Vashon Closed Landfill Western Hillslope Investigation

March 31, 2011

FINAL

King County

Department of Natural Resources and Parks
Water and Land Resources Division
Science and Technical Support Section
King Street Center, KSC-NR-0600
201 South Jackson Street, Suite 600
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http://www.kingcounty.gov/environment/waterandland.aspx

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Prepared for:

Closed Landfill and Environmental Engineering Group
Landfill Engineering and Environmental Monitoring Unit
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Department of Natural Resources and Parks

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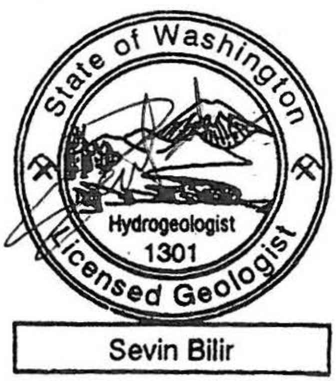
This document was prepared under the supervision and direction of the undersigned whose seal as licensed hydrogeologist is affixed below:



Sevin Bilir, L. HG. (WA)

King County
Department of Natural Resources and Parks
Water & Land Resources Division

3/31/2011

Date

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EXECUTIVE SUMMARY

In the fall of 2005, the King County Solid Waste Division (KCSWD) requested that the Groundwater Group, Water and Land Resources Division provide hydrogeologic services for the Vashon Closed Landfill (VCL) located on the western side of Vashon Island, WA. The specific scope was to provide field investigations along a hillslope, located downgradient of the VCL property. Previous investigations had indicated improving the understanding of the location of outcrops on the hillslope and to correlate, if possible, to hydrogeologic units underlying the VCL.

This scope of work included reconnaissance of approximately 13 acres of steep and muddy hillslopes to refine Unit C outcrops. Due to the increase in field activities on the hillslope, a basic Health and Safety Plan was prepared for different activities to reduce risk of injuries, exposure to contaminants, and potential liability costs to KCSWD.

The following sequence is the current understanding of the hillslope sediments from the top of the hill near the landfill to west of the KC property: Unit A, Unit B, Cc1, Cf, Cc2, Cf, Cc3, Cf, and Unit D. Three additional boreholes were completed as monitoring wells on the hillslope to help correlate the central and southern hillslope areas to the units beneath the VCL. Sediments and saturation encountered during the well installations were as expected.

Saturation of the study area is widespread and was observed to be consistent over the period of this investigation. In summary, there was no saturation observed in the Cc1 outcrops. In the southern areas of the western hillslope, where steep slopes were not traversed, it could not be observed whether there was saturation of Cc1. The coarse-grained unit Cc2 appears to be the source of the daylighting groundwater. Saturation in Cc3 and Unit D was observed. However, due to surface water from uphill portions of the study area, it was not clear what portion was possibly seeping groundwater.

There were elevated values of conductance and volatiles at some of the seepage areas and stream/weir sampling points. Chemical analysis and field water quality data of these hillslope seeps and well locations showed that the source water is likely the same as the groundwater samples collected from monitoring wells in the Cc2 perched zone underlying the landfill.

Saturation in Cc3 and Unit D was observed. However, due to surface water from uphill portions of the study area, it was not clear what portion was possibly seeping groundwater.

Upon completion of the site wide monitoring network evaluation, continued sampling at seepage and stream areas may be recommended. Locations will depend upon results of the site-wide evaluation. Due to the temporary design of the seepage samplers, it is recommended than the samplers be removed and replaced if continued sampling occurs upon completion of the site wide monitoring network evaluation. Minor recommendations are made for changes in sampling parameters and locations upon continued sampling.

Should further studies occur on the hillslope, continued maintenance is recommended due to constant downed trees in sampling and trail areas, slope erosion, changing stream locations, and annual growth of the nettle and berry bushes along the sampling and trail areas.

1.0. INTRODUCTION

1.1 Overview & Objectives

In the fall of 2005, the King County (KC) Solid Waste Division (SWD) requested that Water and Land Resources Division (WLRD) provide hydrogeologic services for the Vashon Closed Landfill (VCL) located at 18910 Westside Hwy SW on the western side of Vashon Island, WA (Figure 1).

The specific request was to provide field investigations along a western facing hillslope, downgradient and west of the VCL (Figure 1). Previous investigations recommended evaluating the location of outcrops on the hillslope and to correlate them to the hydrogeologic units underlying the VCL footprint.

The first scope of work (Appendix A; KCWLRD, 2006b) was focused on the western hillslope. The scope of work results in geologic maps and cross sections for the western hillslope, with correlations of hillslope outcrop units to the underlying units at VCL. This document was submitted to assist KCSWD in evaluating the potential for impacts to the areas within and adjacent to the VCL property while taking into consideration the previous efforts and present understanding of contaminant transport modes at the property. As a result of these initial results, there is a better understanding of the spatial orientation of saturation and outcrops on the hillslope and identification of these areas with respect to property lines. Recommendations were proposed and presented in a second scope of work (KCWLRD, 2006b).

The second scope of work proposed to conduct further surface water and groundwater investigations in the area of the hillslope to the west of VCL to address the following questions:

- Where do the coarse grained units of Unit C (Cc1, Cc2, and Cc3) outcrop on the hillslope?
- Is there any saturation in the Cc1 outcrop, if present?
- What water source is being sampled at sampling weirs SW-W1, SW-W2 and SW-W3?

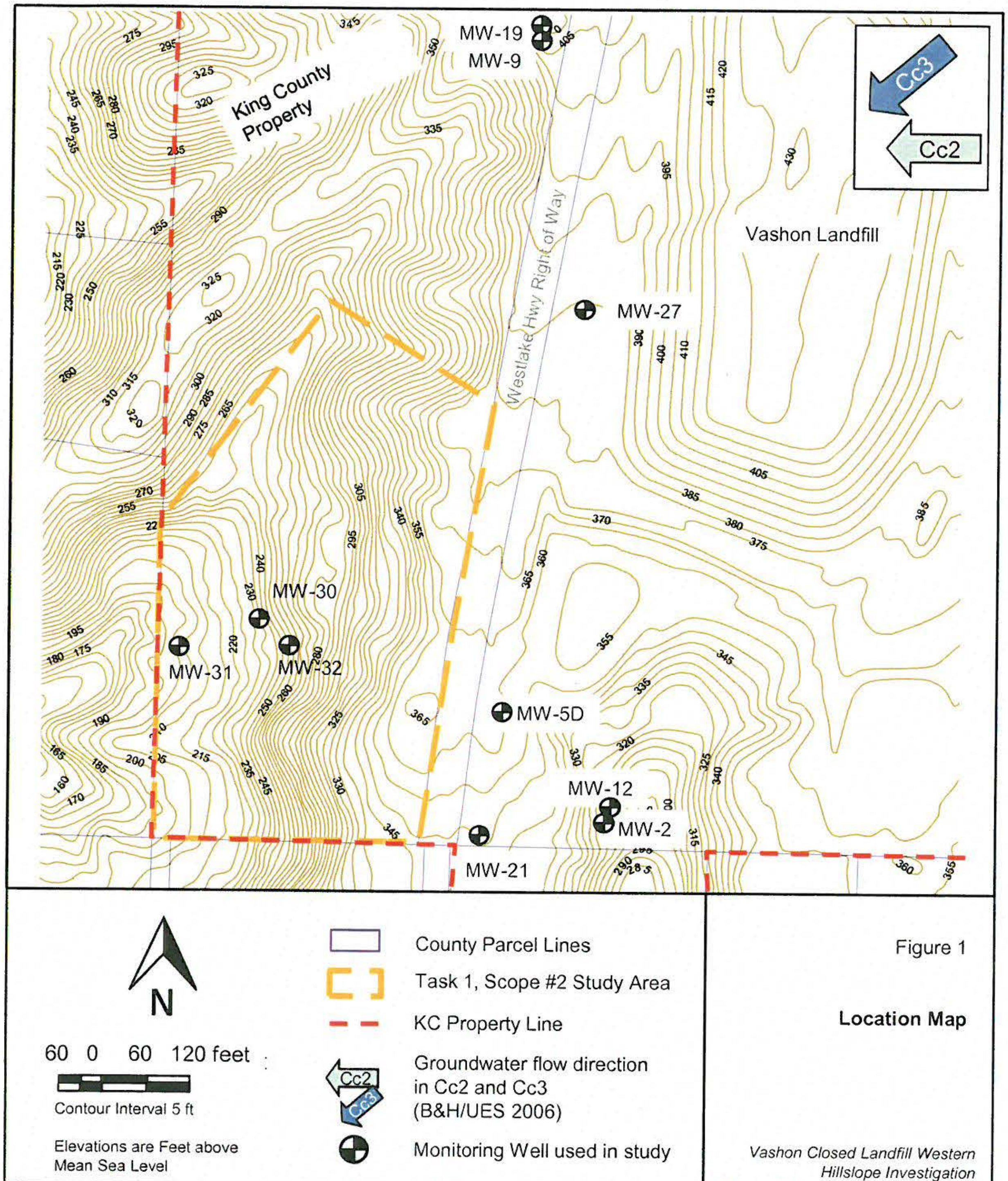
The objectives of the Task#1 Work Plan (KCWLRD, 2006b) were to redesign and install seepage and stream/weir sampling arrays, design a discharge measurement plan, install wells onsite at the hillslope, and conduct a water sampling program for the weirs, seepage samplers and wells over a period of one year upon installation.

1.2 Scope of Work

1.2.1 Surface Water Discharge & Water Quality

In order to define the local flow regime for the surface and groundwater on the hillslope, discharge rates of streams flowing offsite were collected. A new and larger weir array was installed along streams exiting the property along the hillslope. Discharge measurements and water quality sampling were conducted at each location upon installation for a period of one year in order to observe any seasonal changes. The array, frequency goal, and analytes were reevaluated after reviewing one year of data. Due to inclement weather or scheduling conflicts, some monthly discharge measurements were missed.

Figure 1. Location Map



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1.2.2 Investigation for Potential Offsite Impacts to the West

In order to refine the hydrostratigraphic model and assist in answering questions related to further defining the potential for offsite impacts, three wells were installed on the hillslope on KC property. The main objective is to correlate the Cc2 and Cc3 outcrops in the central and southern hillslopes with the units beneath the VCL.

Upon completion of well installation, water quality parameters were measured and groundwater samples collected for chemical analysis for a period of one year in order to observe any seasonal changes.

1.3 Setting

The VCL is located on a 141-acre parcel in the west central portion of Vashon Island. Groundwater monitoring at the landfill has occurred since 1986 (KCSWD, 2010). Most of the property exists in sparsely to wooded, gently rolling terrain at elevations of 150 to 400 feet. The western hillslope of the property (located west of Westside Highway) is undeveloped, forested land that slopes steeply towards Colvos Passage to the west.

The hydrogeology at the VCL has been previously characterized as presented and referenced the following latest reports:

- *Vashon Island Landfill Draft Hydrogeologic Report, (*B&H/UES). 1999
- *Vashon Island Landfill Hydrogeologic Report Update, (*B&H/UES). 2004.
- *Vashon Island Closed Landfill 2009 Annual Groundwater Data Evaluation Report,* (KCSWD). 2010.

The Vashon Island Hydrogeologic Report Update (B&H/UES, 2004) outlined geologic Units A through G beneath the landfill (see Figures 25-28). Unit C is a lacustrine silt interpreted to be laterally continuous beneath the property and incised by three distinct fluvial sand and gravel channel deposits (Cc1, Cc2 and Cc3). Perched saturated zones identified beneath the VCL property occur in channel deposits Cc1 & Cc2 within the uppermost lacustrine silt (Unit C). Groundwater in the deeper saturated zone occurs in sands and gravels within the lowermost Unit Cc3 channel deposits and within Units D and F. This deeper Cc3 saturated zone was reported as hydraulically continuous with the regional aquifer (B&H/UES 2000 and 2004). Units D and F are generally separated by an aquitard (Unit E).

Geologic cross-sections of the landfill show the relationship of the geologic units beneath the property and the identified water-bearing zones (B&H/UES, 2004). Channel Cc2 and the regional aquifer are the only water bearing units with sufficient information to produce potentiometric maps. In order to simplify this document, interpretations by Berryman & Henigar, Inc. (B&H) and Udaloy Environmental Associates (UES) (B&H/UES) are assumed to be correct. The current understanding of the hydrogeologic setting at the landfill is presented in recent reports by UES that are listed in Section 5.0 References.

The direction of regional groundwater flow within the Principal Aquifer in the vicinity of landfill is generally westward. The direction of groundwater flow within the regional aquifer is indeterminate, with flow components potentially northward, westward and southward. Recharge of this Principal Aquifer occurs from infiltration of rainwater through the till (KCSWD, 2010).

2.0. FIELD ACTIVTIES

2.1 Health and Safety Communication

Health and safety plans (H&S Plan) were prepared to assist in injury prevention and to reduce exposure to impacted soils and groundwater. Personnel that worked on the hillslope were given a copy of the H&S Plan and were briefed for each visit and updated on any changes. A copy of each plan prepared for this study is presented in Appendix B.

When this study began, most of the hillslope was highly vegetated and there were no trails. It was difficult to see the sediment, hillslope changes, potential seeps, property lines and changes in sediment. At this time, there are many established trails and the visibility of the area and the safety of accessing the hillslope is much improved. Continual maintenance of the trails and sampling areas was required due to tree falls, slope erosion, changing stream locations, and annual growth of the nettle and berry bushes.

2.2 Sampling Array Design & Installation

In order to enhance the characterization of the water chemistry and discharge rates for the hillslope seepage area, the sampling array was improved. A new sampling array was installed along the western hillslope as per the recommended locations included in the report for SOW#1 (KCWLRD, 2006b), shown in Figures 2a and 2b.

2.2.1 Weirs

A new stream/weir sampling and discharge measurement array was installed on September 19, 2006. Weirs at SW-W2 and SW-W3 were replaced at the same locations with updated weirs. Four additional weirs (SW-W4, SW-W5, SW-W6, and SW-W7) were installed in the downstream portions of the seepage areas and upstream of the KCSWD property lines (Figures 2a and 2b). A stream location just about 30 feet north of weir SW-W3, identified as SW-14E in this report, was sampled once for comparison to data from SW-W3.

Due to high precipitation events and constant flow at each weir, upkeep of each weir was necessary to main the weir structure. It was often necessary after high precipitation events to clean out the weir and improve the supports around the weir.

2.2.2 Seepage Samplers

Along the hillslope to the west are several focused groundwater seepage areas. Previous studies indicated that groundwater appears to be daylighting on the hillslope from outcropping units of Cc2 and Cc3 (KCWLRD, 2006a). A seepage sampling array was designed and seepage samplers installed at six locations on the uphill area of the saturated area on the western hillslope (Figures 2a and 2b) in January 2007. These samplers are temporary and were designed to last the duration of the study. Figure 3 shows the design for the seepage samplers (SW-S1, SW-S2, SW-S3, SW-S4, SW-S5, and SW-S6) and location of the screen with respect to the seep. An additional seepage location (SW-24S) was maintained as a water quality sampling location sampling directly from the surface water.

Figure 2a. Sampling and Well Installation Locations

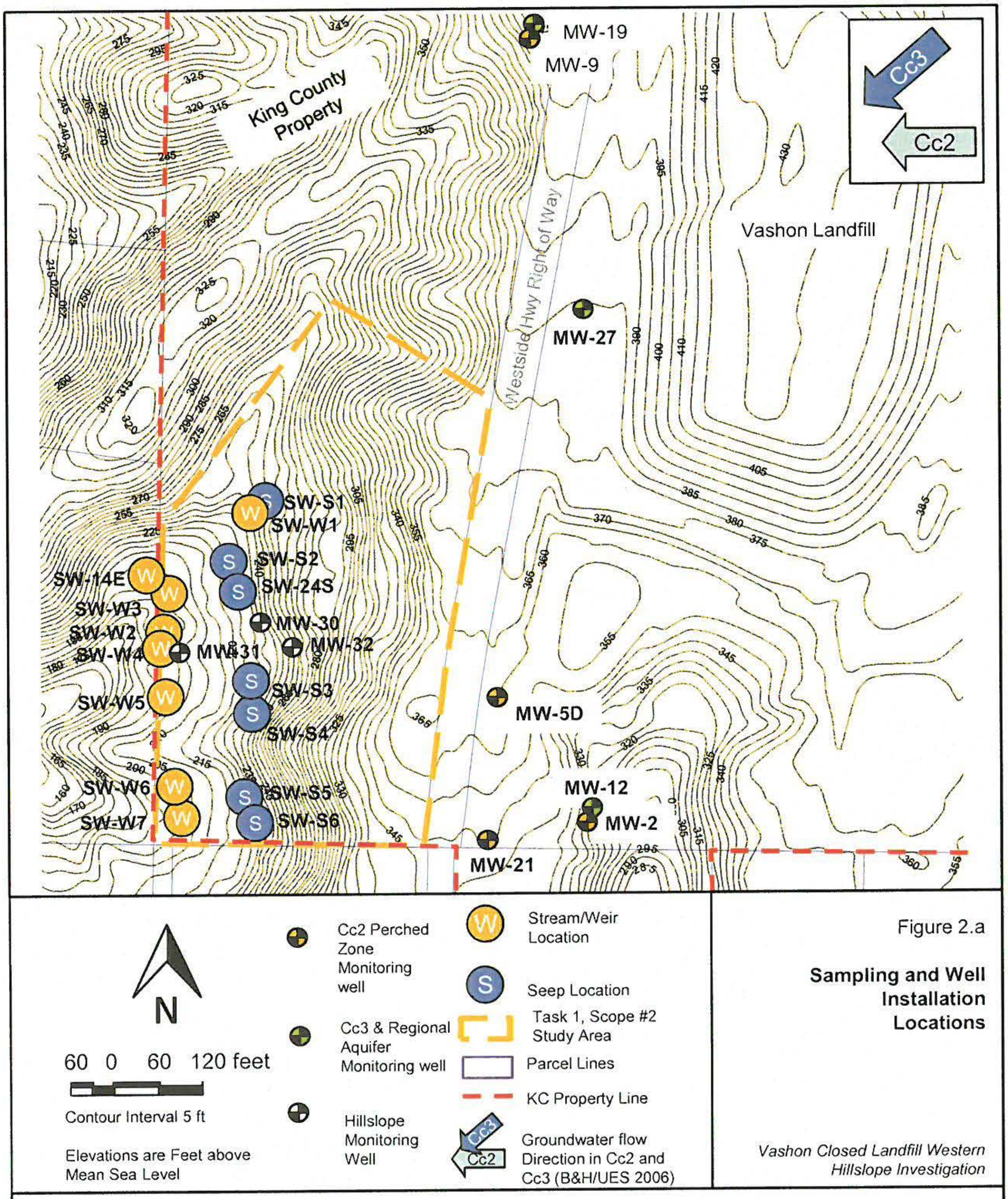

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Figure 2b. Sampling and Well Installation Locations

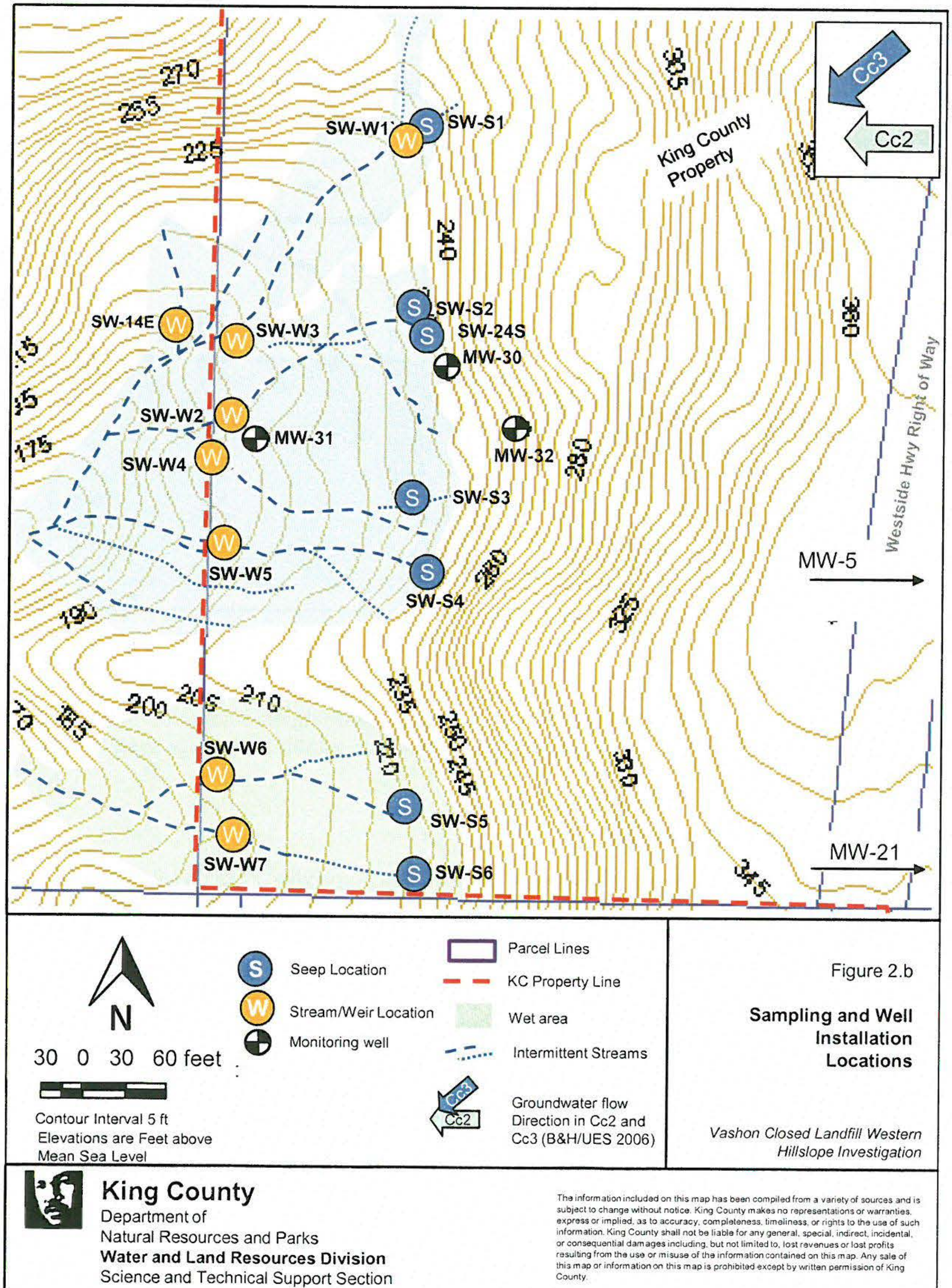
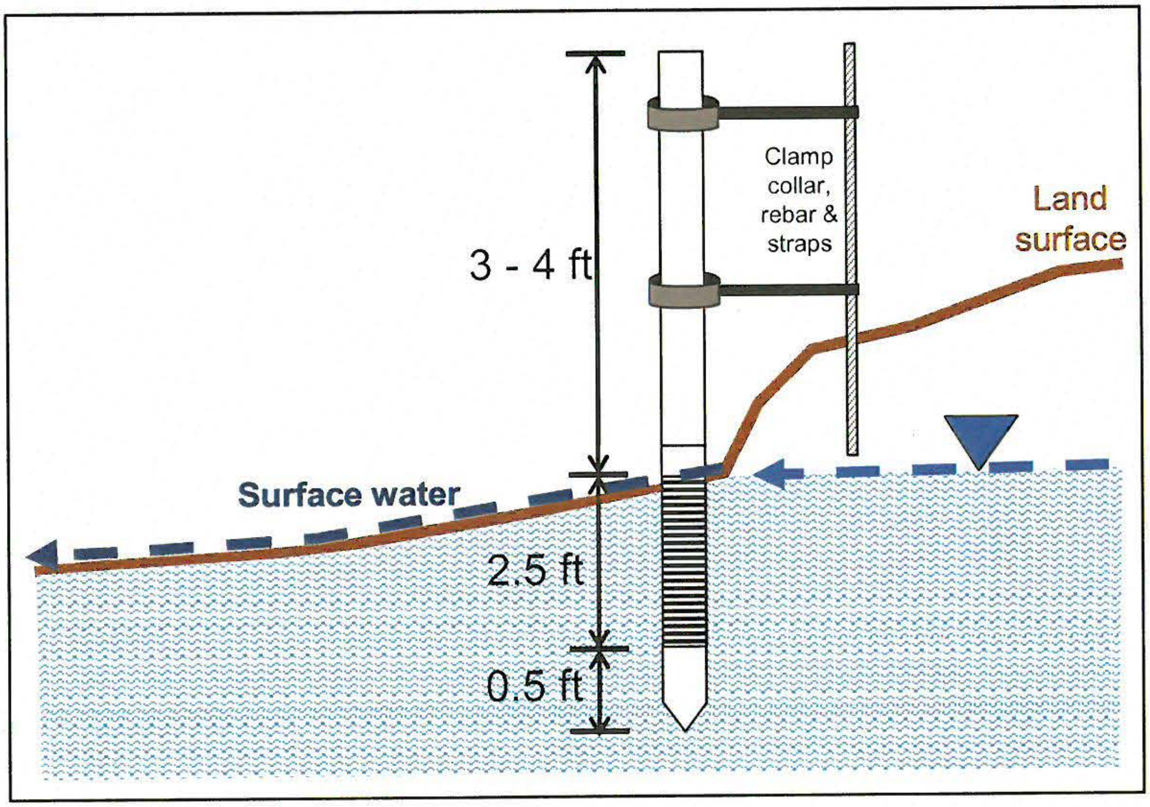


Figure 3. Seepage Sampler Design



Since installation, sediments have been building up in samplers, reducing the casing volume for sampling. Lower flow rates are often necessary to reduce disturbing the sediment. Some of the samplers appear to have iron oxidation staining on them, most notably at seepage sampler SW-S2.

2.2.3 Well Installations

The work plan for well installation activities is presented in Appendix D (KCWLRD, 2009). Three boreholes were hand augered with monitoring wells installed at each location in December 2009. Actual locations differ from the proposed locations due to field conditions. However, the same water bearing zones were targeted for the screened interval as planned for that corresponding well. Lithologic data was recorded during augering activities. A technical memorandum (KCWLRD, 2010) summarizing these activities was submitted to KCSWD and is included in Appendix B. Pictures of well installation activities are included in Appendix D.

Monitoring well MW-32 could not be installed any deeper due to the limitation of the augering equipment. Due to constant hillslope erosion and the steep slopes, each monitoring well was installed with a floating wood platform to improve safety for the personnel sampling at the well. These platforms are temporary and required some maintenance to ensure improved safety.

2.3 Surface Water Discharge

Discharge measurements at all weirs were taken on a monthly basis. Appendix E.1 includes pictures of discharge field measurements.

2.4 Water Quality Field Testing & Sampling

Field parameters and water samples were collected at all sampling locations on a quarterly basis. Table 1 is a table of the sampling analyte program for all locations. Field sheets for each location are presented in Appendix F. Chain-of Custody procedures were followed and forms are presented in Appendix G.

An Orion 105A+ Meter was used to measure Specific Conductance (μs) and temperature (°C) in the field (Orion Research, 2000a). An Orion 230A+ Meter was used to measure pH, temperature, and oxidation reduction potential (Orion Research, 2000b). A YSI 85 was used to measure dissolved oxygen (% and mg/L), pH, temperature and specific conductance in the field (YSI, 1998).

Field water quality data and samples from the western hillslope were taken by KCWLRD and KCSWD personnel. Field water quality data and samples from monitoring wells more adjacent to the landfill were taken by KCSWD samplers.

Sampling procedures followed for all sampling were as per the *Environmental Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan for Vashon Island Closed Landfill* (KCSWD, 2006).

2.5 Surveying

Sampling and seepage locations were marked and surveyed by a KC surveyor. This field event required preparation of maps for the surveyor, serving as a field assistant, and clearing the line-of-sight between control points. Due to difficulties in clearing brush, some locations were measured from a surveyed location. A few locations were estimated due to the distance from any surveyed location. The locations survey data is included in Table 2.

