with transducers in them prior to transducer removal, Aspect will coordinate with KCSWD to reinstall all pumps and ancillary tubing prior to KCSWD’s sampling.

10.0 INVESTIGATIVE-DERIVED WASTE

All drill cuttings from the drilling, installation, and decommissioning of the monitoring wells will be contained in DOT approved 55-gallon drums or in drop boxes designed for hauling to an approved facility following designation sampling. All drum and/or drop boxes will be appropriately labeled as investigative-derived waste. Soil cuttings within each drop box will be segregated by borehole using plastic sheathing. Soil cuttings from each well will be composited and a representative sample will be submitted for laboratory analysis for disposal profiling and characterization purposes.

All water generated during the drilling, aquifer testing and decommissioning activities will be temporarily contained in DOT approved 55-gallon drums. The water generated during drilling will be sampled for analysis and compared to KCSWD leachate/wastewater discharge permit conditions. If the water meets those conditions, it will be discharged into the leachate ponds on site.
11.0 REFERENCES


Aspect Consulting, 2015, Email correspondence between Aaron Pruitt, John Strunk, and Dan Swope, January 23.


TABLES
### Table 1 - Proposed Wells for Geophysical Logging

#### Project # 090057-310.1.9, Vashon Island Landfill

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (ft, bgs)</th>
<th>Diameter</th>
<th>Completion Unit</th>
<th>EM</th>
<th>Natural Gamma</th>
<th>GPR</th>
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</thead>
<tbody>
<tr>
<td>MW-21</td>
<td>110</td>
<td>2-in</td>
<td>Cc2</td>
<td>O</td>
<td>O</td>
<td>C</td>
</tr>
<tr>
<td>MW-27</td>
<td>201</td>
<td>4-in</td>
<td>Cc3/R</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>MW-7</td>
<td>232</td>
<td>2-in</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td>C</td>
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<tr>
<td>MW-29</td>
<td>253</td>
<td>4-in</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td>C</td>
</tr>
<tr>
<td>MW-19</td>
<td>272</td>
<td>2-in</td>
<td>R</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>MW-26</td>
<td>261</td>
<td>4-in</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td>C</td>
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<td>MW-33</td>
<td>150 (est)</td>
<td>4-in</td>
<td>Cc2</td>
<td>O</td>
<td>O</td>
<td>C</td>
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<tr>
<td>MW-34</td>
<td>250 (est)</td>
<td>4-in</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td>C</td>
</tr>
<tr>
<td>MW-35</td>
<td>130 (est)</td>
<td>4-in</td>
<td>Cc2</td>
<td>O</td>
<td>O</td>
<td>C</td>
</tr>
</tbody>
</table>

**Notes:**

- Y = Yes, geophysical log to be run on this well
- C = Conditional, geophysical log will be run if results are successful on MW-19 and MW-27
- O = Optional
- EM = Electromagnetic Induction
- GPR = Ground Penetrating Radar

Unit designations from Berryman & Henigar (2006)
Table 2 - Hydraulic Conductivity Testing: Proposed and Previously Tested Wells

