ST. JOHNS LANDFILL CLOSURE PROJECT

ANNUAL REPORT

TO THE

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY

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METRO
Regional Environmental Management
Engineering Division
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ENVIRONMENTAL MONITORING

Metro monitors for contaminants and chemical changes in groundwater, surface water, stormwater, sediment, leachate, landfill gas, and flare emissions in order to detect changes in risk to health, safety, and the environment at and around St. Johns Landfill. Metro also monitors groundwater movement and leachate levels in the landfill to evaluate the predictions of its contaminant flow model and the effectiveness of the final cover. Metro submits monitoring data to DEQ and the City of Portland as required by permits issued by these regulatory agencies.

In September 1997, Metro submitted to DEQ a draft environmental monitoring plan for the St. Johns Landfill and the Smith & Bybee Lakes Natural Area which surrounds it. This plan covers monitoring related to water quality and elevation. Landfill gas and flare emissions monitoring methods are presented in the operation and maintenance manual. Although Metro has received comments from DEQ concerning this draft plan, Metro expects to delay submission of a final plan document until after DEQ issues an updated regulatory framework governing future efforts (including monitoring) at St. Johns Landfill. This is because monitoring should be structured to reflect the concerns and objectives made evident by this regulatory framework.

This annual report highlights information gained through long-term monitoring of groundwater, leachate mound levels, and stormwater. It also discusses a project aimed at better understanding the complex interactions which influence water quality in Columbia Slough adjacent to St. Johns Landfill.

GROUNDWATER

It is important to determine the level of risk to public health, safety and the environment from St. Johns Landfill. One way that Metro and DEQ can assess risk is to monitor for contaminants in environmental media such as the groundwater surrounding the buried solid waste. Then, they can determine whether the presence of various contaminants constitutes a significant risk. Metro's monitoring program gathers most of the information needed to perform risk assessment.

Another way to generate information about contaminant movement at the landfill site is to construct computerized mathematical models. These models are tools to predict the rate and direction at which various contaminants will travel in the groundwater. Such predictions help determine where to monitor for contaminants and what contaminants to monitor for. They can be used to estimate the location of contaminants in the future. However, model predictions are verified by comparison to actual monitoring data. The actual monitoring data are the ultimate source of information to assess risk at any given time.

In September 1996, DEQ commented about a Metro report which presented the results of a 1995 groundwater modeling effort by a team led by Dr. Shuguang Li of Portland State University (PSU). The DEQ staff noted that the hydrogeology around St. Johns Landfill is complex. This leads to uncertainty about inputs to the model such as silt thickness and hydraulic conductivity. The staff believed that there was a need to evaluate information generated in the last 10 years about characteristics such as these and their use in the model. There was a need to interpret the existing groundwater monitoring data to test the model predictions and estimate the current impact of the landfill on groundwater.

In response, Metro selected a hydrogeology consultant, EMCON, and gave it the following goals:

1. Evaluate critical groundwater model input parameters and assumptions and verify predictions from PSU's 1995 groundwater model (especially in regards to the silt aquifer).
2. Compare input parameters, assumptions, and predictions with existing information from Metro and elsewhere (chemical database and water elevation data).
3. Provide recommendations for additional information and analysis needed to adequately predict the transport of a variety of contaminants and to quantify leachate pathways in the site conceptual model suitable for use in a future risk assessment.

The EMCON team reviewed and interpreted observations and data about the composition of the subsurface strata based on logs from many borings made by Metro and others. The team also analyzed and evaluated a large amount of data about groundwater quality and elevation collected by Metro and others. The results of this work are presented in the report titled **Assessment of PSU Groundwater Flow Model of St. Johns Landfill, Portland, Oregon, September 29, l997**.

The hydrostratigraphic interpretation presented in the report generally supports the findings of previous investigations regarding the nature, distribution, and extent of the three unconsolidated units beneath the solid waste. These are named the Overbank Silt (OBS) unit (in which the solid waste is buried), and also the Columbia River Sands (CRS) and Pleistocene Gravel (PG) units, which are below the OBS.

This report differs from previous reports by interpreting boring records to indicate more heterogeneity in the OBS, and a somewhat thinner unit which could be defined as OBS rather than CRS. The team also interprets boring data and literature values to indicate that a higher overall vertical hydraulic conductivity should be assumed for the OBS than was assumed in the PSU model. The higher vertical hydraulic conductivity would tend to increase the predicted percentage of contaminants migrating downward, and therefore decrease the percentage of contaminants moving laterally toward surface water.