3.0. RESULTS

3.1 Surface Water Discharge

Surface water discharge results from weirs SW-W2 to SW-W7 were measured between November 2006 and November 2010 (Appendix E and Table 3). Field measurements are presented in Appendix E. Maximum, median, average and minimum for the entire data collection period are presented for each weir. Rates are graphed against daily accumulated precipitation data collected from King County Gauge 28Y located at the VCL. The range of total gallons per day are as follows:

	DAILY TOTAL (gpd)			
	Maximum	Minimum	Median	Average
SW-W2	91,258	8,673	11,418	15,529
SW-W3	123,037	5,843	9,094	14,192
SW-W4	91,258	8,673	13,473	31,720
SW-W5	78,399	3,467	12,020	13,586
SW-W6	27,722	1,803	2,686	3,802
SW-W7	105,458	17,023	22,465	26,055

~105,000 gpd 0.16 cfs

Figure 4 is a graph of the entire data collection time period for all weirs. Two high rates were recorded at all weirs in December 2007 and November 2010. Weir SW-W7 was recorded consistently at higher rates (more than 10 gpm) than all other weirs. Weirs SW-W2, SW-W3, and SW–W5 consistently recorded in a mid-range (~2 to 15 gpm). Weirs SW-W4 and SW-W6 consistently recorded lower rates (less than 3 gpm).

Figures 5 to 10 are graphs of discharge rates at weirs SW-W2 to SW-W7, respectively. Because the data between weirs vary widely, these individual graphs show data within the data range for each weir. All graphs appear to mimic precipitation events, even with only collecting monthly data.

3.2 Water Quality

This section presents the evaluations on the field water quality and lab analytical surface water and groundwater quality data collected from the western hillslope sampling locations and from a few representative wells from the landfill. The landfill wells discussed in this report are representative of the Cc2 perched water bearing zone and from the Cc3 & Regional aquifer zone.

All western hillslope data, May 2007 through December 2010, are considered in this report to assist in evaluating the correlation between water quality beneath the landfill with that at the western hillslope. Ground water monitoring data at the landfill are from January 2000 through December 2010.

Table 4 is the listing of water quality standards for the Federal Drinking Water Standards (FDWS) (40 CFR 141 & 143) and the Groundwater Quality Criteria (GQC) (173-200 WAC). These standards are used for comparison of the data results for this study.

Figure 4. Average Discharge Rates at Weirs vs. Precipitation

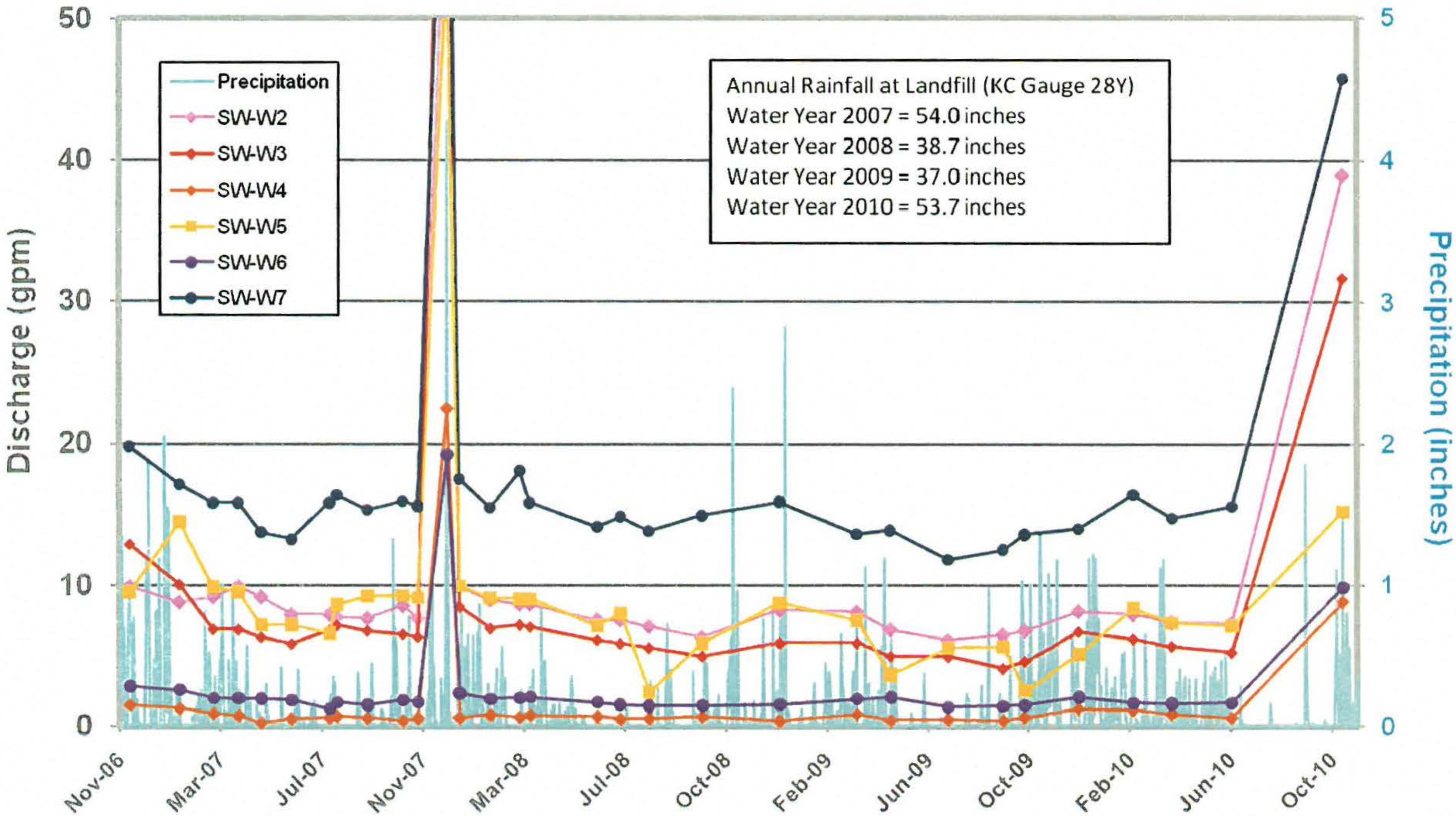


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Figure 5 SW-W2 Discharge Rates vs. Precipitation

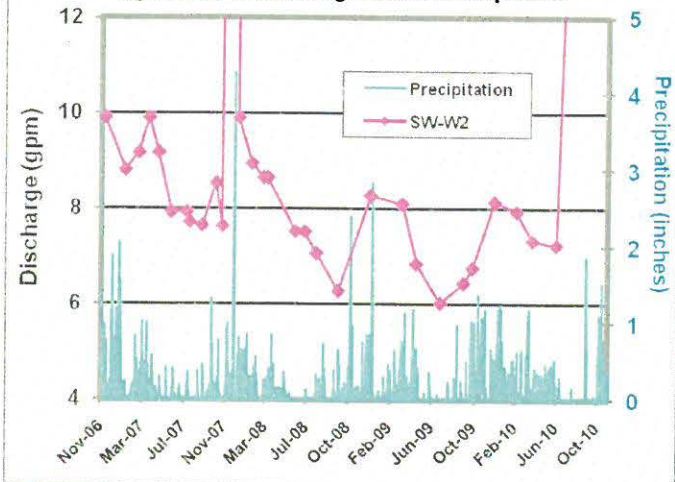


Figure 6 SW-W3 Discharge Rates vs. Precipitation

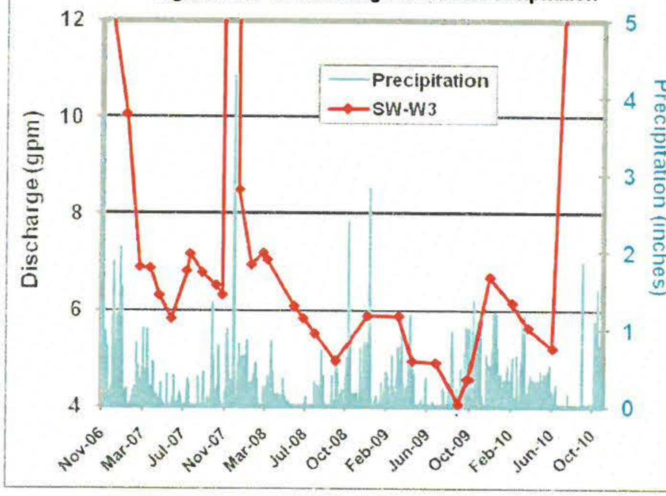


Figure 7 SW-W4 Discharge Rates vs. Precipitation

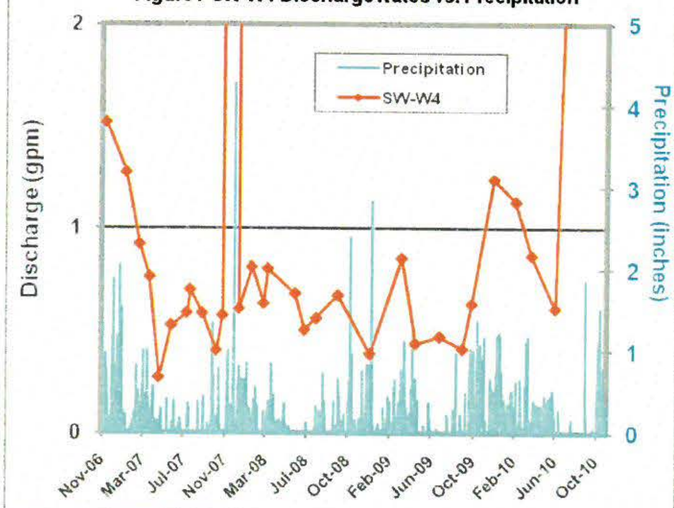


Figure 8 SW-W5 Discharge Rates vs. Precpitation

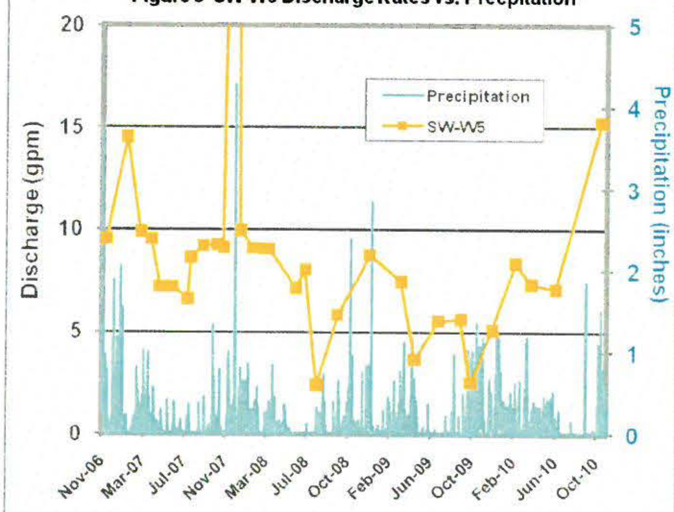


Figure 9 SW-W6 Dishcarge Rates vs. Precipitation

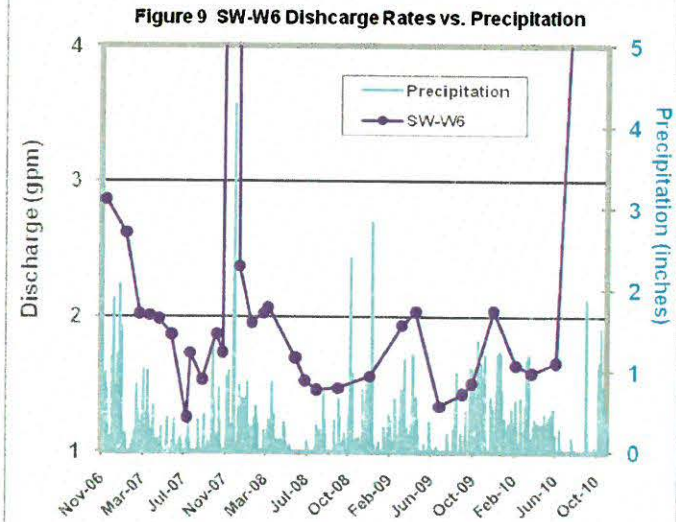
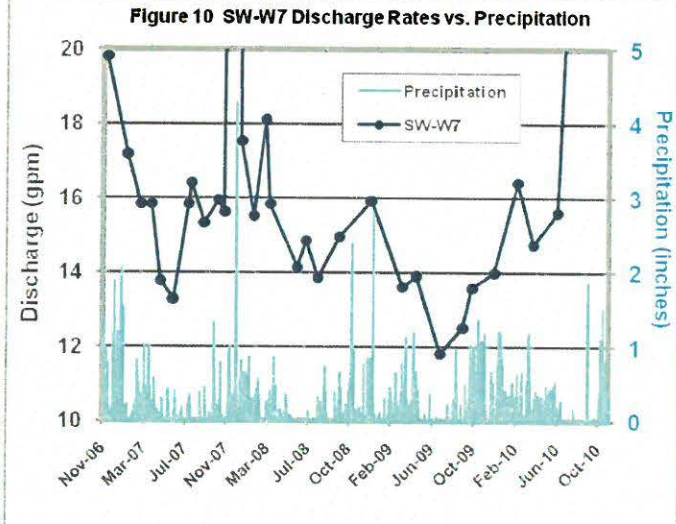


Figure 10 SW-W7 Discharge Rates vs. Precipitation



Ion balance calculations are shown in Appendix H. Data tables are included in Appendix M and times series plots are included in Appendix L. Non-detects are considered as half their method detection limit for the sake of plotting data.

As discussed in Sections 1.2.1 *Surface Water Discharge* and 1.2.2 *Investigation of Potential Offsite Impact to the West*, the main objective is to correlate the Cc2 and Cc3 outcrops in the western hillslope with the geologic and water bearing units beneath the VCL and assist in answering the questions related to offsite transport in this area. This section will present the central and southern hillslope data in comparison to monitoring well data from the landfill area.

3.2.1 Field Water Quality

Seeps/seepage samplers (SW-24S, SW-S1 to SW-S6), streams at weirs (SW-14E, SW-W1 to SW-W7), groundwater from hillslope monitoring wells (MW-30 to MW-32), groundwater from Cc2 perched water bearing zone monitoring wells on the landfill (MW-2,MW-5D, MW-9, and MW-21), and groundwater from Cc3 & Regional aquifer zone monitoring wells on the landfill (MW-12, MW-19, MW-27) were tested for field water quality parameters. Testing locations are shown in Figure 2.a and 2.b. Each location was field tested for conductance (µs/cm), pH (pH units), and temperature (°C). Dissolved oxygen (DO; mg/L) and turbidity (ntu) data were taken at seepage samplers and weirs.

The field water quality data (2007 – 2010) for the new hillslope locations are shown in Table 5. Appendix J is a table of all field water quality taken on both the western hillslope and the landfill sides of the property during 2000 - 2010.

3.2.1.1 Conductance

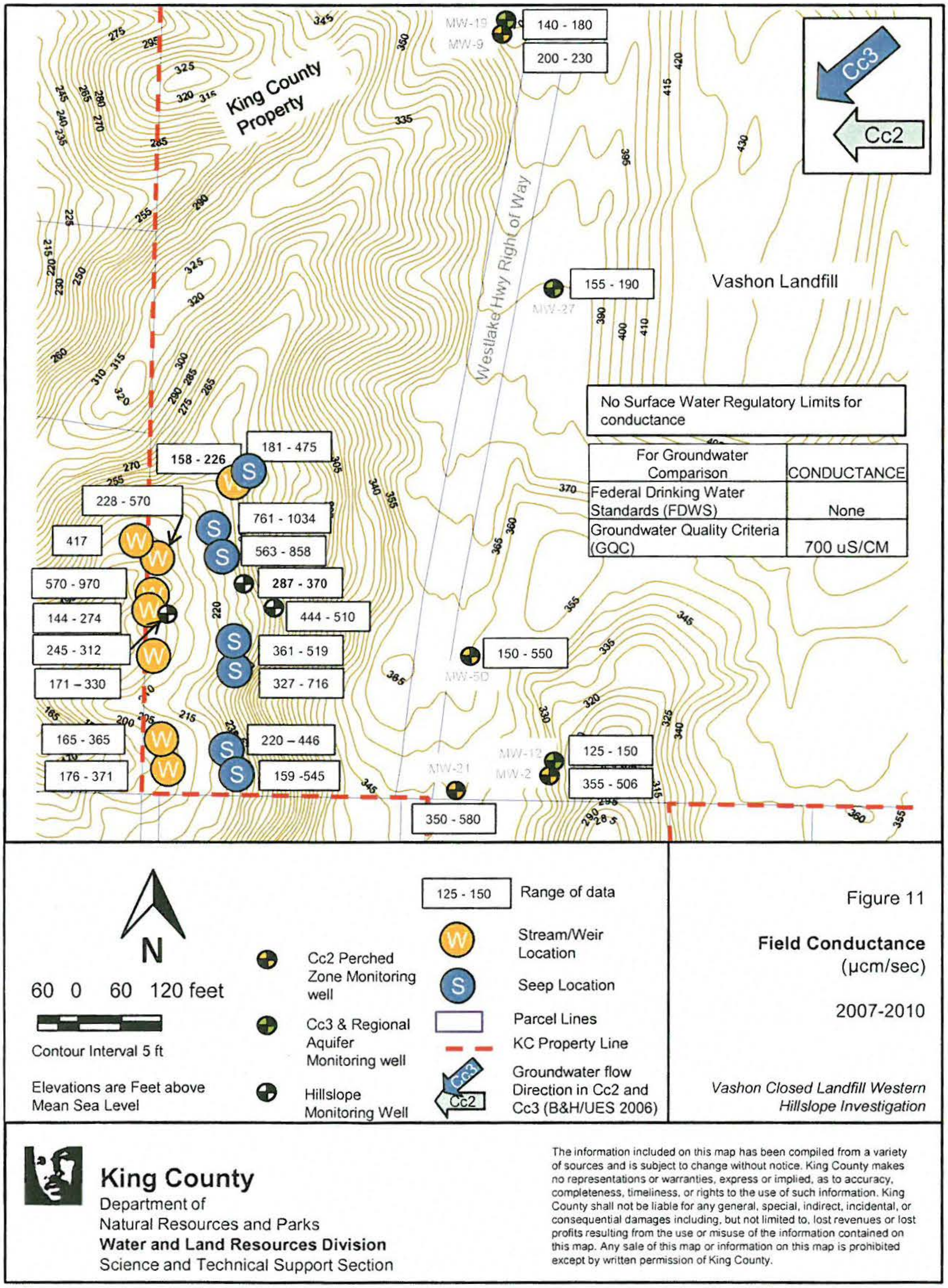
Conductance ranged between 110 and 1034 µs/cm (Figure 11; Table 5; Appendix J). Ranges of conductance (Table 5; Appendix J) measured at all locations are the following:

Western Hillslope Wells	245 to 510 µs/cm
Seeps/Seepage Samplers	158.2 to 1034 µs/cm
Streams/Weirs	144.3 to 970 µs/cm
Cc2 Perched Zone Wells	110 to 600 µs/cm
Cc3 & Regional Aquifer Wells	125 to 230 µs/cm

Elevated values (over 300 µs/cm) were located at Cc2 perched zone landfill wells MW-2, MW-5D, and MW-21; western hillslope wells MW-30 to MW-32; seeps/seepage samplers SW-24S, SW-S2 to SW-S7, and streams/weirs SW-14E, SW-W1 to SW-W3, SW-W5 to SW-W7. There are no Surface Water Quality Criteria (SWQC) calculated for the study. Only one value over the GQC of 700 µs/cm was found (MW-5D, November 2001),

Conductance at weirs are likely to be greatly affected by rainfall, mostly visible in data in the winter time period. Weirs SW-W1 to SW-W3 show an overall downward trend since 2000 (Appendix L.3 Figure 1). Conductance for new weirs SW-4 to SW-W7 fluctuate since 2007, but show no overall trend (Appendix L.3 Figure 1 to 4).

Figure 11. Field Conductance



It appears that during high rainfall events groundwater seepage from the seeps are slightly higher, likely due to flow in the soil and organic matter from uphill slopes. Highest recorded values of conductance were regularly measured at seep locations. Seep SW-24S and sampler SW-S2 show an overall downward trend in conductance since 2007 (Appendix L.3 Figures 5 to 8). Conductance at seepage sampler SW-S4 shows an overall increasing trend (Appendix L.3 Figures 6 and 8). The remaining hillslope seepage locations showed no overall trend (Appendix L.3 Figures 5 to 8).

Conductance for seeps, weirs and western hillslope wells fall within the same ranges as both Cc2 and Cc3 & Regional aquifer monitoring wells on the landfill. Due to the correlating elevations of the geologic units and the elevated values of conductance on the hillslope, these elevated locations are likely to be from groundwater on the Cc2 zone.

3.2.1.2 pH

pH at the hillslope locations ranged between 6.08 and 10.71 pH units. The FDWS and GQC for groundwater are the same for pH at a range of between 6.5 and 8.5 pH units. pH in MW-30 exceeded the FDWS and GQC in November 2010. Monitoring wells in the Cc2 perched zone and the Cc3 & Regional aquifer monitoring wells did not exceed the limits since 2000. (Table 5; Appendix L; Appendix L.3 Figures 13 to 16).

The SWQC for pH is a WA state range of 6.5 to 8.5 pH units (chronic) and Federal range of 6.5 to 9 pH units (chronic). The pH in weir samples exceeded this range in SW-W3 three times (September 2000 and 2002 and April 2010). The pH in seeps/seepage sampler samples exceeded this range a total of six times (SW-S2, SW-S3, SW-S4, SW-S5 and SW-S6).

Ranges of pH (Table 5; Appendix J) measured at all locations are the following:

Western Hillslope Wells	6.37 to 7.53 pH units
Seeps/Seepage Samplers	6.08 to 8.04 pH units
Streams/Weirs	6.5 to 10.71 pH units
Cc2 Perched Zone Wells	6.45 to 7.75 pH units
Cc3 & Regional aquifer Wells	6.54 to 8.08 pH units

pH at the weirs appears to have an overall downward trend and is generally higher than pH at both the Cc2 and Cc3 & Regional aquifer monitoring wells (Appendix L-3 Figure 9 to 12). pH for seeps mostly fall within 6.5 and 7.5 with occasional rises up to pH 8 and decreases down to pH 6 in more recent years. pH for western hillslope wells were between 6.37 and 7.53.

3.2.1.3 Temperature

Water temperatures fluctuated during and after rainfall and snow precipitation. Ranges of temperatures (Table 5; Appendix J) measured at all locations are the following:

Western Hillslope Wells	8.5 to 12.8 °C
Seeps/Seepage Samplers	6.5 to 13.8 °C
Streams/Weirs	5.7 to 17.3 °C
Cc2 Perched Zone Wells	9.1 to 12.1 °C
Cc3 & Regional Aquifer Wells	9.5 to 12.6 °C

The WA state SWQC (chronic) for temperature is 18 °C. This level was not exceeded at any time during the study period.

Even though temperatures at all hillslope locations overlap with the temperatures measured at landfill wells, there does not appear to be a correlation to either Cc2 or Cc3 & Regional aquifer.

3.2.1.4 Turbidity

Turbidity was measured at weir and seepage locations. Turbidity increased during and after rainfall and snow precipitation events.

Ranges of turbidity (Table 5; Appendix J) were the following:

Western Hillslope Wells	Not measured
Seeps/Seepage Samplers	1.28 to 158 ntus
Streams/Weirs	1.08 to 271ntus
Cc2 Perched Zone Wells	Not measured
Cc3 & Regional Aquifer Wells	Not measured

Most of the higher values at the seeps/seepage samplers were taken from seep SW-24S, where measurements are taken directly from the seep, not a seepage sampler. Turbidity was expected to be higher at this location.

The SWQC for turbidity is 5 ntus above background. This value could not be compared since there is no background calculated for the study.

3.2.1.5 Dissolved Oxygen

Dissolved oxygen (DO) was measured at weir and seep/seepage samplers (Figure 12; Table 5; Appendix J). Ranges of DO measured at the hillslope locations are the following:

	DO (mg/L)	Range of Median DO values (mg/L)
Seeps/Seepage Samplers	0.6 to 6.7 mg/L	2.7 to 6.7 mg/L
Streams/Weirs	6.1 – 17.5 mg/L	7.9 to 9.5 mg/L

The SWQC for dissolved oxygen is as below:

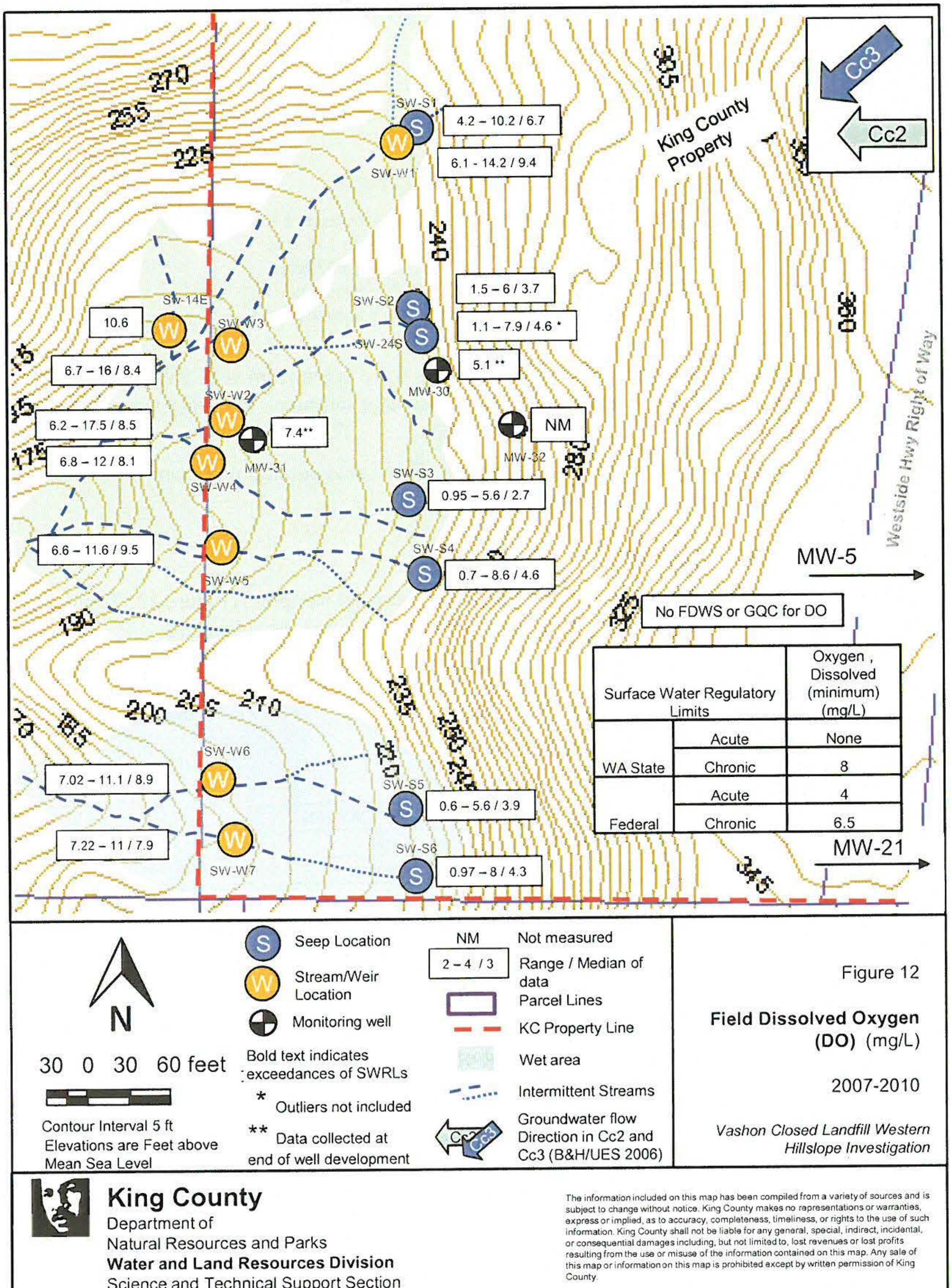
		DISSOLVED OXYGEN
Surface Water Regulatory		mg/l
WA State	Acute	None
	Chronic	8
Federal	Acute	4
	Chronic	6.5

Table 5 shows that the WA state and Federal SWQC's were often exceeded. As expected, the range of DO medians for weirs is higher than that of the seeps/seepage samplers. The DO increases as the surface water travels downhill to the weirs and is exposed to more oxygen.

