M E M O R A N D U M

September 2, 2016

To: Hansville Landfill Environmental Monitoring 2016 File

From: David L. South

Subject: Hansville Landfill Cleanup Site, FSID 2605, CSID 695
Groundwater Data Review

Introduction

This memorandum provides a review of selected groundwater data collected at the Hansville Landfill Site from January 23, 2007 to January 6, 2016. Figure 1 shows the Site location. Figure 2 is a map of the Site and surrounding area.

Consent Decree 95-2-03005-1, dated August 5, 2011, governs cleanup of the Site. The Potentially Liable Persons are Kitsap County and Waste Management of Washington, Inc. SCS Engineers provides technical services to Kitsap County and Waste Management.

The Consent Decree required implementation of cleanup actions described Exhibit B of the Consent Decree, the Cleanup Action Plan (CAP).

Construction is complete. Maintenance, gas collection, and groundwater performance monitoring is ongoing.

A Five-Year Periodic Review is due in 2016. When the Review is issued for public comment notice should be sent to the Port Gamble S'Klallam Tribe (see below under Restoration Time Frame).[1] Notice should also be sent to the Kitsap Public Health District, which issued a post-closure permit for the landfill in 2015.

The primary documents of interest for this memorandum are:

- Consent Decree 95-2-03005-1 with attached CAP, August 5, 2011
- Compliance Monitoring Plan, September 15, 2011
- 2011 through 2015 Annual Monitoring Reports
- First Quarter 2016 Environmental Monitoring Report, April 29, 2016
- Remedial Action Status Report, May 5, 2016

These documents referred are posted to the Toxics Cleanup Programs Document Storage and Retrieval System (DSARS) and may be accessed through Ecology's Hansville Landfill web site.

[1] Ecology and the Port Gamble S'Klallam Tribe have a Memorandum of Agreement (dated 11/9/1993) to provide for an effective, cooperative working relationship with regard to environmental concerns raised by the Hansville Landfill Site.

Three Excel workbooks and a Statgraphics file contain the groundwater data assessed in this memorandum, as well as some of the assessments:

- **Table B-2 Statistics Database 1Q16.xlsx** – prepared by SCS Engineers. This workbook contains vinyl chloride and arsenic data since January 23, 2007. Vinyl chloride and arsenic are the chemicals of interest for assessing compliance.[2]
- **Table B-2 Statistics Database 1Q16 – Selected Wells.xlsx** – Prepared by David L. South. Projects attenuation curves to 2034.
- **Hansville As and VC Data.sgp** and associated data file **Hansville As and VC Data.sgd** – Prepared by David L. South. These are Statgraphics® files. They assess whether concentration data show a statistically significant decline. See below for further explanation.
- **Hansville As and VC Data.xlsx** – prepared by David L. South. This workbook contains the vinyl chloride and arsenic data from Table B-2 Statistics 1Q16.xlsx and evaluation of it. The evaluation is done in terms of normalized concentrations. A chemical's normalized concentration is its measured concentration divided by its cleanup level. Hence, if the normalized concentration is greater than 1, the chemical concentration is greater than its cleanup level. This database evaluates the trend of the 95% upper confidence limit (95UCL) of the four quarters of monitoring data in the years 2011 and 2015, and whether the upper and lower confidence limits converge or diverge (termed their vergence).

Purpose

The purpose of this memorandum is to assess whether groundwater monitoring data indicate groundwater cleanup levels will be achieved within the restoration time frame given in the CAP.

Site Background

Hansville Landfill is located 4½ miles south of the community of Hansville on the northernmost reach of the Kitsap Peninsula. The Hansville Landfill operated as a municipal landfill serving the northern portion of Kitsap County from about 1962 to 1989. The landfill is divided into three separate areas: a 13-acre municipal solid waste landfill; a four-acre demolition landfill that accepted construction, demolition, and land clearing wastes; and a one-third acre septage lagoon that accepted septic tank pumping waste. None have a bottom liner.

The remaining landfill property consists of access roads, a soil borrow area and wooded land.

[2] The earliest data in Ecology's Environmental Information Management System (EIM) is from October 4, 2011. It contains the complete suite of chemicals that are being measured at the Site. Note that in some cases the same chemical is reported in μg/L for some monitoring rounds, and mg/L for others.

The land to the west of the property, between the landfill and Port Gamble Bay, belongs to the Port Gamble S'Klallam Tribe.

