Lake Goodwin Landfill 2011 4th Quarter Groundwater Monitoring Report

Photo taken 8/1/08 J. Greninger

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1.0 INTRODUCTION

The following report presents the fourth quarter ground water monitoring results for 2011 at the Lake Goodwin Landfill (*Lake Goodwin Landfill, Site*). The site is located immediately west of Frank Waters Road in northwestern Snohomish County, about one and one half (*1.5*) miles northwest of Lake Goodwin and about five-(*5*) miles south of Stanwood (*T31N, R4E, sections 17, 20 Willamette Meridian*). The landfill is located at 18520 Frank Waters Road, Stanwood, Washington, 98292. The location of the site relative to existing municipal improvements is shown on the **Vicinity Map** (*figure 1*).

1.1 BACKGROUND

The Lake Goodwin Landfill is sited within a former County gravel pit. Waste disposed at the landfill reportedly consisted of municipal waste, including garbage and demolition debris, and some industrial waste. Waste was placed in the landfill starting in the early 1960's under the direction of **Snohomish County's Road Maintenance Division**. The landfill was closed in September 1982. Upon closure a cover system was installed. The landfill is not lined nor does it have leachate or gas collection systems. The Lake Goodwin Landfill is currently permitted for post-closure monitoring by the **Snohomish Health District** (*SHD*) with a Solid Waste Facility Permit (*SW-085, 2012*). Monitoring results are reviewed by both the **SHD** and the **Department of Ecology**.

1.2 PERMIT INFORMATION

Monitoring activities at the landfill are governed by the Solid Waste Facility Permit SW-085 (*landfill permit, Snohomish Health District 2012*). This permit requires post-closure ground water monitoring on a quarterly basis until the facility has been shown to be stable and/or not harmful to human health or the environment. The **SHD** permits and evaluates post-closure conditions at the Lake Goodwin Landfill using the Snohomish Health District Sanitary Codes, *Chapter 3.1, Solid Waste Handling Regulations*; *Chapter 173-304 WAC Minimum Functional Standards for Solid Waste*; *Chapter 173-200 WAC Water Quality Standards for Ground Waters*; and *Chapter 246-290 WAC Drinking Water Regulations.* There is no current Sampling & Analysis Plan (SAP) for this landfill.

1.3 SITE DESCRIPTION AND PHYSICAL CONDITIONS

The closed landfill is approximately 11.5 acres in size and is part of a larger County owned parcel of land. The Lake Goodwin Landfill is bounded by private residential property or commercial forest to the south, west and north. The Frank Waters Road is located along the eastern side of the site. Access into the site is from a partially paved and partially graveled driveway off of the Frank Waters Road. Existing site improvements are shown on the **Site Map** (*figure 2*).

The Lake Goodwin Landfill is located on a topographic feature known as the Tulalip Plateau, a rolling upland area bounded by the Stillaguamish River to the north, the Puget Sound to the west and south, and by a topographic low called the Marysville Trough to the east. The general topography in the immediate vicinity of the site is typical of glaciated areas within western Washington State – gently rolling landscapes bisected by seasonal and/or year round drainages, creeks and rivers. Several small to medium sized lakes are found in the immediate vicinity of the site. Lake Martha, Lake Howard and Lake Goodwin are all located within a few miles of the Landfill. There are no named drainages, creeks or rivers located in the immediate vicinity of the site. Elevations in the immediate vicinity of the landfill range from approximately el. 320 to el. 380 feet above mean sea level. Relative to existing surrounding topography the landfill itself is approximately 60 ft high. It has been graded and slopes gently in a north to northeast direction. Site Topography is shown on the **Topographic Map** (*figure 3*). In most places the landfill cover is well vegetated with grass, clover and weeds. A few Douglas fir have naturally reseeded in the fill cover near the edge of the site. There are no stormwater detention ponds or leachate collection ponds located on the site.

1.4 LOCAL HYDROGEOLOGY

Surficial geology of the site area is shown on the **Geologic Map** (*figure 4*). Based on the Geologic Map and the site explorations, surficial geology at the landfill site consists of Advance Outwash (*Qva*) sands and gravels locally overlain by sandy silts to silty sands and gravels – Glacial Till (*Qvt*).

The Lake Goodwin Landfill is located on an upland area known as the Tulalip Plateau. Below the Tulalip Plateau the most productive aquifer is the Advance Outwash (*Qva*) aquifer which is underlain by Transitional Bed (*Qtb*) silts and clays. Where overlain by Glacial Till (*Qvt*), the aquifer is confined. In the vicinity of the Lake Goodwin Landfill where Glacial Till (*Qvt*) is absent, ground water is unconfined. With the exception of the surficial Glacial Till (*Qvt*) found overlying the Advance Outwash (*Qva*) sands and gravels along the southern edge of the landfill (*LG-02*), permeable soils were encountered from the surface down in all site explorations at the landfill. Ground water elevations below the landfill ranged from el. 148 to el. 153 with a north to northwest gradient in an unconfined condition within the Advance Outwash (*Qva*) aquifer.

1.5 EXISTING MONITORING NETWORK

As outlined in the Solid Waste Facility Permit SW-085, quarterly monitoring of ground water is required at the Lake Goodwin Landfill. There are currently five-(*5*) ground water monitoring wells (*LG-01 thru LG-05*) at the Lake Goodwin Landfill site that are read on a quarterly basis. Well locations are shown on the **Network Monitoring Map** (*figure 5*). Of these wells, one-(*1*) is considered to be an up-gradient well monitoring background ground water conditions in the immediate vicinity of the site (*LG-02*). The remaining four-(*4*) wells are located in and/or down gradient of the landfill (*LG-01, and LG-03 thru LG-05*) and monitor ground water conditions that may be impacted from the site. Fourth quarter monitoring results are discussed in section 2.0 below.

2.0 GROUND WATER MONITORING

Fourth quarter 2011 monitoring of the ground water wells at the Lake Goodwin Landfill was performed by **Snohomish County** personnel. Depth to water was measured and ground water samples were collected following approved sampling protocol. The following sections describe field procedures used and analytical results derived from the sampling event.

2.1 Ground Water Level Measurements

The depth to ground water within each well was measured prior to ground water sampling activities. The depth to ground water was measured using an electronic water level indicator in increments to the nearest 0.01 ft. as taken from a marked survey point on the top of each well casing.

Fourth Quarter Ground Water Measurements are shown in *Table 1* below. **Hydrographs** of the fourth quarter 2011 monitoring well readings are contained in *Appendix A* of this report. Fourth quarter well readings show water depth rising in two wells (*LG-02 and LG-03*) and declining in the other three (*LG-01, LG-04 and LG-05*). Variances from third quarter measurements are less than two-(*2*) feet. Readings confirm that the aquifer is unconfined in the immediate vicinity of the site. The **Fourth Quarter Ground Water Contour Map** developed from the field data is shown in *Figure 6* of this report.

Measured precipitation at the Stanwood Weather Station (WA-SN-11 http://www.cocorahs.org/state.aspx?state=wa) during the fourth quarter monitoring period was 4.77 inches (through 11/21/11). For reference purposes, precipitation measured at station WA-SN-11 during the monitoring period has been included on the hydrographs.

Table 1 - Fourth Quarter Groundwater Measurements and Elevations

Well Numbers	Casing Elevation	4th Quarter Delta/Elevation	
LG-01	239.18	-1.79	154.15
LG-02	268.67	+1.09	155.59
LG-03	241.20	+1.90	156.21
LG-04	206.93	-0.68	152.61
LG-05	235.00	-0.90	153.09

2.2 Fourth Quarter Ground Water Sampling Event

Purging and sampling of each of the five-(5) monitoring wells was performed during the fourth quarter by Snohomish County personnel in accordance with the facilities closure permit. Approximately 1.9 to 3.3 gallons of water was purged from each well prior to sampling. Water samples were collected by slowly filling laboratory-supplied containers in such a manner as to reduce aeration. Sample containers were filled so that no headspace or air bubbles remained within the container. Samples were placed in coolers and packed in ice to keep samples at approximately 4C for delivery to the laboratory for testing. Samples were picked up by **Amtest** and taken to their Kirkland, WA laboratory for analysis of dissolved metals, volatile organic compounds (*VOC's*), and conventional chemistry parameters. Analytical Data is included in *Appendix B*, Ground Water Analytical Data of this report. The analytical data was compared to the maximum contaminant levels (*MCL's*). A complete statistical analysis of the data was also performed utilizing **DUMPStat**. Results are discussed below.

2.3 Evaluation of Fourth Quarter Ground Water Analytical Results

Fourth Quarter Ground Water Test Results for each well are summarized in *Table 2* below. Comparison of results to regulatory criteria (MCL's) shows:

Fourth Quarter: There were measured exceedances of the MCL's for conductivity, nitrate nitrogen, pH, sodium and arsenic. No other dissolved metals or VOC's were observed exceeding WAC level MCL's during this sampling event. An elevated conductivity level above

780 micro ohms per centimeter (*umhos/cm*) was measured in well LG-05 during this sampling event. Out of compliance levels for pH were measured in wells LG-03, LG-04, and LG-05 during this sampling event. Elevated levels of sodium were measured in well LG-03 and LG-05 during this sampling event.

Table 2 - Summary of Test Results - Fourth Quarter

Well	4th Quarter 2011 Groundwater Standard Exceedances
LG-01	Arsenic
LG-02	Arsenic
LG-03	pH, sodium, arsenic
LG-04	pH, arsenic
LG-05	Conductivity, nitrate nitrogen, pH, sodium, arsenic

2.4 Statistical Evaluation

State health regulations under which the Lake Goodwin Landfill closure is permitted require that the landfill "...shall not cause exceedances of *Chapter 173-200 WAC*, **Water Quality Standards for Groundwater**, and *Chapter 246-290 WAC*, **Drinking Water Regulations**." The intent of these state regulations is to limit the impact that a landfill will have on the surrounding ground water resources. Collected ground water samples are tested for Primary and Secondary Drinking Water Standards, Dissolved Metals and Volatile Organic Compounds – and compared to the standards listed in the above referenced WAC's. Where an exceedance to the standards occurs, a statistical analysis is provided to determine the significance of the change or exceedance. Each of these exceedances has been statistically analyzed using **DUMPStat Software** (*version 2.1.9 by Robert D. Gibbons Lt., 2000*) per the *Subtitle D* regulations and as specifically referenced in the **U.S. EPA** guidance manual. Mean, standard deviation, prediction limits, and confidence values were calculated by **DUMPStat**.

The Sens Trend analysis test was performed for the entire data set stretching back to 1988 and the results of that analysis – increasing or decreasing trends are recorded on the spreadsheet in Appendix B. The trend analysis in Appendix C is run between 2006 and current time. This allows us to place multiple constituents on a single graph to better see any potential correlation between the geochemistry and dissolved metals. Per Ecology and Snohomish Health District request, the prediction limit is updated in the first quarter of the year and subsequent data sets are compared against that prediction limit. The fourth quarter 2011 readings were compared to the first quarter prediction limits for the first time in this fourth quarter report.

Based on the statistical analysis, exceedances to the prediction limits in all down-gradient wells were high for all of the conventional chemistry parameters, minimal for the dissolved metals and there were no exceedances in the VOC's at any well. Calculated exceedances to the prediction limits in the fourth quarter are shown in *Table 3* below.

Table 3 - Statistical Summary - Fourth Quarter Limit Exceedances for 2011

Well	4th Quarter 2011 Exceedances
LG-01	Bicarbonate, conductivity, magnesium, nitrate, pH, potassium, barium
LG-02	Total Organic Carbon
LG-03	Alkalinity, bicarbonate, calcium, chloride, conductivity, magnesium, nitrate, pH, potassium, sodium, sulfate, barium, nickel, zinc
LG-04	Bicarbonate, calcium, magnesium, pH, potassium, barium, zinc
LG-05	Alkalinity, bicarbonate, calcium, chloride, conductivity, magnesium, nitrate, nitrite, pH, potassium, sodium, sulfate, barium

Stiff Diagrams, Trilinear Diagrams and **Statistically Significant Trends Analyses** results are included in *Appendix C* of this report.

3.0 SUMMARY AND RECOMMENDATIONS

The ground water data collected during the 2011 fourth quarter sampling events indicates the following:

- Ground water elevations below the landfill remained fairly consistent during this quarter.
- VOC's were not detected in any monitoring well during the sampling event.
- Measured conductivity was above background levels (*LG-02*) in all down gradient wells during this sampling event. Conductivity levels observed at wells LG-03 and LG-05 were significantly higher than the surrounding wells during this sampling event. Nitrate levels are increasing in LG-01 and LG-03.
- Statistical analysis did show significant impacts to wells LG-03 and LG-05. Lesser impacts where indicated in wells LG-01 and LG-04. Time series plots based on the **DUMPStat** analysis indicates that there were many more significant decreasing trends (*7*) than increasing trends (*3*) during this sampling event.
- There were very minimal impacts to the ground water from dissolved metals. Small exceedances to the calculated prediction limits for Barium, Nickel and Zinc were found in the down-gradient wells.

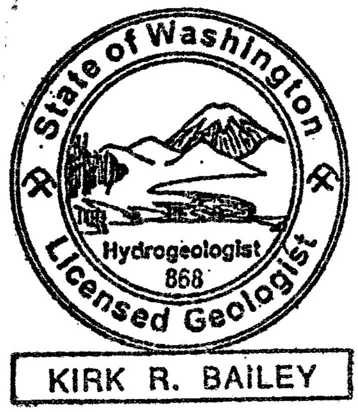
- The new arsenic level in the "Interim Guidance for the Ground Water Quality Standards" is so low that every well exceeded it. Due to the natural background levels of Arsenic in the ground water around the Lake Goodwin Landfill, this parameter is no longer a good indication of potential arsenic impacts to the groundwater caused by the landfill.

3.1 CONCLUSIONS/RECOMMENDATIONS

Fourth quarter 2011 data indicates a continued moderate leachate impact to the underlying Advance Outwash (*Qva*) aquifer below the Lake Goodwin Landfill. Statistical analysis indicates a large number of significantly decreasing trends which would suggest that the leachate impact to the ground water below the landfill is decreasing at this time, however, two increasing trends have been monitored in down gradient well LG-01 and at least one increasing trend was found in LG-03. The data also suggests that the leachate plume impacting ground water extends beyond the landfill boundaries following the ground water gradient to the north-northeast through LG-03 and LG-05.