3.2.2 Analytical Laboratory Results

Water samples from seeps/seepage samplers (SW-24S, SW-S1 to SW-S6), streams/weirs (SW-14E, SW-W1 to SW-W7), groundwater from hillslope monitoring wells (MW-30 to MW-32), groundwater from Cc2 perched zone monitoring wells (MW-2,MW-5D, MW-9, and MW-21),

Figure 12. Dissolved Oxygen



and groundwater from Cc3 & Regional aquifer monitoring wells (MW-12, MW-19, MW-27) were tested for metals, volatile organic constituents, and conventionals.

Testing locations are shown in Figure 2.a and 2.b. Table 3 is a listing of the sampling analyte program for this study. The analytical data for all locations are shown in Appendix M. Time series plots for analytes of interest are shown in Appendix L.

3.2.2.1 Equipment and VOA Trip Blanks

Equipment blanks were collected from tubing used during sampling of seepage samplers for dissolved metals and for tubing used to collect from seepage samplers. Table 6 lists only the metals detected during equipment blank collection. Calcium was detected at 0.018 mg/L at weir SW-W2 in April 2010. Sodium was detected at 0.961 mg/L at weir SW-W5 in July 2009. No other equipment blanks at other locations had detections.

VOA trip blanks were included with each chain of custody set including volatile analysis requests when picked up from and delivered to the laboratory. Table7 lists only the analytes detected during the sampling program for hillslope locations. Acetone, bromomethane, chloromethane, and methylene chloride were detected.

3.2.2.2 Dissolved Metals

Appendix M.1 shows dissolved metals results for all sampling locations. Time series plots of dissolved metals of interest are shown in Appendix L.1.

Dissolved Iron

Appendix L.1 Figures 1 to 5 show time series plots of seeps/seepage samplers and weirs versus the Cc2 perched zone and Cc3 & Regional aquifer. Ranges of dissolved iron measured at all locations are the following:

Western Hillslope Wells	Non-Detect to 0.056 mg/L
Seeps/Seepage Samplers	Non-Detect to 27 mg/L
Streams/Weirs	Non-Detect to 1.43 mg/L
Cc2 Perched Zone Wells	Non-Detect to 23 mg/L
Cc3 & Regional Aquifer Wells	Non-Detect to 0.42 mg/L

The FDWS and GQC for dissolved iron (0.3 mg/L) in groundwater are secondary standards. Both of these levels were exceeded at Cc2 perched zone wells MW-2, MW-5D and MW-21 and at Cc3 & Regional aquifer well MW-12 (Figure 13). There are no calculated SWQCs for dissolved iron in surface water.

Dissolved Magnesium

Dissolved magnesium data is shown in Figure 14; Appendix M.1 and in time series plots in Appendix L.1 Figures 6 to 9. Ranges of dissolved magnesium measured are the following:

Western Hillslope Wells	19.2 - 32.1 mg/L
Seeps/Seepage Samplers	12 - 82.7 mg/L
Streams/Weirs	12 - 65.1 mg/L
Cc2 Perched Zone Wells	8.37 - 43.2 mg/L
Cc3 & Regional Aquifer Wells	6.9 - 16.2 mg/L

Figure 13. Dissolved Iron

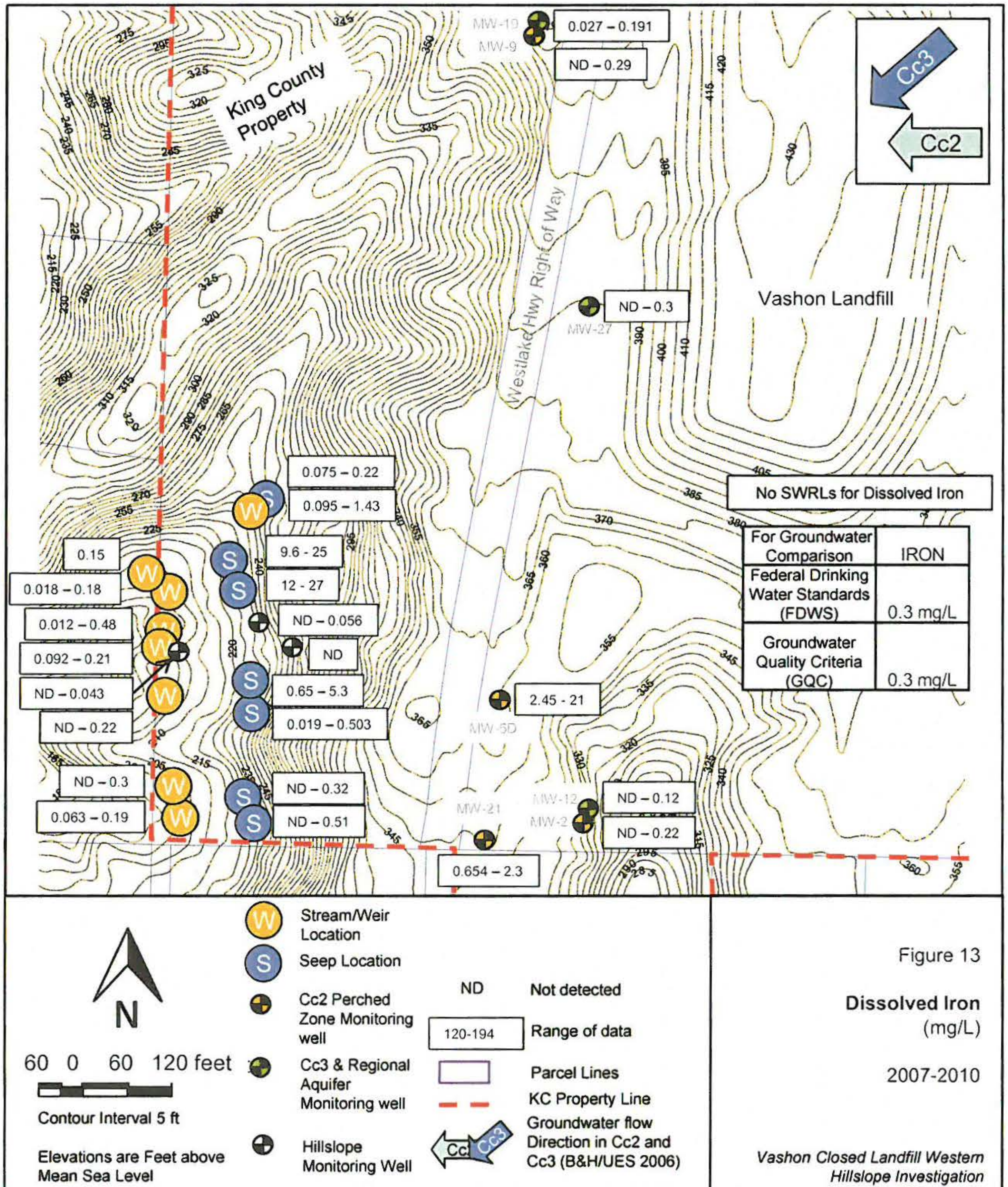


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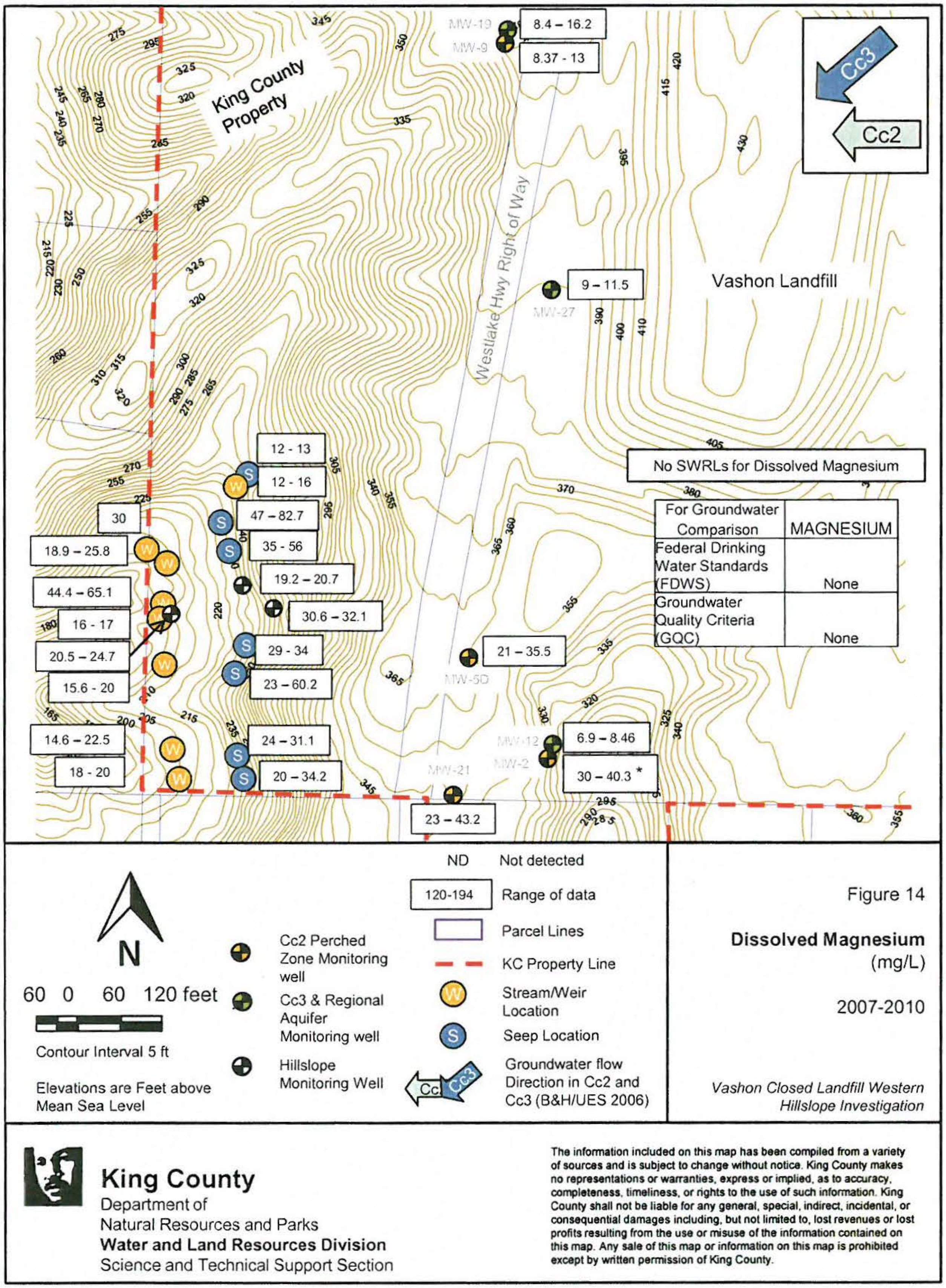
Figure 14. Dissolved Magnesium



There are no FDWS and GQC levels for dissolved magnesium in groundwater. There are no calculated SWQCs for dissolved magnesium in surface water.

Seepage samplers and weirs show an increasing trend for dissolved magnesium values. Dissolved magnesium results in hillslope samples are likely an indication of a source of groundwater from the Cc2 perched zone wells.

Dissolved Manganese

Dissolved manganese data is shown in Figure 15; Appendix M.1 and in time series plots in Appendix L.1 Figures 10 to 13. Ranges of dissolved manganese measured at all locations are the following:

Western Hillslope Wells	0.00361 - 0.0888 mg/L
Seeps/Seepage Samplers	Non-detect - 6.4 mg/L
Streams/Weirs	0.00176 - 3.18 mg/L
Cc2 Perched Zone Wells	Non-detect - 2.14 mg/L
Cc3 & Regional Aquifer Wells	Non-detect – 1.35 mg/L

The FDWS and GQC for dissolved manganese (0.05 mg/L) in groundwater are secondary standards. These levels were exceeded in groundwater samples from Cc3 & Regional aquifer well MW-19, western hillslope well MW-30 and all Cc2 perched zone wells. There are no calculated SWQCs for dissolved manganese in surface water.

Dissolved manganese in seepage samplers and Cc2 perched zone wells show a decreasing trend. With the exception of an increasing trend at SW-W1, all other weirs showed a decreasing or stable trend.

Other Dissolved Metals

The additional dissolved metals detected were aluminum, antimony, arsenic, barium, cadmium, calcium, chromium, copper, mercury, nickel, selenium, silver, tin, vanadium, and zinc (Appendix M.1). Time series plots for arsenic, calcium, potassium and sodium are shown in Appendix L.1 Figures 14 to 21.

The GQC for arsenic (0.00005 mg/L) was exceeded at all groundwater sampling locations. The FDWS (0.01 mg/L) was exceeded in Cc2 perched zone wells MW-5D and MW-21.

The FDWS and GQC for aluminum (0.05 – 0.2 mg/L) was exceeded at Cc2 perched zone wells MW-2, MW-9, MW-21 and at Cc3 & Regional aquifer wells MW-12, MW-19 and MW-27.

Where there were FDWS or GQC levels assigned to the remaining dissolved metal analytes, no exceedances were reported in groundwater samples. There are no calculated SWQCs for dissolved metals.

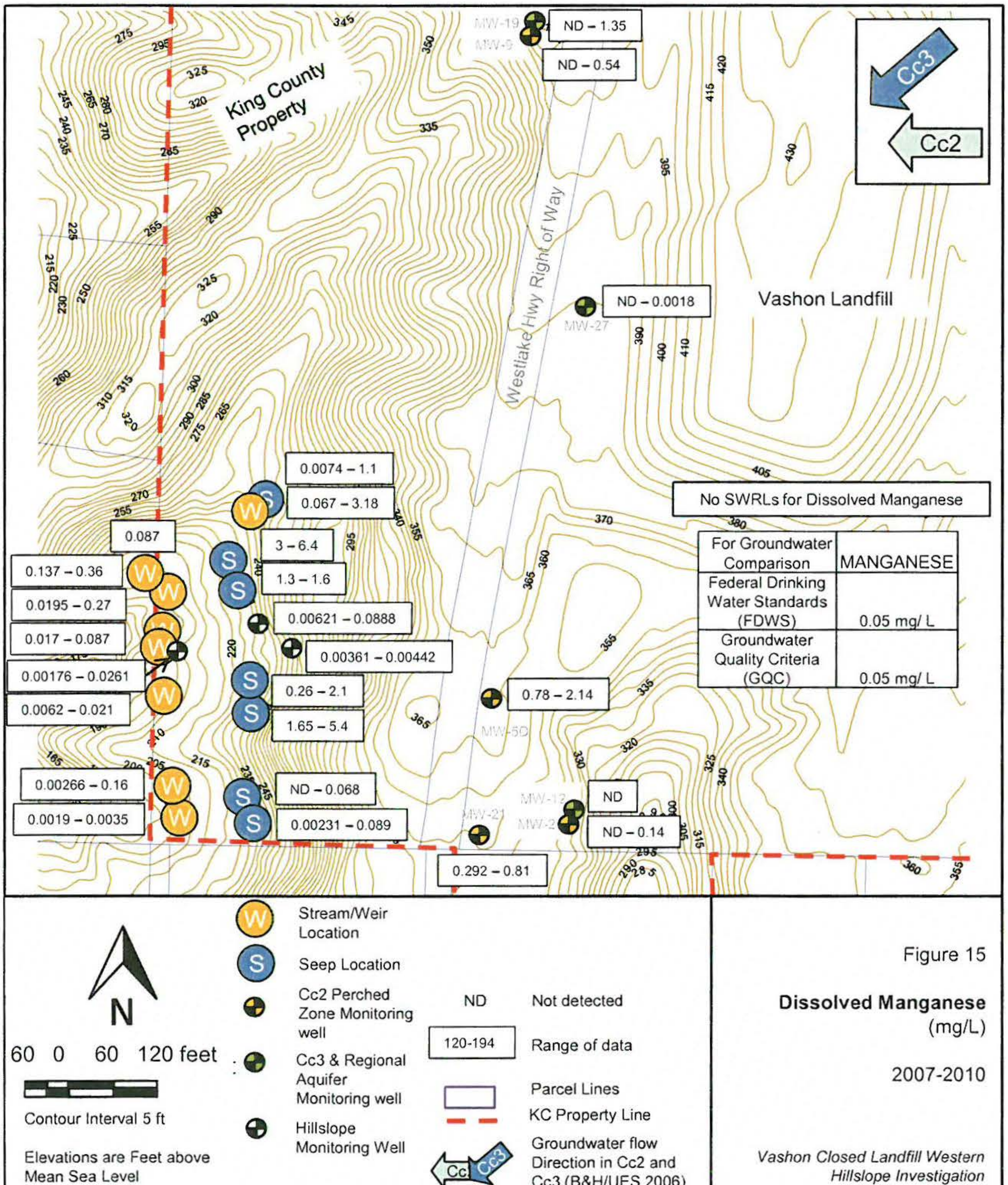
3.2.2.3 Volatiles Organic Constituents

Appendix M.2 shows volatile organic constituent detections for all sampling locations. Time series plots of volatile organic constituents of interest are shown in Appendix L.2.

Benzene

Appendix L.2 Figure 1 shows the benzene time series plot of detections at seeps/seepage samplers versus detections in the Cc2 perched zone wells. Ranges of benzene measured at all

Figure 15. Dissolved Manganese



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locations are the following:

Western Hillslope Wells	Non-Detect
Seeps/Seepage Samplers	Non-Detect to 3.2 µg /L
Streams/Weirs	Non-Detect
Cc2 Perched Zone Wells	Non-Detect to 0.42 µg /L
Cc3 & Regional Aquifer Wells	Non-Detect

The FDWS (5 µg/L) was not exceeded at any groundwater sampling locations. The GQC (1 µg/L) was exceeded at Cc2 perched zone monitoring well MW-5D. The SWQC for benzene (Federal acute level; 5300 µg/L) was not exceeded at any seepage and stream/weir sampling locations (Figure 17; Appendix M.2). Benzene detections show an increasing trend at seepage sampler SW-S2 (Appendix L.2 Figure 1).

Toluene

Appendix L.2 (Figures 2) shows a time series plot hillslope locations versus the Cc2 perched zone and Cc3 & Regional aquifer. Ranges of toluene measured at all locations were the following:

Western Hillslope Wells	0.21 – 0.485 µg /L
Seeps/Seepage Samplers	Non-Detect to 4.3 µg /L
Streams/Weirs	Non-Detect
Cc2 Perched Zone Wells	Non-Detect
Cc3 & Regional Aquifer Wells	Non-Detect – 0.946 µg /L

The FDWS and GQC of 1000 µg/L for toluene were not exceeded in any groundwater samples (Figure 16; Appendix M.2). The Federal acute SWQC of 17500 µg/L for toluene was not exceeded in any seepage or stream/weir sampling locations. Western hillslope monitoring wells MW-31 and MW-32 showed a decreasing trend of toluene in 2010.

1,2-Dichloropropane (1,2-DCP)

Appendix L.2 (Figure 3) show time series plots of detections at seeps/seepage samplers versus detections in the Cc2 perched zone. Ranges of 1,2-DCP measured at all locations are the following:

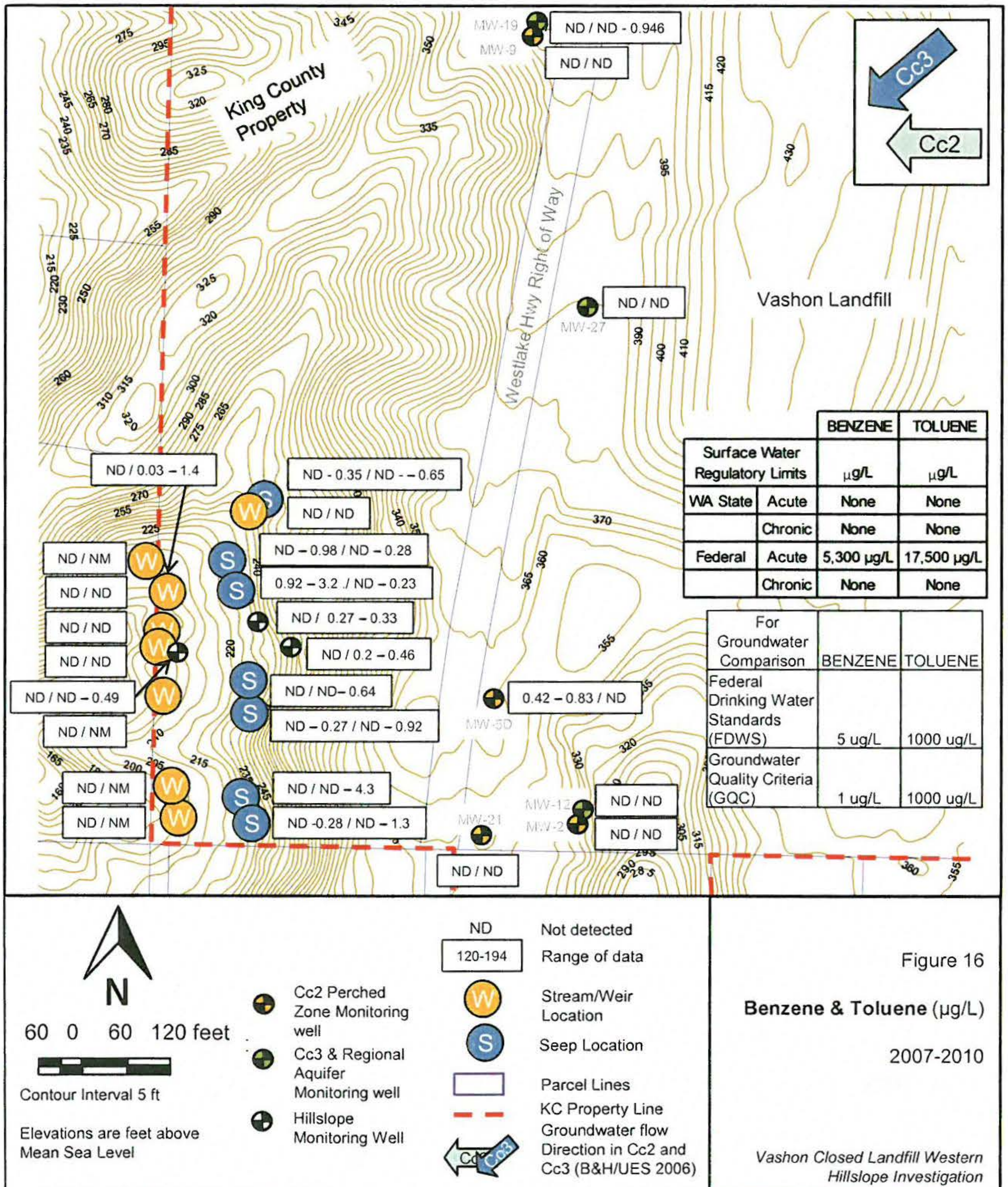
Western Hillslope Wells	Non-Detect
Seeps/Seepage Samplers	Non-Detect to 7.6 µg /L
Streams/Weirs	Non-Detect
Cc2 Perched Zone Wells	Non-Detect to 0.9 µg /L
Cc3 & Regional Aquifer Wells	Non-Detect

FDWS of 5 µg/L for 1,2-DCP was not exceeded in any groundwater samples. The Federal acute (23,000 µg/L) and chronic (5,700 µg/L) levels for 1,2-DCP were not exceeded in seepage and stream/weir sampling locations (Figure 17; Appendix M.2).

Vinyl chloride

Appendix L.2 (Figures 4 to 5) show time series plots of seeps/seepage samplers and weirs versus the Cc2 perched zone and Cc3 & Regional aquifer. Ranges of vinyl chloride measured at all locations are the following:

Figure 16. Benzene and Toluene



Surface Water Regulatory Limits		BENZENE µg/L	TOLUENE µg/L
WA State	Acute	None	None
	Chronic	None	None
Federal	Acute	5,300 µg/L	17,500 µg/L
	Chronic	None	None

For Groundwater Comparison	BENZENE	TOLUENE
Federal Drinking Water Standards (FDWS)	5 ug/L	1000 ug/L
Groundwater Quality Criteria (GQC)	1 ug/L	1000 ug/L

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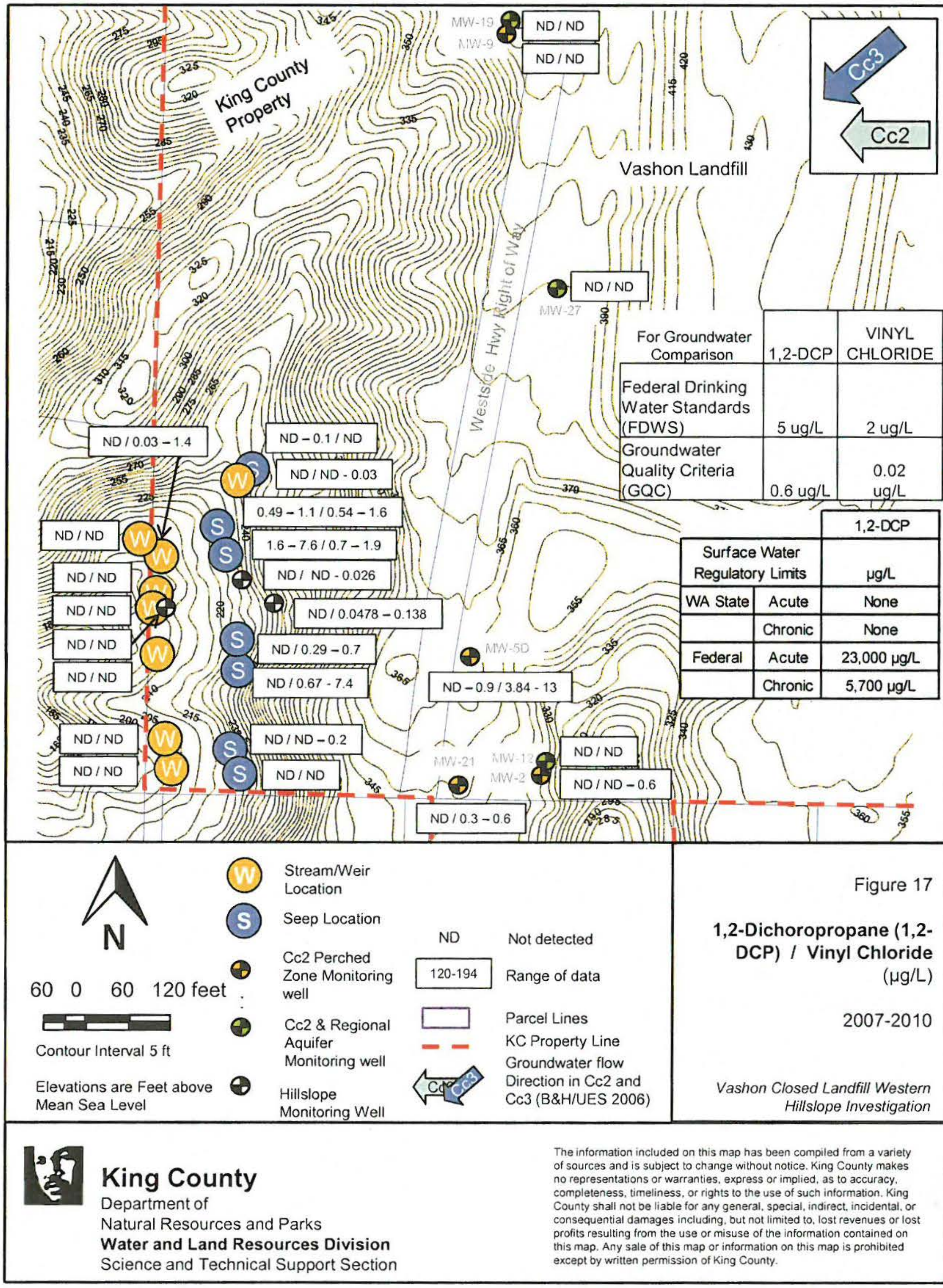
Figure 17. 1,2-Dichloropropane and Vinyl Chloride



Western Hillslope Wells	Non-Detect to 0.14 µg /L
Seeps/Seepage Samplers	Non-Detect to 7.4 µg /L
Streams/Weirs	Non-Detect to 1.4 µg /L
Cc2 Perched Zone Wells	Non-Detect to 13 µg /L
Cc3 & Regional Aquifer Wells	Non-Detect

The GQC of 0.02 µg/L for vinyl chloride was exceeded at western hillslope wells MW-30 and MW-32 and Cc2 perched zone wells MW-2, MW-5D, and MW-21 (Figure 17; Appendix M.2). The FDWS of 2 µg/L for vinyl chloride was not exceeded at any groundwater sampling locations. There are no SWQCs for vinyl chloride.