<table>
<thead>
<tr>
<th>Number</th>
<th>Units</th>
<th>Screen Top (fbgs)</th>
<th>Screen bottom (fbgs)</th>
<th>Static DTW (fbgs)</th>
<th>Well Dia.</th>
<th>Screen Slot (inches)</th>
<th>Prior Testing</th>
<th>Prior Test Result</th>
<th>Well Completion Zone</th>
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<td>MW-1*</td>
<td>Cc1</td>
<td>118</td>
<td>128</td>
<td>127.52</td>
<td>3</td>
<td>0.010</td>
<td>Bailer</td>
<td>3.3E-04</td>
<td>Screen in fine to medium sand (SM-SP)</td>
</tr>
<tr>
<td>MW-3</td>
<td>Cc1</td>
<td>35</td>
<td>40.15</td>
<td>42.12</td>
<td>3</td>
<td>0.010</td>
<td>Bailer</td>
<td>6.1E-03</td>
<td>Upper 4' of screen in sand (SP) and lower 1' of screen in silt (ML)</td>
</tr>
<tr>
<td>MW-4</td>
<td>Cc1</td>
<td>100</td>
<td>110</td>
<td>105.65</td>
<td>3</td>
<td>0.010</td>
<td>Bailer</td>
<td>3.0E-04</td>
<td>Upper 3' of screen in sand (SP) and lower 7' of screen in silt (ML)</td>
</tr>
<tr>
<td>MW-5S</td>
<td>Cc1</td>
<td>74</td>
<td>84</td>
<td>dry</td>
<td>2</td>
<td>0.020</td>
<td>Infiltration</td>
<td>5.7E-03</td>
<td>Screen in sand (SP); lower 0.5' of in silt</td>
</tr>
<tr>
<td>MW-13</td>
<td>Cc1</td>
<td>108</td>
<td>113</td>
<td>101.32</td>
<td>3</td>
<td>0.020</td>
<td>none</td>
<td>none</td>
<td>Entire 5' screen completed in a 6' sand (SM-SP) layer between silt (ML) layers</td>
</tr>
<tr>
<td>MW-2</td>
<td>Cc2</td>
<td>79</td>
<td>84</td>
<td>74.6</td>
<td>3</td>
<td>0.010</td>
<td>none</td>
<td>Screen in Silt (ML)</td>
<td></td>
</tr>
<tr>
<td>MW-24</td>
<td>Cc1</td>
<td>80.5</td>
<td>90.5</td>
<td>89.31</td>
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<td>0.020</td>
<td>none</td>
<td>Upper 7' of screen in sandy sand (SM) and lower 3' of screen in silt (ML)</td>
<td></td>
</tr>
<tr>
<td>MW-5D</td>
<td>Cc2</td>
<td>115</td>
<td>126</td>
<td>117.6</td>
<td>2</td>
<td>0.020</td>
<td>Infiltration</td>
<td>3.7E-06</td>
<td>Upper 9' of screen in sandy sand (SM) and lower 2' of screen in clayey silt (CH)</td>
</tr>
<tr>
<td>MW-9</td>
<td>Cc2</td>
<td>167</td>
<td>177</td>
<td>166.5</td>
<td>2</td>
<td>0.010</td>
<td>Slug Test (RH)</td>
<td>3.2E-02</td>
<td>Upper 2' of screen in gravel (GP) and lower 8' of screen in gravelly sand (SW)</td>
</tr>
<tr>
<td>MW-10</td>
<td>Cc1</td>
<td>143</td>
<td>153</td>
<td>145.27</td>
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<td>0.010</td>
<td>Slug Test (RH)</td>
<td>4.0E-03</td>
<td>Screen in sand (SP-SM)</td>
</tr>
<tr>
<td>MW-20</td>
<td>Cc2</td>
<td>127.7</td>
<td>132</td>
<td>123.98</td>
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<td>0.020</td>
<td>none</td>
<td>Upper 3.8' of screen in sand (SM-SP) and lower 0.5' of screen in silt (ML)</td>
<td></td>
</tr>
<tr>
<td>MW-21</td>
<td>Cc2</td>
<td>100.6</td>
<td>110</td>
<td>107.15</td>
<td>2</td>
<td>0.020</td>
<td>none</td>
<td>Entire 9.4' screen in and (SP); silt (ML) layer directly below screen</td>
<td></td>
</tr>
<tr>
<td>MW-14</td>
<td>Cc3</td>
<td>161</td>
<td>171</td>
<td>141.91</td>
<td>2</td>
<td>0.020</td>
<td>Slug Test (FH &amp; RH)</td>
<td>2.5E-03</td>
<td>Upper 9' of screen in sand (SP-SM) and lower 1' in silt (ML)</td>
</tr>
<tr>
<td>MW-8</td>
<td>Cc3</td>
<td>168</td>
<td>178</td>
<td>177.01</td>
<td>2</td>
<td>0.010</td>
<td>Slug Test (RH)</td>
<td>1.6E-02</td>
<td>Screen in sand (SM)</td>
</tr>
<tr>
<td>MW-7</td>
<td>R</td>
<td>220</td>
<td>230</td>
<td>192.43</td>
<td>2</td>
<td>0.010</td>
<td>Slug Test (FH &amp; RH)</td>
<td>6.3E-03</td>
<td>Screen in sand (SP-SM)</td>
</tr>
<tr>
<td>MW-12</td>
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<td>170.5</td>
<td>180.5</td>
<td>142.97</td>
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<td>0.020</td>
<td>Slug Test (FH &amp; RH)</td>
<td>4.3E-03</td>
<td>Screen in sand (SP-SM)</td>
</tr>
<tr>
<td>MW-19</td>
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<td>259.5</td>
<td>269.5</td>
<td>245.35</td>
<td>2</td>
<td>0.020</td>
<td>Slug Test (FH &amp; RH)</td>
<td>7.2E-03</td>
<td>Screen in sand (SP-SM)</td>
</tr>
<tr>
<td>MW-25</td>
<td>R</td>
<td>248.5</td>
<td>262.6</td>
<td>244.02</td>
<td>4</td>
<td>0.040</td>
<td>none</td>
<td>Screen in silty gravel (GP-GM)</td>
<td></td>
</tr>
<tr>
<td>MW-26</td>
<td>R</td>
<td>246.1</td>
<td>260.2</td>
<td>246.94</td>
<td>4</td>
<td>0.040</td>
<td>none</td>
<td>Upper 7' of screen in gravel (GW) and lower 7.1' of screen in silty gravel (GC)</td>
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</tr>
<tr>
<td>MW-33</td>
<td>Cc2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>0.020</td>
<td>none</td>
<td>Not yet drilled - testing dependent on completion</td>
<td></td>
</tr>
<tr>
<td>MW-34</td>
<td>R</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>0.020</td>
<td>none</td>
<td>Not yet drilled - testing dependent on completion</td>
<td></td>
</tr>
<tr>
<td>MW-35</td>
<td>Cc2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
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</tr>
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<td>MW-36</td>
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<td>-</td>
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<td>4</td>
<td>0.020</td>
<td>none</td>
<td>Not yet drilled - testing dependent on completion</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

Gray highlighted rows indicate wells that are proposed to be tested.

fbgs = feet below surveyed ground surface elevation relative to site datum.