3.2 SIGNATURES and CERTIFICATIONS

Kirk R. Bailey, LEG, LHG
SCPW – Engineering Services

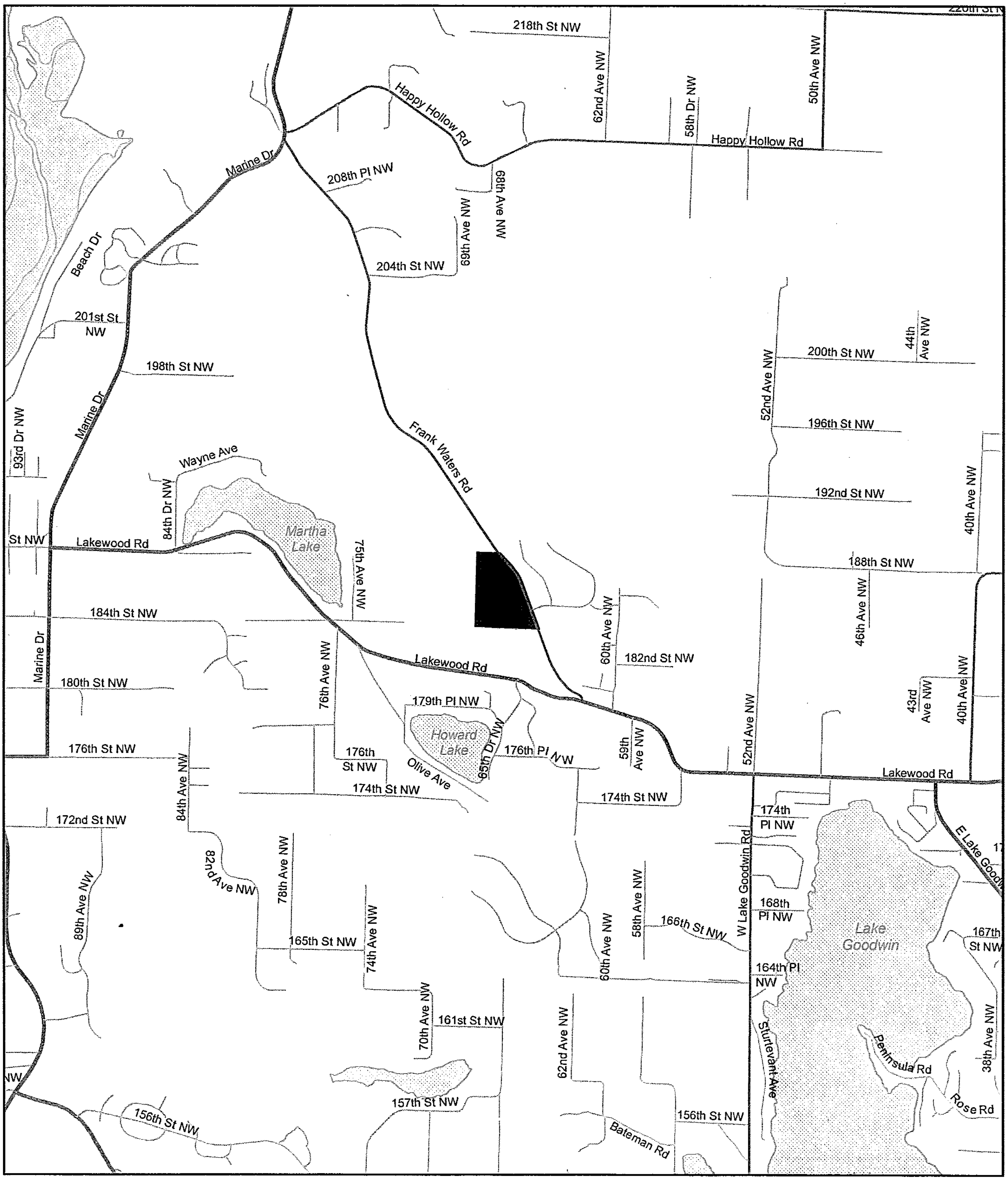


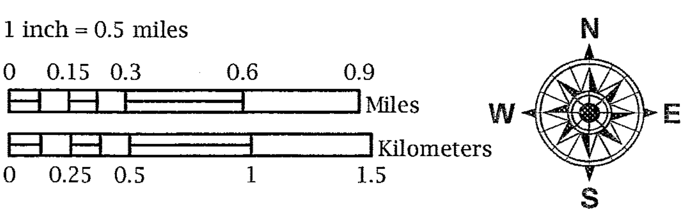
Deanna Carveth
SCPW – Solid Waste Division

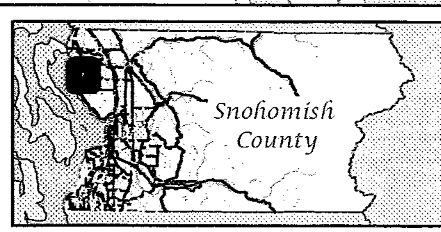
January 17, 2012

Figure 1

Lake Goodwin Landfill



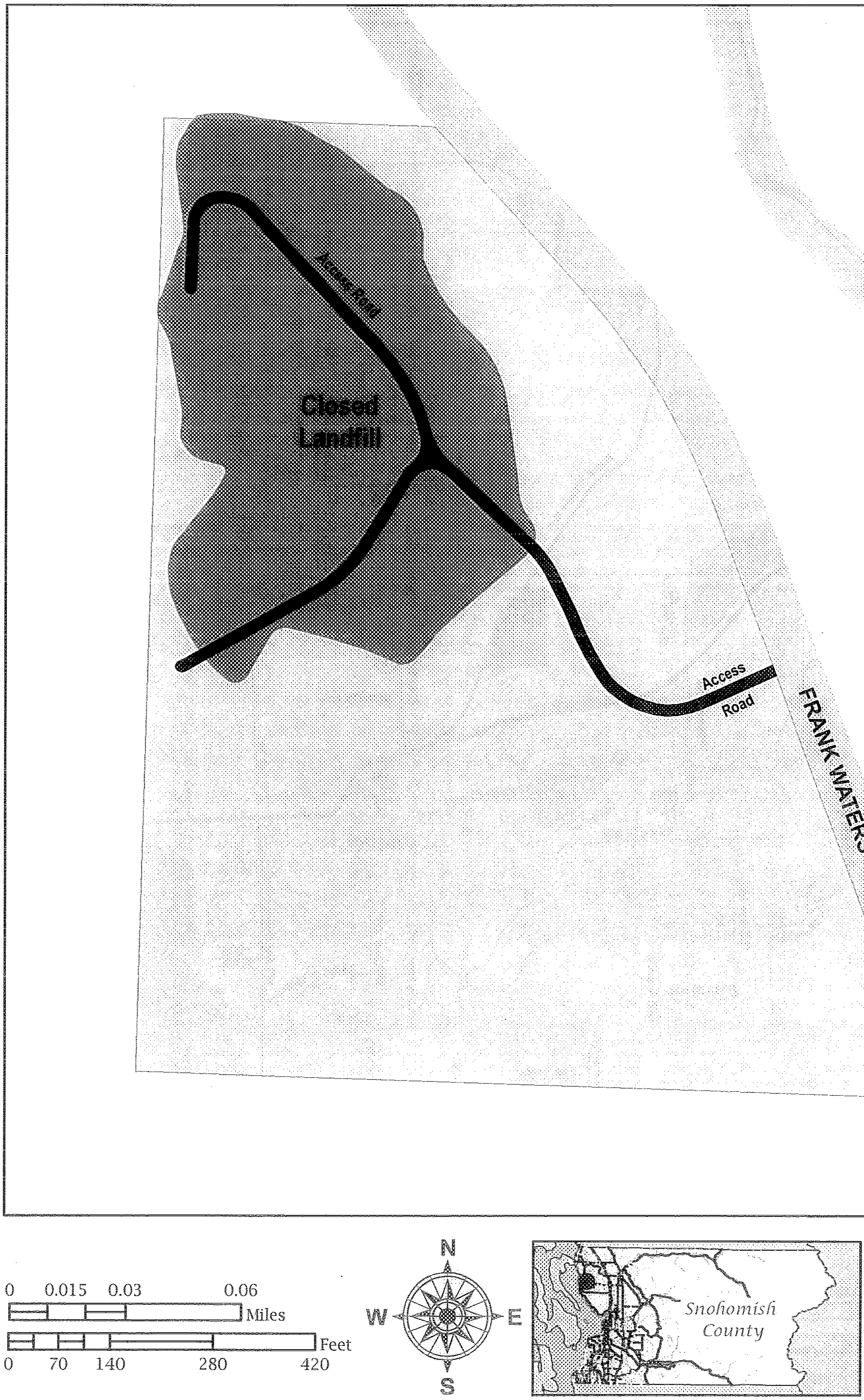




Snohomish County
Public Works
Solid Waste Division
March 22, 2010

Figure 2

Lake Goodwin Landfill Site Map



Snohomish County
Public Works
Solid Waste Division
March 25, 2010

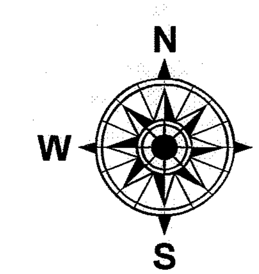
Figure 3

Lake Goodwin Landfill

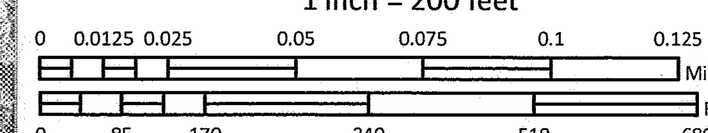
Topography

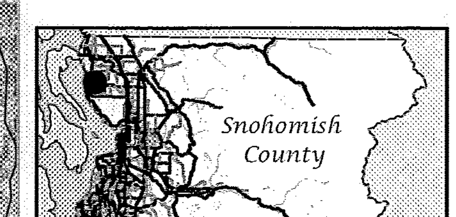
Map Features

- Parcel Boundary
- Subject Property Boundary
- 5 Foot Contours



1 inch = 200 feet





Snohomish County
Public Works
Solid Waste Division
March 23, 2010

Figure 4

Lake Goodwin Landfill

Geologic Map

Map Features

- Parcel Boundary
- Subject Property Boundary

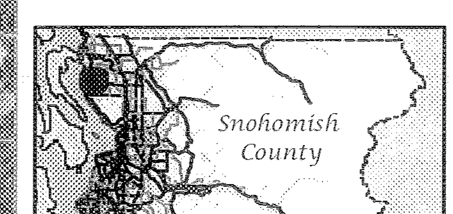
Geologic Description

- Vashon advance outwash (Qva)
- Vashon recessional outwash
- Vashon till (Qvt)
- Water
- Modified Land

1 inch = 600 feet

0 | 0.035 | 0.07 | 0.14 | 0.21 | 0.28 | 0.35 Miles

0 | 240 | 480 | 960 | 1,440 | 1,920 Feet



N S E W

Snohomish County
Public Works
Solid Waste Division
May 6, 2010

Figure 5

Lake Goodwin Landfill

Groundwater Monitoring Network

Map Features

Parcel Boundary

Subject Property Boundary

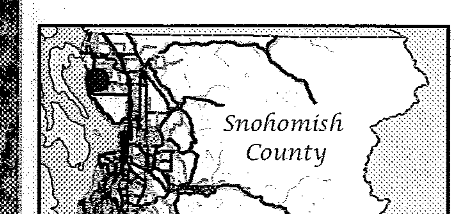
Aquifer Unit (Active Wells)

Deep Aquifer

1 inch = 200 feet

0 0.0125 0.025 0.05 0.075 0.1 0.125 Miles

0 80 160 320 480 640 Feet



N W E S

Snohomish County Public Works
Solid Waste Division
April 15, 2010

Figure 6

Lake Goodwin Landfill

Water Elevation Contours 4th Quarter 2011

DIRECTION OF GROUNDWATER FLOW
1.89 ft/day
690 ft/year
38.87 degrees to the positive x-axis

PARCEL BOUNDARY

SUBJECT PROPERTY BOUNDARY

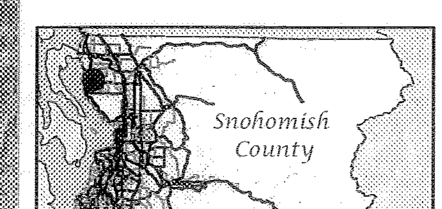
1 FT CONTOUR

WELL LOCATION

WELL_ID	SAMP_DATE	MEAS_HEAD
LG-01	10/18/2011	154.15
LG-02	10/18/2011	155.91
LG-03	10/18/2011	156.21
LG-04	10/18/2011	152.61
LG-05	10/18/2011	153.09