Cis -1,2-dichloroethene

Appendix L.2 (Figures 6 to7) show time series plots of seeps/seepage samplers and weirs versus the Cc2 perched zone and Cc3 & Regional aquifer. Ranges of cis-1,2-dichloroethene measured at all locations are the following:

Western Hillslope Wells	Non-Detect to 2.3 µg /L
Seeps/Seepage Samplers	Non-Detect to 2 µg /L
Streams/Weirs	Non-Detect
Cc2 Perched Zone Wells	Non-Detect to 13 µg /L
Cc3 & Regional Aquifer Wells	Non-Detect

The FDWS and GQC of 70 µg/L for cis-1,2-dichloroethene was not exceeded at any groundwater sampling locations. The Federal acute SWQC (11,600 µg/L) was not exceeded in seepage and stream/weir sampling locations (Figure 18; Appendix M.2).

Trans -1,2-dichloroethene

Appendix L.2 (Figures 8 to 9) show time series plots of seeps/seepage samplers and weirs versus the Cc2 perched zone and Cc3 & Regional aquifer. Ranges of trans-1,2-dichloroethene measured at all locations are the following:

Western Hillslope Wells	Non-Detect
Seeps/Seepage Samplers	Non-Detect to 0.61 µg /L
Streams/Weirs	Non-Detect
Cc2 Perched Zone Wells	Non-Detect to 0.48 µg /L
Cc3 & Regional Aquifer Wells	Non-Detect

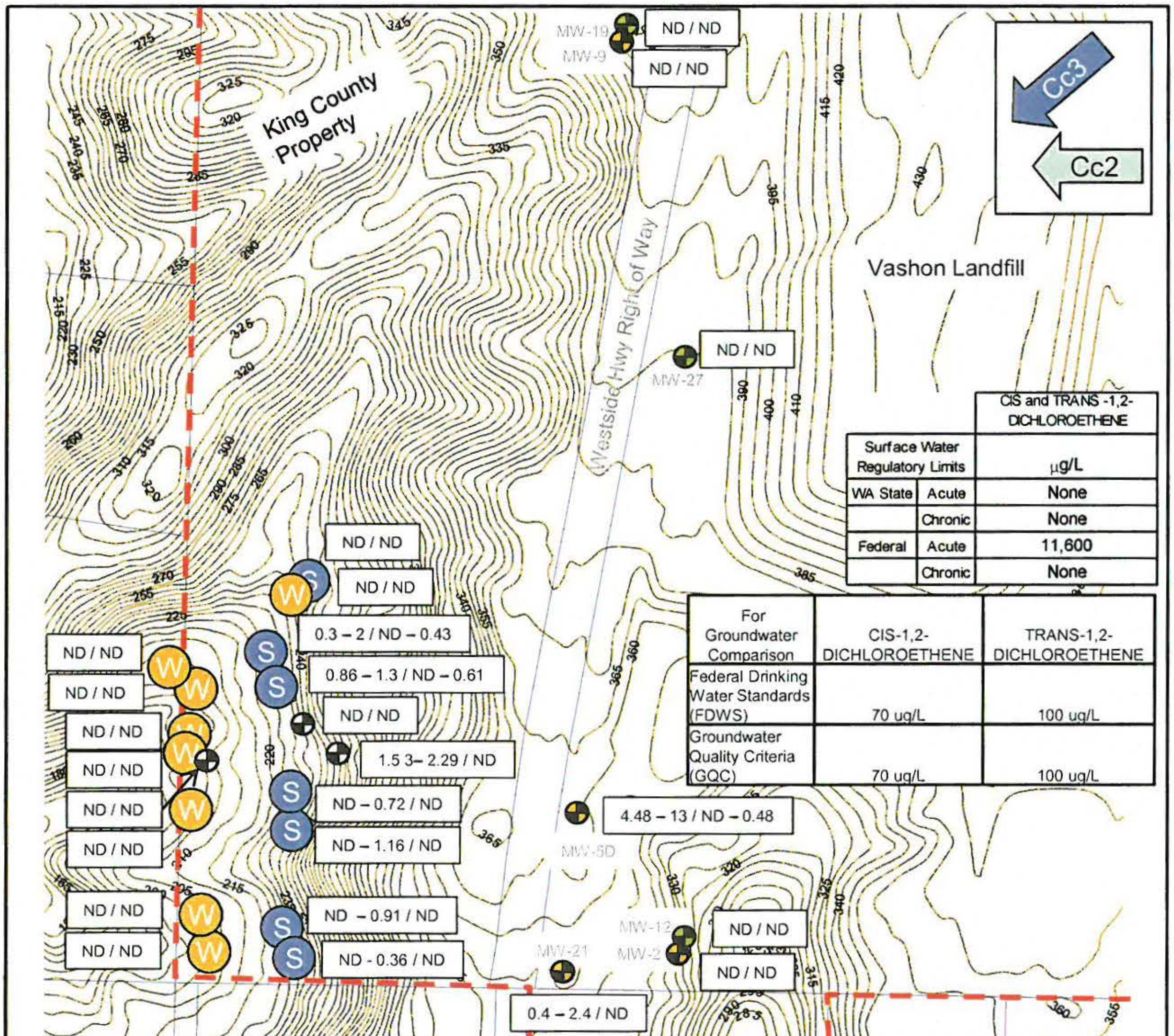
The FDWS and GQC of 100 µg/L for trans-1,2-dichloroethene was not exceeded at any groundwater sampling locations. The Federal acute SWQC (11,600 µg/L) was not exceeded in seepage and stream/weir sampling locations (Figure 18; Appendix M.2).

Other volatile organic constituents

There were several other volatiles that were detected at least once at a sampling location. The following is a list of additional volatiles detected:

1,1,1-trichloroethane	Dichlorofluoromethane & Trichlorofluoromethane
1,1-dichloroethane	Ethylbenzene
1,2- dichloroethane	M&P Xylene & O-Xylene
Acetone	Methyl iodide
Acrylnitrile	Trichloroethene
Bromomethane	Trichlorofluoromethane
Carbon disulfide	Chloromethane
Chloroethane	Chloroform

Figure 18. cis-1,2-dichloroethene and trans-1,2-dichloroethene



Surface Water Regulatory Limits		CIS and TRANS -1,2-DICHLOROETHENE µg/L
WA State	Acute	None
	Chronic	None
Federal	Acute	11,600
	Chronic	None

For Groundwater Comparison	CIS-1,2-DICHLOROETHENE	TRANS-1,2-DICHLOROETHENE
Federal Drinking Water Standards (FDWS)	70 ug/L	100 ug/L
Groundwater Quality Criteria (GQC)	70 ug/L	100 ug/L

N

60 0 60 120 feet

Contour Interval 5 ft

Elevations are Feet above Mean Sea Level

- Cc2 Perched Zone Monitoring well
- Cc3 & Regional Aquifer Monitoring well
- Hillslope Monitoring Well

- ND — Not detected
- 120-194 — Range of data
- W — Stream/Weir Location
- S — Seep Location
- Parcel Lines
- KC Property Line
- Cc2 / Cc3 — Groundwater flow Direction in Cc2 and Cc3 (B&H/UES 2006)

Figure 18

cis-1,2-dichloroethene / trans-1,2-dichloroethene

(µg/L)

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Where there were FDWS or GQC levels assigned to an analyte, no exceedances in groundwater samples were reported. Where there were SWQCs assigned to an analyte, no exceedances in seepage and stream/weir sampling locations were reported (Appendix M.2).

3.2.2.4 Conventionals

Appendix M.3 shows the conventionals data analyzed at the laboratory. Analytes listed are total alkalinity (as CaCO3), ammonia (as nitrate), chloride, hardness, nitrate, sulfate, total dissolved solids (TDS), total solids, total suspended solids and total organic carbon. Testing locations are shown in Figure 2.a and 2.b. Times series plots are shown in Appendix L.3.

Total Dissolved Solids (TDS)

TDS ranged between 58 to 720 mg/L (Figure 19; Appendix M.3; Appendix L.3 Figures 17 to 22). Ranges of TDS measured at all locations are the following:

Western Hillslope Wells	190 to 309 mg/L
Seeps/Seepage Samplers	110 to 720 mg/L
Streams/Weirs	110 to 520 mg/L
Cc2 Perched Zone Wells	58 to 351 mg/L
Cc3 & Regional Zone Wells	83 to 170 mg/L

There were no exceedances of the FDWS (500 mg/L) and GQC(500 mg/L) for TDS in groundwater samples. There are no SWQCs for TDS.

Time series plots (Appendix L.3 Figures 17 to 22) show that TDS in the Cc2 perched zone wells are less than 200 mg/L and TDS in the Cc3 & Regional aquifer zone wells are greater than 200 mg/L. Based on the TDS data, it is likely that the groundwater seeping out the seeps and flowing downstream to the hillslope weirs are from the Cc2 perched zone.

Ammonia

Time series plots (Appendix L.3 Figures 23 to 29) show ammonia (as nitrate). Ranges of ammonia measured at all locations are the following:

Western Hillslope Wells	Non detect to 0.162 mg/L
Seeps/Seepage Samplers	Non detect to 1.3 m
Streams/Weirs	Non detect to 0.11 mg/L
Cc2 Perched Zone Wells	Non detect to 0.31 mg/L
Cc3 & Regional Zone Wells	Non detect to 0.21 mg/L

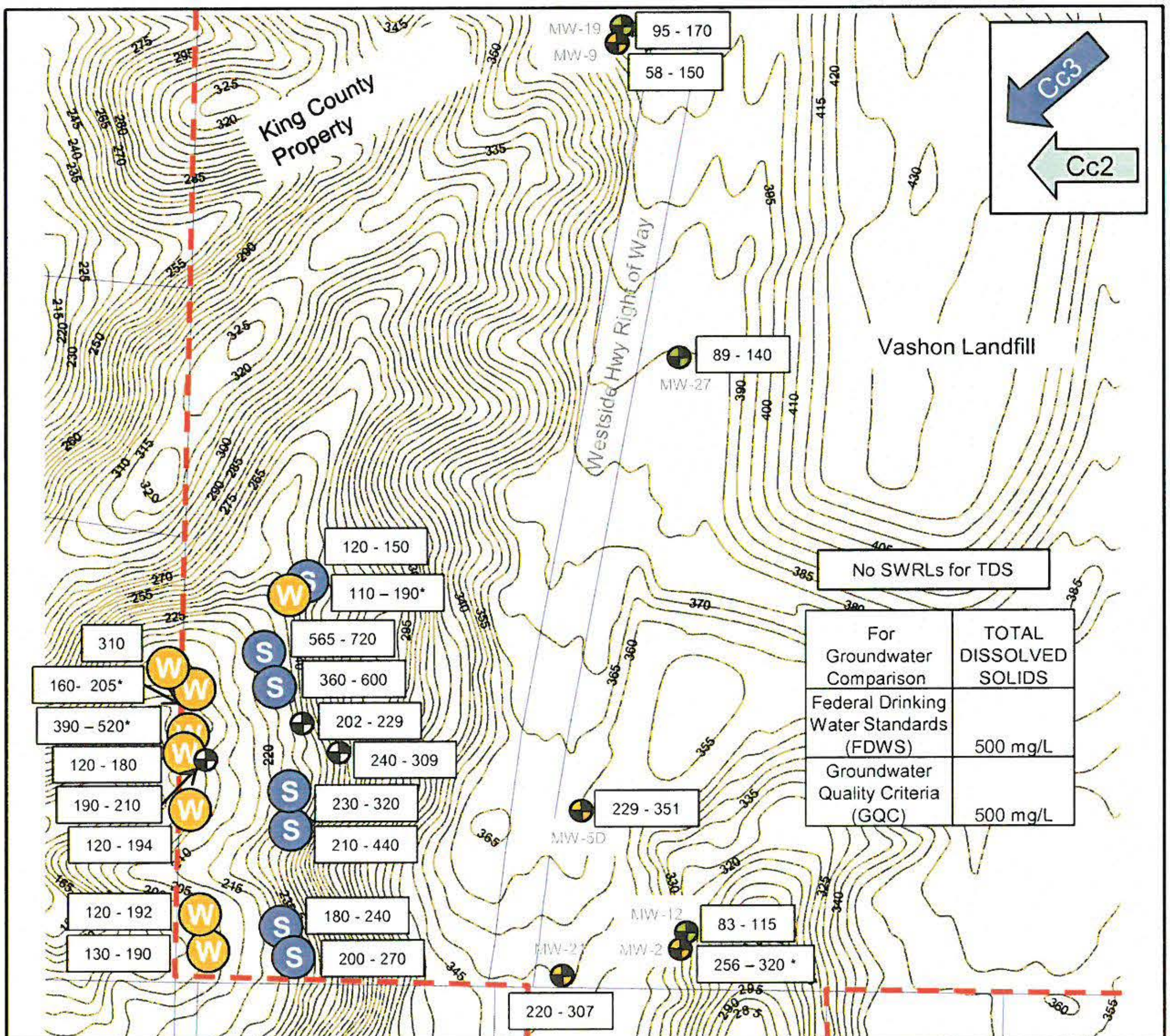
There is no FDWS and GQC for ammonia in groundwater samples. The SWQCs for ammonia were not calculated for this study.

Chloride

Time series plots of chloride are shown in Appendix L.3 Figures 30 to 35. Ranges of chloride measured at all locations are the following:

Western Hillslope Wells	3.22 to 8.73 mg/L
Seeps/Seepage Samplers	Non detect to 53.2 mg/L
Streams/Weirs	Non detect to 34.4 mg/L
Cc2 Perched Zone Wells	2.6 to 8.5 mg/L
Cc3 & Regional Zone Wells	2.6 to 6.7 mg/L

Figure 19. Total Dissolved Solids



For Groundwater Comparison	TOTAL DISSOLVED SOLIDS
Federal Drinking Water Standards (FDWS)	500 mg/L
Groundwater Quality Criteria (GQC)	500 mg/L

N

60 0 60 120 feet

Contour Interval 5 ft

Elevations are Feet above Mean Sea Level

Cc2 Perched Zone Monitoring well

Cc3 & Regional Aquifer Monitoring well

Hillslope Monitoring Well

* Outliers not used

120-194 Range of data

W Stream/Weir Location

S Seep Location

Parcel Lines

KC Property Line

Cc3 Cc2 Groundwater flow Direction in Cc2 and Cc3 (B&H/UES 2006)

Figure 19

Total Dissolved Solids

(mg/L)

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The FDWS and GQC for chloride in groundwater is 250 mg/L. All groundwater samples analyzed for chloride were well below both the FDWS and GQC (Appendix M.3). The SWQC for chloride (WA state chronic SWQC of 230 mg/L) was not exceeded in samples from seepage and stream/weir sampling locations (Appendix M.3).

Seeps/seepage samples qualified with dilution factors ranged from 10 to 59 mg/L. Streams/weir samples qualified with dilution factors ranged from 9.4 to 38 mg/L. There was one Cc2 perched zone well sample (11 mg/L) qualified with dilution factors.

Sulfate

Time series plots of sulfate are shown in Appendix L.3 Figures 36 to 41. Ranges of sulfate measured at all locations are the following:

Western Hillslope Wells	8.52 to 28.5 mg/L
Seeps/Seepage Samplers	3.2 to 19 mg/L
Streams/Weirs	5 to 18 mg/L
Cc2 Perched Zone Wells	5.7 to 19 mg/L
Cc3 & Regional Zone Wells	7.8 to 22 mg/L

The FDWS and GQC for sulfate is 250 mg/L. All groundwater samples measured for sulfate were well below both the FDWS and GQC (Appendix M.3). There are no calculated SWQCs for sulfate in surface waters.

Sulfate in the groundwater from western hillslope wells are mostly within the same range as all other samples. However, MW-32 had sulfate results at 19.1 and 28.5 mg/L. Sulfate in groundwater in the Cc2 perched zone wells show an increasing trend since 2000 and range between 5 and 20 mg/L. Sulfate in the Cc3 & Regional aquifer zone wells show stable to slightly decreasing trend since 2000 and range between 7 and 23 mg/L.

Total Alkalinity

Time series plots of total alkalinity (as $CaCO_3$) are shown in Appendix L.3 Figures 42 to 46. Appendix M.3 shows total alkalinity results for all sampling locations. Many samples resulted in matrix interference, blank contamination and dilution factors. Ranges of ammonia measured at all locations are the following:

Western Hillslope Wells	119 to 286 mg/L
Seeps/Seepage Samplers	169 to 554 mg/L
Streams/Weirs	83.4 to 418 mg/L
Cc2 Perched Zone Wells	63.3 to 314 mg/L
Cc3 & Regional Zone Wells	52.5 to 109 mg/L

There are no FDWS and GQC levels for total alkalinity in groundwater samples. The SWQC for alkalinity (as $CaCO_3$) is the Federal chronic level of a minimum of 20 mg/L. At seepage sampler SW-S6 a total alkalinity of 4.2 mg/L was recorded in October 2009 (qualified as T=estimated, less than reporting detection limit but greater than method detection limit).

About half of the seepage sampler samples were qualified as having dilution factors. These samples ranged from 88 to 640 mg/L. With the exception of an upward trend at seepage sampler SW-S4, all other seepage sampler data shows a decreasing or stable trend since 2007.

Weir samples qualified as having dilution factors ranged from 90 to 530 mg/L. Results show a mostly stable trend since 2007 in weir samples.

Cc2 perched zone monitoring wells samples qualified as having dilution factors ranged from 56 to 440 mg/L. With the exception of a downward trend at MW-5D, the other wells show an upward trend in total alkalinity since 2000.

Groundwater samples in the Cc3 and Regional aquifer zone wells qualified as having dilution factors ranged from 30 to 110 mg/L. With the exception of an upward trend at MW-19, the other wells show mostly stable total alkalinity results since 2000.

Based on this data, it is likely that the groundwater seeping out the seeps and flowing downstream to the hillslope weirs are from the Cc2 perched zone.

Other conventionals

There were conventionals that were measured at least once at a sampling location (Appendix M.3). The following is a list of additional conventionals measured:

Nitrate	Total Solids
Hardness	Total Suspended Solids
Total Organic Carbon	

Where there were FDWS or GQC levels assigned to an analyte, no exceedances were reported in groundwater samples. There were no SWQCs assigned to these other conventional analytes.

3.2.3 Ion Balance Calculations

Appendix H shows the ion balance calculations for all locations during the 2007 – 2010 time period. Red text indicates sampling events that were calculated to have a greater than 10% difference in the cation/anion ratio.

With the exception of two sampling events at MW-12 (May 2008 and August 2008), all other cation/anion ratio percent differences for Cc2 perched zone monitoring wells were less than 10%.

All cation/anion ratio percent differences for the hillslope and Cc3 & Regional aquifer monitoring wells were less than 10%.

With the exception of sampling events at SW-S2 and SW-S4 (October 2007, December 2007 and July 2008) and at SW-S6 (October 2009), all other cation/anion ratio percent differences for hillslope seeps/seepage samplers were less than 10%.

Four weir sampling locations had cation/anion ratio percent differences slightly greater than 10%. These were at SW-W2 (July 2008 and January 2009); SW-W3 (October 2007 and March 2008); SW-W4 (August 2007); and SW-W5 (March 2009).

3.2.4 Piper Diagrams

Appendix K shows piper diagrams created using RockWorks15. Using the same samples as used in the ion balance calculations having a less than 10% difference in the cation/anion ratio (Appendix H), piper diagrams were made for Cc2 perched zone monitoring wells, Cc3 & Regional aquifer monitoring wells, hillslope monitoring wells, hillslope seeps/seepage samplers, and hillslope streams/weirs.

Based on the piper diagrams in Appendix K, figures were constructed, showing the location of the water composition of the groundwater in the wells screened in the Cc2 perched zone and the Cc3 & Regional aquifer at the landfill. The monitoring well details are shown in Table 2. Screened units were designated from the *Vashon Island Closed Landfill 2009 Annual Groundwater Data Evaluation Report* (KCSWD, 2010).

The outlines for the areas represented on the diagram by the water samples identified as coming from the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells are shown in Figures 20 to 24. Figures 20 and 21 depict the correlation of these samples to the actual samples from those different water bearing zones. Close-ups of the piper diagrams are located in Appendix K.

Further discussion on these landfill monitoring wells can be viewed in the *Vashon Island Closed Landfill 2009 Annual Groundwater Data Evaluation Report* (KCSWD, 2010).

Figure 20. Piper Diagram - Cc2 Perched Zone Monitoring Wells

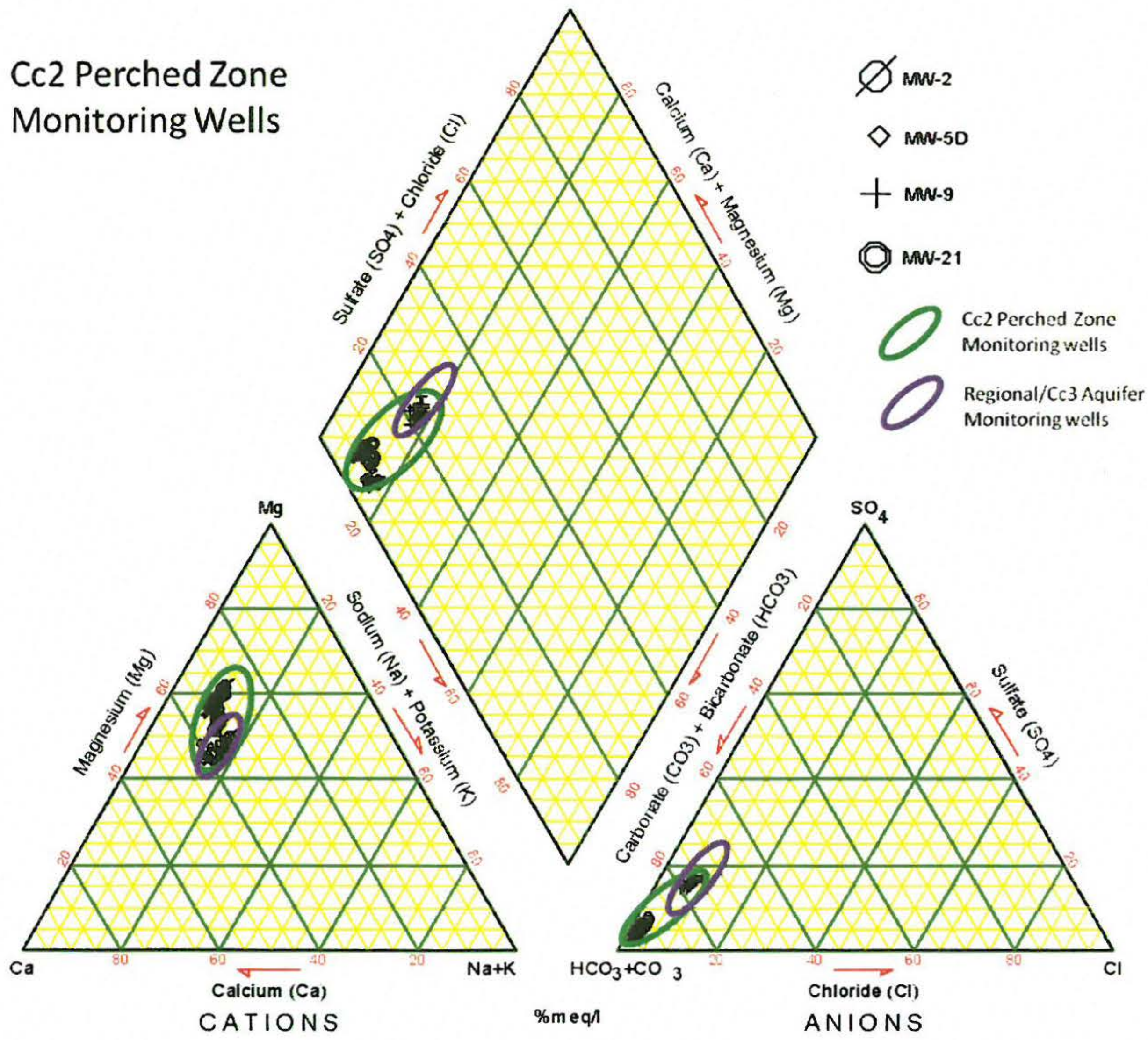


Figure 21. Piper Diagram - Regional / Cc3 Aquifer Monitoring Wells

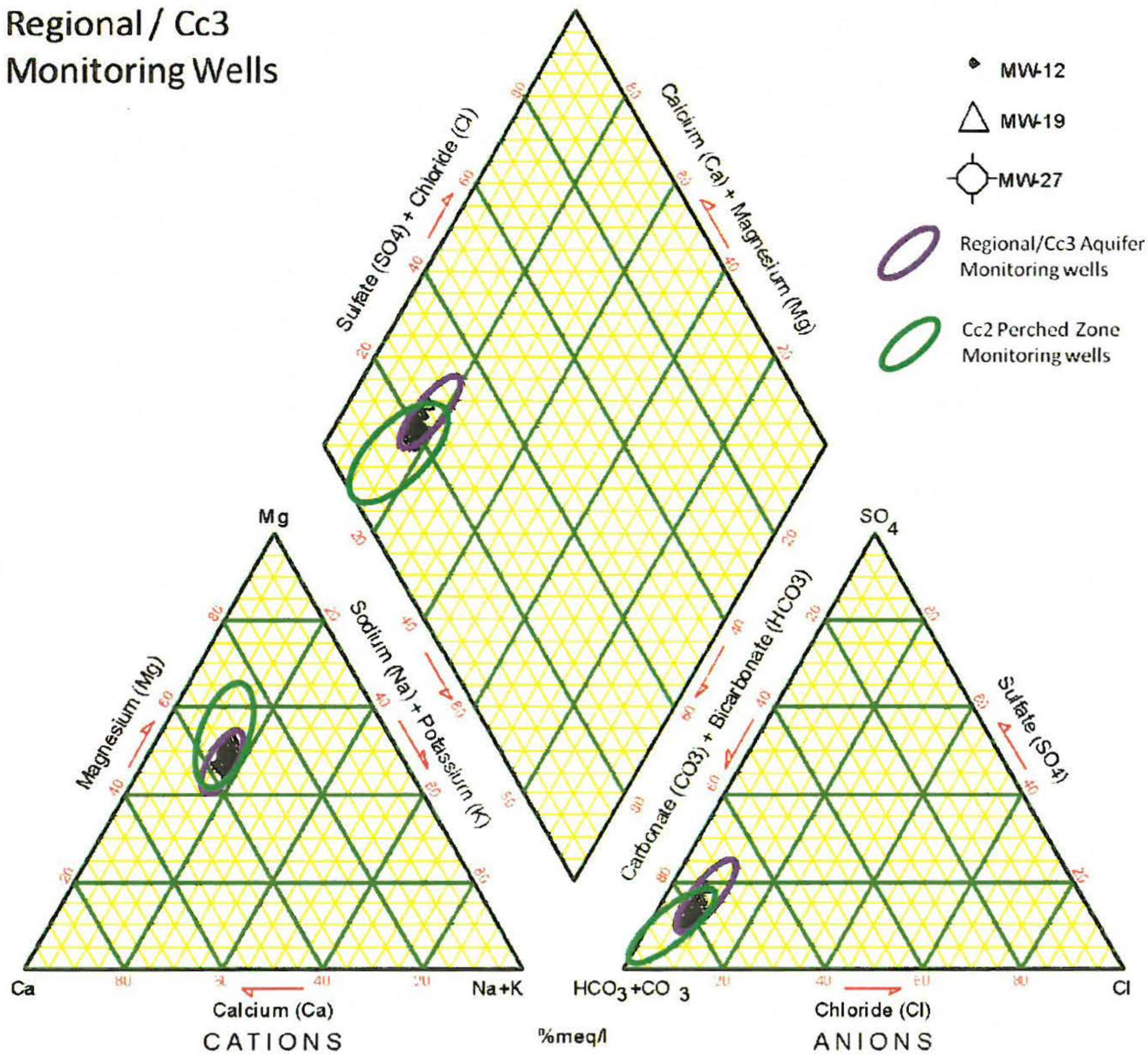


Figure 22 shows the samples from the western hillslope monitoring wells (close-ups in Appendix K). Since data was only collected for one year on a quarterly basis, there are at most four samples per location. There are only two samples for monitoring well MW-32 because the well was dry during one quarter and had insufficient volume to collect all samples during another.