In its analysis of the groundwater monitoring data, the review team notes that the distribution of certain characteristic leachate indicators does not yet show a site-wide downward migration of contaminants through the OBS to the CRS and PG. An exception is well G7, which is screened in fine-grained CRS underlying a thin portion of the OBS.

Although the concentrations of leachate indicators appear to be increasing in the mid and lower portion of the OBS, their concentrations are still significantly lower than in wells screened in the upper portion of the OBS near the buried solid waste. An exception is D-3b (which monitors contaminants in the mid region of the OBS).

The figures presented in the report show off-site wells in the CRS and PG around the landfill with low concentrations of all seven leachate indicators (all of which could be naturally occurring). This suggests no leachate impacts in these wells. However, these wells monitor low but fairly constant concentrations of certain volatile organic carbon (VOC) contaminants. Some of these VOCs are above regulatory standards for drinking water; most are different from VOCs detected in wells in the OBS near the buried waste.

From its analysis of groundwater monitoring data the team concluded that:

1. Impacts to groundwater appear to be significantly less than might be expected given the age, size, location, length of operation, and minimal engineered environmental protection features at St. Johns Landfill.
2. Assessment of leachate indicators and VOCs in groundwater and leachate suggest that an off-site source may be contributing to VOCs detected in groundwater in wells monitoring contamination in the gravel aquifer under the east and south sides of the landfill.
3. Some wells monitoring groundwater in the upper portion of the low permeable OBS aquifer (located between the solid waste and lower aquifers), or in the OBS perimeter dike (between the solid waste and surface water) show elevated levels of leachate indicator contaminants and the same general collection of VOCs as those detected in leachate.

Finally, the team critiqued the 1995 PSU models and 1997 silt flow net model, their underlying assumptions, and their use to yield estimates of current and future flow and contaminant transport. This critique was detailed and thorough.

In response to the report, Metro directed the PSU modeling team to perform additional model runs in order to evaluate the issues raised by the EMCON team. Metro's objective was to determine the level of significance of these issues when evaluating the usefulness of the PSU model as a reasonable representation of contaminant movement.

The PSU team examined the issues by incorporating variations into the models based on the issues raised, and then running the models to determine whether these variations would cause the major predictions to change significantly. These model results are presented in the November 1997 report titled **St. Johns Landfill Modeling System: Sensitivity Simulations and Response to EMCON Review Comments**.

Certain general conclusions can be drawn from the 1997 study of St. Johns Landfill hydrogeology and our understanding of this.

1. The 1997 hydrogeology study is a thorough evaluation of existing information.
2. So far, impacts of landfill contaminants on groundwater appear to be significantly less than expected.
3. The PSU models provide a concept of the hydrogeology which agrees reasonably well with the monitoring well data.
4. Additional information in critical areas will improve the predictive power of the models.

HYDROGEOLOGY UPDATE

The PSU model predictions of the rate of contaminant movement both horizontally and vertically in the OBS are significantly influenced by the vertical and horizontal hydraulic conductivity used as model inputs. Since there was some question about the conductivity values used in the PSU model, Metro took the opportunity to collect more conductivity data during an investigation of a portion of the perimeter dike (levee) fronting the North Slough arm of Columbia Slough.

Two bores were drilled into the native OBS. They used a hollow -stem auger to drill through solid waste, and a clean water rotary wash method to drill into the native silt. A relatively undisturbed, thin-walled Shelby tube sample of native silt was obtained in bore Q-4 for constant head (ASTM D5084) laboratory testing to determine vertical hydraulic conductivity.

Horizontal conductivity measurements were conducted using rising head and falling head slug tests in temporary wells which were constructed to isolate the test zone from the overlying refuse layer.

The field test results generally support the hydraulic conductivity numbers used in the PSU model. The vertical hydraulic conductivity of the OBS sample was 4.0×10^{-7}cm./sec. This is comparable to the range (4×10^{-6} to 2×10^{-7} cm./sec.) of 21 previous tests. The PSU model predictions are based on an OBS vertical hydraulic conductivity of 1×10^{-6} cm./sec. The average horizontal hydraulic conductivities were 2×10^{-4} in one well and 3×10^{-5} cm./sec. in the other. These values are comparable to those (4×10^{-5} to 3×10^{-8} cm./sec.) of 26 previous tests. The PSU model predictions were based on OBS horizontal hydraulic conductivities as high as 1×10^{-4} cm./sec.