0 0.015 0.03 0.06 0.09 0.12 Miles

0 80 160 320 480 640 Feet



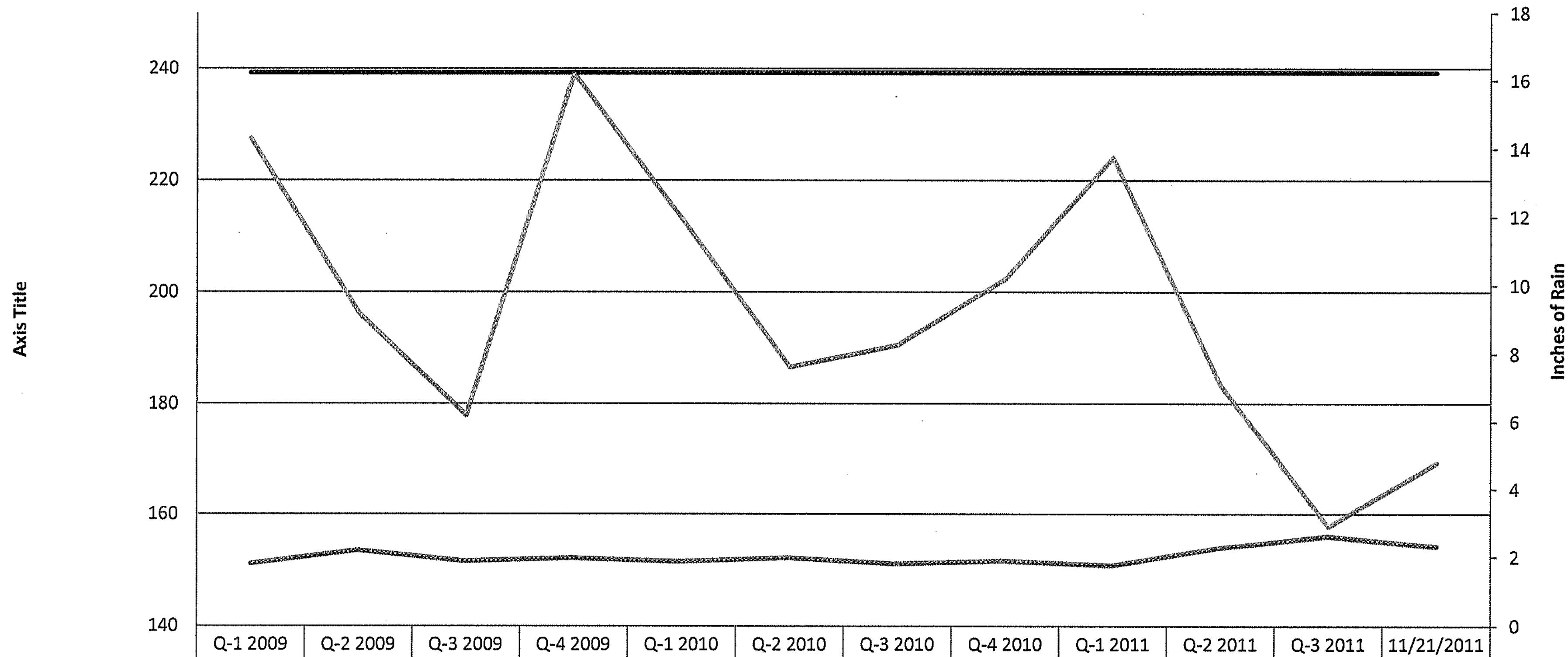
N W E S

Snohomish County
Public Works
Solid Waste Division
December 12, 2011

Appendix A

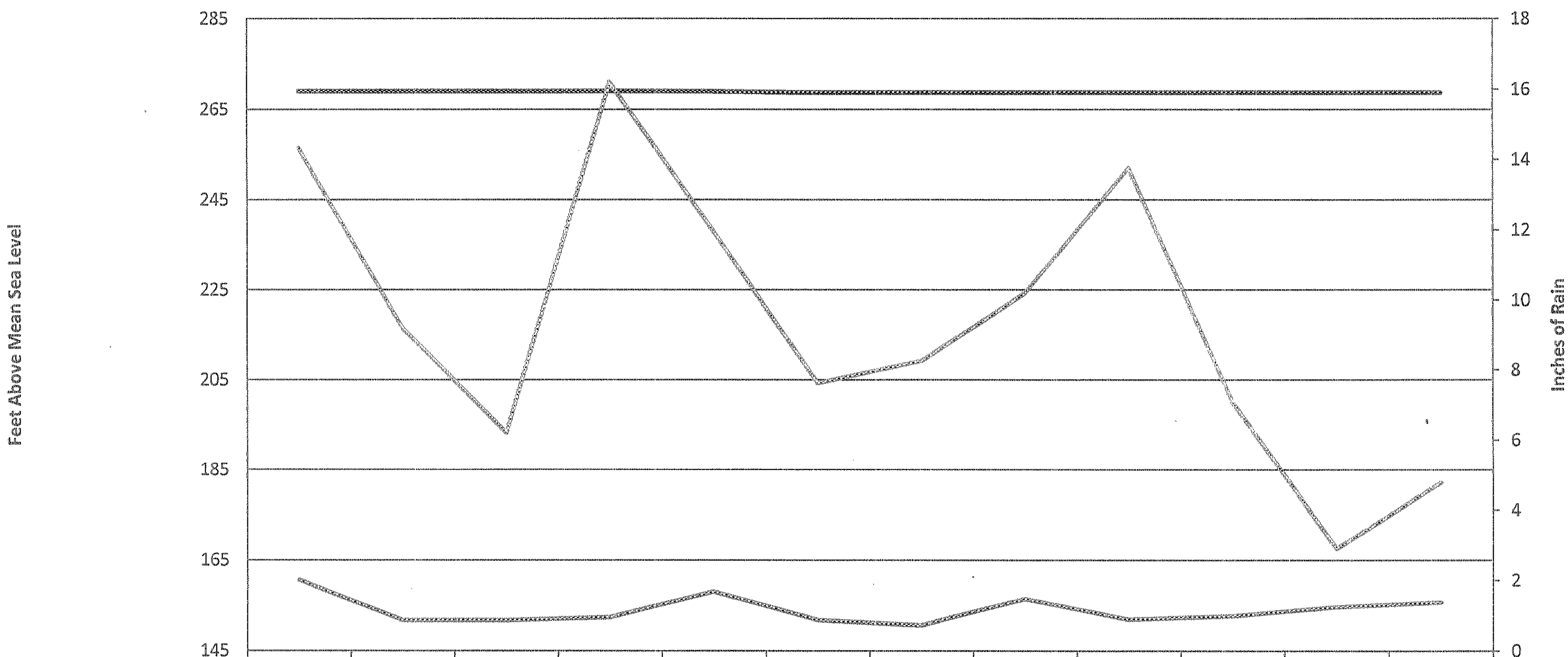
Hydrographs

Lake Goodwin Well LG-01



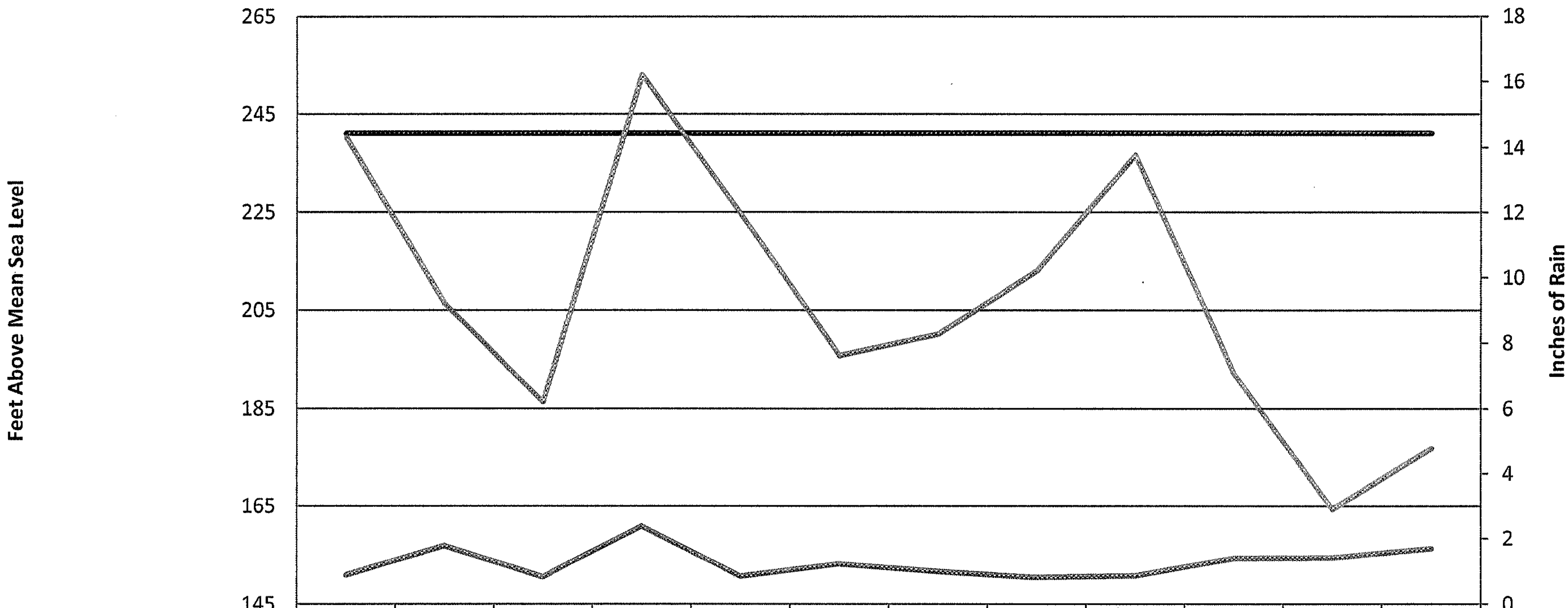
	Q-1 2009	Q-2 2009	Q-3 2009	Q-4 2009	Q-1 2010	Q-2 2010	Q-3 2010	Q-4 2010	Q-1 2011	Q-2 2011	Q-3 2011	11/21/2011
Depth to Water	151.06	153.43	151.48	152.04	151.46	152.09	151.05	151.56	150.71	153.87	155.94	154.15
Well Casing	239.18	239.18	239.18	239.18	239.18	239.18	239.18	239.18	239.18	239.18	239.18	239.18
Precipitation	14.3	9.2	6.2	16.2	11.96	7.62	8.26	10.2	13.75	7.08	2.89	4.77

Lake Goodwin Well LG-02



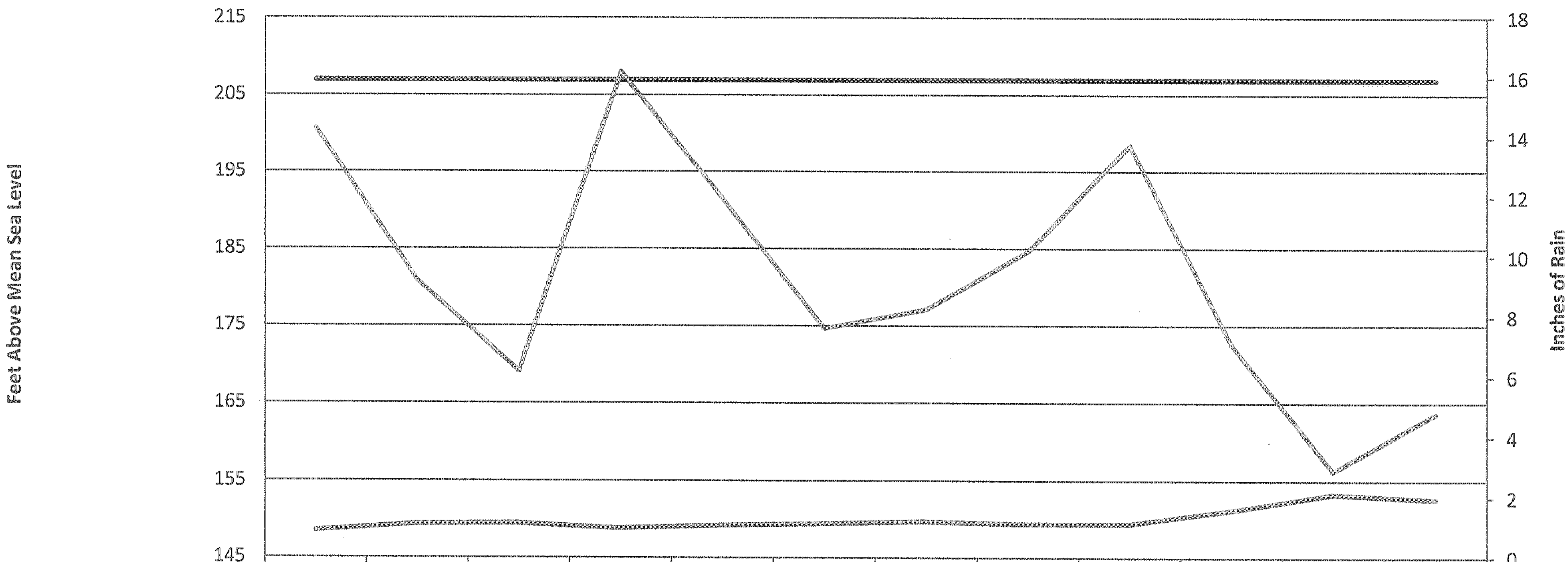
	Q-1 2009	Q-2 2009	Q-3 2009	Q-4 2009	Q-1 2010	Q-2 2010	Q-3 2010	Q-4 2010	Q-1 2011	Q-2 2011	Q-3 2011	11/21/2011
Groundwater Elevation	160.57	151.56	151.59	152.25	158.1	151.67	150.54	156.37	151.74	152.53	154.5	155.59
Well Casing	268.99	268.99	268.99	268.99	268.99	268.67	268.67	268.67	268.67	268.67	268.67	268.67
Precipitation	14.3	9.2	6.2	16.2	11.96	7.62	8.26	10.2	13.75	7.08	2.89	4.77

Lake Goodwin Well LG-03



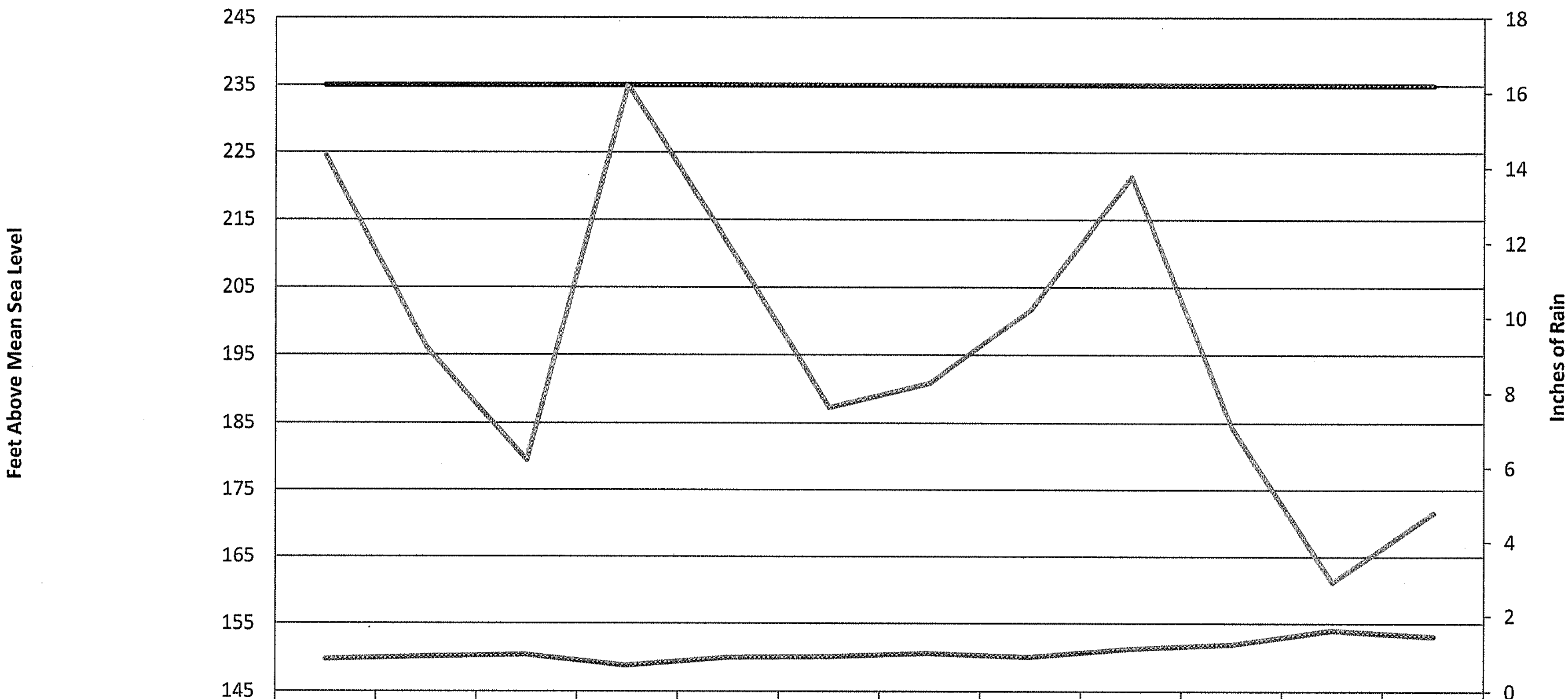
	Q-1 2009	Q-2 2009	Q-3 2009	Q-4 2009	Q-1 2010	Q-2 2010	Q-3 2010	Q-4 2010	Q-1 2011	Q-2 2011	Q-3 2011	11/21/2011
Groundwater Elevations	150.86	156.82	150.51	160.84	150.59	153.1	151.59	150.35	150.64	154.19	154.31	156.21
Well Casing	241.2	241.2	241.2	241.2	241.2	241.2	241.2	241.2	241.2	241.2	241.2	241.2
Precipitation	14.3	9.2	6.2	16.2	11.96	7.62	8.26	10.2	13.75	7.08	2.89	4.77

Lake Goodwin Well LG-04



	Q-1 2009	Q-2 2009	Q-3 2009	Q-4 2009	Q-1 2010	Q-2 2010	Q-3 2010	Q-4 2010	Q-1 2011	Q-2 2011	Q-3 2011	11/21/2011
Groundwater Elevation	148.5	149.34	149.46	148.84	149.22	149.42	149.72	149.39	149.4	151.14	153.29	152.61
Well Casing	206.93	206.93	206.93	206.93	206.93	206.93	206.93	206.93	206.93	206.93	206.93	206.93
Precipitation	14.3	9.2	6.2	16.2	11.96	7.62	8.26	10.2	13.75	7.08	2.89	4.77

Lake Goodwin Well LG-05



	Q-1 2009	Q-2 2009	Q-3 2009	Q-4 2009	Q-1 2010	Q-2 2010	Q-3 2010	Q-4 2010	Q-1 2011	Q-2 2011	Q-3 2011	11/21/2011
Groundwater Elevation	149.71	150.11	150.39	148.79	149.98	150.09	150.62	150.05	151.28	151.93	153.99	153.09
Well Casing	235	235	235	235	235	235	235	235	235	235	235	235
Precipitation	14.3	9.2	6.2	16.2	11.96	7.62	8.26	10.2	13.75	7.08	2.89	4.77