Western hillslope monitoring wells samples fall entirely within the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells areas on the piper diagram. They are more closely similar to the Cc2 perched zone monitoring wells.

Samples taken from hillslope monitoring well MW-32 were taken over a period of days due to the very slow recovery rate. It is possible that the piper diagram does not accurately represent the actual water chemistry at MW-32.

Figure 22. Piper Diagram – Western Hillslope Monitoring Wells

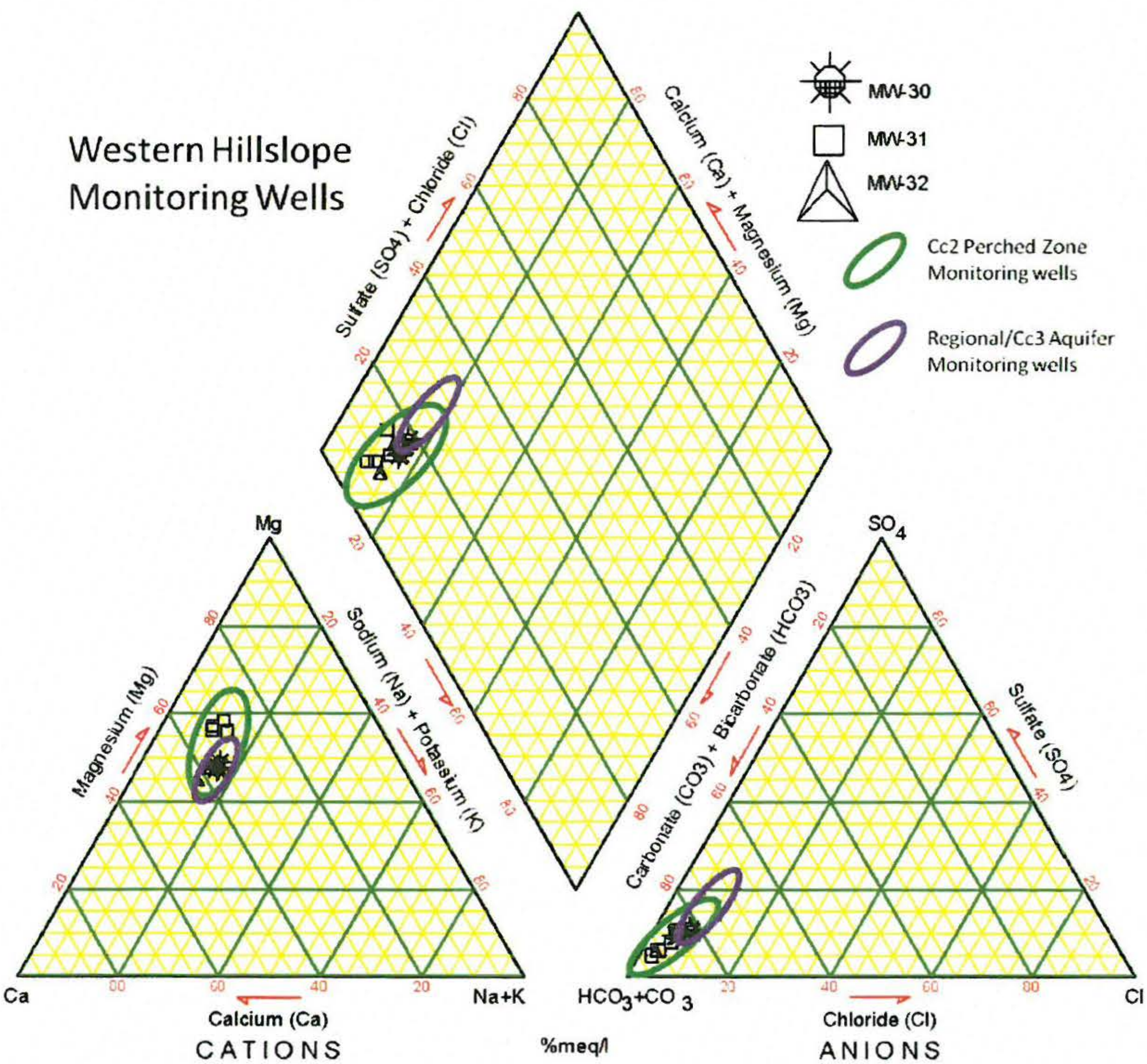
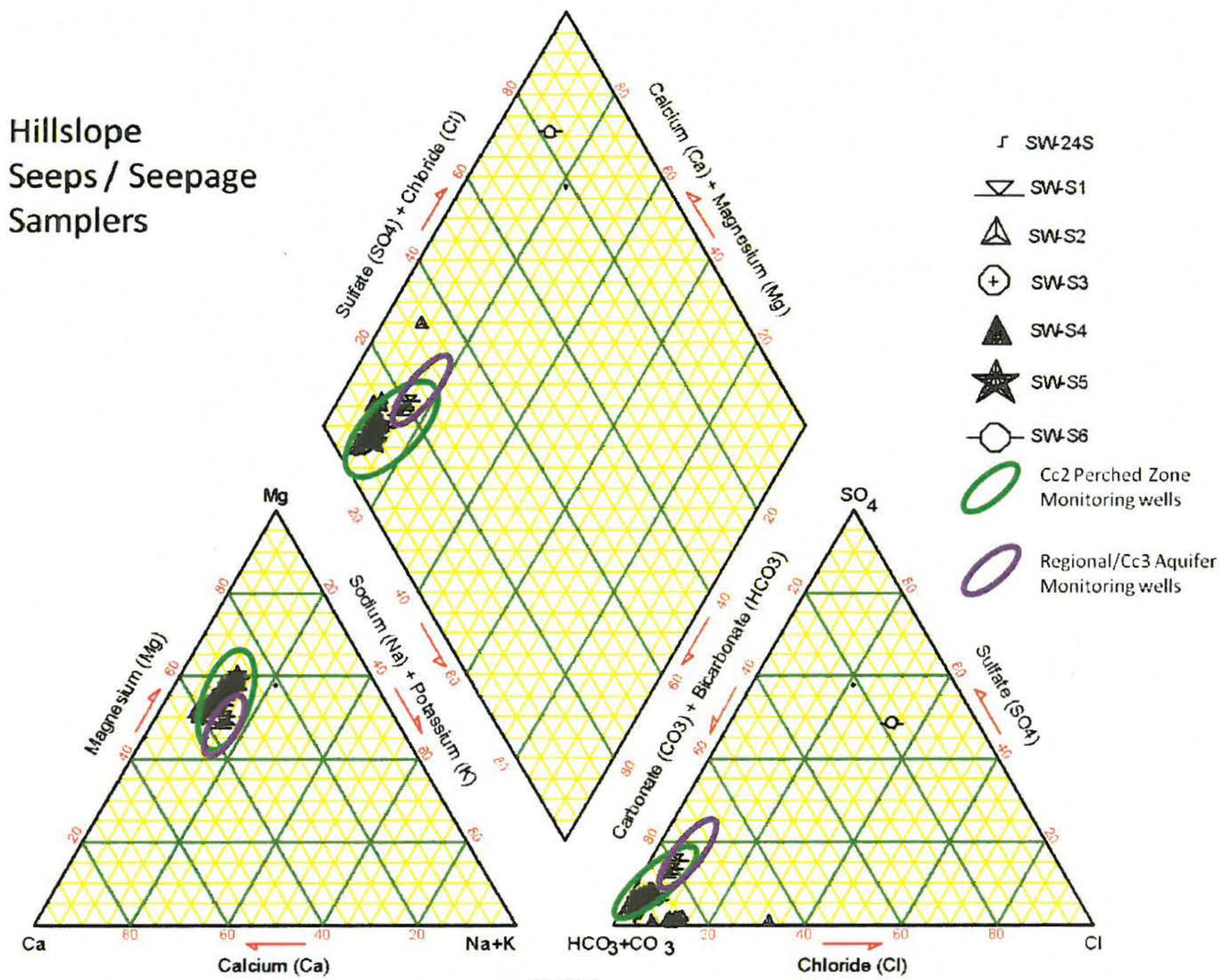


Figure 23 shows the samples from the western hillslope seeps and seepage samplers. Three seepage sampling locations (SW-24S, SW-S1, and SW-S3) were sampled during the first year upon installation. Afterwards, the data was evaluated and a decision to refine the sample program resulted in these locations continuing with only collection of field water quality parameters.

With the exception of a few samples (SW-S1, SW-S4, and SW-S6), the samples from the western hillslope seeps and seepage samplers fall mostly within areas representing samples identified as from the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells. Overall, hillslope seeps/seepage samples appear to be more similar to the samples from wells identified as screened in the Cc2 perched zone monitoring wells.

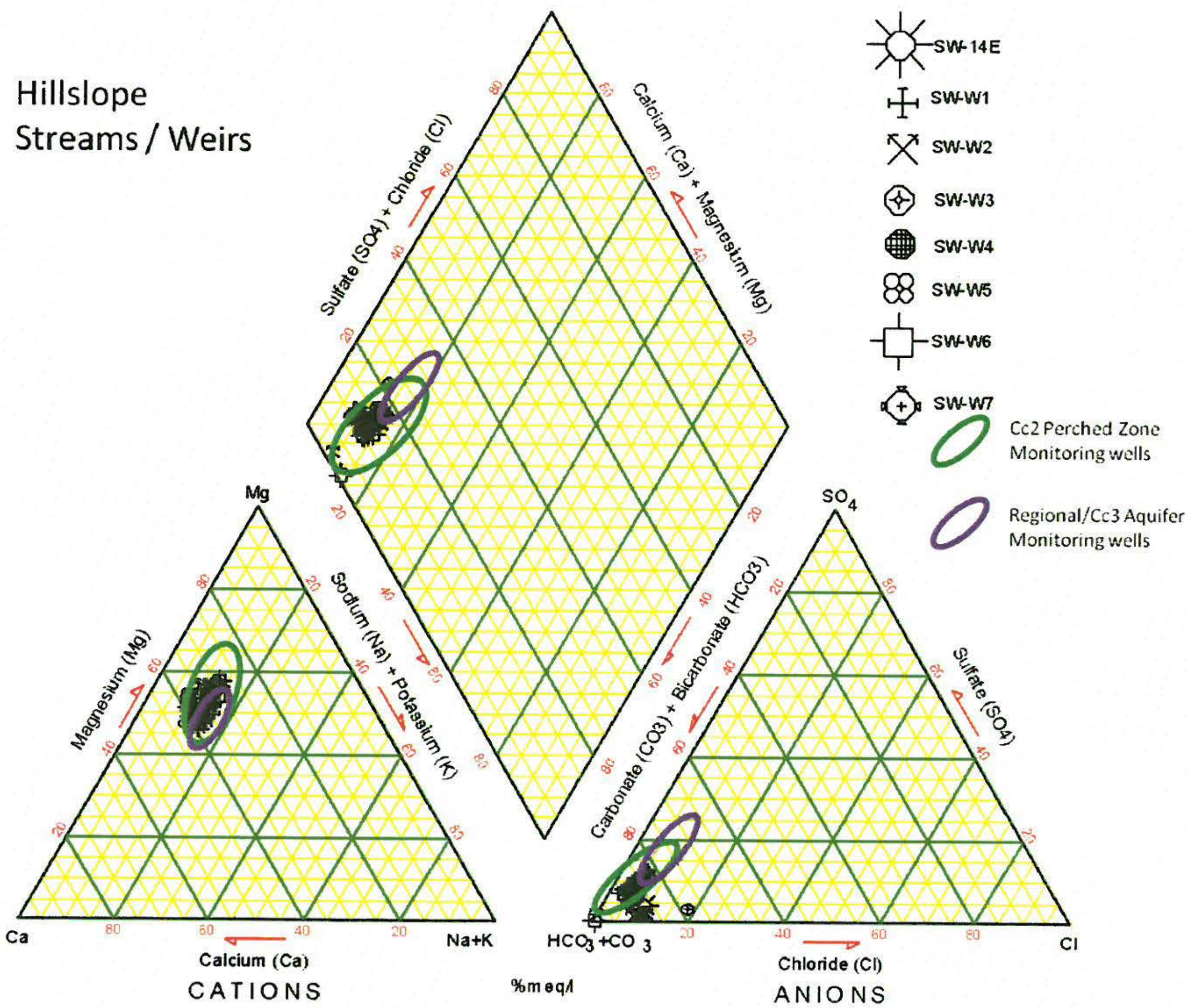
Figure 23. Piper Diagram – Western Hillslope Seeps / Seepage Samplers



Only samples at seepage sampler SW-S1 showed possible correlation to the area represented by samples identified as from the Cc3 & Regional aquifer monitoring wells. However, this sampling location often represented precipitation as it rarely had enough water for sampling, with the exception of sampling events during high rainfall events. A few times, samples taken from SW-S1 were taken over a period of days due to the very slow recovery rate. It is likely that the piper diagram does not accurately represent the actual water chemistry at SW-S1. In addition, this location is significantly higher in elevation than expected for the Cc3 & Regional aquifer unit.

Figure 24 shows the results for samples from the western hillslope streams/weirs. These samples fall mostly within the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells areas on the piper diagram. These samples are more closely similar to the Cc2 perched zone monitoring wells. Close-ups of the piper diagrams are located in Appendix K.

Figure 24. Piper Diagram – Western Hillslope Streams / Weirs



3.2.5 Water Quality Summary

3.2.5.1 Field Water Quality

Regarding field water quality, the data that most indicated a possible correlation between hillslope locations and landfill monitoring wells was conductance. The following is a summary of conductance values:

- Elevated values (over 300 µs/cm) were located at Cc2 perched zone landfill wells MW-2, MW-5D, and MW-21; western hillslope wells MW-30 to MW-32; seeps/seepage samplers SW-24S, SW-S2 to SW-S7, and streams/weirs SW-14E, SW-W1 to SW-W3, SW-W5 to SW-W7.
- There are no SWQCs calculated for the study. Only one value over the GQC (700 µs/cm) was found in groundwater from a Cc2 perched zone monitoring well, MW-5D, in 2001.
- A downward trend of conductance was observed at weirs SW-W1 to SW-W3 since 2000.
- Seep SW-24S and sampler SW-S2 show an overall downward trend.
- Conductance at seepage sampler SW-S4 shows an overall increasing trend.

The following is a summary of pH values:

- Even though pH at all hillslope locations overlap with the respective data measured at landfill wells, there does not appear to be a correlation to either Cc2 or Regional & Cc3 zones
- The FDWS and GQC for groundwater are the same for pH at a range of between 6.5 and 8.5 pH units. pH values at MW-30 exceeded the FDWS and GQC in November 2010. Monitoring wells in the Cc2 perched zone and the Cc3 & Regional aquifer monitoring wells did not exceed the limits since 2000.
- The SWQC for pH is a WA state range of 6.5 to 8.5 pH units (chronic) and Federal range of 6.5 to 9 pH units (chronic). The pH in weir samples exceeded this range in SW-W3 three times (September 2000/ 2002 and April 2010). The pH in seeps/seepage sampler samples exceeded this range a total of six times (SW-S2, SW-S3, SW-S4, SW-S5 and SW-S6).

Even though temperatures at all hillslope locations overlap with the respective data measured at landfill wells, there does not appear to be a correlation to either Cc2 perched zone or Cc3 & Regional aquifer. The WA state SWQC (chronic) for temperature (18 °C) not exceeded at seeps/seepage sampler and weir sampling locations.

Turbidity values at locations on the hillslope were higher after and during precipitation events. The SWQC for turbidity is 5 ntus above background. Most values were above 5 ntus at all seeps/seepage sampler and stream/weir sampling locations.

Dissolved oxygen was lower at the seeps/seepage samplers than at the weirs. The WA state and Federal SWQC's were often exceeded at seeps/seepage and stream/weir sampling locations.

3.2.5.2 Dissolved Metals

The following is a summary of dissolved metals results:

- The FDWS and GQC for dissolved iron (0.3 mg/L) in groundwater were exceeded at Cc2 perched zone wells MW-2, MW-5D and MW-21 and at Cc3 & Regional aquifer well MW-12. There are no calculated SWQCs for dissolved iron in surface water.
- There are no FDWS and GQC levels for dissolved magnesium in groundwater. There are no calculated SWQCs for dissolved magnesium in surface water. Dissolved magnesium results in hillslope samples are likely an indication of a source of groundwater from the Cc2 perched zone wells.
- The FDWS and GQC for dissolved manganese (0.05 mg/L) in groundwater were exceeded in groundwater samples from Cc3 & Regional aquifer well MW-19, western hillslope well MW-30 and all Cc2 perched zone wells. There are no calculated SWQCs for dissolved manganese in surface water.
- Dissolved manganese in seepage samplers and groundwater from Cc2 perched zone wells show a decreasing trend. With the exception of an increasing trend at SW-W1, all other weirs showed a decreasing or stable trend.
- The GQC for arsenic (0.00005 mg/L) was exceeded at all groundwater sampling locations. The FDWS (0.01 mg/L) was exceeded in Cc2 perched zone wells MW-5D and MW-21.
- The FDWS and GQC for aluminum (0.05 – 0.2 mg/L) was exceeded at Cc2 perched zone wells MW-2, MW-9, MW-21 and at Cc3 & Regional aquifer wells MW-12, MW-19 and MW-27.
- Where there were FDWS or GQC levels assigned to the remaining dissolved metal analytes, no exceedances were reported in groundwater samples. There are no calculated SWQCs for dissolved metals.

3.2.5.3 Volatiles Organic Constituents

The following is a summary of volatiles organic constituent detections:

- The FDWS (5 µg/L) for benzene was not exceeded at any groundwater sampling locations. The GQC (1 µg/L) was exceeded at Cc2 perched zone monitoring well MW-5D. The SWQC for benzene (Federal acute level; 5300 µg/L) was not exceeded at any seepage and stream/weir sampling locations. Benzene detections show an increasing trend at seepage sampler SW-S2.
- The FDWS and GQC of 1000 µg/L for toluene were not exceeded in any groundwater samples. The Federal acute SWQC of 17500 µg/L for toluene was not exceeded in any seepage or stream/weir sampling locations. Western hillslope monitoring wells MW-31 and MW-32 showed a decreasing trend of toluene in 2010.
- The FDWS of 5 µg/L for 1,2-DCP was not exceeded in any groundwater samples. The Federal acute (23000 µg/L) and chronic (5700 µg/L) levels for 1,2-DCP were not exceeded in seepage and stream/weir sampling locations.
- The GQC of 0.02 µg/L for vinyl chloride was exceeded at western hillslope wells MW-30 and MW-32 and Cc2 perched zone wells MW-2, MW-5D, and MW-21. The FDWS of 2 µg/L for vinyl chloride was not exceeded at any groundwater sampling locations. There are no SWQCs for vinyl chloride.

- The FDWS and GQC of 70 µg/L for cis-1,2-dichloroethene was not exceeded at any groundwater sampling locations. The Federal acute SWQC (11600 µg/L) was not exceeded in seepage and stream/weir sampling locations.
- The FDWS and GQC of 100 µg/L for trans-1,2-dichloroethene was not exceeded at any groundwater sampling locations. The Federal acute SWQC (11600 µg/L) was not exceeded in seepage and stream/weir sampling locations.
- Where there were FDWS or GQC levels assigned to other volatiles organic constituents, no exceedances in groundwater samples were reported. Where there were SWQCs assigned to other volatiles organic constituents, no exceedances in seepage and stream/weir sampling locations were reported.

3.2.5.4 Conventionals

The following is a summary of conventionals results:

- TDS at all hillslope locations overlap with the TDS measured at landfill wells. Based on this data it is most likely that the groundwater seeping out the seeps and flowing downstream to the hillslope weirs are from the Cc2 perched zone.
- There were no exceedances of the FDWS (500 mg/L) and GQC(500 mg/L) for TDS in groundwater samples. There are no SWQCs for TDS.
- Ammonia as nitrate results ranged between non-detect and 1.3 mg/L. There is no FDWS and GQC for ammonia in groundwater samples. The SWQCs for ammonia were not calculated for this study.
- All sulfate and chloride values were well below the FDWS and GQC (250 mg/L). The SWQC for chloride (WA state chronic SWQC of 230 mg/L) was not exceeded in samples from seepage and stream/weir sampling locations. There are no calculated SWQCs for sulfate in surface waters.
- There are no FDWS and GQC levels for total alkalinity in groundwater samples. The Federal chronic SWQC for alkalinity (as $CaCO_3$) (>20 mg/L) was not met at seepage sampler SW-S6 (4.2 mg/L) in October 2009 (qualified as T=estimated, less than reporting detection limit but greater than method detection limit).
- Based on the total alkalinity data, it is likely that the groundwater seeping out the seeps and flowing downstream to the hillslope weirs are from the Cc2 perched zone.
- Where there were FDWS or GQC levels assigned to other conventional analytes, no exceedances were reported in groundwater samples. There were no SWQCs assigned to these other conventional analytes.

3.2.5.5 Piper Diagrams

The following is a summary of piper diagram results:

- Western hillslope monitoring wells samples fall entirely within the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells areas on the piper diagram. They are more closely similar to the Cc2 perched zone monitoring wells.
- Samples from the western hillslope seeps and seepage samplers fall mostly within areas representing samples identified as from the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells. The western hillslope seeps/seepage samples appear to be more

similar to the samples from wells identified as screened in the Cc2 perched zone monitoring wells.

- Samples from seeps/seepage samplers fall more closely to the area represented by the samples identified as being from the Cc2 perched zone.
- The samples from the western hillslope streams/weir sampling locations fall mostly within the Cc2 perched zone and Cc3 & Regional aquifer monitoring wells areas on the piper diagram. These samples are more closely similar to the Cc2 perched zone monitoring wells.

3.3 Hydrogeologic Mapping

Hydrogeologic investigations at the closed landfill have resulted in an understanding of overall units at the landfill property. Figure 25 depicts the current understanding of the hydrogeologic units underlying and surrounding the closed landfill. Unit C (shown in orange highlight) is the main unit of interest and contains sub units Cc1, Cc2, Cc3 and various fine grained Cf units. Saturation is indicated by the blue shading within the units.

Results from preliminary mapping of sediments on the hillslope were presented in *Vashon Island Landfill Hillslope; Report for Scope of Work #1 Part of the Vashon Island Landfill Hydrogeologic Investigation* (KCWLRD, 2006a). Hydrogeologic maps and cross sections presented in that report were updated with information collected during the installation of monitoring wells on the hillslope. Figure 26 depicts the location of the mapped geologic units, monitoring well, and locations of geologic cross-sections in Figures 27 and 28.

The following sequence is the current understanding of the hillslope sediments from the top of the hill near the landfill to west of the KC property: Unit A, Unit B, Cc1, Cf, Cc2, Cf, Cc3, Cf, and Unit D. It is still not clear about the exact location and nature of the contacts between the fine grained units (Cf) of Unit C between Cc1 and Cc2 and between Cc2 and Cc3 (KCWLRD, 2006a).

Table 8 shows the hydrogeologic profile at wells MW-4, MW-5, and MW-21 compared with the resulting profile from the initial field mapping exercise. There is a 10-15 ft thick hard silt/clay layer beneath what is identified as Cc3. It is possible that this unit is the same Cf layer identified in the well logs and geologic cross sections from previous reports as the Cf unit between Cc2 and Cc3 in this area.

As discussed in a previous report (KCWLRD, 2006a), there is a change in slope coinciding with a persistently wet area caused by groundwater daylighting from the hillside at about an elevation of 240 ft, MSL. The change in slope is well established and seeping groundwater is causing erosion of the hillslope. A small scarp-like face (about 1 to 2 feet high) is formed above most of the focused seepage areas. Plants are often perched on the top of this feature and eventually topple due to undercutting. In most areas, dampness and moisture is observed uphill from the seepage area. This may be due to capillary action or a seasonally higher water table.