LEACHATE LEVELS IN THE LANDFILL

The driving force exerted by the contaminated liquid (leachate) in the buried waste also influences the rate of contaminant movement in the groundwater at St. Johns Landfill. It is desirable to measure the elevations of this leachate actually in the solid waste to verify or improve the predictions of the PSU groundwater model. Fortunately, the numerous gas wells in the waste can be used to measure if the elevations of this leachate change with the different seasonal groundwater pressure changes, and/or change with time because the cover cap prevents rain from entering the solid waste.

General Approach: Leachate levels in St. Johns Landfill tend to show localized variability. the gas wells provide a large number of collection points from which to determine what is occuring throughout the landfill, both spatially and generally over time. In order to analyze this data, three basins were designated (see Figure 4) because of natural or constructed hydrogeologic boundaries, as well as the refuse fill conditions and age of fill. For example, BasinsA and B are divided by roads. Since they were constructed over time, they create a vertical wall (most likely made of compacted clay/silt) down toward the underlying silt. The road cosntruction can be seen the 1956 photograph in *Water Quality Impact Investigation, Volume II* (Sweet-Edwards/Emcon, 1989). The boundary between between Basins A and C is the old Blind Slough. This is because the silt thickness is distinctively greater under Basin B than Basin C. This can be seen in *St. Johns Landfill Groundwater Modeling System: Predicting Leachate Mounding, Fluxes and Offsite Migration* (Li, 1995). Fill conditions in Basin C were significantly different than in Basins A and B, in that the area was filled quickly (within a few years), quite recently (after 1988) and to a higher elevation, and the refuse was much better compacted during filling and later by preloading the area. Also, there is a natural silt dike between Basins A and C (see *Controlling Seepage from St. Johns Landfill to Surrounding Surface Water*, May 1995). In contrast, Basins A and B are much older, were filled over many years to a much lower elevation, and with minimal compaction.

Data Analysis: Depth-to-water readings in the gas wells have been recorded since 1994. This data generally has a great deal of variability because of the difficulty of accurate measurement. The following procedure was used to analyze this data: Only single completion and deeper, double-completion wells were included, because it was believed that these wells resembled each other (in that their well screens were near the underlying silt). The reference elevation was based on a 1997 survey. It is assumed that there has been minimal settlement in the silt underlying the well casing (although significant settlement may have occurred in the refuse), and thus it is valid to use this survey data throught the period of study, 1994 -1998.

A visual inspection of data plots was used to eliminate any obviously bad data from the study; for example, if at a given well the data is relatively flat with one spurious data point significantly different than the others, it was not included. Or if the data seemed to be erratic, the entire set of data for that well was not used. This method was applied because there were not enough data points per well to apply standard outlier tests.

The elevation data for each basin was avereged for each sampling period (Figure 5), resulting in a trend line. In Basin C, numerous wells were constructed over the four-year samploing period, and preload was added from May 5, 11995 to April 26, 1996. For these reasons, the average datapoints were left unconnected over this period. Also, box plots were determined within each basin for each sampling period (Figure 6), showing the median value and range of data (with the number of observations noted below the x-axis).

Conclusions:

1. Leachate levels do not change significantly over time, not even seasonally. Therefore, leachate is not leaving the landfill, neither moving down vertically to the underlying aquifer, nor out laterally to the surrounding surface water. The lack of vertical seepage may be partially caused by perched water, such that there is not much effective pressure on the underlying silt. The data suggests that the groundwater model developed by PSU (li, 1995) over-predicts the rate at which leachate leaves the landfill, and the rate at which the leachate mound will dissipate.
2. Relative to the temporal variability, there is a great deal more spatial variability (Figure 7). Basin B has the least spatial variability; Basin C has the most, as well as the highest water level elevations (see Figure 5, showing leachate levels and their averages). Increased variability and water levels are typically a result of saller effective permeability (refuse added to Basin C was more tightly compacted, the large quantity of preload added, and the well-compacted engineered dike surrounding it). The higher elevations seem to be a function of topography, as well as the fill conditions of Basin C.
3. There may be a net movement from Basin C to Basin A. For example, Figure 5 shows the higher elevation wells in Basin A increaseing over time, and Figure 4 shows that these wells are generally located near Basin C. This possible movement will continue to be observed over time.