Appendix B

Analytical Data

GROUNDWATER SUMMARY: FOURTH QUARTER 2011
LAKE GOODWIN LANDFILL
SNOHOMISH COUNTY, WASHINGTON

	Statistical Method	Prediction Limit (a)	MCL	Downgradient LG-01 10/18/11 D V T C	Downgradient LG-03 10/18/11 D V T C	Downgradient LG-04 10/18/11 D V T C	Downgradient LG-05 10/18/11 D V T C	Upgradient LG-02 10/18/11 D V T C
CONVENTIONAL CHEMISTRY PARAMETERS								
(mg/L unless noted)								
Alkalinity (as CaCO3)	normal	**141.1815**	--	140 V	**260** V	140 P	**330** V	84
Ammonia Nitrogen	nonpar	**0.056**	--	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Bicarbonate	normal	**130.7366**	--	**140** V	**260** V	**140** V	**330** V	84
Calcium, Dissolved	normal	**20.8776**	--	19.8 I N	**35** V	**21.5** V	**38.8** V	17.3
Chemical Oxygen Demand	nonpar	**26**	--	10 U	10 U	10 U	10 U	10 U
Chloride	nonpar	**9.4**	250	9.1	**17** V	7.6	**18** E	9.2
Conductivity (umhos/cm)	normal	**325.3534**	700	**340** E	**660** V	310	780 V	230
Magnesium, Dissolved	normal	**19.5453**	--	**27.4** V	**51.4** V	**21.2** V	**55** V	15.1
Nitrate Nitrogen (mg-N/L)	nonpar	**2.6**	10	**2.7** I N	**5.3** E I N	1.2 V	**14** V	1.9
Nitrite Nitrogen (mg-N/L)	nonpar	**0.003**	1	0.001 U	0.001 U	0.001 U	**0.003** Y	0.001 U
pH (std units)	normal	**6.7-7.75**	6.5-8.5	**6.69** E D N	6.01 V	5.68 V	6.46 V D N	7.1
Potassium, Dissolved	lognor	**3.443**	--	**3.78** V	**5.04** V	**3.49** E Y	**6.98** V	2.94
Sodium, Dissolved	nonpar	**13.8**	20	11 D N	28.6 V	11 D N	41.6 V D N	9.8
Sulfate	normal	**16.2676**	250	14	**47** V	10 **D** N	**25** E D N	14
Total Dissolved Solids	nonpar	**550**	500	220	380	210	490	160
Total Organic Carbon	nonpar	**13**	--	2.9	5.6	3.2	7.7	**19**
DISSOLVED METALS								
EPA Methods 6010B/7131A (mg/L)								
Antimony	nonpar	**0.01**	0.006	0.00005 U	0.00005 U	0.00022	0.00005 U	0.00007
Arsenic	nonpar	**0.078**	0.00005	0.00046	0.0005	0.0003	0.00074	0.00289
Barium	normal	**0.0138**	2	**0.0178** V	**0.0398** V	**0.0251** V	**0.0552** V	0.0108
Beryllium	nonpar	**0.0005**	0.004	0.0005 U	0.0005 U	0.0005 U	0.0005 U	0.0005 U
Cadmium	nonpar	**0.0002**	0.005	0.00005 U	0.00005 U	0.00005 U	0.00005 U	0.00005 U
Chromium	normal	**0.0102**	0.1	0.001 U	0.001 U	0.0011	0.0014	0.0044
Cobalt	nonpar	**0.008**	--	0.001 U	0.002	0.001 U	0.001 U	0.001 U
Copper	nonpar	**0.004**	1.3	0.001	0.003	0.001 U	0.002	0.001 U
Iron	nonpar	**0.031**	0.3	0.005 U	0.007	0.005 U	0.01	0.005 U
Lead	nonpar	**0.001**	0.015	0.00005 U	0.00005 U	0.00005 U	0.00005 U	0.00005 U
Manganese	nonpar	**0.0061**	0.05	0.0005 U	0.0005 U	0.0005 U	0.0005 U	0.0005 U
Nickel	nonpar	**0.005**	0.1	0.005 U	**0.008**	0.005 U	0.005 U	0.005 U
Selenium	nonpar	**0.002**	0.05	0.0005 U	0.0005 U	0.0005 U	0.0005 U	0.00053
Silver	nonpar	**4.2501**	0.1	0.00005 U	0.00005 U	0.00005 U	0.00005 U	0.00005 U
Thallium	nonpar	**0.001**	0.002	0.00005 U	0.00005 U	0.00005 U	0.00005 U	0.00005 U
Vanadium	nonpar	**0.01**	--	0.005 U	0.005 U	0.00500 U	0.005 U	0.005 U
Zinc	nonpar	**0.007**	5	0.003	**0.015** E	**0.011** E	0.004	0.001
VOLATILE ORGANIC COMPOUUS (VOCs)								
EPA Method 8260 (µg/L)								
1,1,1-Trichloroethane	Too Many	N/A	200	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	Too Many	N/A	--	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	Too Many	N/A	--	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	Too Many	N/A	1	1 U	1 U	1 U	1 U	1 U

GROUNDWATER SUMMARY: FOURTH QUARTER 2011
LAKE GOODWIN LANDFILL
SNOHOMISH COUNTY, WASHINGTON

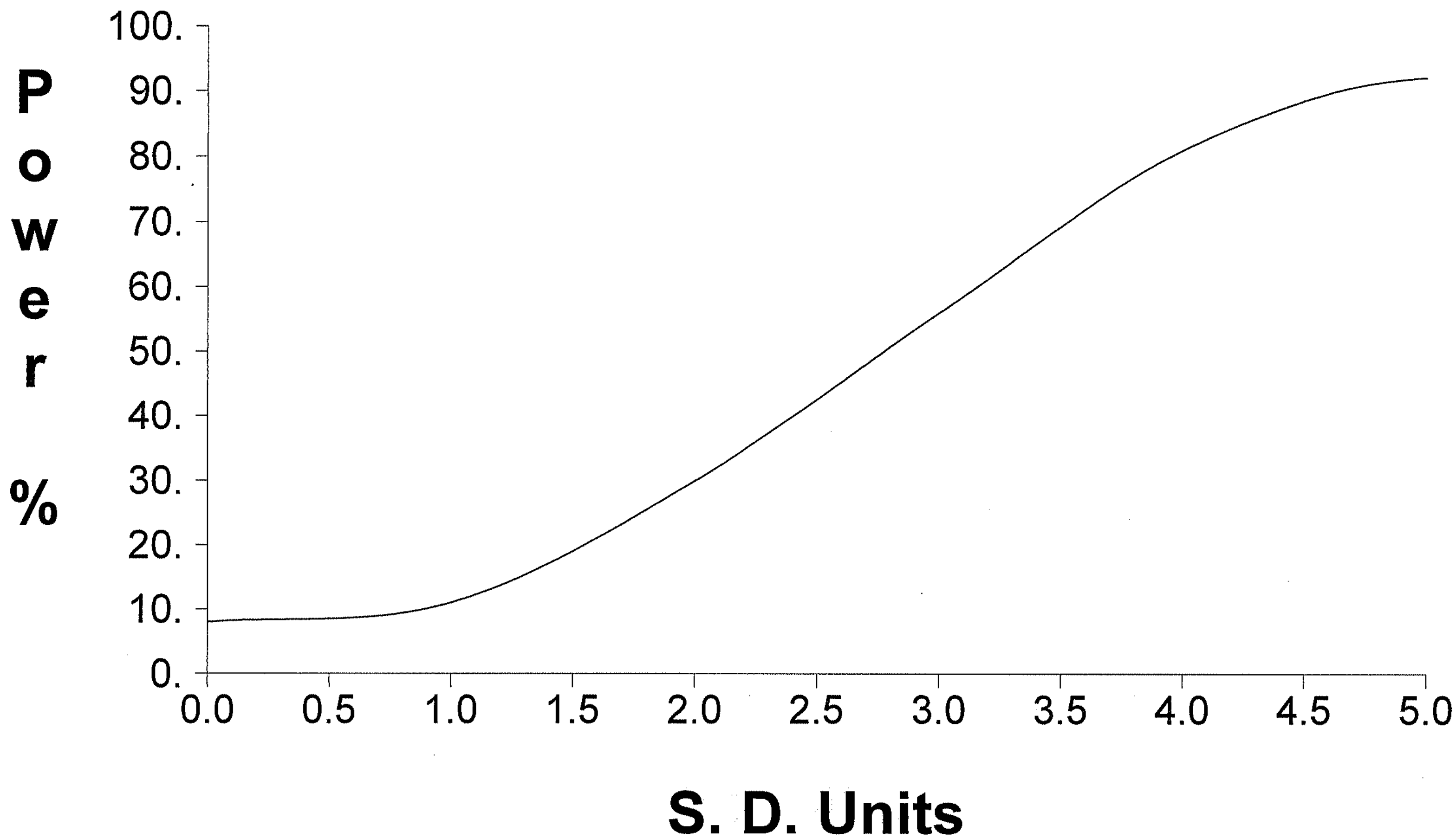
	Statistical Method	Prediction Limit (a)	MCL	Downgradient																				Upgradient				
				LG-01					LG-03					LG-04					LG-05					LG-02				
				10/18/11	D	V	T	C	10/18/11	D	V	T	C	10/18/11	D	V	T	C	10/18/11	D	V	T	C	10/18/11	D	V	T	C
1,1-Dichloroethylene	Too Many	N/A	7	1	U				1	U				1	U				1	U				1	U			
1,2,3-Trichloropropane	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
1,2-Dibromo-3-chloropropane	Too Many	N/A	5	5	U				5	U				5	U				5	U				5	U			
1,2-Dibromoethane	Too Many	N/A	1	1	U				1	U				1	U				1	U				1	U			
1,2-Dichlorobenzene	Too Many	N/A	600	1	U				1	U				1	U				1	U				1	U			
1,2-Dichloroethane	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
1,2-Dichloropropane	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
1,4-Dichlorobenzene	Too Many	N/A	75	4	U				4	U				4	U				4	U				4	U			
2-Butanone	Too Many	N/A	--	5	U				5	U				5	U				5	U				5	U			
2-Hexanone	Too Many	N/A	--	5	U				5	U				5	U				5	U				5	U			
4-Methyl-2-Pentanone (MIBK)	Too Many	N/A	--	5	U				5	U				5	U				5	U				5	U			
Acetone	Too Many	N/A	--	6.6					5	U				5	U				5	U				6.1				
Acrylonitrile	Too Many	N/A	5	5	U				5	U				5	U				5	U				5	U			
Benzene	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
Bromodichloromethane	Too Many	N/A	1	1	U				1	U				1	U				1	U				1	U			
Bromoform	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
Bromomethane	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
Carbon Disulfide	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
Carbon Tetrachloride	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
Chlorobenzene	Too Many	N/A	100	1	U				1	U				1	U				1	U				1	U			
Chlorodibromomethane	Too Many	N/A	1	1	U				1	U				1	U				1	U				1	U			
Chloroethane	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
Chloroform	Too Many	N/A	7	1	U				1	U				1	U				1	U				1	U			
Chloromethane	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
cis-1,2-Dichloroethene	Too Many	N/A	70	1	U				1	U				1	U				1	U				1	U			
cis-1,3-Dichloropropene	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
Dibromomethane	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
Ethyl Benzene	Too Many	N/A	700	1	U				1	U				1	U				1	U				1	U			
m,p-Xylene	Too Many	N/A	10000	1	U				1	U				1	U				1	U				1	U			
Methyl Iodide	Too Many	N/A	--	5	U				5	U				5	U				5	U				5	U			
Methylene Chloride	Too Many	N/A	5	1.5	U				1.5	U				1.5	U				1.5	U				1.5	U			
o-Xylene	Too Many	N/A	10000	1	U				1	U				1	U				1	U				1	U			
Styrene	Too Many	N/A	100	1	U				1	U				1	U				1	U				1	U			
Tetrachloroethylene	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
Toluene	Too Many	N/A	1000	1	U				1	U				1	U				1	U				1	U			
trans-1,2-Dichloroethene	Too Many	N/A	100	1	U				1	U				1	U				1	U				1	U			
trans-1,3-Dichloropropene	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
trans-1,4-Dichloro-2-butene	Too Many	N/A	--	5	U				5	U				5	U				5	U				5	U			
Trichlorethene (1,1,2-Trichloroethylene)	Too Many	N/A	5	1	U				1	U				1	U				1	U				1	U			
Trichlorofluoromethane	Too Many	N/A	--	1	U				1	U				1	U				1	U				1	U			
Vinyl Acetate	Too Many	N/A	--	5	U				5	U				5	U				5	U				5	U			
Vinyl Chloride	Too Many	N/A	2	0.2	U				0.2	U				0.2					0.2	U				0.2	U			

mg/L = milligrams per liter (ppm), µg/L = micrograms per liter (ppb).
U = Indicates compound was not detected at the given reporting limit.
D Column: U = Compound not detected in any sample
V Column: V = verified hit, E = exceedance, waiting verification; P = Passed, exceedance not verified
I means increasing trend, D means decreasing trend via Mann-Kendall Analysis
Ch? = a change in the trend analysis, N is no, Y is yes. Compared to previous quarter.