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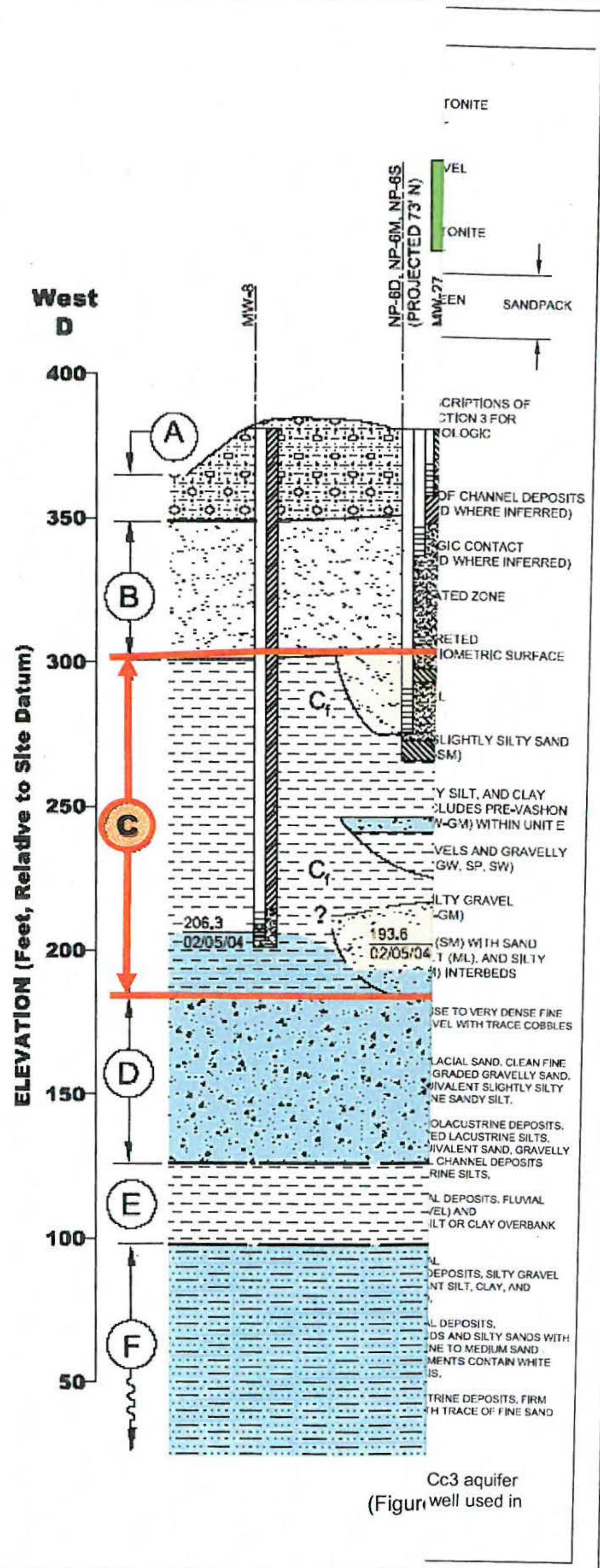

King County
Department of
Natural Resources and Parks
Water and Land Resources Division
Science and Technical Support Section

Figure 25

East – West Hydrogeologic Cross Section D – D'

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Figure 26. Hillslope Geologic Map

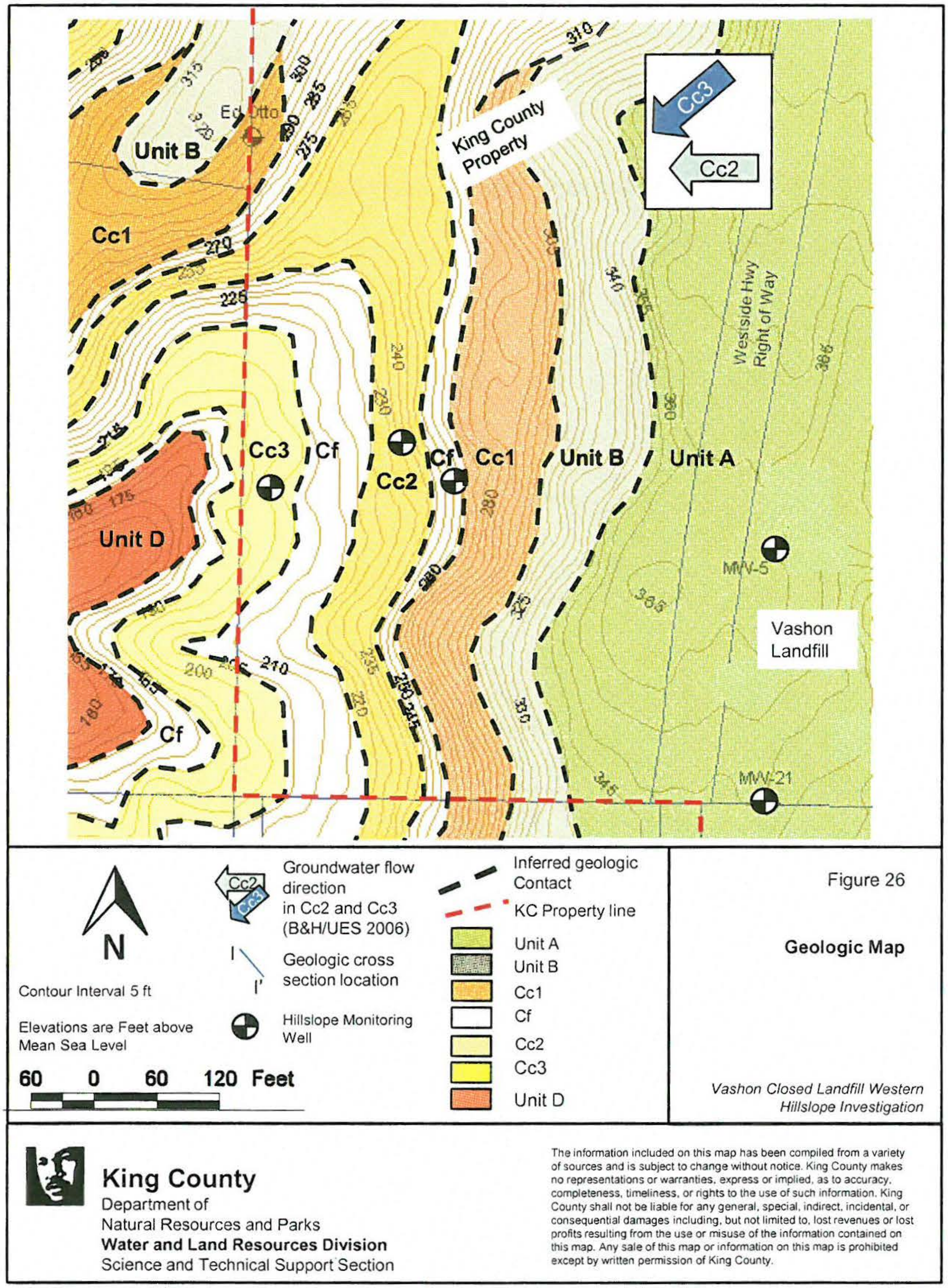

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Figure 27. Updated Geologic Cross Section F – F'

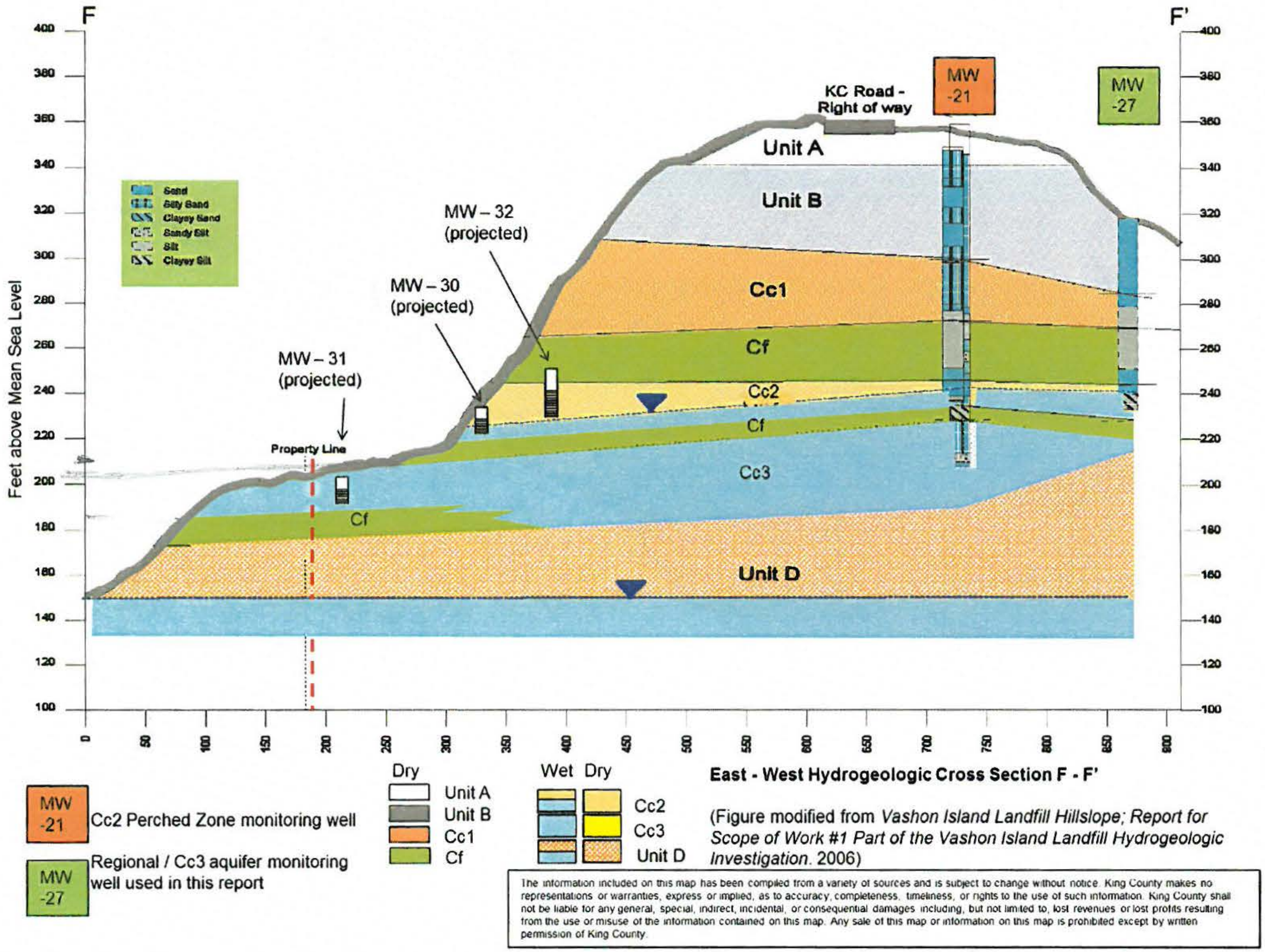
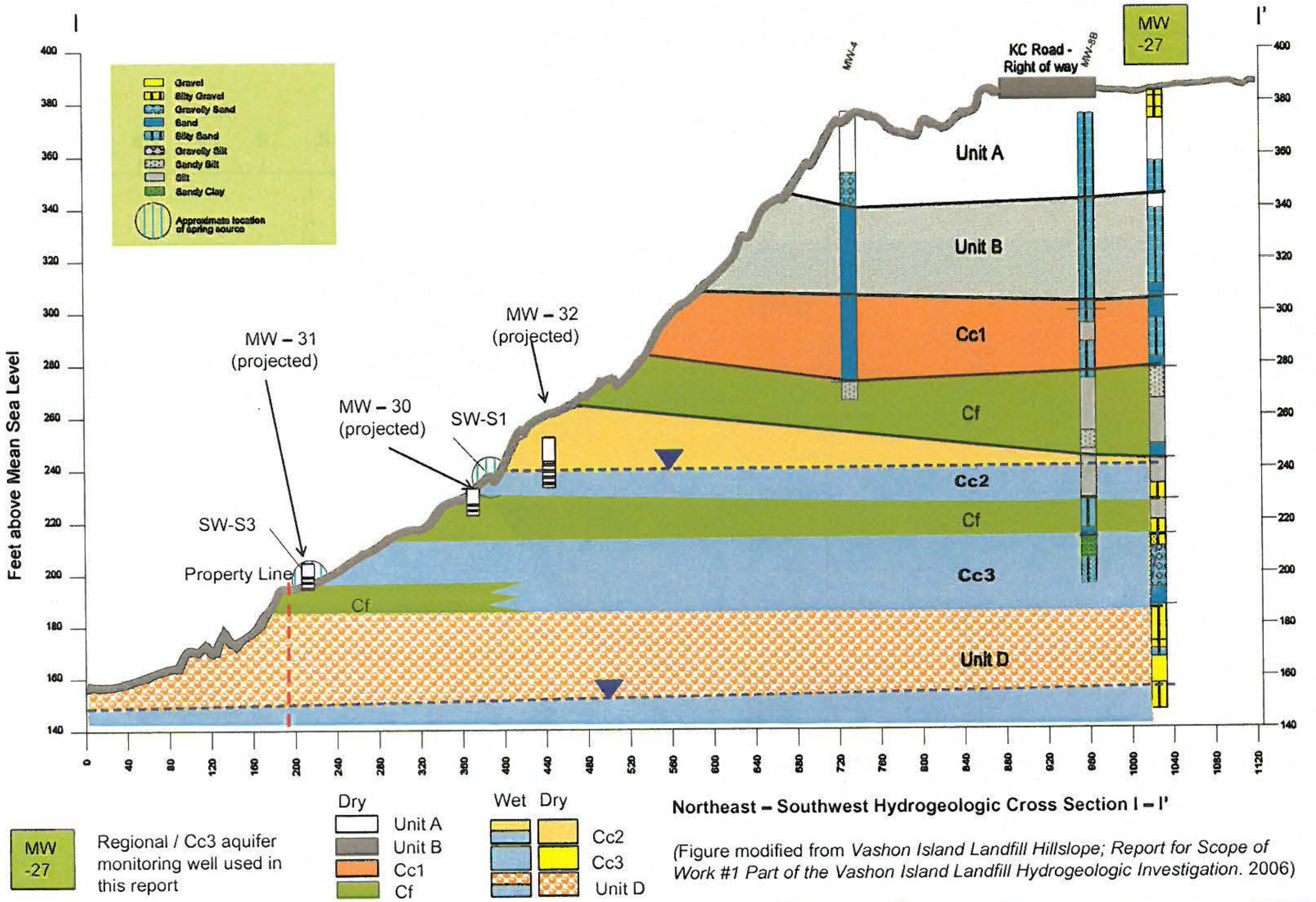


Figure 28. Updated Geologic Cross Section I – I'



4.0. SUMMARY

The main scope of work was to redesign and install seepage and stream/weir sampling arrays, design a discharge measurement plan, install wells onsite at the hillslope, and conduct a water sampling program for the weirs, seepage samplers and wells over a period of one year upon installation. The objective of the field work was to gather enough information to answer a few key questions:

- Where do the coarse grained units of Unit C (Cc1, Cc2, and Cc3) outcrop on the hillslope?
- Is there any saturation in the Cc1 outcrop, if present?
- What water source is being sampled at sampling weirs SW-W1, SW-W2 and SW-W3?

The above listed questions are answered here within this section. The supporting data and related information is presented in Section 3 Results and Discussion. The corresponding recommendations are listed in Section 4.5 Recommendations.

4.1 Surface Water Discharge

Monthly data from all of the weirs appear to mimic precipitation events. With the exception of a few outlier measurements, data was consistent over time and with respect to other weirs.

4.2 Unit Cc1, Cc2, and Cc3 Outcrops

Additional borehole descriptions from monitoring well installation activities did not change the current understanding of outcrop locations along the hillslope.

4.3 Saturation of Unit Cc1 Outcrops

Saturation of Cc1 outcrops on the hillslope was not observed in the main study area. In the southern areas of the western hillslope, where steep slopes were not traversed, it could not be observed whether there was saturation of Cc1. Observations made from lower elevations indicated vegetation changes, possible hillslope creep, and possible moisture at the elevation that Cc1 may be outcropping on the slope.

4.4 Water Sources for Sampling Weirs SW-W1, SW-W2 and SW-W3

The information gathered from this study amends the findings in a previous report (KCWLRD, 2006a). Weirs SW-W1, SW-W2, and SW-W3 have been sampled regularly and were thought to represent groundwater solely from the springs identified in previous work (respectively, springs Seep 1, Seep 2 and Seep3, as per *Vashon Island Closed Landfill 2009 Annual Groundwater Data Evaluation Report*. (KCSWD, 2010)). Field observations of surface flow, mapping of seepage areas and geologic units, and water quality testing has indicated that the samples taken at the weirs do not represent each respective spring's water alone. SW-W1 appears to represent surface water flowing across Unit A, Unit B, and Cc1 and possibly groundwater seepage from upper portions of Cc2. Both SW-W2 and SW-W3 appear to measure water quality from seeping groundwater from Cc2 and possibly Cc3. In addition, a significant amount of surface water from rainfall events flows through all of the weirs. Sampled waters at the weirs most likely represented highly diluted forms of the seeping groundwater.

Based on detections of volatiles and piper diagram results, sources for the uphill source seeps (SW-24S and SW-S1 to SW-S6) appear to be most likely the same water as seen in the landfill Cc2 perched zone monitoring wells.

4.5 Recommendations

Upon completion of the site wide monitoring network evaluation, continued sampling at seepage and stream areas may be recommended. Locations will depend upon results of the site-wide evaluation. When this study was initiated, most of the hillslope was overgrown with vegetation, downed trees and there were no trails. It was difficult to observe sediments, hillslope changes, potential seeps, KCSWD property boundaries and to outline the saturated area. At this time, there are established trails and the visibility of the area is much improved. Should further studies occur on the hillslope, continued maintenance is recommended due to constant downed tree in sampling and trail areas, slope erosion, changing stream locations, and annual growth of the nettle and berry bushes along the sampling and trail areas.

Due to the temporary nature of the seepage sampler installations and the ongoing build up of sediments in each sampler, it is recommended than the samplers be removed and replaced if continued sampling occurs upon completion of the site wide monitoring network evaluation.

Due to the proximity of weir SW-W1 and seepage sampler SW-S1, it is not necessary to sample or collect field water quality at both locations. Seepage sampler SW-S1 is uphill and closer to the seepage source than weir SW-W1. Since SW-W3 is located downstream of SW-W1, it is a duplication on sampling on the same stream, with regards to sampling water exiting the property. It is recommended that SW-W1 be removed as one of the quarterly sampling locations for the landfill. Unless the site wide monitoring network evaluation recommends sampling in this area, continued water quality data collection at seepage sampler SW-S1 is not recommended.

The western hillslope is steep and undergoes constant erosion. The monitoring wells were installed with floating platform around the wellhead to improve worker safety. Due to constant maintenance, it is recommended that future designs be improved.

Dissolved oxygen was not measured in landfill wells. This data might have been helpful to identify the typical DO for each water bearing zone and assist in correlating the units outcropping on the hillslope. Should further studies continue at the hillslope, it is recommended that dissolved oxygen be included in the collected well field water quality parameters.

5.0. REFERENCES

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Tables

Tables

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Table 1. Sampling Analyte Program

		Seepage Locations							Stream / Weir Locations								Hillslope Well Locations			Landfill Wells Locations
		SW-S#							SW-W#								MW-#			MW-#
		1	2	24S	3	4	5	6	14E	1	2	3	4	5	6	7	30	31	32	2,5D, 9, 12, 19, 21, 27
Field Water Quality (Temperature, pH, specific conductance, turbidity)		x	x	x	x	x	x	x	O	x	x	x	x	x	x	x	x	x	x	x
Dissolved Solids, Total		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Suspended Solids, Total		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Calculated Solids, Total		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Organic Carbon, Total		O	x	O	O	x	x	x		x	x	x					x	x	x	x
Chloride		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Sulfate as SO4		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Alkalinity, Total (As CaCO3)		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Ammonia, as N		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Nitrate (as N) by Calculation		O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
Calculated Hardness									O	x	x	x	O	x	x	O				
Dissolved Metals	Aluminum								O	x	x	x	O	x	x	O				
	Antimony	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Arsenic	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Barium	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Beryllium	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Cadmium	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Calcium	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Chromium	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Cobalt	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Copper	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Iron	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Lead	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Magnesium	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Manganese	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Mercury	O	x	O	O	x	x	x	O				O	x	x	O	x	x	x	x
	Nickel	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Potassium	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Selenium	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Silver	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Sodium	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	Thallium	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Tin									x	x	x								
	Vanadium	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	Zinc	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	1,1,1,2-Tetrachloroethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,1,1-Trichloroethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,1,2,2-Tetrachloroethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,1,2-Trichloroethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,1-Dichloroethane	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
	1,1-Dichloroethene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,2,3-Trichloropropane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,2-Dibromo-3-Chloropropane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,2-Dibromoethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,2-Dichlorobenzene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
	1,2-Dichloroethane	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x

Table 1. Sampling Analyte Program (continued)

		Seepage Locations							Stream / Weir Locations								Hillslope Well Locations			Landfill Wells Locations
		SW-S#							SW-W#								MW-#			MW-#
		1	2	24S	3	4	5	6	14E	1	2	3	4	5	6	7	30	31	32	2,5D, 9, 12, 19, 21, 27
VOCs	1,2-Dichloropropane	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
VOCs	1,4-Dichlorobenzene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	2-Butanone	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	2-Hexanone	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	4-Methyl-2-Pentanone	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Acetone	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Acrylonitrile	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Benzene	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
VOCs	Bromochloromethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Bromodichloromethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Bromoform	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Bromomethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Carbon Disulfide	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Carbon Tetrachloride	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Chloro-benzene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Chlorodibromomethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Chloroethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Chloroform	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Chloromethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	cis-1,2-Dichloroethene	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
VOCs	cis-1,3-Dichloropropene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Dibromomethane	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Dichlorodifluoromethane	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
VOCs	Ethylbenzene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	m, p-Xylenes	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Methyl Iodide	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Methylene Chloride	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	o-Xylene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Styrene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Tetrachloroethene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Toluene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	trans-1,2-Dichloroethene	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
VOCs	trans-1,3-Dichloropropene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	trans-1,4-Dichloro-2-butene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Trichloroethene	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Trichlorofluoromethane	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x
VOCs	Vinyl Acetate	O	x	O	O	x	x	x		x	x	x					x	x	x	x
VOCs	Vinyl Chloride	O	x	O	O	x	x	x	O	x	x	x	O	x	x	O	x	x	x	x

Notes:

x Sampled for duration of study

O No longer sampled

Location ID	Type	Northing	Easting	SWD Site Northing	SWD Site Easting	TION DETAILS ELEVATIONS				Notes
						Well Screen Top Elevation	Well Screen Bottom Elevation	Well TD Bottom Elevation	BH TD Bottom Elevation	
CC2 PERCHED ZONE - MONITORING WELLS ON LANDFILL SI										
MW-02	MW	**162423.67**	**1227763.90**	123.67	2358.	**233.58**	**228.58**	**228.58**	**227.58**	
MW-05D	MW	**162622.13**	**1227613.97**	322.13	2208.	**240.86**	**229.86**	**229.86**	**204.86**	
MW-09	MW	**163583.59**	**1227673.63**	1283.59	2268.	**233.64**	**221.64**	**221.64**	**220.64**	
MW-21	MW	**162395.24**	**1227623.33**	95.24	2218.	**243.17**	**233.77**	**233.57**	**231.77**	
REGIONAL AQUIFER - MONITORING WELLS ON LANDFILL S										
MW-12	MW	**162433.51**	**1227775.88**	133.51	2370.	**140.12**	**129.12**	**128.12**	**8.62**	
MW-19	MW	**163591.50**	**1227674.88**	1291.5	2269.	**140.60**	**130.60**	**129.10**	**40.60**	
MW-27	MW	**163205.52**	**1227738.31**	905.52	2333.	**194.27**	**180.07**	**180.07**	**143.77**	
WESTERN HILLSLOPE MONITORING WELLS										
MW-30	GW	162670.85	1227273.23	NA	NA	**230.71**	**225.71**	**225.50**	**223.01**	KC Roads Survey
MW-31	GW	162623.95	1227148.95	NA	NA	**198.56**	**193.56**	**193.37**	**193.06**	KC Roads Survey
MW-32	GW	162632.15	1227323.50	NA	NA	**242.79**	**232.79**	**232.83**	**232.79**	KC Roads Survey
SEEP SAMPLING LOCATIONS										
SW-24S	SW	162692.47	1227262.21	439.44	1825.	**227.24**	**224.74**	**224.24**	**224.24**	KC SWD Surveyor
SW-S1	GW/SW	**162845**	**1227270**	592.64	1792	**245.00**	**242.50**	**242.00**	**242.00**	estimated
SW-S2	GW/SW	**162667**	**1227262**	NA	NA	**227.24**	**224.74**	**224.24**	**224.24**	estimated
SW-S3	GW/SW	162603.44	1227244.02	NA	NA	**218.74**	**216.24**	**215.74**	**215.74**	KC Roads Survey
SW-S4	GW/SW	162554.01	1227268.86	NA	NA	**228.92**	**226.42**	**225.92**	**225.92**	KC Roads Survey
SW-S5	GW/SW	162398.89	1227244.82	NA	NA	**215.64**	**213.14**	**212.64**	**212.64**	KC Roads Survey
SW-S6	GW/SW	162352.79	1227257.04	NA	NA	**219.07**	**216.57**	**216.07**	**216.07**	KC Roads Survey
SAMPLING WEIRS ON HILLSLOPE SIDE										
SW-W1	SW	**162882.64**	**1227217.20**	582.64	1812	NA	NA	NA	NA	KC SWD Survey
SW-W2	SW	162653.56	1227126.75	NA	NA	NA	NA	NA	NA	KC Roads Survey
SW-W3	SW	162706.45	1227122.4	NA	NA	NA	NA	NA	NA	KC Roads Survey
SW-W4	SW	162618.39	1227114.01	NA	NA	NA	NA	NA	NA	KC Roads Survey
SW-W5	SW	162571.26	1227122.22	NA	NA	NA	NA	NA	NA	KC Roads Survey
SW-W6	SW	162419.58	1227119.9	NA	NA	NA	NA	NA	NA	KC Roads Survey
SW-W7	SW	162372.43	1227125.38	NA	NA	NA	NA	NA	NA	KC Roads Survey

NOTES: Bold text mean calculated or measured values (KCSWD, 2010).

- NA Not applicable
- NI No information at time of report
- Sch. Schedule
- SWD Solid Waste Division
- in inches
- PVC polyvinyl chloride
- Stick up Stick up defines the height of the top of casin

onally blank.

Table 3. Weir Discharge Data Summary

Weir	Date	Average (gpm)	Daily Weir Total (gpd)			
SW-W2	21-Nov-06	9.9	14,267	**RATE**		
	19-Jan-07	8.8	12,682	Max	63	gpm
	28-Feb-07	9.2	13,210	Median	8	gpm
	30-Mar-07	9.9	14,267	Average	11	gpm
	26-Apr-07	9.2	13,210	Min	6	gpm
	1-Jun-07	7.9	11,413			
	16-Jul-07	7.9	11,413	**DAILY TOTAL**		
	25-Jul-07	7.7	11,119	Max	91,258	gpd
	30-Aug-07	7.6	11,010	Median	11,418	gpd
	11-Oct-07	8.5	12,286	Average	15,529	gpd
	29-Oct-07	7.6	10,992	Min	8,673	gpd
	3-Dec-07	63.4	91,258			
	17-Dec-07	9.9	14,263			
	23-Jan-08	8.9	12,883			
	27-Feb-08	8.6	12,451			
	10-Mar-08	8.6	12,451			
	29-May-08	7.5	10,831			
	25-Jun-08	7.5	10,827			
	29-Jul-08	7.1	10,171			
	30-Sep-08	6.3	9,033			
	31-Dec-08	8.3	11,912			
	2-Apr-09	8.1	11,667			
	12-May-09	6.8	9,849			
	20-Jul-09	6.0	8,673			
	23-Sep-09	6.4	9,269			
	19-Oct-09	6.7	9,717			
	22-Dec-09	8.1	11,711			
	25-Feb-10	7.9	11,418			
	12-Apr-10	7.3	10,552			
	22-Jun-10	7.2	10,417			
	1-Nov-10	39.0	56,162			
SW-W3	21-Nov-06	12.9	18,629	**RATE**		
	19-Jan-07	10.1	14,493	Max	85	gpm
	28-Feb-07	6.9	9,923	Median	6	gpm
	30-Mar-07	6.9	9,885	Average	10	gpm
	26-Apr-07	6.3	9,077	Min	4	gpm
	1-Jun-07	5.8	8,388			
	16-Jul-07	6.8	9,799	**DAILY TOTAL**		
	25-Jul-07	7.2	10,316	Max	123,037	gpd
	30-Aug-07	6.8	9,757	Median	9,094	gpd
	11-Oct-07	6.5	9,381	Average	14,192	gpd
	29-Oct-07	6.3	9,094	Min	5,843	gpd
	3-Dec-07	85.4	123,037			
	17-Dec-07	8.5	12,235			
	23-Jan-08	6.9	9,988			
	27-Feb-08	7.2	10,344			
	10-Mar-08	7.0	10,145			
	29-May-08	6.1	8,757			
	25-Jun-08	5.8	8,392	*(continued on next page)*		

Table 3. Weir Discharge Data Summary (continued)

Weir	Date	Average (gpm)	Daily Weir Total (gpd)			
SW-W3	29-Jul-08	5.5	7,938	*(continued)*		
	30-Sep-08	4.9	7,123			
	31-Dec-08	5.9	8,470			
	2-Apr-09	5.9	8,457			
	12-May-09	4.9	7,111			
	20-Jul-09	4.9	7,061			
	23-Sep-09	4.1	5,843			
	19-Oct-09	4.6	6,585			
	22-Dec-09	6.7	9,613			
	25-Feb-10	6.1	8,846			
	12-Apr-10	5.6	8,108			
	22-Jun-10	5.2	7,490			
	1-Nov-10	31.7	45,654			
SW-W4	21-Nov-06	1.5	2,192	**RATE**		
	19-Jan-07	1.3	1,838	Max	22	gpm
	28-Feb-07	0.9	1,331	Median	1	gpm
	30-Mar-07	0.8	1,099	Average	2	gpm
	26-Apr-07	0.3	389	Min	0.27	gpm
	1-Jun-07	0.5	757			
	16-Jul-07	0.6	846	**DAILY TOTAL**		
	25-Jul-07	0.7	1,007	Max	32,999	gpd
	30-Aug-07	0.6	843	Median	913	gpd
	11-Oct-07	0.4	580	Average	2,401	gpd
	29-Oct-07	0.6	828	Min	389	gpd
	3-Dec-07	22.4	32,299			
	17-Dec-07	0.6	876			
	23-Jan-08	0.8	1,169			
	27-Feb-08	0.6	913			
	10-Mar-08	0.8	1,157			
	29-May-08	0.7	981			
	25-Jun-08	0.5	725			
	29-Jul-08	0.6	807			
	30-Sep-08	0.7	968			
	31-Dec-08	0.4	557			
	2-Apr-09	0.9	1,229			
	12-May-09	0.4	629			
	20-Jul-09	0.5	678			
	23-Sep-09	0.4	590			
	19-Oct-09	0.6	910			
	22-Dec-09	1.2	1,786			
	25-Feb-10	1.1	1,627			
	12-Apr-10	0.9	1,250			
	22-Jun-10	0.6	876			
	1-Nov-10	8.8	12,694			
SW-W5	21-Nov-06	9.5	13,738			
	19-Jan-07	14.5	20,925			
	28-Feb-07	9.9	14,267			
	30-Mar-07	9.5	13,738			
	26-Apr-07	7.2	10,376	*(continued on next page)*		