K=Hydraulic Conductivity

ft/min=feet per minute

1. Unit Designations (Berryman & Henigar, 2006).

2. FH=falling head slug test, RH=rising head test

3. Static depth to water (DTW) measurements made October 31, 2008 by KCSWD personnel.

4. The water level in Cc1 was below the total depth of MW-5S when measured (10/31/08), so this well will only be tested if the water level is sufficiently high enough during time of testing.

5. Bouwer and Rice method was used for the slug test analysis. For wells with both falling and rising head test results available an average is listed here.

*Well has loose monument.
Table 3 - Wells Selected for Pressure Transducer Monitoring
Project # 090057-310.1.9, Vashon Island Landfill

<table>
<thead>
<tr>
<th>Well</th>
<th>Unit</th>
<th>Diameter</th>
<th>Minimum String Length</th>
<th>Minimum Groundwater Elevation</th>
<th>Pump Intake Elevation</th>
<th>Top of Casing Elevation</th>
<th>Top of Screen</th>
<th>Bottom of Screen</th>
<th>Screen length</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-2</td>
<td>Cc2</td>
<td>2</td>
<td>72.57</td>
<td>240.01</td>
<td>227.58</td>
<td>312.58</td>
<td>233.58</td>
<td>228.58</td>
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<td>MW-3</td>
<td>Cc1</td>
<td>3</td>
<td>40 Dry</td>
<td>272.9</td>
<td>312.9</td>
<td>277.9</td>
<td>272.9</td>
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<td>5</td>
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<td>2</td>
<td>141.41</td>
<td>168.71</td>
<td>130.62</td>
<td>310.12</td>
<td>139.62</td>
<td>129.62</td>
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<td>178.2</td>
<td>206.08</td>
<td>203.04</td>
<td>381.24</td>
<td>213.24</td>
<td>203.24</td>
<td>10</td>
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<td>MW-27</td>
<td>R</td>
<td>4</td>
<td>187.21</td>
<td>193.56</td>
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<td>180.07</td>
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<td>165.31</td>
<td>235.33</td>
<td>223.64</td>
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<tr>
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<td>R</td>
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<td>244.24</td>
<td>156.36</td>
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<td>400.6</td>
<td>141.1</td>
<td>131.1</td>
<td>10</td>
</tr>
<tr>
<td>MW-33</td>
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<tr>
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<td>R</td>
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<td>MW-20</td>
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<td>123.17</td>
<td>244.04</td>
<td>235.71</td>
<td>367.21</td>
<td>237.57</td>
<td>233.27</td>
<td>1.82</td>
</tr>
</tbody>
</table>

Note:
Gray highlighted rows indicate wells where the transducer should be placed below the pump.

ft = feet
asl = above sea level
Unit designations from Berryman & Henigar (2006).
FIGURES
Proposed Wells for Hydraulic Conductivity Testing
Vashon Island Landfill Work Plan
Vashon Island Landfill, King County, Washington
Proposed Wells for Pressure Transducer Water Level Monitoring

Vashon Island Landfill Work Plan
Vashon Island Landfill, King County, Washington

Legend:
- Monitoring Well
- Piezometer
- Gas Probe
- Spring
- Decontaminated
- N-W Grid
- Regional

Groundwater Monitoring Locations:
- Groundwater Monitoring Well
- Proposed Well for Pressure Transducer Water Level Monitoring

PHOTOGRAMMETRY BY: (3D) TECHNOLOGIES, INC. 04-26-04

PROJECT NO. 090057
FIGURE NO. 5

JAN 2015
AHP
SCC
SCC
090057
Figure 6 - Typical Well Monument Construction Diagram

- HEIGHT OF CASING = 3 FT MINIMUM
- SEE NOTE "A"
- STEEL LID CASING 1/4" - 1/8" MIN.
- END OF HINGE PIN TO BE WELDED
- 1/2" DIA. HOLE MINIMUM
- WELL CASING LID
- WELL CASING HINGE ASSEMBLY
- END VIEW
- WELL CASING HINGE ASSEMBLY
- NOTE: LID TO BE HORIZONTAL IN THE OPEN POSITION
- OUTER WELL CASING DIAMETER = 0.0
- WELL CASING DIAMETER = I.D. = 2"
- END OF HINGE PIN TO BE WELDED
- TOP VIEW
- WELL CASING HINGE ASSEMBLY

NOTE "A"
- 10" SINGLE COMPLETION OR 12" DOUBLE COMPLETION STEEL SECURITY CASING AND CAP
APPENDICES A-D