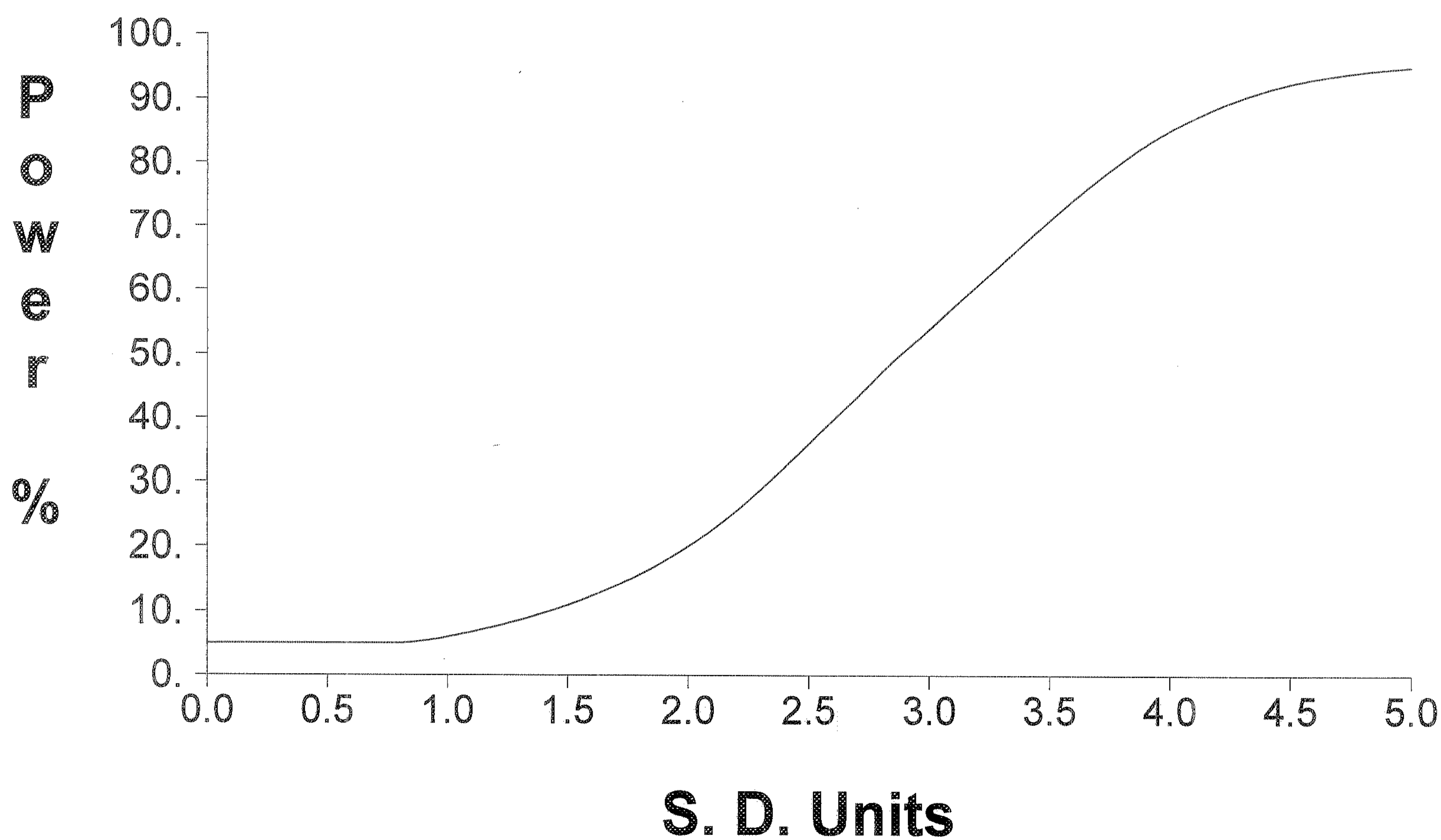
Appendix C

Stiff, Tri-linear and Trend Analysis

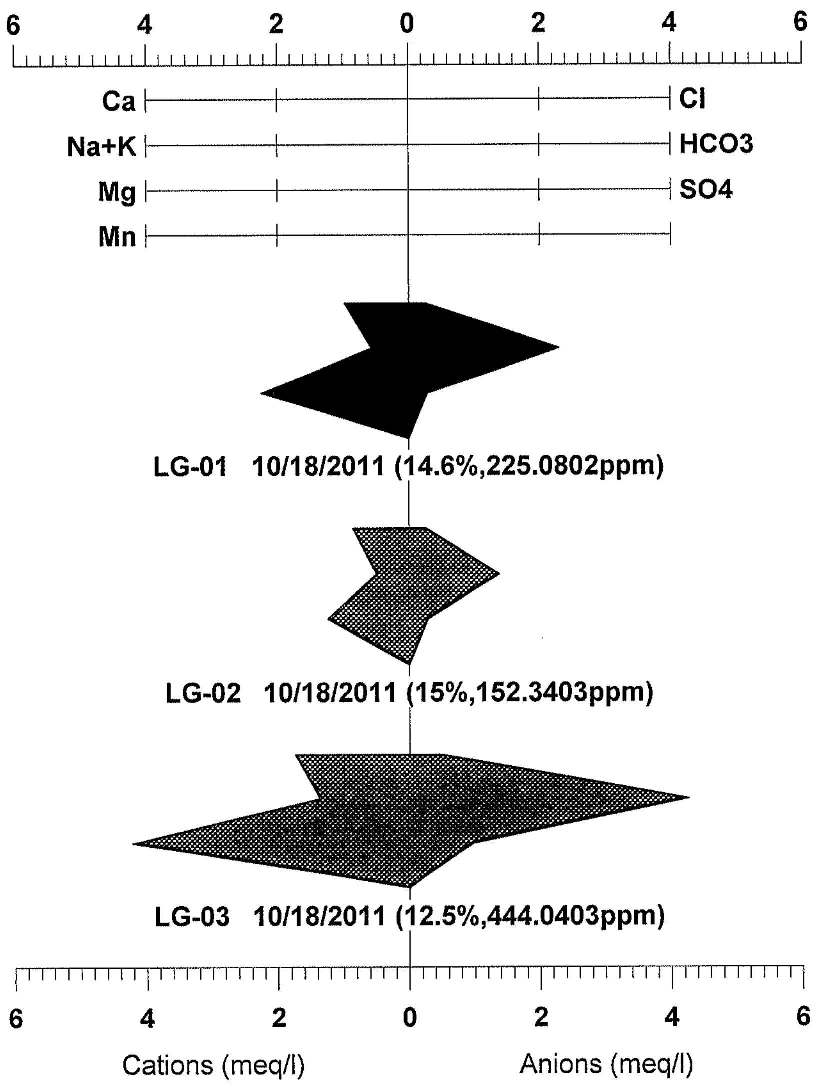
False Positive and False Negative Rates for Current Upgradient vs. Downgradient Monitoring Program

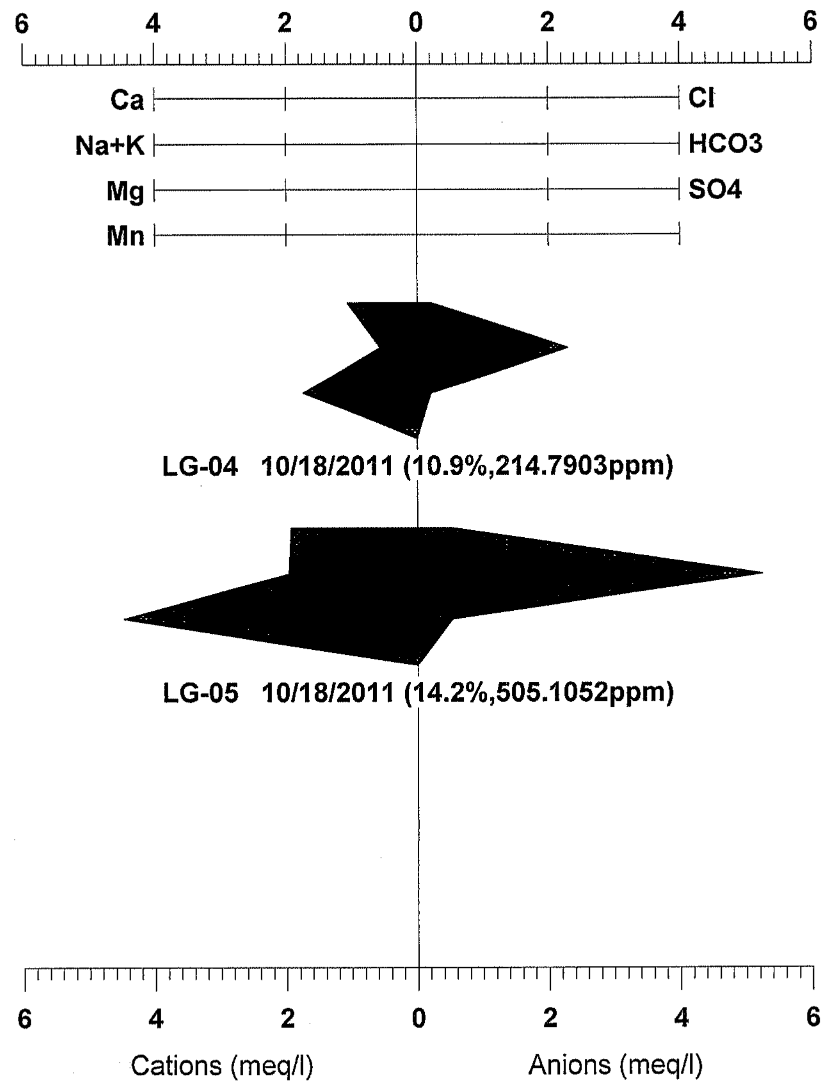


False Positive and False Negative Rates for Current Intra-Well Prediction Limits Monitoring Program



Goodwin Landfill

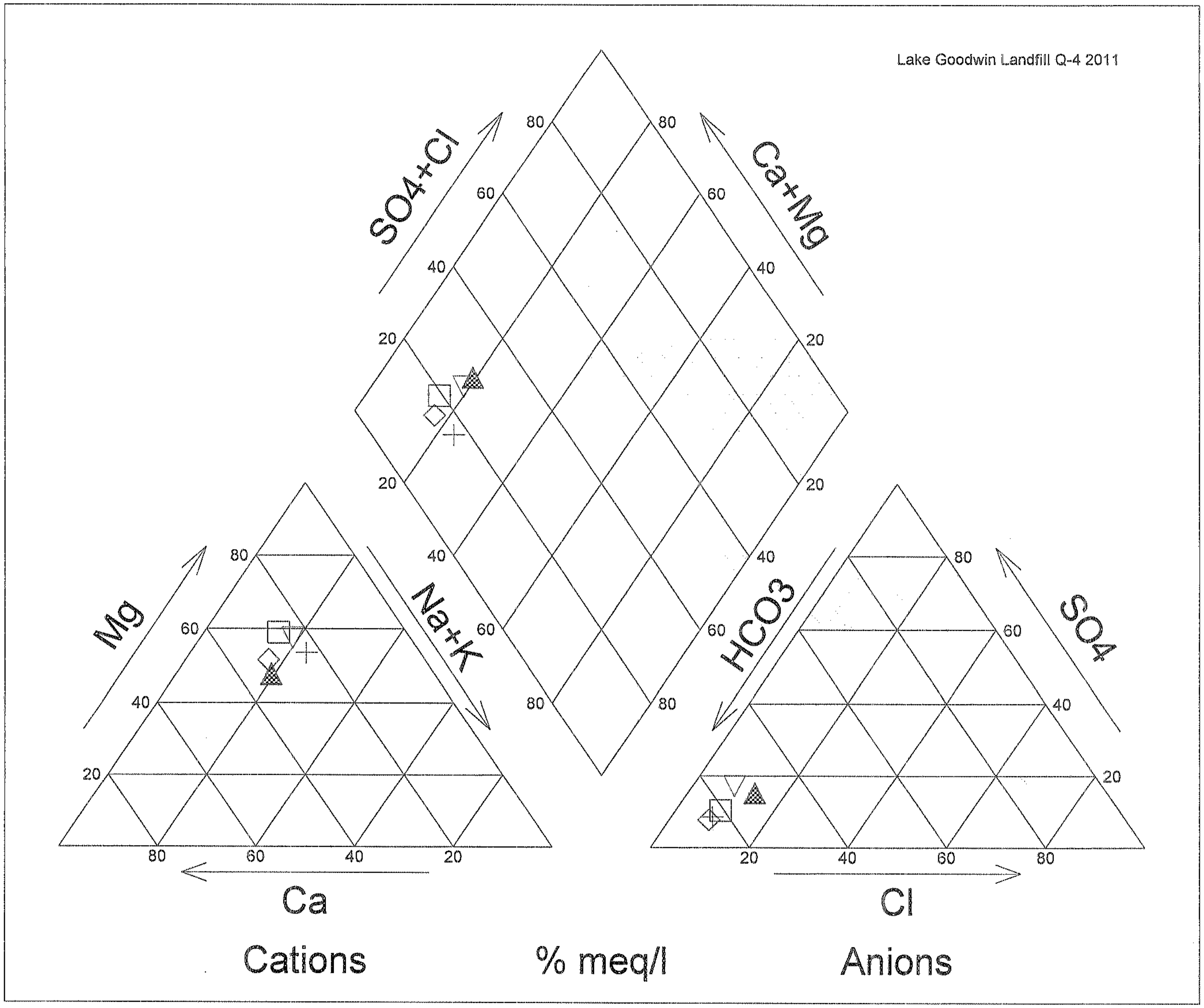




Prepared by: Snohomish County Solid Waste

Goodwin Landfill

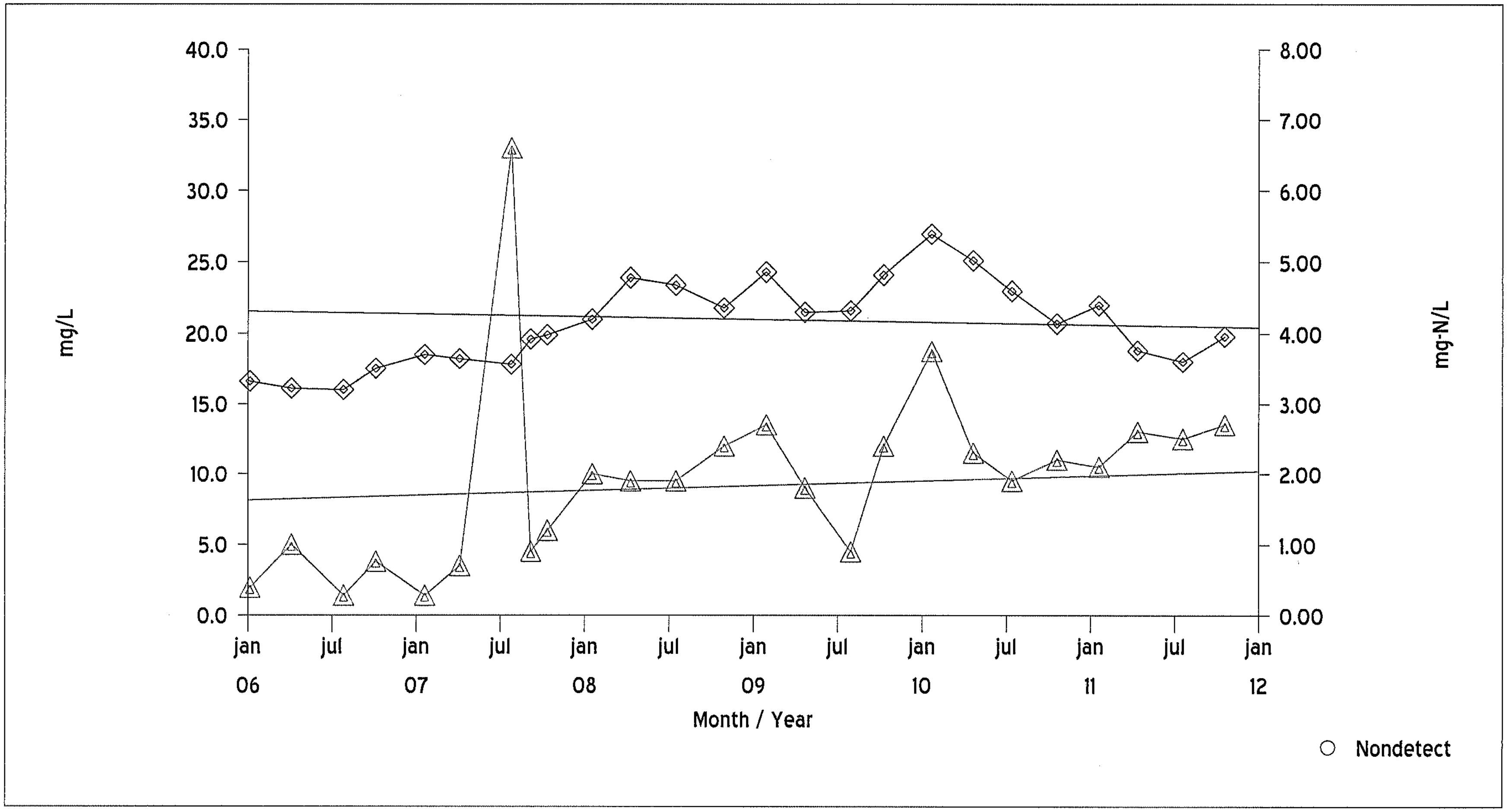
□	LG-01	10/18/2011 (14.6%,225.08ppm)
▲	LG-02	10/18/2011 (15%,152.34ppm)
▽	LG-03	10/18/2011 (12.5%,444.04ppm)
◇	LG-04	10/18/2011 (10.9%,214.79ppm)
+	LG-05	10/18/2011 (14.2%,505.105ppm)



Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-01



Dissolved calcium (cc: -.099)

Nitrate nitrogen (cc: .450)