Table 3. Weir Discharge Data Summary (continued)

Weir	Date	Average (gpm)	Daily Weir Total (gpd)			
SW-W5	1-Jun-07	7.2	10,376	*(continued)*		
	16-Jul-07	6.6	9,511	**RATE**		
	25-Jul-07	8.6	12,451	Max	54	gpm
	30-Aug-07	9.2	13,271	Median	8	gpm
	11-Oct-07	9.3	13,365	Average	9	gpm
	29-Oct-07	9.1	13,137	Min	2	gpm
	3-Dec-07	54.4	78,399			
	17-Dec-07	10.0	14,339	**DAILY TOTAL**		
	23-Jan-08	9.1	13,112	Max	78,399	gpd
	27-Feb-08	9.1	13,044	Median	11,588	gpd
	10-Mar-08	9.1	13,044	Average	13,276	gpd
	29-May-08	7.1	10,262	Min	3,467	gpd
	25-Jun-08	8.0	11,558			
	29-Jul-08	2.4	3,467			
	30-Sep-08	5.8	8,409			
	31-Dec-08	8.8	12,600			
	2-Apr-09	7.5	10,767			
	12-May-09	3.6	5,242			
	20-Jul-09	5.5	7,988			
	23-Sep-09	5.6	8,090			
	19-Oct-09	2.5	3,637			
	22-Dec-09	5.1	7,305			
	25-Feb-10	8.3	12,020			
	12-Apr-10	7.3	10,544			
	22-Jun-10	7.1	10,207			
	1-Nov-10	15.3	21,971			
SW-W6	21-Nov-06	2.9	4,130	**RATE**		
	19-Jan-07	2.6	3,771	Max	19	gpm
	28-Feb-07	2.0	2,907	Median	2	gpm
	30-Mar-07	2.0	2,895	Average	3	gpm
	26-Apr-07	2.0	2,855	Min	1	gpm
	1-Jun-07	1.9	2,686			
	16-Jul-07	1.3	1,803	**DAILY TOTAL**		
	25-Jul-07	1.7	2,487	Max	27,722	gpd
	30-Aug-07	1.5	2,209	Median	2,686	gpd
	11-Oct-07	1.9	2,693	Average	3,802	gpd
	29-Oct-07	1.7	2,495	Min	1,803	gpd
	3-Dec-07	19.3	27,722			
	17-Dec-07	2.4	3,412			
	23-Jan-08	2.0	2,812			
	27-Feb-08	2.0	2,915			
	10-Mar-08	2.1	2,978			
	29-May-08	1.7	2,443			
	25-Jun-08	1.5	2,196			
	29-Jul-08	1.5	2,102			
	30-Sep-08	1.5	2,118			
	31-Dec-08	1.6	2,246	*(continued on next page)*		

Table 3. Weir Discharge Data Summary (continued)

Weir	Date	Average (gpm)	Daily Weir Total (gpd)			
SW-W6	2-Apr-09	1.9	2,784	(continued)		
	12-May-09	2.0	2,933			
	20-Jul-09	1.3	1,927			
	23-Sep-09	1.4	2,061			
	19-Oct-09	1.5	2,169			
	22-Dec-09	2.0	2,940			
	25-Feb-10	1.6	2,362			
	12-Apr-10	1.6	2,283			
	22-Jun-10	1.7	2,386			
	1-Nov-10	9.8	14,157			
SW-W7	21-Nov-06	19.8	28,534	**RATE**		
	19-Jan-07	17.2	24,729	Max	73	gpm
	28-Feb-07	15.9	22,827	Median	16	gpm
	30-Mar-07	15.9	22,827	Average	18	gpm
	26-Apr-07	13.8	19,835	Min	12	gpm
	1-Jun-07	13.3	19,134			
	16-Jul-07	15.9	22,827	**DAILY TOTAL**		
	25-Jul-07	16.4	23,623	Max	105,458	gpd
	30-Aug-07	15.3	22,092	Median	22,465	gpd
	11-Oct-07	16.0	22,982	Average	26,055	gpd
	29-Oct-07	15.6	22,510	Min	17,023	gpd
	3-Dec-07	73.2	105,458			
	17-Dec-07	17.5	25,250			
	23-Jan-08	15.5	22,352			
	27-Feb-08	18.1	26,088			
	10-Mar-08	15.9	22,827			
	29-May-08	14.1	20,366			
	25-Jun-08	14.9	21,393			
	29-Jul-08	13.9	19,961			
	30-Sep-08	15.0	21,537			
	31-Dec-08	15.9	22,930			
	2-Apr-09	13.6	19,614			
	12-May-09	13.9	20,009			
	20-Jul-09	11.8	17,023			
	23-Sep-09	12.5	18,023			
	19-Oct-09	13.6	19,574			
	22-Dec-09	14.0	20,144			
	25-Feb-10	16.4	23,628			
	12-Apr-10	14.8	21,242			
	22-Jun-10	15.6	22,465			
	1-Nov-10	45.8	65,895			

Notes:
gpm, gallons per minute
gpd, gallons per day
Max, maximum
Min, minimum

Table 4. Water Quality Standards

Analyte	CAS No.	Eff. Date	Federal Drinking Water Standards MCL		Ref.	Ground Water Quality Criteria Criterion*		Eff. Date	Ref.
Primary Standards									
A. Inorganics									
Antimony	7440-36-0	17-Jan-94	0.006	mg/L	FR v. 57 No.138	0.006	mg/L	17-Jan-94	WAC 173-200
Arsenic c	7440-38-2	23-Jan-06	0.01	mg/L	66 FR 28342	0.00005	mg/L	01-Dec-90	WAC 173-200
Asbestos	**132207-33-1**	**30-Jul-92**	**7**	**mf/L**	**FR v. 56 No. 20**	**7**	**mf/L**	**30-Jul-92**	**WAC 173-200**
Barium	7440-39-3	1-Jan-93	2.0	mg/L	FR v. 56 No. 126	1.0	mg/L	01-Dec-90	WAC 173-200
Beryllium	7440-41-7	17-Jan-94	0.004	mg/L	FR v. 57 No.138	0.004	mg/L	17-Jan-94	WAC 173-200
Cadmium	7440-43-9	30-Jul-92	0.005	mg/L	FR v. 56 No. 20	0.005	mg/L	01-Dec-90	WAC 173-200
Chromium	7440-47-3	30-Jul-92	0.1	mg/L	FR v. 56 No. 20	0.05	mg/L	01-Dec-90	WAC 173-200
Copper	7440-50-8	7-Dec-92	1.3**	mg/L	FR v. 57 No. 125	1.0	mg/L	01-Dec-90	WAC 173-200
Cyanide	**57-12-5**	**17-Jan-94**	**0.2**	**mg/L**	**FR v. 57 No.138**	**0.2**	**mg/L**	**17-Jan-94**	**WAC 173-200**
Fluoride	**16984-48-8**	**2-Oct-87**	**4.0**	**mg/L**	**40 CFR 141**	**4.0**	**mg/L**	**01-Dec-90**	**WAC 173-200**
Lead	7439-92-1	7-Dec-92	0.015**	mg/L	FR v. 57 No. 125	0.015	mg/L	01-Dec-90	WAC 173-200
Mercury	7439-97-6	2-Apr-86	0.002	mg/L	40 CFR 141	0.002	mg/L	01-Dec-90	WAC 173-200
Nickel	7440-02-0	17-Jan-94	0.1	mg/L	FR v. 57 No.138	0.1	mg/L	17-Jan-94	WAC 173-200
Nitrate	14797-55-8	2-Apr-86	10.0	mg/L	FR v. 56 No. 20	10.0	mg/L	01-Dec-90	WAC 173-200
Nitrate and Nitrite	14797-55-8+	30-Jul-92	10.0	mg/L	FR v. 56 No. 20	10.0	mg/L	30-Jul-92	WAC 173-200
Nitrite	14797-65-0	30-Jul-92	1	mg/L	FR v. 56 No. 20	1.0	mg/L	30-Jul-92	WAC 173-200
Selenium	7782-49-2	30-Jul-92	0.05	mg/L	FR v. 56 No. 20	0.01	mg/L	01-Dec-90	WAC 173-200
Silver	7440-22-4		--			0.05	mg/L	01-Dec-90	WAC 173-200
Sodium	7440-23-5	20-Sep-04	20***	mg/L		20***	mg/L	03-Jul-04	WAC 246-290
Thallium	7440-28-0	17-Jan-94	0.002	mg/L	FR v. 57 No.138	0.002	mg/L	17-Jan-94	WAC 173-200
Total Coliforms		**24-Dec-75**	**1/100**	**mL**	**40 CFR 141**	**1/100**	**mL**	**01-Dec-90**	**WAC 173-200**
Turbidity		24-Dec-75	1	NTU	40 CFR 141	--	--	--	--
B. Organic Chemicals									
Alachlor	**15972-60-8**	**30-Jul-92**	**2**	**ug/L**	**FR v. 56 No. 20**	**2**	**ug/L**	**30-Jul-92**	**WAC 173-200**
Atrazine	**1912-24-9**	**30-Jul-92**	**3**	**ug/L**	**FR v. 56 No. 20**	**3**	**ug/L**	**30-Jul-92**	**WAC 173-200**
Benzene c	71-43-2	9-Jan-89	5	ug/L	40 CFR 141	1	ug/L	01-Dec-90	WAC 173-200
Bis(2-ethylhexyl)phthalate	**117-81-7**	**17-Jan-94**	**6**	**ug/L**	**FR v. 57 No.138**	**6**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Bromodichloromethane c	**75-27-4**		**--**			**0.3**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Bromoform c	**75-25-2**		**--**			**5**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Carbofuran	**1563-66-2**	**30-Jul-92**	**40**	**ug/L**	**FR v. 56 No. 20**	**40**	**ug/L**	**30-Jul-92**	**WAC 173-200**
Carbon Tetrachloride c	**56-23-5**	**9-Jan-89**	**5**	**ug/L**	**40 CFR 141**	**0.3**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Chlordane c	**5103-71-9**	**30-Jul-92**	**2**	**ug/L**	**FR v. 56 No. 20**	**0.06**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Chlorobenzene	**108-90-7**	**30-Jul-92**	**100**	**ug/L**	**FR v. 56 No. 20**	**100**	**ug/L**	**30-Jul-92**	**WAC 173-200**
Chlorodibromomethane c	**124-48-1**		**--**			**0.5**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Chloroform c	67-66-3		--			7	ug/L	01-Dec-90	WAC 173-200
2,4-D	**94-75-7**	**30-Jul-92**	**70**	**ug/L**	**FR v. 56 No. 20**	**70**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Dalapon	**75-99-0**	**17-Jan-94**	**200**	**ug/L**	**FR v. 57 No.138**	**200**	**ug/L**	**17-Jan-94**	**WAC 173-200**
1,2-Dibromo-3-chloropropane	**96-12-8**	**30-Jul-92**	**0.2**	**ug/L**	**FR v. 56 No. 20**	**0.2**	**ug/L**	**30-Jul-92**	**WAC 173-200**
1,2-Dichlorobenzene	**95-50-1**	**30-Jul-92**	**600**	**ug/L**	**FR v. 56 No. 20**	**600**	**ug/L**	**30-Jul-92**	**WAC 173-200**
1,4-Dichlorobenzene c	**106-46-7**	**9-Jan-89**	**75**	**ug/L**	**40 CFR 141**	**4**	**ug/L**	**01-Dec-90**	**WAC 173-200**
1,1-Dichloroethane c	75-34-3		--			1	ug/L	01-Dec-90	WAC 173-200
1,2-Dichloroethane c	107-06-2	9-Jan-89	5	ug/L	40 CFR 141	0.5	ug/L	01-Dec-90	WAC 173-200
1,1-Dichloroethene	**75-35-4**	**9-Jan-89**	**7**	**ug/L**	**40 CFR 141**	**7**	**ug/L**	**01-Dec-90**	**WAC 173-200**
c-1,2-Dichloroethene	156-59-2	30-Jul-92	70	ug/L	FR v. 56 No. 20	70	ug/L	30-Jul-92	WAC 173-200
t-1,2-Dichloroethene	156-60-5	30-Jul-92	100	ug/L	FR v. 56 No. 20	100	ug/L	30-Jul-92	WAC 173-200
1,2-Dichloropropane c	78-87-5	30-Jul-92	5	ug/L	FR v. 56 No. 20	0.6	ug/L	01-Dec-90	WAC 173-200
1,3-Dichloropropene tot. c	**542-75-6**		**--**			**0.2**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Di(ethylhexyl)adipate	**103-23-1**	**17-Jan-94**	**400**	**ug/L**	**FR v. 57 No.138**	**400**	**ug/L**	**17-Jan-94**	**WAC 173-200**
Dinoseb	**88-85-7**	**17-Jan-94**	**7**	**ug/L**	**FR v. 57 No.138**	**7**	**ug/L**	**17-Jan-94**	**WAC 173-200**
Diquat	**231-36-7**	**17-Jan-94**	**20**	**ug/L**	**FR v. 57 No.138**	**20**	**ug/L**	**17-Jan-94**	**WAC 173-200**
Endothall	**145-73-3**	**17-Jan-94**	**100**	**ug/L**	**FR v. 57 No.138**	**100**	**ug/L**	**17-Jan-94**	**WAC 173-200**
Endrin	**72-20-8**	**17-Jan-94**	**2**	**ug/L**	**40 CFR 141**	**0.2**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Ethylbenzene	100-41-4	30-Jul-92	700	ug/L	FR v. 56 No. 20	700	ug/L	30-Jul-92	WAC 173-200
Ethylene dibromide c	**106-93-4**	**30-Jul-92**	**0.05**	**ug/L**	**FR v. 56 No. 20**	**0.001**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Glyphosate	**1071-83-6**	**17-Jan-94**	**70**	**ug/L**	**FR v. 57 No.138**	**70**	**ug/L**	**17-Jan-94**	**WAC 173-200**
Heptachlor c	**76-44-8**	**30-Jul-92**	**0.4**	**ug/L**	**FR v. 56 No. 20**	**0.02**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Heptachlor epoxide c	**1024-57-3**	**30-Jul-92**	**0.2**	**ug/L**	**FR v. 56 No. 20**	**0.009**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Hexachlorobenzene	**118-74-1**	**17-Jan-94**	**1**	**ug/L**	**FR v. 57 No.138**	**0.05**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Hexachlorocyclopentadiene (HE	**77-47-4**	**17-Jan-94**	**50**	**ug/L**	**FR v. 57 No.138**	**50**	**ug/L**	**17-Jan-94**	**WAC 173-200**
Lindane c	**58-89-9**	**30-Jul-92**	**0.2**	**ug/L**	**FR v. 56 No. 20**	**0.06**	**ug/L**	**01-Dec-90**	**WAC 173-200**

Table 4. Water Quality Standards (continued)

Analyte	CAS No.	Eff. Date	Federal Drinking Water Standards MCL		Ref.	Ground Water Quality Criteria Criterion*		Eff. Date	Ref.
Methoxychlor	72-43-5	30-Jul-92	40	ug/L	FR v. 56 No. 20	40	ug/L	30-Jul-92	WAC 173-200
Methylene Chloride c	75-09-2	17-Jan-94	5	ug/L	FR v. 57 No.138	5	ug/L	17-Jan-94	WAC 173-200
Oxamyl (vydate)	23135-22-0	17-Jan-94	200	ug/L	FR v. 57 No.138	200	ug/L	17-Jan-94	WAC 173-200
PAHs [Benzo(a)pyrene]		17-Jan-94	0.2	ug/l	FR v. 57 No.138	0.01	ug/L	17-Jan-94	WAC 173-200
PCBs c	27323-18-8	30-Jul-92	0.5	ug/L	FR v. 56 No. 20	0.01	ug/L	01-Dec-90	WAC 173-200
Pentachlorophenol	87-86-5	1-Jan-93	1	ug/L	FR v. 56 No. 126	1	ug/L	01-Jan-93	WAC 173-200
Picloram	1918-02-1	17-Jan-94	500	ug/L	FR v. 57 No.138	500	ug/L	17-Jan-94	WAC 173-200
Simazine	122-34-9	17-Jan-94	4	ug/L	FR v. 57 No.138	4	ug/L	17-Jan-94	WAC 173-200
Styrene	100-42-5	30-Jul-92	10	ug/L	FR v. 56 No. 20	100	ug/L	30-Jul-92	WAC 173-200
2,3,7,8-Tetrachlorodibenzo-p-dic	1746-01-6	17-Jan-94	3E-05	ug/L	FR v. 57 No.138	0.0000000(	ug/L	01-Dec-90	WAC 173-200
Tetrachloroethylene c	127-18-4	30-Jul-92	5	ug/L	FR v. 56 No. 20	0.8	ug/L	30-Jul-92	WAC 173-200
Toluene	108-88-3	30-Jul-92	1000	ug/L	FR v. 56 No. 20	1000	ug/L	30-Jul-92	WAC 173-200
Total Trihalomethanes c	75-27-4, 75-2	29-Nov-79	100	ug/L	40 CFR 141	--	--	--	--
Toxaphene c	8001-35-2	30-Jul-92	3	ug/L	FR v. 56 No. 20	0.08	ug/L	01-Dec-90	WAC 173-200
2,4,5-TP	93-72-1	30-Jul-92	50	ug/L	FR v. 56 No. 20	100	ug/L	01-Dec-90	WAC 173-200
1,2,4-Trichlorobenzene	120-82-1	17-Jan-94	70	ug/L	FR v. 57 No.138	70	ug/L	17-Jan-94	WAC 173-200
1,1,1-Trichloroethane	71-55-6	9-Jan-89	200	ug/L	40 CFR 141	200	ug/L	01-Dec-90	WAC 173-200
1,1,2-Trichloroethane	79-00-5	17-Jan-94	5	ug/L	FR v. 57 No.138	5	ug/L	17-Jan-94	WAC 173-200
Trichloroethylene (TCE) c	79-01-6	9-Jan-89	5	ug/L	40 CFR 141	3	ug/L	01-Dec-90	WAC 173-200
Vinyl chloride c	75-01-4	9-Jan-89	2	ug/L	40 CFR 141	0.02	ug/L	01-Dec-90	WAC 173-200
Xylenes (total)	1330-20-7	30-Jul-92	10000	ug/L	FR v. 56 No. 20	10000	ug/L	30-Jul-92	WAC 173-200
C. Radionuclides and Radioactivity									
Radium 226 & Radium 228		9-Jul-76	5	pCi/L	FR v. 41 No. 133	5	pCi/L	01-Dec-90	WAC 173-200
Radium 226	13982-63-3		--			3	pCi/L	01-Dec-90	WAC 173-200
Radium 228	15262-20-1		--			5	pCi/L	01-Dec-90	WAC 173-200
Gross Alpha particle activity		9-Jul-76	15	pCi/L	FR v. 41 No. 133	15	pCi/L	01-Dec-90	WAC 173-200
Tritium	10028-17-8	9-Jul-76	20,000	pCi/L	FR v. 41 No. 133	20,000	pCi/L	01-Dec-90	WAC 173-200
Strontium	7440-24-6	9-Jul-76	8	pCi/L	FR v. 41 No. 133	8	pCi/L	01-Dec-90	WAC 173-200
Gross Beta particle activity		9-Jul-76	50	pCi/L	FR v. 41 No. 133	50	pCi/L	01-Dec-90	WAC 173-200
D. Additional Carcinogens Listed in Groundwater Criteria									
Acrylamide	79-06-1		--			0.02	ug/L	01-Dec-90	WAC 173-200
Acrylonitrile	107-13-1		--			0.07	ug/L	01-Dec-90	WAC 173-200
Aldrin	309-00-2		--			0.005	ug/L	01-Dec-90	WAC 173-200
Aniline	62-53-3		--			14	ug/L	01-Dec-90	WAC 173-200
Aramite	140-57-8		--			3	ug/L	01-Dec-90	WAC 173-200
Azobenzene	103-33-3		--			0.7	ug/L	01-Dec-90	WAC 173-200
Benzidine	92-87-5		--			0.0004	ug/L	01-Dec-90	WAC 173-200
Benzo(a)pyrene	50-32-8		--			0.008	ug/L	01-Dec-90	WAC 173-200
Benzotrichloride	98-07-7		--			0.007	ug/L	01-Dec-90	WAC 173-200
Benzyl chloride	100-44-7		--			0.5	ug/L	01-Dec-90	WAC 173-200
Bis(chloroethyl)ether	111-44-4		--			0.07	ug/L	01-Dec-90	WAC 173-200
Bis(chloromethyl)ether	542-88-1		--			0.0004	ug/L	01-Dec-90	WAC 173-200
Carbazole	86-74-8		--			5	ug/L	01-Dec-90	WAC 173-200
4-Chloro-2-methyl analine	95-69-2		--			0.1	ug/L	01-Dec-90	WAC 173-200
4-Chloro-2-methyl analine hydro	3165-93-3		--			0.2	ug/L	01-Dec-90	WAC 173-200
o-Chloronitrobenzene	88-73-3		--			3	ug/L	01-Dec-90	WAC 173-200
p-Chloronitrobenzene	100-00-5		--			5	ug/L	01-Dec-90	WAC 173-200
Chlorthalonil	1897-45-6		--			30	ug/L	01-Dec-90	WAC 173-200
Diallate	2303-16-4		--			1	ug/L	01-Dec-90	WAC 173-200
DDT (includes DDE and DDD)	50-29-3, 72-55-9, 72-54-8		--			0.3	ug/L	01-Dec-90	WAC 173-200
1,2-Dibromomethane	106-93-4		--			0.001	ug/L	01-Dec-90	WAC 173-200
3,3'-Dichlorobenzidine	91-94-1		--			0.2	ug/L	01-Dec-90	WAC 173-200
Dichlorovos	62-73-7		--			0.3	ug/L	01-Dec-90	WAC 173-200
Dieldrin	60-57-1		--			0.005	ug/L	01-Dec-90	WAC 173-200
3,3'-Dimethoxybenzidine	119-90-4		--			6.0	ug/L	01-Dec-90	WAC 173-200
3,3-Dimethylbenzidine	119-93-7		--			0.007	ug/L	01-Dec-90	WAC 173-200
1,2-Dimethylhydrazine	540-73-8		--			60	ug/L	01-Dec-90	WAC 173-200
2,4-Dinitrotoluene	121-14-2		--			0.1	ug/L	01-Dec-90	WAC 173-200
2,6-Dinitrotoluene	606-20-2		--			0.1	ug/L	01-Dec-90	WAC 173-200
1,4-Dioxane	123-91-1		--			7	ug/L	01-Dec-90	WAC 173-200
1,2-Diphenylhydrazine	122-66-7		--			0.09	ug/L	01-Dec-90	WAC 173-200

Table 4. Water Quality Standards (continued)

Analyte	CAS No.	Eff. Date	Federal Drinking Water Standards MCL		Ref.	Ground Water Quality Criteria Criterion*		Eff. Date	Ref.
Direct Black 38	**1937-37-7**		--			**0.009**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Direct Blue 6	**2602-46-2**		--			**0.009**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Direct Brown 95	**16071-86-6**		--			**0.009**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Epichlorohydrin	**106-89-8**		--			**8**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Ethyl acrylate	**140-88-5**		--			**2**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Ethylene thiourea	**96-45-7**		--			**2**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Folpet	**133-07-3**		--			**20**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Furazolidone	**67-45-8**		--			**0.02**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Furium	**531-82-8**		--			**0.002**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Furmecyclox	**60568-05-0**		--			**3**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Hexachlorocyclohexane (alpha)	**319-84-6**		--			**0.001**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Hexachlorocyclohexane (techni	**608-73-1**		--			**0.05**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Hexachlorodibenzo-p-dioxin, mi	**34465-46-8**		--			**0.00001**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Hydrazine/hydrazine sufate	**302-01-2/10034-93-2**		--			**0.03**	**ug/L**	**01-Dec-90**	**WAC 173-200**
2-Methoxy-5-nitroanaline	**99-59-2**		--			**2.0**	**ug/L**	**01-Dec-90**	**WAC 173-200**
2-Methylanaline	**95-53-4**		--			**0.2**	**ug/L**	**01-Dec-90**	**WAC 173-200**
2-Methylanaline hydrochloride	**636-21-5**		--			**0.5**	**ug/L**	**01-Dec-90**	**WAC 173-200**
4,4'-Methylene bis(N,N'-dimethyl	**101-61-1**		--			**2.0**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Mirex	**2385-85-5**		--			**0.05**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Nitrofurazone	**59-87-0**		--			**0.06**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitrosodiethanolamine	**1116-54-7**		--			**0.03**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitrosodiethylamine	**55-18-5**		--			**0.0005**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitrosodimethylamine	**62-75-9**		--			**0.002**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitrosodiphenylamine	**86-30-6**		--			**17.0**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitroso-di-n-propylamine	**621-64-7**		--			**0.01**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitrosopyrrolidine	**930-55-2**		--			**0.04**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitroso-di-n-butylamine	**924-16-3**		--			**0.02**	**ug/L**	**01-Dec-90**	**WAC 173-200**
N-Nitroso-N-methylethylylamine	**10595-95-6**		--			**0.004**	**ug/L**	**01-Dec-90**	**WAC 173-200**
PBBs	**59536-65-1**		--			**0.01**	**ug/L**	**01-Dec-90**	**WAC 173-200**
o-Phenylenediamine	**95-54-5**		--			**0.005**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Propylene oxide	**75-56-9]**		--			**0.01**	**ug/L**	**01-Dec-90**	**WAC 173-200**
p,a,a,a-Tetrachlorotoluene	**5216-25-1**		--			**0.004**	**ug/L**	**01-Dec-90**	**WAC 173-200**
2,4-Toluenediamine	**95-80-7**		--			**0.002**	**ug/L**	**01-Dec-90**	**WAC 173-200**
o-Toluidine	**95-53-4**		--			**0.2**	**ug/L**	**01-Dec-90**	**WAC 173-200**
2,4,6-Trichlorophenol	**88-06-2**		--			**4.0**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Trimethyl phosphate	**512-56-1**		--			**2.0**	**ug/L**	**01-Dec-90**	**WAC 173-200**
Secondary Standards									
Aluminum	7429-90-5	30-Jul-92	0.05-0.2	mg/L	FR v. 56 No. 20	0.05-0.2	mg/L	30-Jul-92	WAC 173-200
Copper	7440-50-8	7-Dec-92	1.0	mg/L	FR v. 57 No. 125	1.0	mg/L	01-Dec-90	WAC 173-200
Iron	7439-89-6	2-Apr-86	0.3	mg/L	40 CFR 143	0.3	mg/L	01-Dec-90	WAC 173-200
Manganese	7439-96-5	2-Apr-86	0.05	mg/L	40 CFR 143	0.05	mg/L	01-Dec-90	WAC 173-200
Color		**2-Apr-86**	**15**	**units**	**40 CFR 143**	**15**	**units**	**01-Dec-90**	**WAC 173-200**
pH	12408-02-5	2-Apr-86	6.5-8.5	units	40 CFR 143	6.5-8.5	units	01-Dec-90	WAC 173-200
Specific Conductivity			--			700	uS/cm		WAC 246-290
Total Dissolved Solids		2-Apr-86	500	mg/L	40 CFR 143	500	mg/L	01-Dec-90	WAC 173-200
Chloride	16887-00-6	2-Apr-86	250	mg/L	40 CFR 143	250	mg/L	01-Dec-90	WAC 173-200
Fluoride	**16984-48-8**	**2-Apr-86**	**2.0**	**mg/L**	**40 CFR 143**	**p**			
Silver	7440-22-4	30-Jul-92	0.1	mg/L	FR v. 56 No. 20	p			
Sulfate	14808-79-8	2-Apr-86	250	mg/L	40 CFR 143	250	mg/L	01-Dec-90	WAC 173-200
Surfactants		2-Apr-86	0.5	mg/L	40 CFR 143	0.5	mg/L	01-Dec-90	WAC 173-200
Corrosivity		2-Apr-86	non-corrosive		40 CFR 143	non-corrosive		01-Dec-90	WAC 173-200
Odor-Threshold		2-Apr-86	3	units	40 CFR 143	3	units	01-Dec-90	WAC 173-200
Zinc	7440-66-6	2-Apr-86	5.0	mg/L	40 CFR 143	5.0	mg/L	01-Dec-90	WAC 173-200