The landfill has been closed in accordance with the requirements of Ch. 173-304 WAC. A final cover system was completed in 1990. An active landfill gas extraction and flaring system was installed in November 1991 and upgraded in 1993.

The selected remedy for groundwater contamination is natural attenuation, institutional controls, and monitoring. Institutional controls are to remain in place until concentrations of indicator hazardous substances in groundwater beneath tribal property decline to beneath cleanup levels (see below under Restoration Time Frame). Groundwater and seep monitoring collects data for statistical evaluation. The statistical evaluation assesses whether contaminant concentrations are declining at a rate which will achieve cleanup levels within a reasonable restoration time frame.

Ecology will conduct periodic reviews at least once every five years. If the data and statistical analysis demonstrate that the site cleanup levels will probably not be met within the restoration time frame, Ecology will evaluate possible additional remedial actions at the Site. Possible actions include those evaluated in the Feasibility Study but not chosen. Other actions can also be considered. (See Chapter 4 of the CAP)

Restoration Time Frame

The PLPs have an agreement with the Port Gamble S'Klallam Tribe[3] to allow contaminated ground water beneath Tribal Land to naturally attenuate over a 23-year restoration time frame.[4] The restoration time frame began on August 5, 2011, the date the Consent Decree was signed. Hence, groundwater cleanup levels are to be achieved at the points of compliance by August 5, 2034.

Contaminants of Concern, Cleanup Levels, Points of Compliance, and Monitoring Locations

Groundwater monitoring is being conducted for vinyl chloride, arsenic, manganese, geochemical indicators, and orthophosphate. Field measurements and static water levels are measured at the time of sample collection. This memorandum will focus on vinyl chloride and arsenic results for selected wells. Cleanup levels are as follows:

- Vinyl chloride – 0.025 μg/L

[3] Settlement Agreement Among Kitsap County, Waste Management of Washington, Inc., and the Port Gamble S'Klallam Tribe, Sept. 20, 1995. There is also a settlement agreement from April 2007. This agreement commits the Tribe to enforce the land use restriction consistent with the final Consent Decree. (See Status Report, p. 21)
[4] CAP Table 4-1 specifies the restoration time frame.

- Arsenic – 0.005 mg/L

The CAP (p. 9) establishes three conditional points of compliance for the Hansville Site. The conditional points of compliance and the wells and surface seeps used as compliance monitoring locations are as follows (See Figure 2);

1. The Upper Aquifer at the Landfill Property boundary. Compliance monitoring groundwater wells are MW-07, MW-06, and MW-14. These wells are located upgradient of the property boundary, with wells MW-6 and MW-14 200 to 400 feet upgradient and only 25 feet downgradient of the landfill boundary, but the CAP establishes them as the compliance monitoring point representative of groundwater passing the property boundary.
2. The Upper Aquifer downgradient of the Landfill Property boundary and upgradient of the creek headwaters on tribal property. Compliance monitoring groundwater wells are MW-13D and MW-12I.
3. Groundwater discharge to surface water at the headwaters of Creek A, Creek B, and Middle Creek on tribal property. Compliance monitoring surface water locations are SW-1, SW-4, SW-6, and SW-7.

Compliance monitoring locations are shown on Figure 2.

CAP Requirements for Evaluation of Groundwater Monitoring Data

The *Compliance Monitoring Plan* provide that water quality data will be evaluated on a quarterly basis through (Section 5.1, p. 25):

- Comparison with applicable water quality standards,
- Tracking of natural attenuation parameters to assess the effectiveness of the selected remedy,
- Statistical analysis of groundwater chemicals of concern (arsenic and vinyl chloride) to project contaminant trends.

Upper and lower confidence limits for vinyl chloride and arsenic in groundwater are calculated on an annual basis for comparison with Site cleanup levels.

The statistical methods specified in the *Compliance Monitoring Plan* are (Section 5.1.2, p. 26):

- Statistically derived trend analysis which helps identify and maintain downward trends (Mann-Kendall and Sen's Slope),
- Statistical curve fitting for several years, as far as is feasible given the data, which enables a projection of hypothetical cleanup time frames, and
- Confidence limit comparison which ultimately determines the end of corrective action.

The confidence limit comparison is particularly important. The 95% Upper Confidence Limit (95UCL) is the metric which decides whether compliance has been achieved in a compliance well and hence whether cleanup has been achieved.

The key questions before Ecology with regard to the Five-Year Periodic Review due in 2016: Do data collected to date predict with sufficient certainty that compliance will be achieved in each well within the restoration time frame ending August 5, 2034? If not, what actions should be taken?