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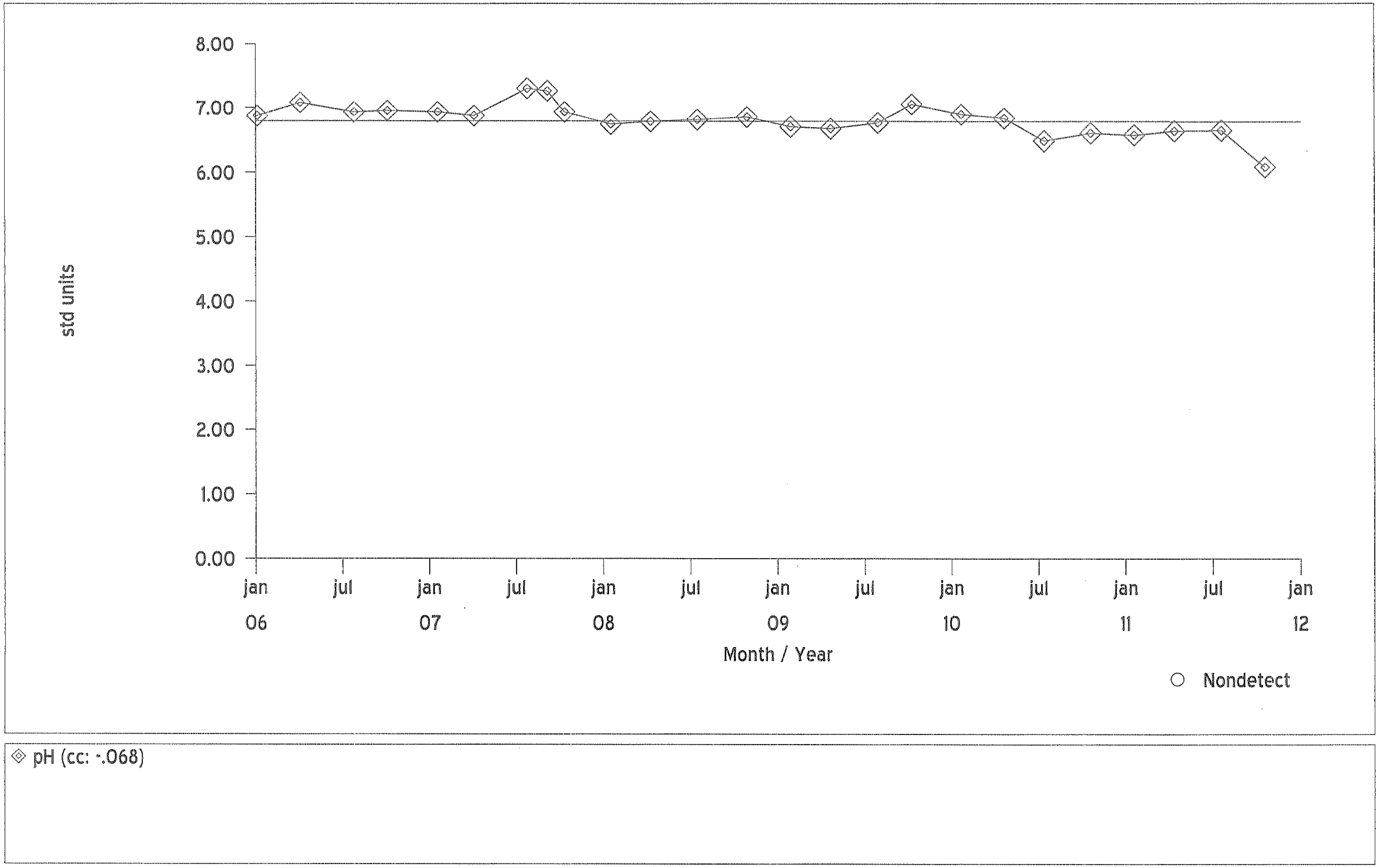
Goodwin Landfill

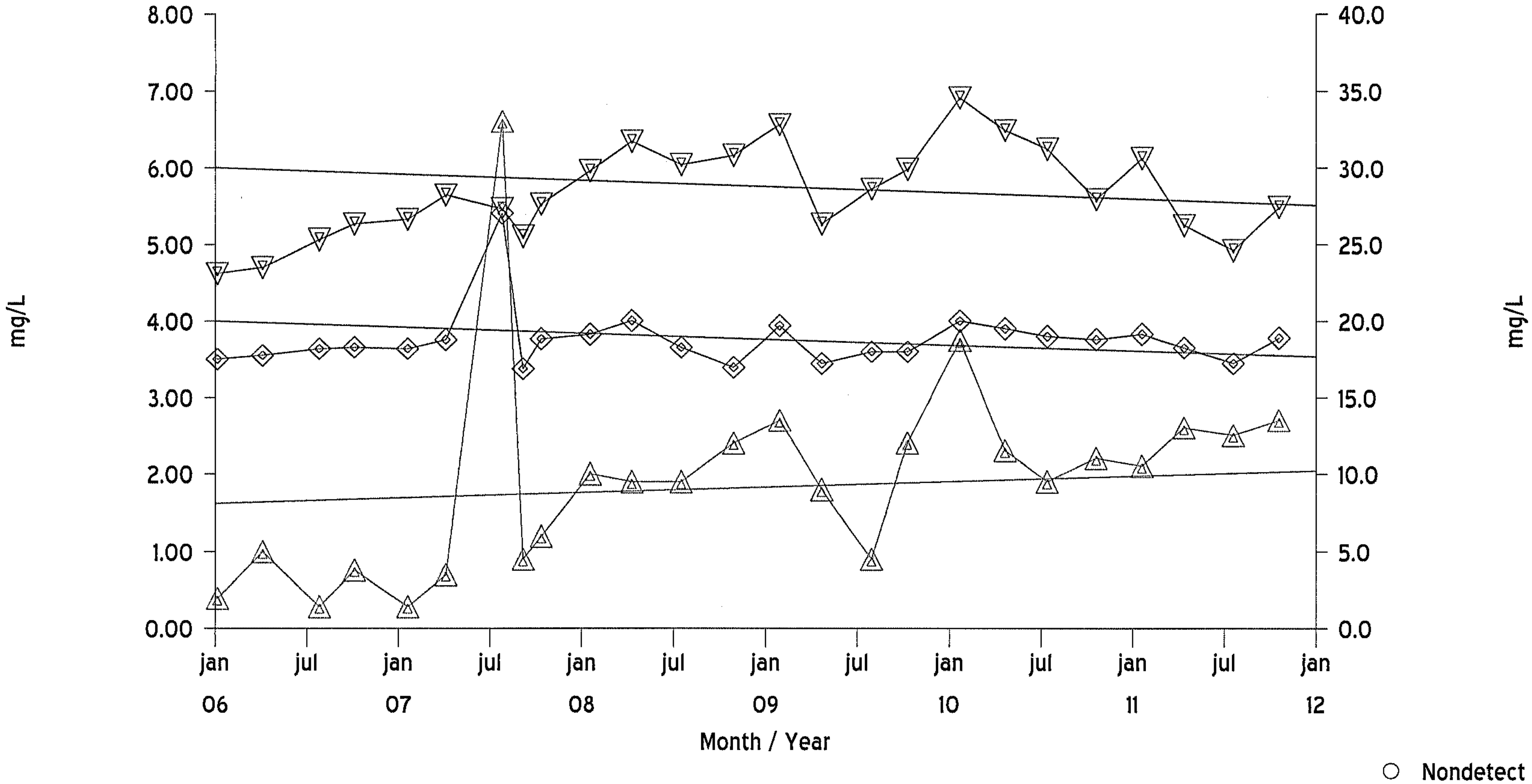
Time Series Plot for LG-01



Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-01



Dissolved potassium (cc: -.411)
Nitrate nitrogen (cc: .450)
Dissolved magnesium (cc: -.239)

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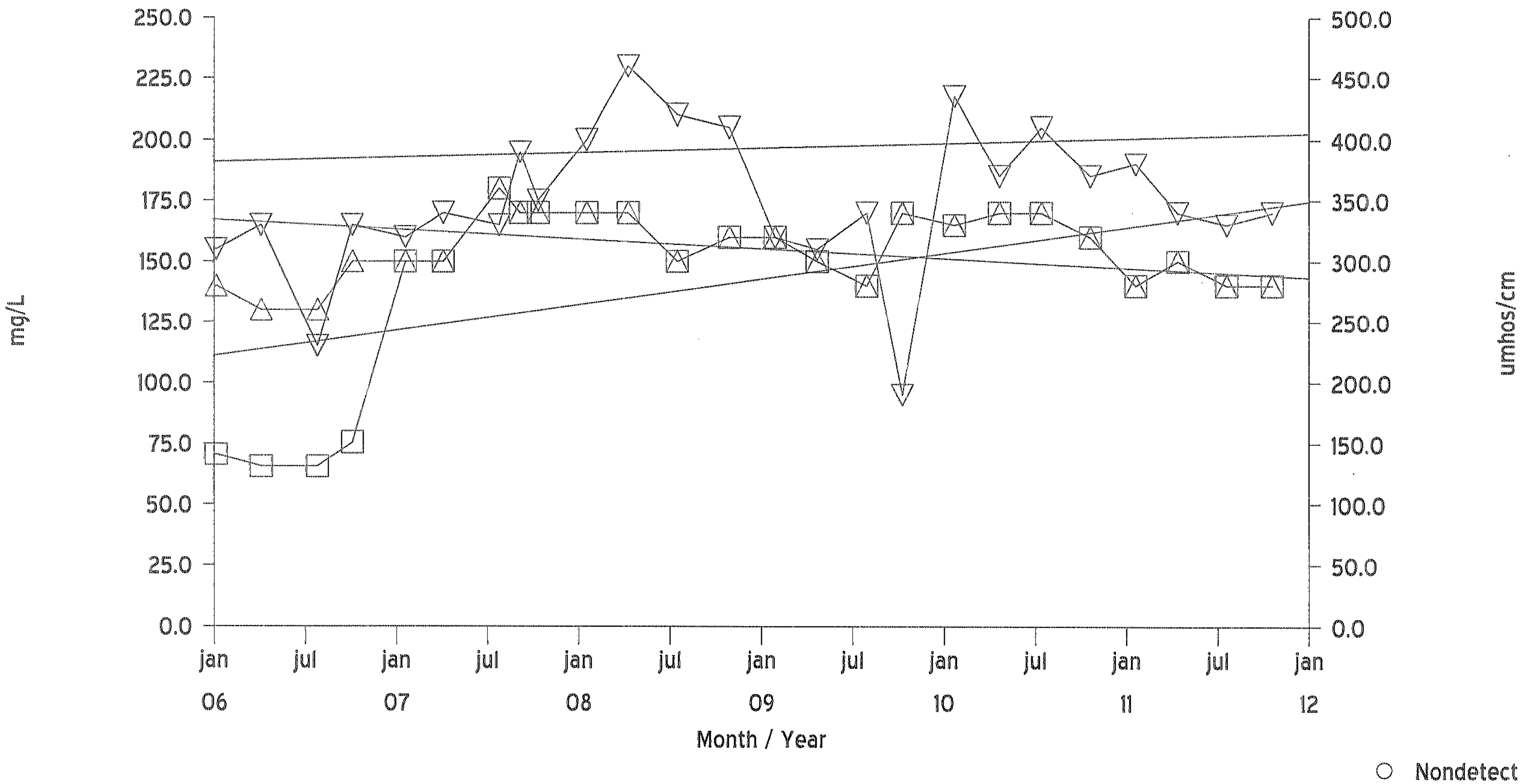
Goodwin Landfill

Time Series Plot for LG-01



△ Bicarbonate (cc: -.396)
□ Alkalinity (as caco3) (cc: .663)

▽ Conductivity (cc: .188)

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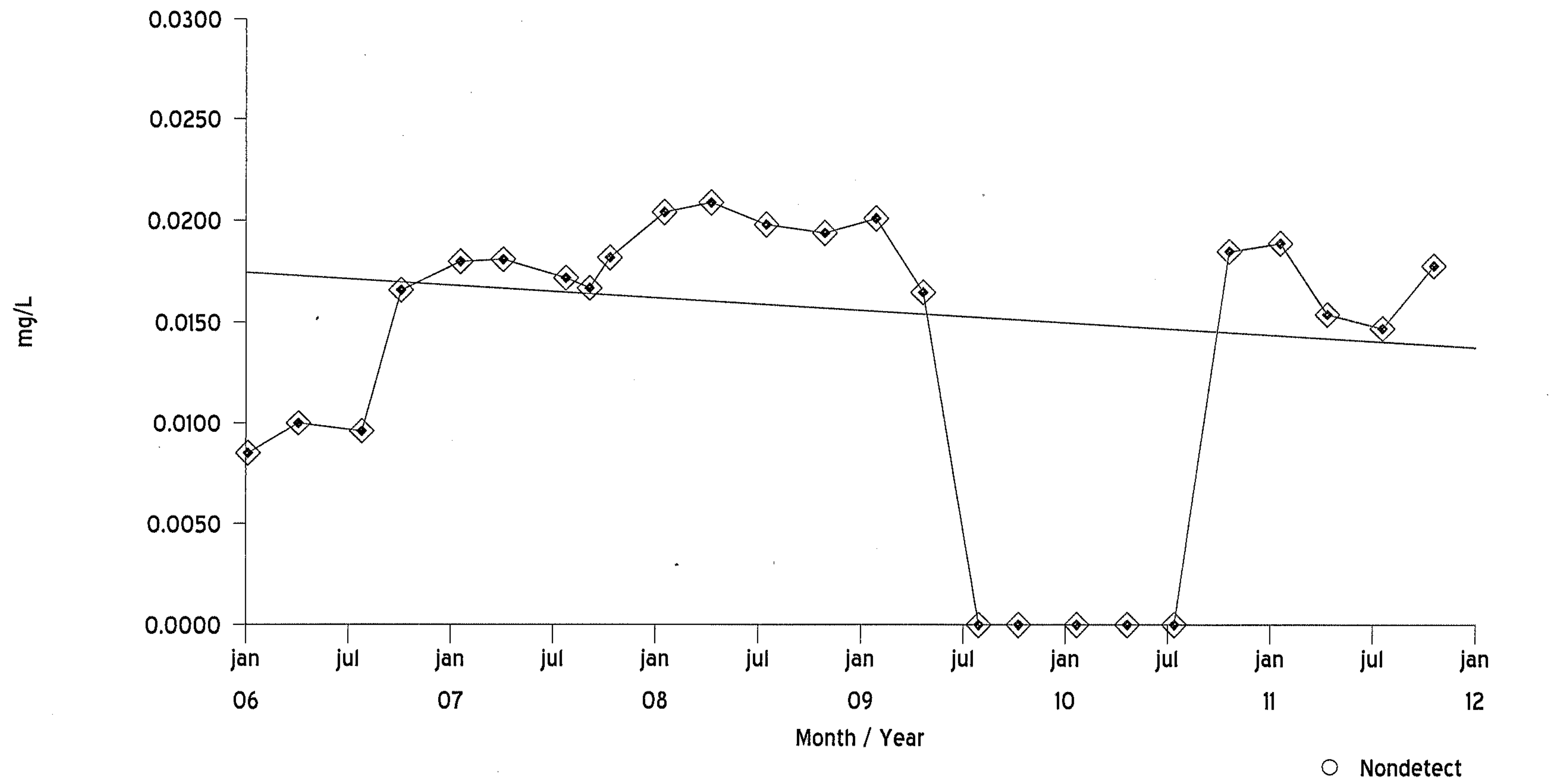
Goodwin Landfill

Time Series Plot for LG-01



◈ Dissolved barium (cc: -.315)