NOTES: pCi/L=picocuries per liter; mg/L=milligrams per liter; mf/L=million fibers per liter
p=Listed as a Primary Standard; --'=no standard established; i=listed individually as groundwater criteria
c=Listed as a carcinogen in the Ground Water Criteria; MCL=Maximum Contaminant Level
*=Criteria shall be the most stringent concentration of the Federal MCLG, MCL; or State MCL; MCLG= Maximum Contaminant Level Goal
=treatment technique in lieu of an MCL; *= A Drinking Water Advisory, not an enforceable standard.
Ground Water Quality Criteria=Water Quality Standards for Ground Waters of the State of Washington

Compiled by KCSWD 1/12/94. Revised 1/23/06

Table 5. Field Water Quality Parameters for Hillslope Locations (2007 – 2010)

		CONDUCTANCE	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY
Surface Water Regulatory Limits (SWRL)		µs/cm	mg/l	pH units	deg c	ntu
WA State	Acute	None	None	None	None	None
	Chronic	None	8	6.5 - 8.5	18 °C	> 5 ntu
Federal	Acute	NC	4	NC	None	NC
	Chronic	NC	6.5	6.5 - 9	None	NC
SEEPAGE SAMPLING LOCATIONS						
SW-24S	5/9/2007	858	4.69	6.87	12.5	6.59
	8/15/2007	755	19.5	6.87	11.5	22.7
	10/31/2007	652	4.02	6.83	9.6	5.2
	12/19/2007	685			9.5	89.3
	3/11/2008	760	3.74	7.06	8.8	23.6
	10/7/2008	714	4.34	6.77	10.8	25
	1/7/2009	649	4.51	6.87	10.8	85.3
	3/25/2009	563	5.69	6.94	9.1	64.6
	7/14/2009	645	5.64	7.01	12.5	13.7
	10/27/2009	709	1.13	6.82	10.1	13.9
	1/28/2010	622	7.88	6.73	10.6	
	4/15/2010	620	36.9	6.53	10.5	19.3
	8/12/2010	823		6.77	11.7	15.8
	11/2/2010	691	2.06	6.65	11.6	63.5
SW-S1	5/11/2007	179.6	7.49	7.49	11.4	50.9
	8/14/2007	200	4.95	7.12	13.5	48.7
	10/31/2007	192	6.3	7.06	9.1	5.93
	12/19/2007	224	8.69	7.89	7.7	7.11
	3/11/2008	211	6.4	7.69	7.9	18.8
	10/7/2008	226	8.09	6.75	11.7	158
	1/7/2009	214	10.2	6.8	9.2	88
	3/25/2009	183.1	6.71	7.35	7.4	13.3
	7/14/2009	197	4.16	6.82	13.8	42.1
	10/27/2009	163.3	6.89	6.8	8.6	45.9
	2/4/2010	167.2	4.29	7.24		12.2
	4/15/2010	196.8	7.65	6.79	9.6	5.92
	11/2/2010	158.2	5.27	6.94	12.1	7.92
SW-S2	5/9/2007	1031	6.01	7.05	12.5	6.49
	8/15/2007	936	1.63	6.72	11.8	54
	10/31/2007	942	5.11	7.14	9.3	130
	12/19/2007	978			9.8	54
	3/11/2008	1034	4.01	7.04	9.5	33.8
	7/16/2008	1024	3.5	6.93	11.2	4.47
	10/7/2008	1027	4.18	6.85	10.9	5.66
	1/7/2009	886	3.56	6.85	10.6	3.03
	3/25/2009	905	3.23	6.81		24.9
	7/14/2009	870	3.97	6.91	11.8	25.7
	10/27/2009	766	4.44	6.78	10.1	13.6
	2/4/2010	965	3.33	6.87	10.6	2.02
	8/12/2010	915		6.65	12	24.6
	11/2/2010	761	1.48	6.49	11.8	27.5
SW-S3	5/11/2007	365	4.33	7.07	11	
	8/15/2007	507	0.95	6.79	15	9.61
	10/30/2007	411	2.23	6.92	10	51.9
	12/20/2007	438	3.99	7.37	6.7	15.9
	3/11/2008	447	2.37	6.98	8	13.9
	10/7/2008	447	5.58	7.13	12.1	22
	1/7/2009	361	4.11	6.84	8.8	17.2
	3/25/2009	398	4.15	6.86	6.9	11.1

Table 5. Field Water Quality Parameters for Hillslope Locations (2007 – 2010) (continued)

		CONDUCTANCE	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY
Surface Water Regulatory Limits (SWRL)		µs/cm	mg/l	pH units	deg c	ntu
WA State	Acute	None	None	None	None	None
	Chronic	None	8	6.5 - 8.5	18 °C	> 5 ntu
Federal	Acute	NC	4	NC	None	NC
	Chronic	NC	6.5	6.5 - 9	None	NC
SEEPAGE SAMPLING LOCATIONS (continued)						
SW-S3	7/14/2009	519	1.34	7.02	13.8	13.7
(cont.)	10/27/2009	432	2.7	6.91	9.6	15.6
	2/4/2010	365	1.98	6.65	8.5	19.9
	4/15/2010	393	2.75	6.37	9.2	24.3
	8/12/2010	472		6.42	13.7	16.8
	11/2/2010	450	1.45	6.61	11.9	3.37
SW-S4	5/10/2007	445	6.94	6.94	10.3	
	8/16/2007	465	0.69	6.95	10.5	8.42
	10/30/2007	443	5.94	7.08	9.9	111
	12/19/2007	403	5.35	7.6	8.8	59.9
	3/13/2008	327	2.3	7.06	8.5	81.5
	7/16/2008	407	4.87	7.18	12.9	11.7
	10/7/2008	540	4.79	7.12	11.4	7.41
	1/7/2009	440	2.12	6.96	10	39.5
	3/23/2009	426	7.03	7.45	8.7	9.15
	7/14/2009	562	8.55	7.11	13.4	109
	10/27/2009	579	1.89	6.83	9.5	214
	1/29/2010	530	4.4	7.18	10	63.1
	4/14/2010	570	2.85	6.2	9.1	14
	8/11/2010	717		6.9	14.2	4.27
	11/2/2010	456	1.53	6.69	11.3	3.81
SW-S5	5/10/2007	319	2.86	7.08	10.5	6.17
	8/16/2007	259	0.61	6.95	12.3	6.57
	11/1/2007	392	3.88	7.09	9.7	34.1
	12/18/2007	407	3.45	7.33	8.5	34.1
	3/13/2008	344	4.07	6.98	8.7	1.31
	7/16/2008	350	3.81	7.25	11.6	5.87
	10/7/2008	346	5.31	7.62	10.9	4.16
	1/7/2009	363	5.55	7.43	9.8	2.34
	3/24/2009	361	4.92	7.46	8.6	3.59
	7/16/2009	349	4.24	6.9	12.8	1.67
	10/27/2009	220	4.18	7.12	9.4	2.28
	1/29/2010	446	5.08	7.2	9.6	1.26
	4/14/2010	360	2.2	6.35	9.5	1.23
	8/11/2010	466		6.51	12.9	1.28
	11/5/2010	328	2.48	6.62	11.3	5.03
SW-S6	5/10/2007	388	5.82	7.01	10.4	
	8/16/2007	356	0.97	6.82	13	11.6
	11/1/2007	377	2.75	6.81	9.4	34.1
	12/18/2007	402	5.24	7.23	6.6	109
	3/13/2008	344	4.95	7.06	7.3	40.5
	7/16/2008	358	2.36	7.12	12.8	25.8
	10/7/2008	333	6.7	7.15	11.4	46.7
	1/6/2009	277	8	8.04	6.9	8.19
	3/24/2009	396	5.16	7.15	7.9	8.63
	10/27/2009	159.5	3.62	7.1	8.2	38
	1/29/2010	332		7.08	9.3	
	4/14/2010	378	3.64	6.08	8.8	19.8

Table 5. Field Water Quality Parameters for Hillslope Locations (2007 – 2010) (continued)

		CONDUCTANCE	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY
Surface Water Regulatory Limits (SWRL)		µs/cm	mg/l	pH units	deg c	ntu
WA State	Acute	None	None	None	None	None
	Chronic	None	8	6.5 - 8.5	18 °C	> 5 ntu
Federal	Acute	NC	4	NC	None	NC
	Chronic	NC	6.5	6.5 - 9	None	NC
SEEPAGE SAMPLING LOCATIONS (continued)						
SW-S6	8/11/2010	545		6.72	14	30.4
(cont.)	11/5/2010	392	2.1	6.87	11.2	14.5
WESTERN HILLSLOPE STREAMS/WEIR SAMPLING LOCATIONS						
SW-14E	5/9/2007	417	10.6	8.11	10.5	32.8
SW-W1	3/28/2007	181.2	9.5	7.76	9.1	7.87
	5/9/2007	199	11.42	7.8	11.2	14
	8/14/2007	229	7.04	7.73	13.9	238
	11/1/2007	239	13.33	7.69	9.1	87.9
	3/12/2008	216	7.05	7.82	7.4	271
	5/21/2008	248	5.6	7.82	11.3	10.7
	7/15/2008	205	8.61	7.91	13.8	53.9
	10/6/2008	228	8.48	7.2	12.4	27.3
	3/26/2009	202	9.87	8.43	5.6	3.15
	10/20/2009	173.1	6.07	7.84	11.3	18.8
	1/21/2010	192.3	14.2	7.29	8.6	11.4
	4/19/2010	237		7.11	13.1	6.01
	8/16/2010	197		7.22	17.3	34.5
	11/9/2010	200	9.33	6.65	8.6	47.9
SW-W2	3/28/2007	595	17.5	8.35	8.6	5.21
	5/9/2007	708	12.48	8.3	10.5	14.6
	8/14/2007	698	9.56	8.26	12.9	15.7
	10/30/2007	647	7.69	8.19	9	8.2
	12/18/2007	681	8.4	8.32	6.6	8.75
	3/12/2008	741	7.14	8.44	6.7	9.7
	5/21/2008	851	6.18	8.46	11.3	8.17
	7/15/2008	774	8.02	8.31	13.3	14.8
	10/6/2008	771	8.28	8.3	11.6	10.9
	1/6/2009	846	10.08	8.16	7	8.94
	3/26/2009	757	10.62	8.34	5.7	10.1
	7/13/2009	889	8.5	7.42	13.4	15.1
	10/20/2009	658	8.07	8.02	10.6	9.75
	1/21/2010	728	10.5	7.64	8.5	12.6
	4/19/2010	694		7.95	11.6	7.95
	8/16/2010	606		7.75	15.4	17.2
	11/9/2010	570	9.39	7.61	8.4	61.1
SW-W3	3/28/2007	288	16	8.12	8.7	10.1
	5/9/2007	326	12.86	8.08	10.5	19.4
	8/14/2007	345	10.02	8.07	12.2	13.5
	10/30/2007	309	6.92	7.84	10	54.9
	12/18/2007	360	7.95	8.17	7.5	9.29
	3/12/2008	347	7.06	8.12	7.6	9.54
	5/21/2008	407	6.7	8.21	10.7	15.4
	7/15/2008	374	7.99	7.73	12.6	25.2
	10/6/2008	384	8.1	7.36	11.6	6.8
	1/6/2009	431	10.3	7.17	7.2	5.8
	3/26/2009	389	11.43	7.75	6.6	6.16
	7/13/2009	484	7.65	8.01	13.5	9.54
	10/20/2009	389	8.35	7.04	10.8	7.62

Table 5. Field Water Quality Parameters for Hillslope Locations (2007 – 2010) (continued)

		CONDUCTANCE	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY
Surface Water Regulatory Limits (SWRL)		µs/cm	mg/l	pH units	deg c	ntu
WA State	Acute	None	None	None	None	None
	Chronic	None	8	6.5 - 8.5	18 °C	> 5 ntu
Federal	Acute	NC	4	NC	None	NC
	Chronic	NC	6.5	6.5 - 9	None	NC
WESTERN HILLSLOPE STREAMS/WEIR SAMPLING LOCATIONS (continued)						
SW-W3	1/21/2010	377	10.11	8.05	9.2	7.08
(cont.)	4/19/2010	312		10.71	11	9.41
	8/16/2010	228		6.75	14.1	9.14
	11/9/2010	310	9.39	7.06	8.5	33.7
SW-W4	5/10/2007	239	8.21	7.85	13.5	6.32
	8/14/2007	231	7.53	7.71	14	43.3
	10/31/2007	212	6.78	7.78	8.6	8.63
	12/18/2007	203	8.11	8.08	6.5	5.11
	3/12/2008	223	6.94	8.05	6.7	9.54
	10/6/2008	274	6.8	8.25	11.8	14.9
	1/6/2009	236	8.78	8.25	6.5	11.6
	3/23/2009	194.7	10.35	6.96	7.3	24.4
	7/13/2009	244	6.92	7.16	13.5	23.2
	10/19/2009	250	8.4	7.83	11.3	18.4
	1/22/2010	188.7	12.1	7.18	7.5	9.68
	4/19/2010	224		7.76	12.1	7.82
	8/11/2010	265		7.16	14.5	17.5
	11/1/2010	144.3	6.22	7.1	10.7	61.6
SW-W5	5/10/2007	238	9.47	8.06	9.9	6.42
	8/14/2007	232	9.63	7.85	11.5	4
	10/30/2007	229	9.44	7.96	9.3	2.91
	12/18/2007	251	9.53	6.95	7.7	25.6
	3/12/2008	266	8.82	7.75	8.4	5.51
	7/15/2008	274	9.48	8.07	11.8	12.1
	10/6/2008	285	10.43	7.93	11.1	2.3
	1/6/2009	270	8.55	8.05	7.9	3.22
	3/23/2009	217	11.62	7.43	8.2	5.75
	7/10/2009	315	7.45	7.34	12.1	3.66
	10/19/2009	255	8.98	7.47	10.8	3.1
	4/19/2010	245		7.58	11.3	7.69
	8/12/2010	330		6.95	12.2	3.8
	11/1/2010	171.4	6.6	6.97	10.6	27
SW-W6	5/10/2007	242	8.52	7.88	9.4	1.51
	8/14/2007	246	7.02	7.82	12.7	1.41
	11/1/2007	275	8.8	8.03	8.7	1.29
	12/18/2007	247	9.33	7.77	6.9	39.8
	3/12/2008	288	7.97	7.92	6.8	1.77
	7/15/2008	304	9.23	8.01	12.6	1.09
	10/6/2008	263	7.71	8.12	11.5	2.13
	3/24/2009	228	8.89	7.73	7.1	3.34
	7/10/2009	323	9.1	7.71	13.3	2.09
	10/19/2009	249	7.89	7.82	11.2	4.94
	1/22/2010	203	11.1	7.07	7.5	2.75
	4/19/2010	287		7.16	12.5	10.4
	8/12/2010	349		7.12	13.8	3.96
	11/1/2010	165.4	9.03	6.67	10.8	13.5

Table 5. Field Water Quality Parameters for Hillslope Locations (2007 – 2010) (continued)

		CONDUCTANCE	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY
Surface Water Regulatory Limits (SWRL)		µs/cm	mg/l	pH units	deg c	ntu
WA State	Acute	None	None	None	None	None
	Chronic	None	8	6.5 - 8.5	18 °C	> 5 ntu
Federal	Acute	NC	4	NC	None	NC
	Chronic	NC	6.5	6.5 - 9	None	NC
WESTERN HILLSLOPE STREAMS/WEIR SAMPLING LOCATIONS (continued)						
SW-W7	5/10/2007	251	7.65	8.1	10	4.63
	8/14/2007	253	7.65	7.91	12.5	5.9
	11/1/2007	289	7.51	8.1	8.7	11.2
	12/18/2007	245	8.25	8.01	6.9	38.1
	3/12/2008	258	7.22	7.87	7.2	3.19
	10/6/2008	298	8.07	8.17	11.1	9.2
	1/6/2009	270	10.95	8.07	7.1	3.29
	3/24/2009	227	10.23	8.02	7.4	3.31
	7/10/2009	325	7.59	7.92	12.5	4.15
	10/19/2009	258	7.52	7.76	10.9	5.26
	1/22/2010	216	10.5	7.13	8.2	
	4/19/2010	269		7.46	13.8	4.39
	8/11/2010	371		7.7	12.6	5.48
	11/1/2010	176.3	10.87	6.5	11	69.1

Table 5. Field Water Quality Parameters for Hillslope Locations (2007 – 2010) (continued)

		CONDUCTANCE	DISSOLVED OXYGEN	pH	TEMPERATURE	TURBIDITY
		µs/cm	mg/l	pH units	deg c	ntu
Federal Drinking Water Standards (FDWS)		None	None	6.5-8.5	None	1
Groundwater Quality Criteria (GQC)		700 uS/CM	None	6.5-8.5	None	None
WESTERN HILLSLOPE MONITORING WELLS						
MW-30	1/26/2010	370		6.72	8.5	
	4/29/2010	314		6.67	11.4	
	8/17/2010	287		6.6	13.3	
	11/8/2010	307		6.37	11	
MW-31	1/28/2010	245		7	9	
	4/22/2010	269		6.7	9.6	
	8/20/2010	290		6.76	12.8	
	11/8/2010	312		6.84	11.3	
MW-32	2/19/2010	510		7.3	10.3	
	4/29/2010	476		6.63	10	
	11/8/2010	444		7.53	10.6	

NOTE: Blank cell notes sample not analyzed for constituent
SWRL, FDWS, and GQC provided by KCSWD (2011).
NC Not calculated

QUAL	QUALIFIER DESCRIPTION for samples taken prior to 4/1/2009 (as per KC SWD)
B	Analyte Found In Associated Method Blank
D	Compound Analyzed at a Secondary Dilution Factor.
E	Exceed The Calibration or Linear Range.
J	Estimated Value Less Than Practical Quantitation Limit And Greater Than The Method Detection Limit.
M	Raised Detection Limit. Due to Matrix Interference.
O	Analyzed Beyond Specified Holding Time.
P	Pesticide/PCBs > 25% Difference Between Columns.
R	Rejected Data
U	Analyte Not Detected at Given Value.
CG	Confluent Growth (Bacterial Analyses Only)
ED	Excess Debris on Growth Media (Bacterial Analyses Only).

Non-numeric result NOTATIONS:

Not	Not Analyzed
NT	Not Tested
TNTC	Too numerous to count
NM	Coliforms 'Not Measured' in sample (no CO2 production).
P	Coliforms 'Present' in sample (CO2 production) but can't be quantified.

QUAL	QUALIFIER DESCRIPTION for samples taken after 4/12/2009 (as per KC SWD)		
U	Undetected Analyte concentration <MDL – Less than Method detection limit		
T	Estimated, Less than Reporting Detection Limit but greater than Method detection limit		
J	Reported value is an estimate	R	Data Rejected
B	Contamination present in Blank	S	Sample handling errors
C	Confluent Growth	X	Too numerous to count
E	Estimated, outside expected accuracy	D	Dilution
H	Exceeds holding time	P	PASS – Qualitative result acceptable
F	FAIL – Qualitative result is not acceptable	L	Less than
G	Greater than		

Table 6. Dissolved Metals in Equipment Blank Samples

		CALCIUM	SODIUM
		mg/L	mg/L
Federal Drinking Water Standards (FDWS)		Not applicable	20
Groundwater Quality Criteria (GQC)		Not applicable	20
SVW5090710E	7/10/2009	< 0.01 U	0.961
SVW5091019E	10/19/2009	< 0.01 U	< 0.05 U
SVW5100122E	1/22/2010	< 0.01 U	< 0.05 U
SVW2100419E	4/19/2010	0.018 T	< 0.05 U
SVW2100816E	8/16/2010	< 0.01 U	< 0.05 U
SVW5101101E	11/1/2010	< 0.01 DU	< 0.05 U

QUAL	QUALIFIER DESCRIPTION for samples taken prior to 4/1/2009 (as per KC SWD)
B	Analyte Found In Associated Method Blank
D	Compound Analyzed at a Secondary Dilution Factor.
E	Exceed The Calibration or Linear Range.
J	Estimated Value Less Than Practical Quantitation Limit And Greater Than The Method Detection Limit.
M	Raised Detection Limit. Due to Matrix Interference.
O	Analyzed Beyond Specified Holding Time.
P	Pesticide/PCBs > 25% Difference Between Columns.
R	Rejected Data
U	Analyte Not Detected at Given Value.
CG	Confluent Growth (Bacterial Analyses Only)
ED	Excess Debris on Growth Media (Bacterial Analyses Only).
Non-numeric result NOTATIONS:	
Not	Not Analyzed
NT	Not Tested
TNTC	Too numerous to count
NM	Coliforms 'Not Measured' in sample (no CO2 production).
P	Coliforms 'Present' in sample (CO2 production) but can't be quantified.

QUAL	QUALIFIER DESCRIPTION for samples taken after 4/12/2009 (as per KC SWD)
U	Undetected Analyte concentration <MDL – Less than Method detection limit
T	Estimated, Less than Reporting Detection Limit but greater than Method detection limit
J	Reported value is an estimate
B	Contamination present in Blank
C	Confluent Growth
E	Estimated, outside expected accuracy
H	Exceeds holding time
R	Data Rejected
S	Sample handling errors
X	Too numerous to count
D	Dilution
P	PASS – Qualitative result acceptable
F	FAIL – Qualitative result is not acceptable
G	Greater than
L	Less than

Table 7. Detections in Volatiles Trip Blank Samples

	ACETONE	BROMOMETHANE	CHLOROMETHANE	METHYLENE CHLORIDE
	ug/l	ug/l	ug/l	ug/l
Federal Drinking Water Standards	NA	NA	NA	5
Groundwater Quality Criteria Criterion	NA	NA	NA	5
VTRP090106R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP090106T				
VTRP090107T	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP090515R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP090710R				
VTRP090713R	< 4 U	< 0.2 U	0.21 T	< 0.2 U
VTRP090714R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP090716R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP090720R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP090812T	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP091019R				
VTRP091020R	< 4 U	0.21 T	0.559	0.38 T
VTRP100121R	< 4 U	< 0.2 U	0.36 BT	< 0.2 U
VTRP100129T	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100204R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100414R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100415R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100416R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100422R	< 4 U	< 0.2 U	< 0.2 U	0.22 T
VTRP100429R	< 4 U	< 0.2 U	< 0.2 U	0.802
VTRP100505S	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100505T	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100714T	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100811R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100812R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100812T				
VTRP100811T	5.56 B	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100816R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100817R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100820R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP100908T	< 4 U	< 0.2 U	< 0.2 U	0.39 T
VTRP101101R				
VTRP101102R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP101105R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP101108R	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP101109T	< 4 U	< 0.2 U	< 0.2 U	< 0.2 U
VTRP101109R	< 4 U	< 0.2 U	< 0.2 U	0.28 T

NOTE: Blank cell notes sample not analyzed for constituent

QUAL	QUALIFIER DESCRIPTION for samples taken prior to 4/1/2009 (as per KC SWD)
B	Analyte Found In Associated Method Blank
D	Compound Analyzed at a Secondary Dilution Factor.
E	Exceed The Calibration or Linear Range.
J	Estimated Value Less Than Practical Quantitation Limit And Greater Than The Method Detection Limit.
M	Raised Detection Limit. Due to Matrix Interference.
O	Analyzed Beyond Specified Holding Time.
P	Pesticide/PCBs > 25% Difference Between Columns.
R	Rejected Data
U	Analyte Not Detected at Given Value.
CG	Confluent Growth (Bacterial Analyses Only)
ED	Excess Debris on Growth Media (Bacterial Analyses Only).
Non-numeric result NOTATIONS:	
Not	Not Analyzed
NT	Not Tested
TNTC	Too numerous to count
NM	Coliforms 'Not Measured' in sample (no CO2 production).
P	Coliforms 'Present' in sample (CO2 production) but can't be quantified.

QUAL	QUALIFIER DESCRIPTION for samples taken after 4/12/2009 (as per KC SWD)
U	Undetected Analyte concentration <MDL – Less than Method detection limit
T	Estimated, Less than Reporting Detection Limit but greater than Method detection limit
J	Reported value is an estimate
B	Contamination present in Blank
C	Confluent Growth
E	Estimated, outside expected accuracy
H	Exceeds holding time
R	Data Rejected
S	Sample handling errors
X	Too numerous to count
D	Dilution
P	PASS – Qualitative result acceptable
F	FAIL – Qualitative result is not acceptable
G	Greater than
L	Less than

Table 8. Geologic Boring Data

Wells MW-4, -5, and -21)			Hillslope Mapping				MW-30			MW-31			MW-32		
Unit	Approx Thickness (ft)	Notes	Unit	Approx Thickness (ft)	Notes	Comments on Contacts	Unit	Approx Thickness (ft)	Notes	Unit	Approx Thickness (ft)	Notes	Unit	Approx Thickness (ft)	Notes
A	30+		A	30+		Upper – n/a Lower – marked change									
B	80		B	80		Upper & Lower – marked change									
Cc1	60	Pinches out to north; expected dry	Cc1	80	Pinches out to north; Possibly wet to the south	Upper & Lower - inferred									
Cf	30		Cf	20	Minor difference from Cc1	Upper & Lower - inferred							Cf	16+ (Eroded)	Clayey silts - fine sand, brown - gray, wet at 5, 100+, gradational lower contact
Cc2	30		Cc2	40	Saturated; soupy	Upper & Lower - inferred	Cc2	11+ (Eroded)	Fine to medium sand, some silty lenses, grayish brown, high permeability, wet				Cc2	3.5+	Medium to fine sand, grayish brown, high permeability, wet
Cf	10	Hard silt	Cf	20	"Whipped cream" appearance to silt/clay	Upper - inferred Lower – located at location 21.4; inferred elsewhere									
Cc3	20		Cc3	30		Upper – located at location 21.4; inferred elsewhere; Lower - sharp				Cc3	9+ (Eroded)	Bluish gray, coarse sand with silty lenses, mod. high permeability, wet			
			Cf	10	Hard silt	Upper/ Lower- sharp				Cf	1+	Upper contact sharp, stiff, greenish gray, low permeability, wet			
D	100+		D	100+	Cemented at 140 ft MSL and deeper	Upper - depends on if sand beneath hard silt is Cc3 and not Unit D. Lower –n/a									

Appendices

Appendices

Appendix A. *Vashon Island Landfill & Transfer Station: Hydrogeologic Services, Proposed Scope of Work #2*. October 23, 2006

Appendix B. Health & Safety Plans

- B.1 *Weirs, Water Sampling & BMPs*. October 2006.
- B.2 *Weirs, Water Sampling, BMPs, & Trail Maintenance*. April 2007
- B.2 *Western Hillslope Sampling Activities*. April 2010.

Appendix C. Seepage Sampler & Weir Installation Photos

Appendix D. Well Installations

- D.1 *Work Plan: Hand Augering, Sediment Sampling, and Monitoring Well Installation, Development & Sampling Activities*. 2009.
- D.2 *Technical Memorandum: Hand Augering, Sediment Sampling, and Monitoring Well Installation, Development & Sampling Activities*. 2010.
- D.3 Well Installation Pictures

Appendix E. Weir Discharge Activity

- E.1 Pictures of Taking Discharge Measurements
- E.2 Discharge Data Table

Appendix F. Sampling Field Sheets

Appendix G. Chain of Custody Forms

Appendix H. Ion Balance Calculations

- H.1 Seeps/Seepage Sampling Locations
- H.2 Streams/Weirs Sampling Locations
- H.3 Cc2 Perched Zone Monitoring Wells
- H.4 Cc3 & Regional Aquifer Monitoring Wells
- H.5 Western Hillslope Monitoring Wells

Appendix I. Laboratory Data Deliverables

Appendix J. Field Water Quality Parameters

Appendix K. Piper Diagrams

Appendix L. Time Series Plots (2000 – 2010)

- L.1 Dissolved Metals
- L.2 Volatiles
- L.3 Conventionals

Appendix M. Analytical Results (2000 – 2010)

M.1 Dissolved Metals

M.2 Volatiles

M.3 Conventionals