Wells out of Compliance

The following wells remain out of compliance with respect to the following chemicals of concern:

Table 1: Wells out of compliance.

Well	Chemical
MW-06	Vinyl chloride
MW-12I	Vinyl chloride
MW-14	Vinyl chloride
MW-14	Arsenic

Data collected from these wells is evaluated with respect to the three statistical methods listed above.

Well Data Evaluation

Statistically Derived Trend Analysis and Statistical Curve Fitting

The *Remedial Action Status Report* states that vinyl chloride in the three exceeding wells show a declining attenuation curve. It further notes, however, that only vinyl chloride in MW-14 shows a statistically significant trend. It concludes that the results are consistent with the ongoing, gradual improvement in groundwater quality at the Site. This conclusion is somewhat surprising, since only vinyl chloride in MW-14 shows a statistically significant trend. There is significant uncertainty in the results.

One concern with *Remedial Action Status Report* data evaluation is that the statistically derived trend analysis uses only data collected since January 25, 2011, whereas the statistical curve fitting uses data collected since January 23, 2007. Hence, the two analyses are not being conducted on the same data set. Visual inspection of the attenuation curves for vinyl chloride concentrations in MW-06 and MW-12I indicate if only data since January 25, 2011 is considered the downward trend is questionable.

Fitting an exponential curve to the same January 25, 2011 to January 6, 2016 data as was used for the Mann-Kendal and Sen's Slope trend tests found the same result: only vinyl chloride in MW-14 showed a statistically significant relationship downward trend.[5]

The *Compliance Monitoring Plan* specifies that the attenuation curves "… will be extended forward in time (several years) as far as is feasible given the data" (See p. 26). This has been done for a three year period and can be seen on the charts in the *Remedial Action Status Report* (See Appendix C of the report or Excel Workbook Table B-2 Statistics Database 1Q16.xlsx, prepared by SCS Engineers.). None of the four wells of interest come into compliance within this three year period.

While a three year projection is of some interest, the key question asked above is what do the data collected to date predict about whether the wells will come into compliance by 2034. While projecting this far beyond the data has a great deal of uncertainty, it does give some insight as to whether Ecology should require additional remedial actions. As noted above, considering whether additional remedial actions should be required is one of the things Ecology is to consider during periodic reviews. (See Chapter 4 of the CAP).

Ecology will conduct periodic reviews at least once every five years. If the data and statistical analysis demonstrate that the site cleanup levels will probably not be met within the restoration time frame, Ecology will evaluate possible additional remedial actions at the Site. Possible actions include those evaluated in the Feasibility Study but not chosen. Other actions can also be considered. (See Chapter 4 of the CAP)

The charts in Excel Workbook Table B-2 Statistics Database 1Q16.xlsx were reformatted to extend the curves to 2034. These curves may be viewed in Excel Workbook Table B-2 Statistics Database 1Q16 – Selected Wells.xlsx. The extended curves give the following results:

Table 2: Restoration time frame assessment using attenuation curves.

Chemical	Well	Attenuation curve crosses cleanup level before 2034
Vinyl chloride	MW-06	No
Vinyl chloride	MW-12I	Yes, 2024
Vinyl chloride	MW-14	Yes, 2025
Arsenic	MW-14	No, but close

Perhaps the best use of these extended projections is to simply watch how they change from this periodic review to the next and see if additional data results in the attenuation curves reaching the cleanup level more or less quickly than when using only data collected through 2015.

[5] This analysis was done using Statgraphics®. See files Hansville As and VC Data.sgp and Hansville As and VC Data.sgd.

Confidence Limit Comparison

The 95UCL ultimately determines the end of the corrective action and hence whether the restoration time frame has been met. The confidence limits and means are presented for each 4 quarters of data for each of the years 2011 to 2015. The *Compliance Monitoring Plan* states that the upper confidence limit and the lower confidence limit will be compared to the site-specific cleanup levels to determine the position of the upper and lower confidence limits relative to these criteria (above or below) and whether the confidence limits are still converging and approaching the cleanup level. If a downward trend in the groundwater data is present, the mean, upper confidence limit, and lower confidence limit should trend downward.