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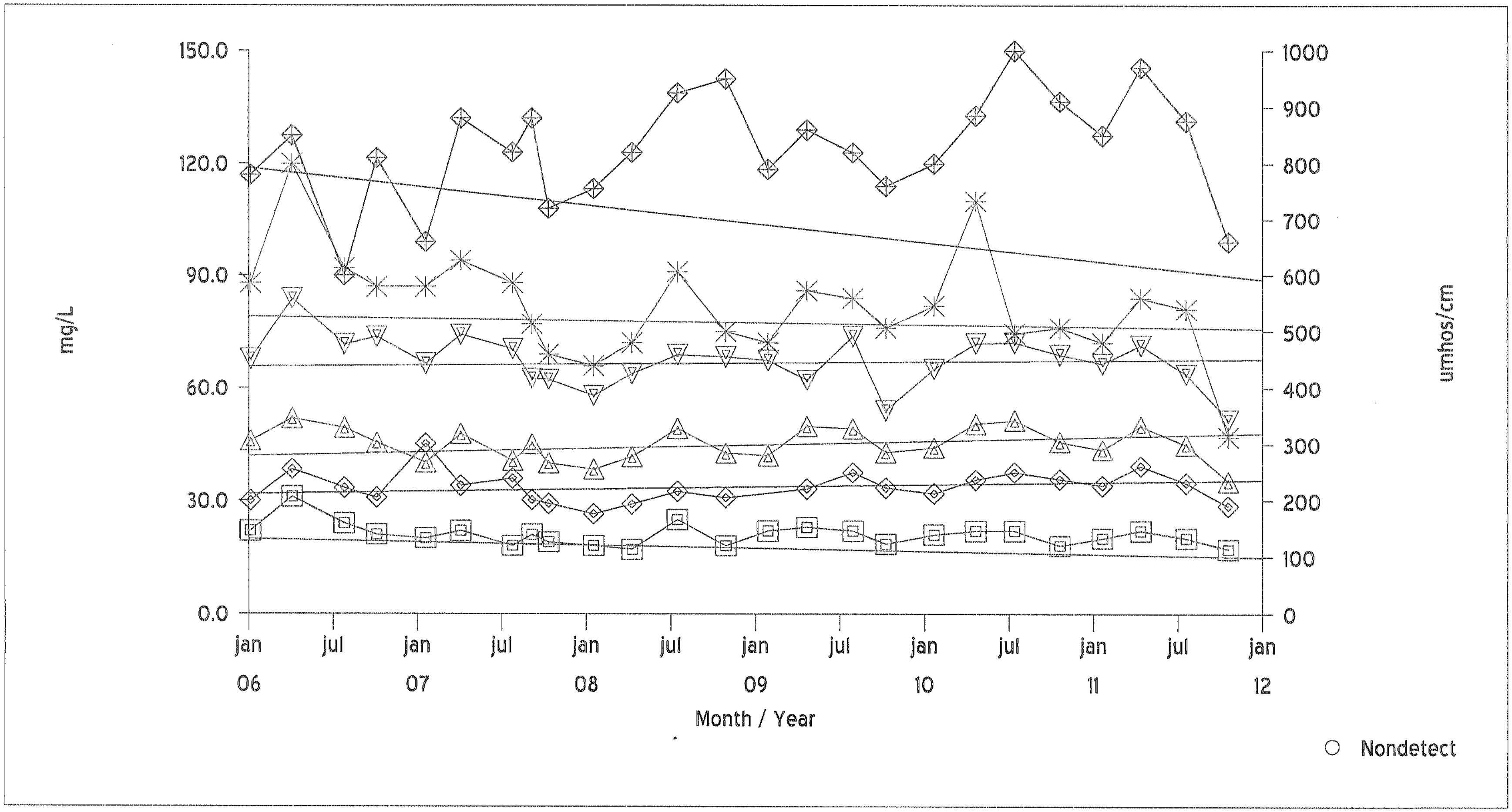
Goodwin Landfill

Time Series Plot for LG-03

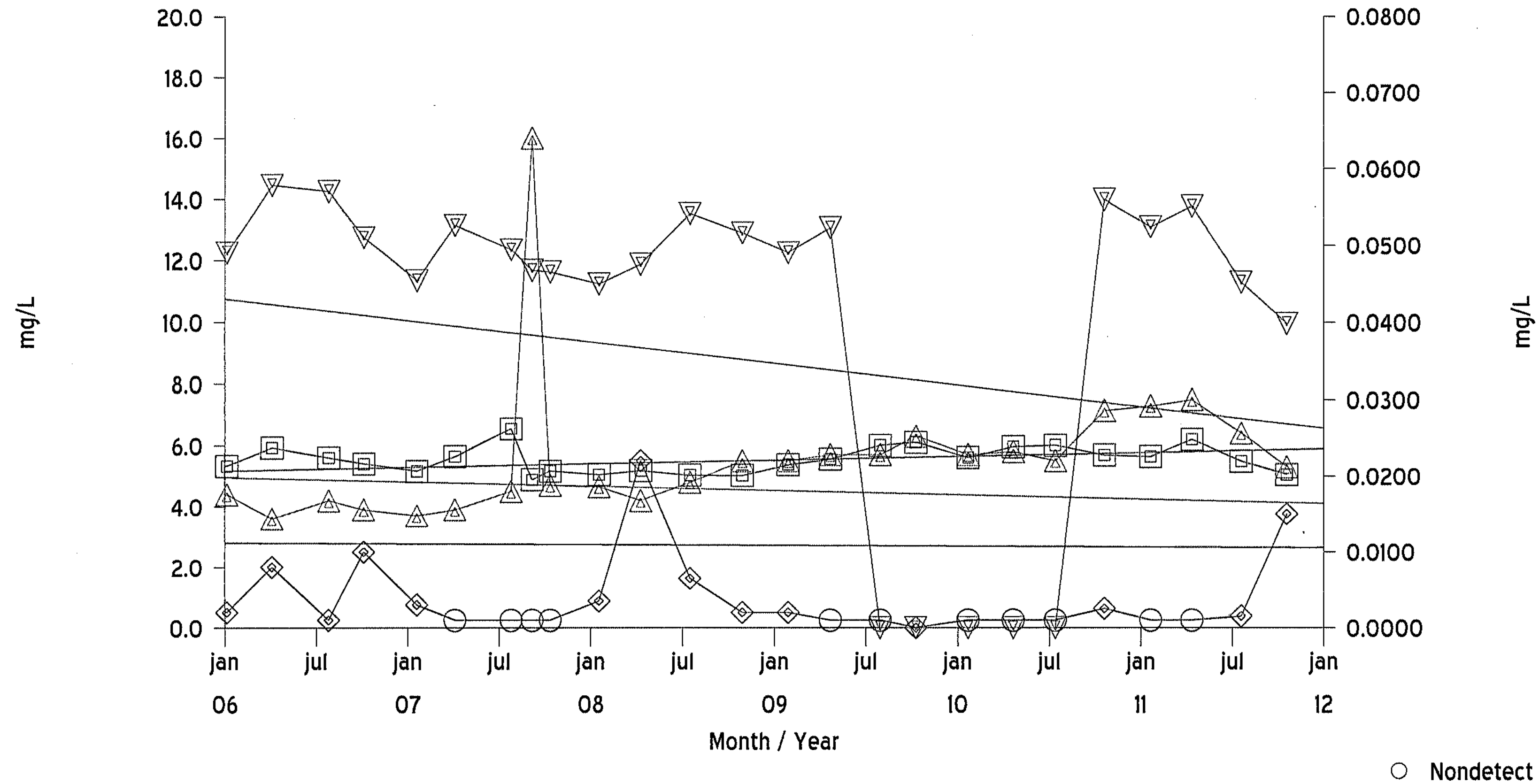


Chloride (cc: -.626)
Dissolved calcium (cc: .314)
Dissolved magnesium (cc: .080)
Dissolved sodium (cc: .321)
Sulfate (cc: -.161)
Conductivity (cc: -.183)

Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-03

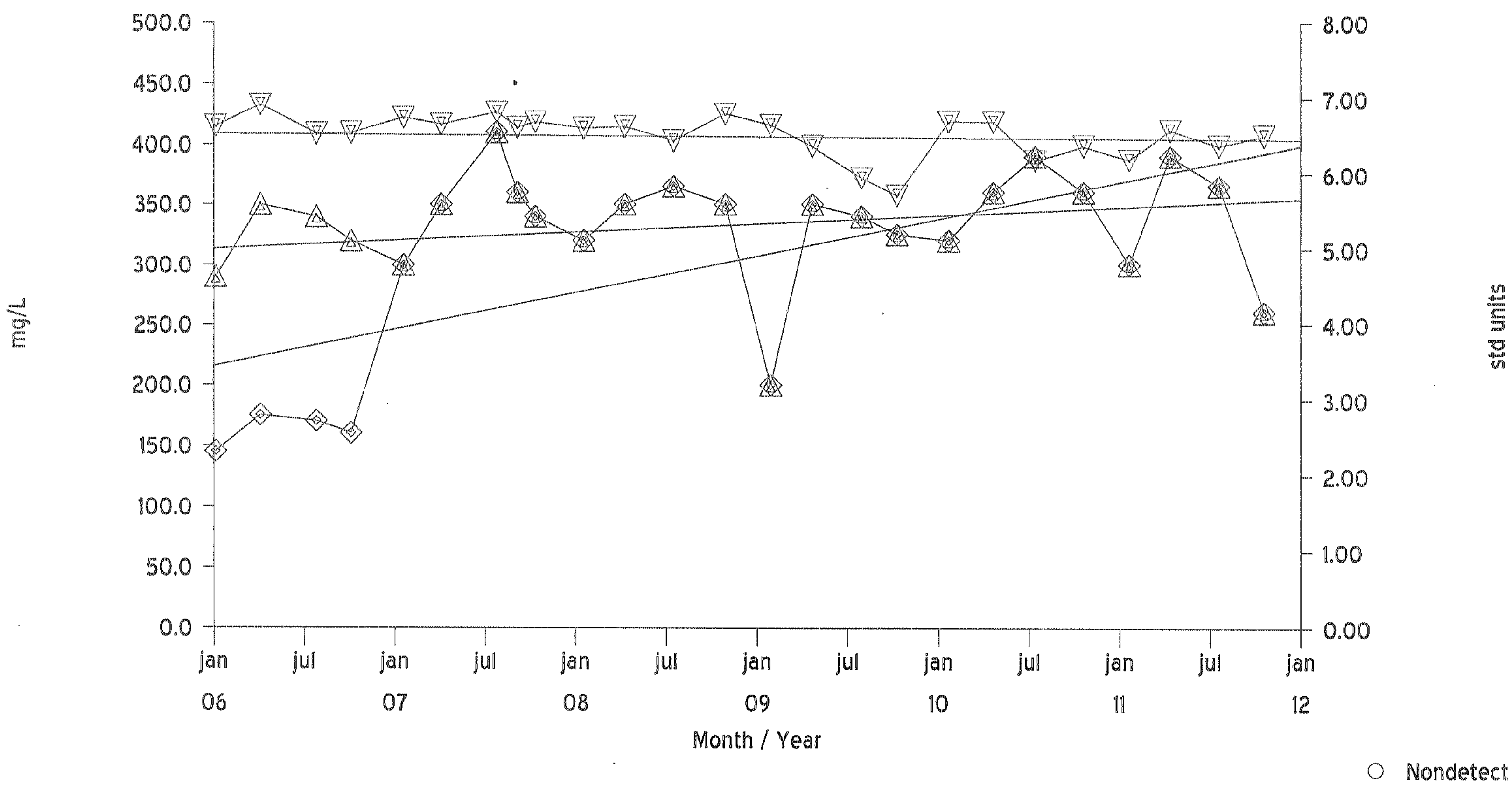


Dissolved potassium (cc: .491)
Nitrate nitrogen (cc: -.330)
Dissolved barium (cc: -.612)
Dissolved zinc (cc: -.050)

Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-03



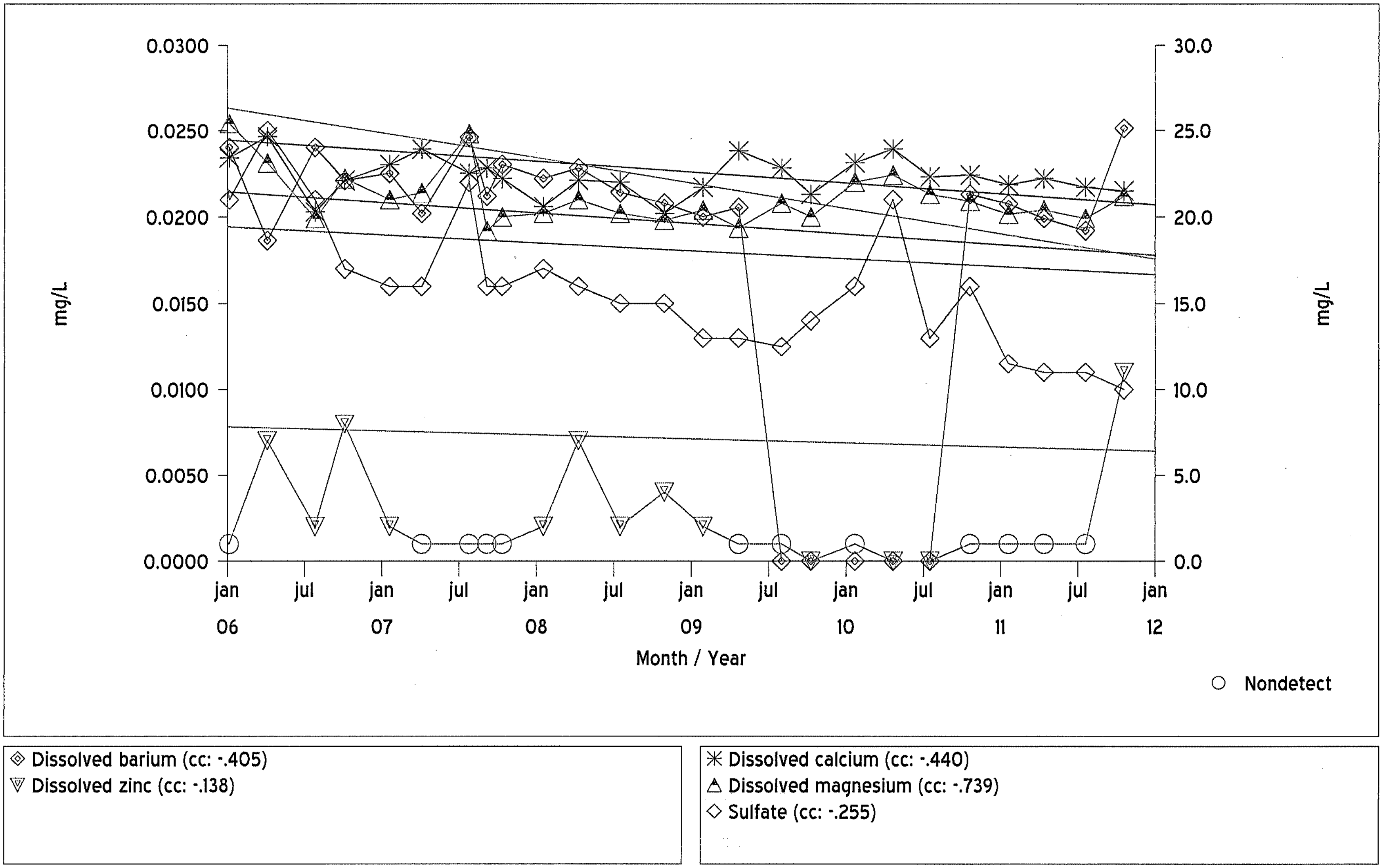
Bicarbonate (cc: .378)
Alkalinity (as caco3) (cc: .795)

pH (cc: -.384)

Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-04



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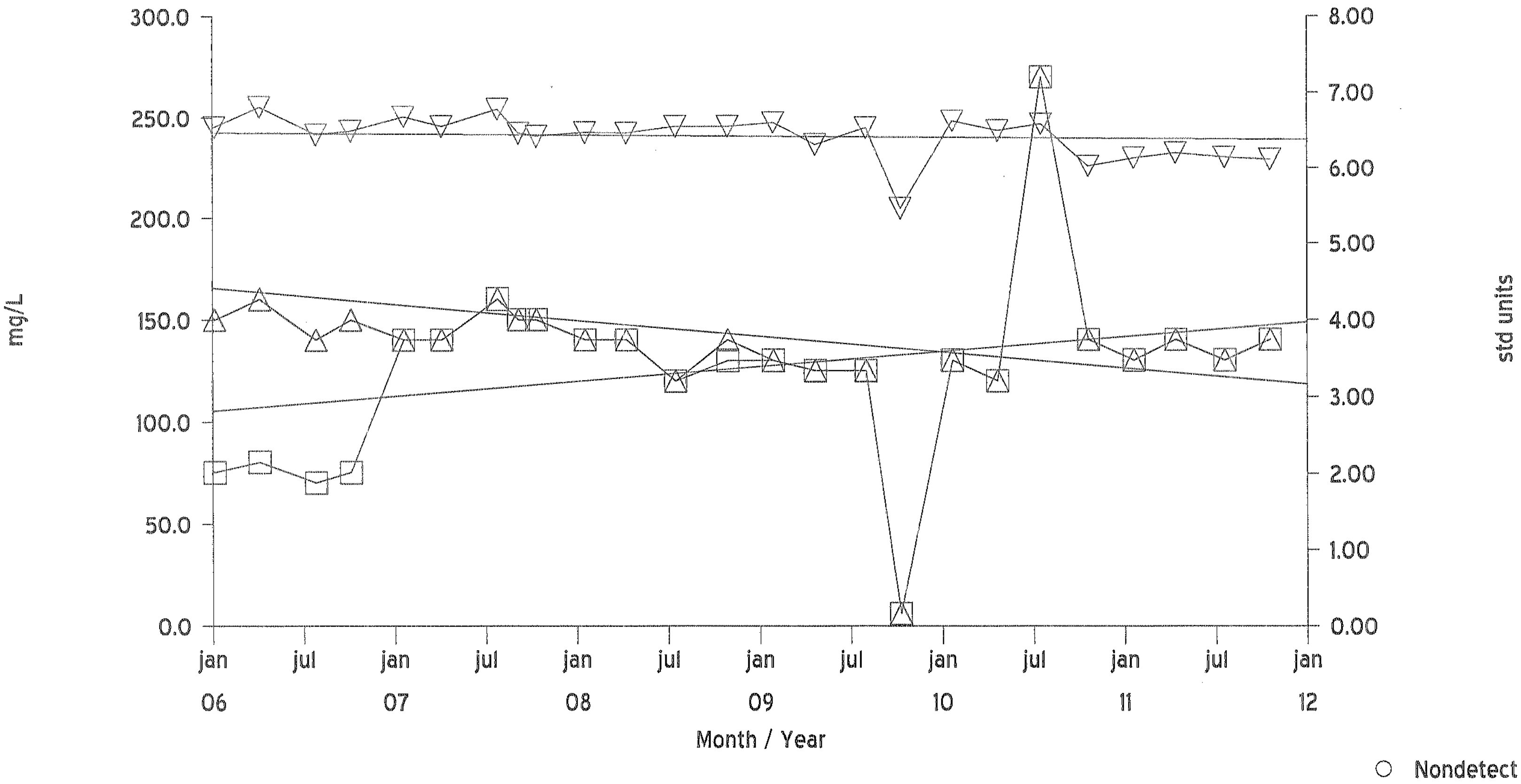
Goodwin Landfill

Time Series Plot for LG-04



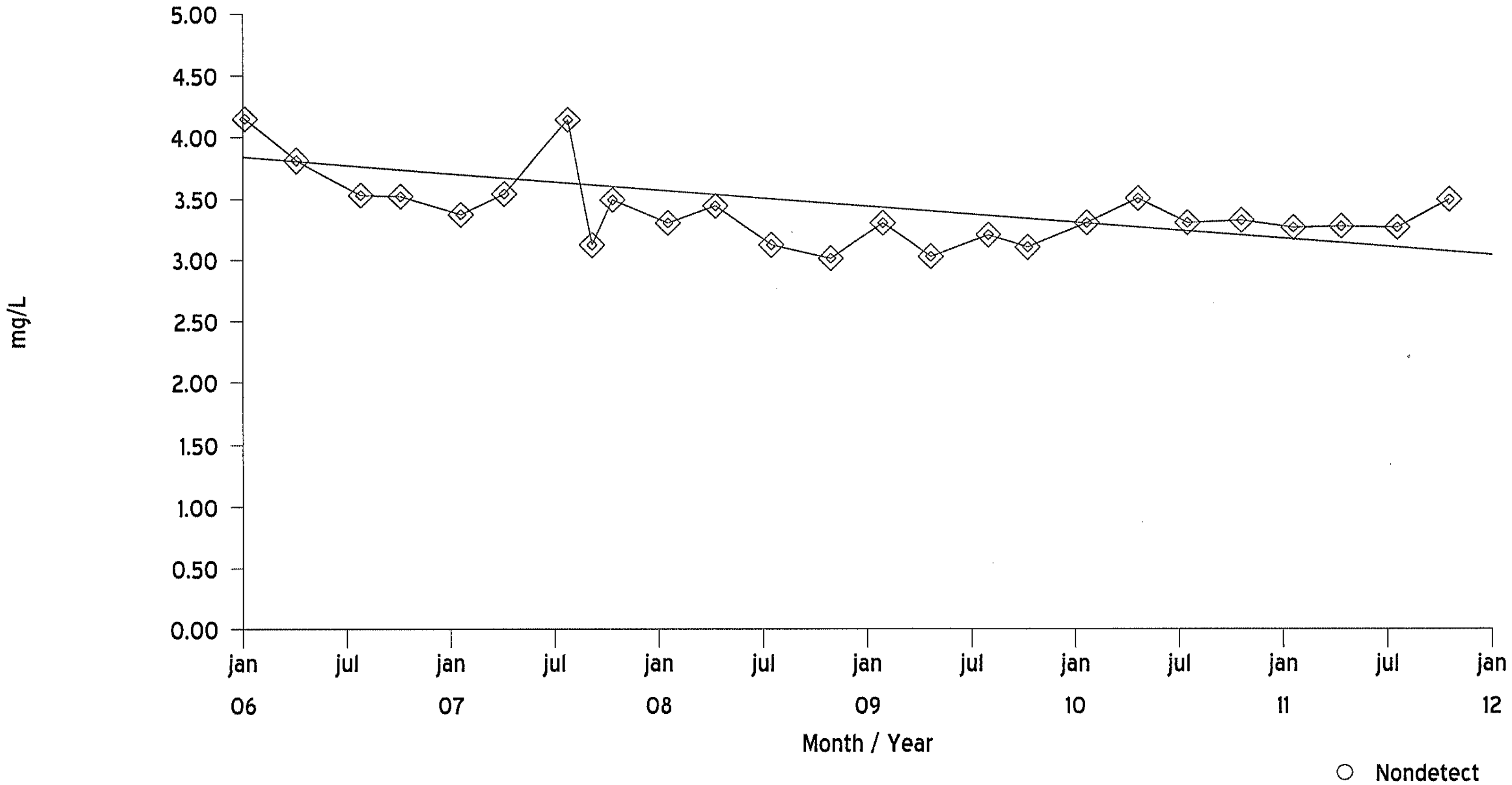
☐ Alkalinity (as caco3) (cc: .444)
△ Bicarbonate (cc: -.486)

▽ pH (cc: -.406)

Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-04



Dissolved potassium (cc: -.687)

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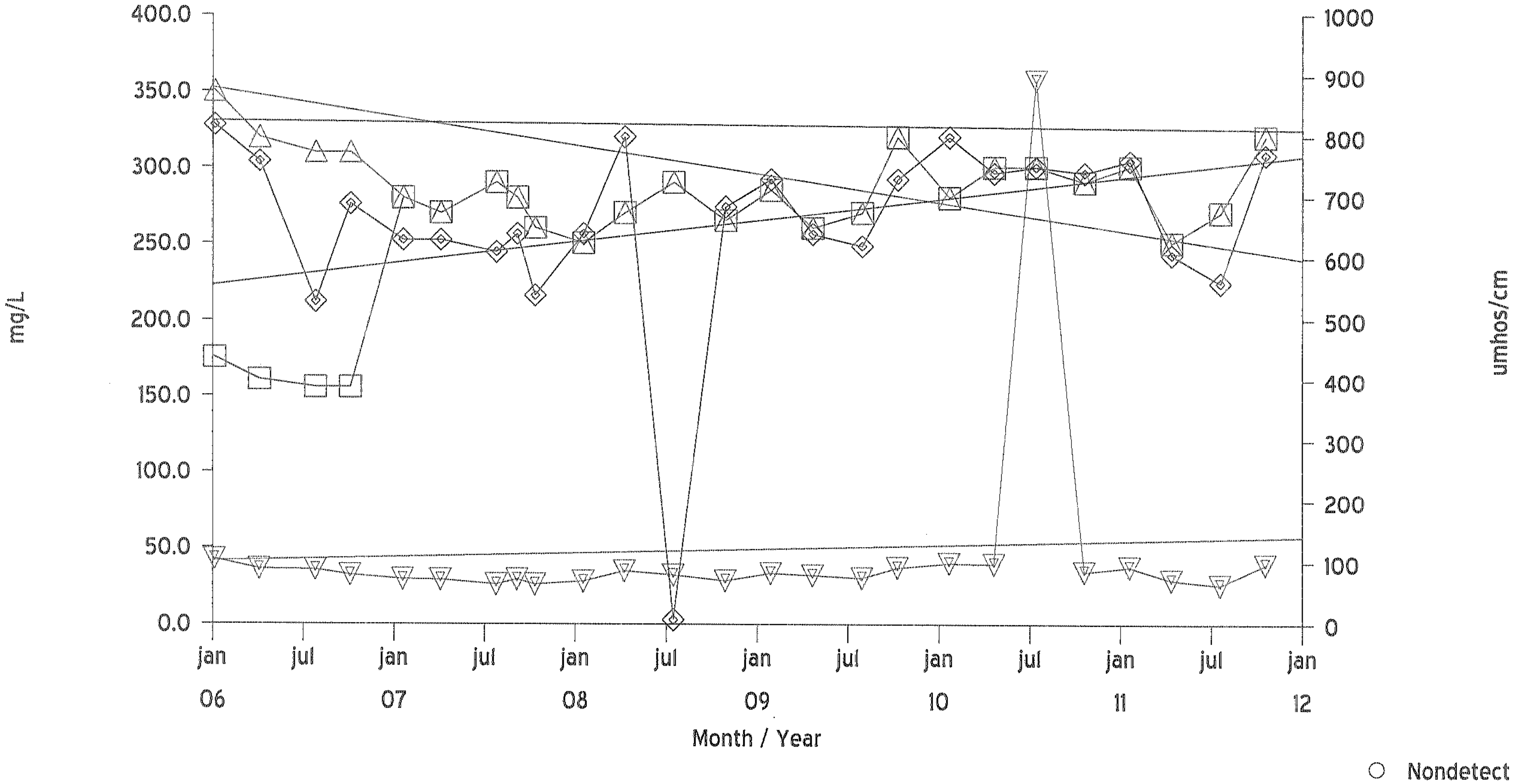
Goodwin Landfill

Time Series Plot for LG-05



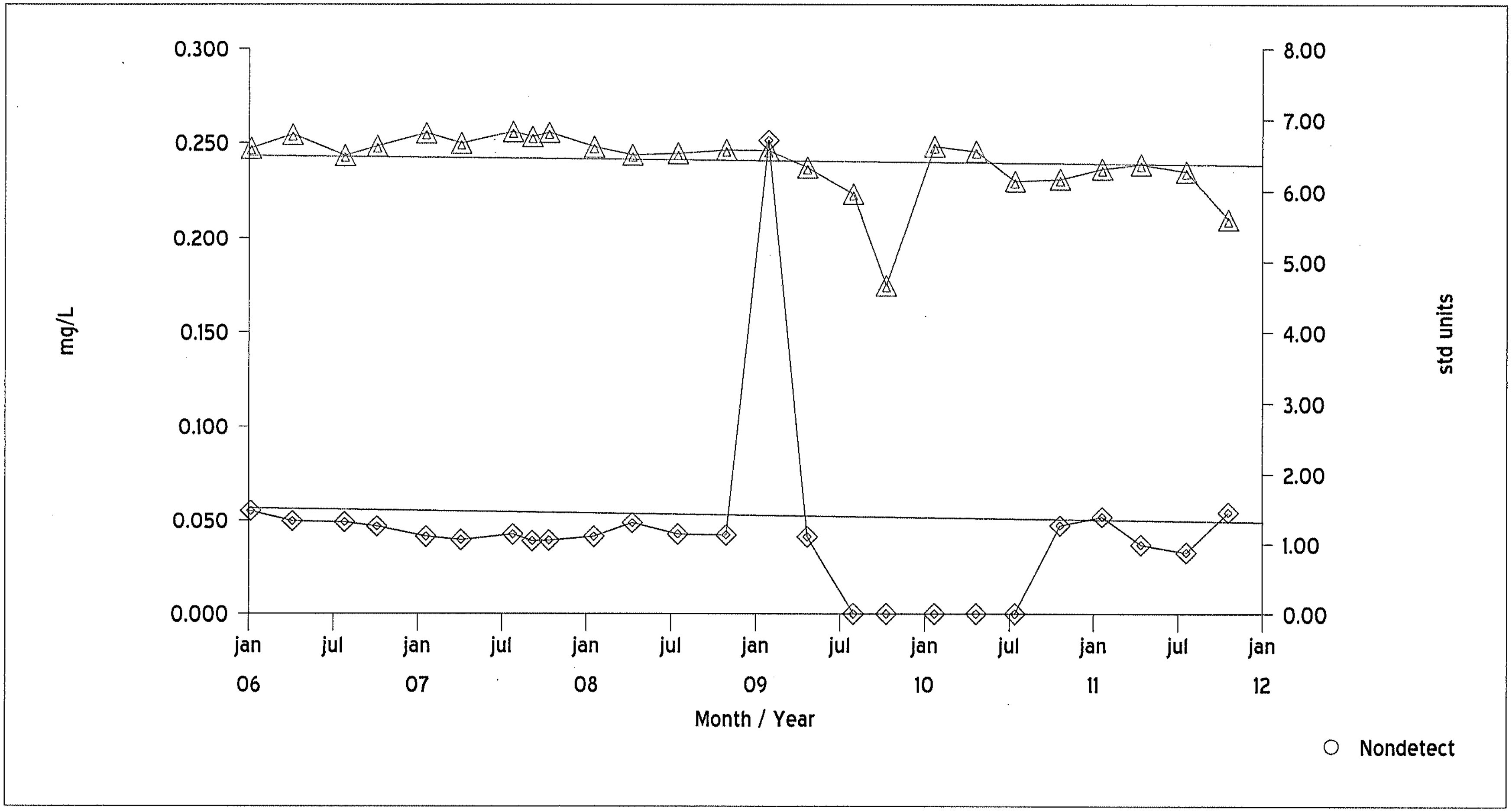
□ Alkalinity (as caco3) (cc: .735)
△ Bicarbonate (cc: -.804)
▽ Dissolved calcium (cc: .124)

◇ Conductivity (cc: -.064)

Prepared by: Snohomish County Solid Waste

Goodwin Landfill

Time Series Plot for LG-05



◈ Dissolved barium (cc: -.206)

◬ pH (cc: -.396)

Prepared by: Snohomish County Solid Waste