The annual monitoring reports (2011 – 2015) submitted to date show mean, lower confidence limit, and upper confidence limit for each well/chemical based on the 4 quarters of data for that year [See the *Compliance Monitoring Plan*, p. 27, calculation of Upper and Lower Confidence Limits (Annual)]. Neither the annual monitoring reports nor the Remedial Action Status Report assess whether the confidence limits are converging or diverging over time or the time frame over which the 95UCL will approach the relevant cleanup levels.

The means, lower confidence limits, and upper confidence limits were obtained from the 2011 – 2015 annual monitoring reports and entered into Excel Workbook Hansville As and VC Data.xlsx. See Worksheet Cf limits, which contains additional data.

Please refer to the workbook while reading the following text.

Three charts were prepared for each well/chemical combination. **These analysis use the normalized mean upper and lower confidence limits.** This is simply the concentration divided by the relevant cleanup levels. **Values greater than 1 are exceedances.**

The first is labeled UCL_LCL_Mean. It is a High/Low/Close chart which shows the upper confidence and lower confidence limits at the top and bottom of a bar with a dot showing the mean.

The second is labeled CfL Vergence. It calculates the difference between the upper and lower confidence limits for each year and provides linear and exponential trend lines. It assesses whether the confidence limits are converging over time.

The third chart is labeled Exp. It is an exponential fit to the upper confidence limit.

Review of the High/Low/Close and Vergence charts indicates that the confidence limits converge only for vinyl chloride in MW-14. The rest diverge according to both the linear and exponential trend lines.

Review of the exponential fits to the 95UCL indicate the 95UCL is increasing for vinyl chloride in MW-06 and MW-12I over the first five years of data collected. Vinyl chloride in MW-14 shows a strong downward trend. Extending this trend to 2034 indicates the 95UCL for vinyl

chloride in MW-14 will meet the restoration time frame in 2025. Arsenic in MW-14 shows a weak downward trend. Extending this trend to 2034 indicates the 95UCL for arsenic in MW-14 will closely approach, but not quite not meet the restoration time frame.

Summary of Evaluations

Table 3 summarizes the above evaluations. It should be kept in mind these evaluation are based on limited data and have a good deal of uncertainty associated with them.

Table 3: Summary of evaluations.

Statistical Method	Vinyl Chloride MW-06	Vinyl Chloride MW-12I	Vinyl Chloride MW-14	Arsenic MW-14
Mann-Kendall and Sen's Slope Trend Analysis	No trend.	No trend	Downward trend.	No trend.
Statistical Curve Fitting of individual data points	Will not meet restoration time frame	Will meet restoration time frame in 2024	Will meet restoration time frame in 2025	Will not meet restoration time frame
Confidence limit vergence	Diverge	Diverge	Converge	Diverge
95% Upper Confidence Limit	Upward trend, will not meet restoration time frame	Upward trend, will not meet restoration time frame	Strong downward trend, will meet restoration time frame	Weak downward trend, will closely approach, but will not quite meet restoration time frame

Conclusions and Recommendations

Taken together, the data collected to date indicate it is uncertain whether the 95UCL for vinyl chloride in MW-06 and MW-12I and arsenic in MW-14 will decline to below the vinyl chloride cleanup level by 2034. Statistical analysis of the available data indicate these wells will not come into compliance within the 23-year restoration time frame, that is, by 2034. However, this is only the first five years of monitoring data, and the uncertainty is high. A particular concern is that the decision metric is the 95UCL on the mean of four data points. Using only four points means that if there is considerable variance in the data the 95UCL will be higher than if more data points were used.

With regard to the key questions before Ecology with regard to the 2016 Five-Year Periodic Review noted above:

- Data collected to date does not predict with sufficient certainty that compliance will be achieved in all compliance monitoring wells within the restoration time frame ending August 5, 2034.
- Nor does the data predict that compliance will not be achieved with sufficient certainty to require additional remedial actions at this time.
- Future reports should include the following:

- Mann-Kendall, Sen's Slope, and curve fitting should be performed with the same data set.
- Curves should be extended to the time at which cleanup levels are achieved. As data comes in, the increase or decrease of the time at which cleanup levels are achieved can be used as a qualitative assessment of the progress of the natural attenuation.
- The 95UCL should be plotted for all of the monitoring wells as was done in Workbook Hansville As and VC Data.xlsx

The 2021 Periodic Review should carefully consider whether compliance is likely to be achieved within the restoration time frame in light of having 10 years of compliance monitoring data rather than only five. Specifically, the statistical measures should show the following:

- Mann-Kendall and Sen's Slope trend tests should start showing downward trends,
- Attenuation curves should show quicker times to reach the cleanup level; that is, the curves should show decreasing restoration time frames.
- The trends of the 95UCLs should all be downward.
- The trends of the 95UCLs should predict the well/chemical combination will meet the restoration time frame.

If the statistical measures do not show the above improvement, additional remedial actions should be considered for implementation in 2022 in order to meet the Consent Decree requirement of achieving compliance by 2034.

Figure 1: Hansville Landfill Site Location Map.

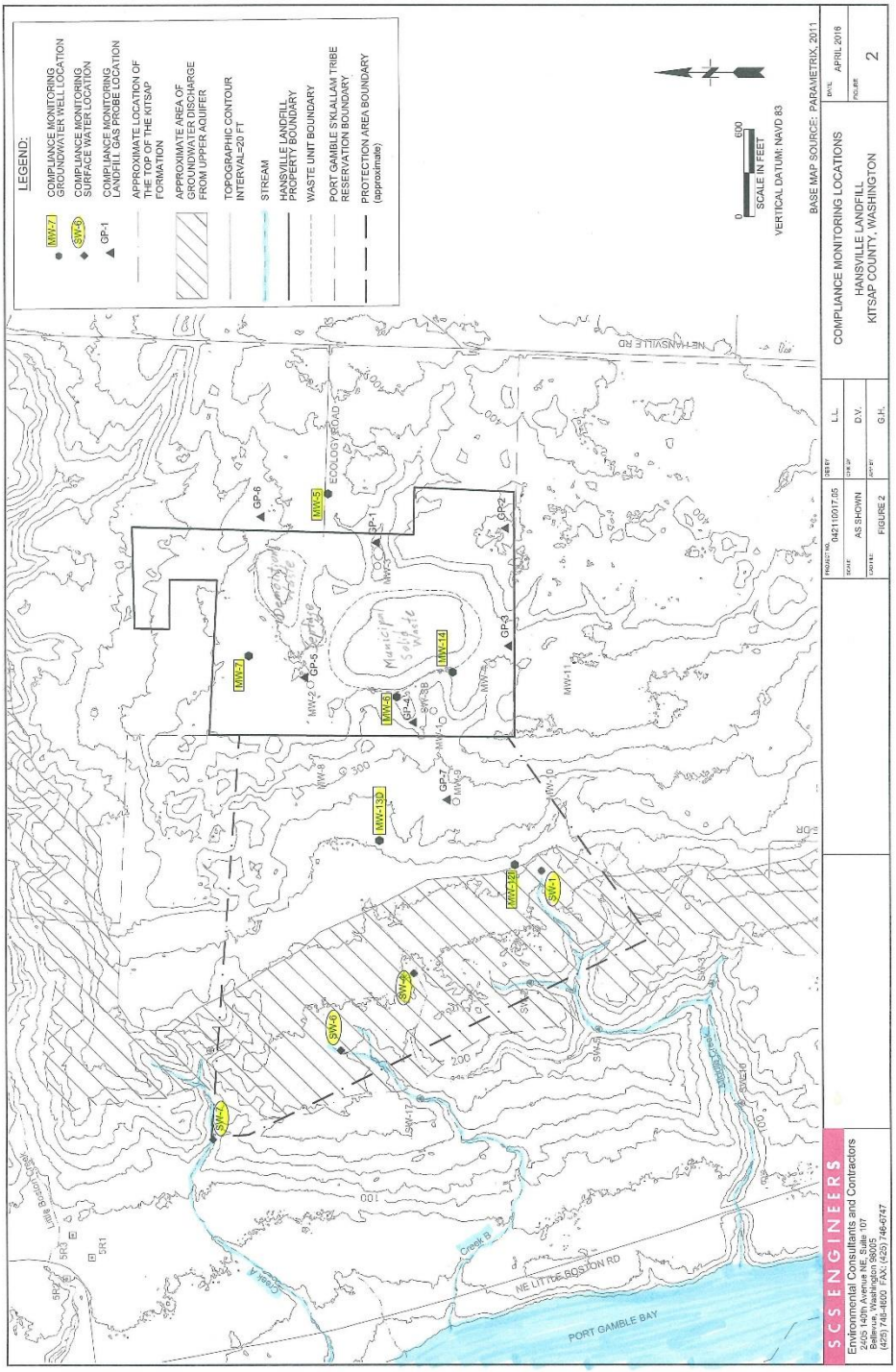

Figure 2: Site Map showing Compliance Monitoring Locations.