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Phil Nollmeyer
Lincoln County
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Davenport, WA 99122

February 21, 2012

Project Number X09032

PROJECT: South Wilbur Petroleum Site
Wilbur, WA

SUBJECT: 2011 Quarterly Groundwater Monitoring and Evaluation of Natural Attenuation

Dear Mr. Nollmeyer,

This report presents quarterly groundwater monitoring results for 2011 and a discussion regarding natural attenuation of petroleum constituents in the shallow water table. Summaries of field and analytical data are attached, along with laboratory reports, QA/QC results and chain of custody forms.

Groundwater levels and chemical analyses from 2011 are similar to past sampling events. Most of the wells had similar petroleum concentrations when compared to previous years. Natural attenuation is very slow, though it does not appear that petroleum constituents are significantly migrating. Levels of petroleum constituents vary as the water table moves up and down and through areas of contaminated soils.

If you have any questions regarding this report, please call.

Respectfully Submitted:
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- Figure 3: Groundwater Elevation Maps
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- Table 2: Laboratory Summary
- Analytical and QA/QC Results

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EXHIBITS

INTRODUCTION

The south Wilbur Petroleum site has been undergoing long term ground water monitoring following remediation of release(s) from an underground storage tank system. This report presents the results of the 2011 monitoring effort along with evaluation of natural attenuation of the release. The work was performed for Lincoln County to help facilitate compliance with Washington State Department of Ecology regulations.

LOCATION

The subject property is located one block south of Highway 2 at 103 SE Front Street in Wilbur, WA. The subject property has been assigned the Washington State Department of Ecology (WSDOE) Facility/Site number 9365829 and is also referred to as "WA DOT Wilbur Front Street". The property is bounded to the north by Goose Creek, to the south by Front Avenue, to the east by Anne Street, and to the west by the City Park, as illustrated in the attached Vicinity Map and Site Plan.

GENERAL BACKGROUND

Background information from the WSDOE (WDOE-TCP, 2003) describes the subject property is an amalgamation of two properties: the Washington State Department of Transportation (WSDOT) Maintenance Facility and the Lincoln County Maintenance Facility. Associated with this site is the former Lincoln Mutual Number 3 fueling station located east of the site, to the northeast of the intersection of Anne Street and Front Avenue. Environmental conditions at this site have been addressed by multiple consultants and government agencies since the early 1990's.

The WSDOT property was located immediately west of the Lincoln County Maintenance Facility, and has subsequently become part of the subject property. The WSDOT property was active between the 1930's and 1970's. Major activities included fueling, vehicular maintenance, and storage of materials related to road maintenance. This property contained multiple underground storage tanks (UST) and above ground storage tanks (AST). A 1,000 gallon UST and 1,100 gallon AST were used to store diesel. A 1,000 gallon UST was used to store gasoline. These tanks were removed in 1991, during which time 5 cubic yards of petroleum contaminated soil was removed in the early 1990's. A 5,000 gallon AST was also present on site and used to store asphalt, but has since been emptied.

The Lincoln County Maintenance Facility has been active since 1930's, and incorporated the WSDOT property in 2001. Activities at the Lincoln County Maintenance Facility generally included vehicular fueling and maintenance and storage of materials related to road maintenance. The site housed two 500 gallon unleaded gasoline unleaded UST's, a 500 gallon waste oil UST, and an 8,000 gallon diesel UST.

Across Anne Street from the subject property was the former Lincoln Mutual number 3 property fueling station. The fueling station was active sometime between the 1950's to the 1980's. The property included a fueling island, a 1,900 gallon diesel AST, and two UST's near the fueling island. This site is currently used as office building and paved/gravel parking.

Multiple investigations by the WSDOT and WSDOE identified petroleum constitutes in soil and groundwater. Contamination included diesel, gasoline, oil, and BTEX constituents. Long term groundwater monitoring has been performed since to monitor and evaluate natural attenuation.

SITE CONDITIONS

Geologic Setting

The site is located on an area mapped as Miocene Columbia River Basalt Group (CRBG), Wanapum Basalt (WSDNR, 2011). Basalts from the CRBG cover much of eastern Washington and can be several hundred feet thick in places. North of the site, along river, are a series of older rocks including Cretaceous intrusive rocks and Paleozoic to Precambrian sedimentary and metamorphis rocks. WSDNR (2001) illustrates an anticline-syncline pairs (folding of the crust) of concealed by the CRBG. The overlying CRBG may have a gentle slope between flows due to the older topography of the surface that it flowed over, or subsequent ground level changes due to faulting and folding.

Well logs from the area of the subject site were reviewed (WSDOE, 2011). Well logs reports that basalt extends to depths greater than 300 feet below ground surface. Boring logs from the site also described an approximately 15 foot cover of silty sand to sandy gravel materials.

Soils from the site were mapped as "Onyx silt loam" (USDA, 2011). The Onyx series are generally found on flood plains and are dominantly fine sediments with occasional sand lenses according to the USDA Official Series Description. Due to heavy excavation in the area for building construction and removal of petroleum contaminated soils we would also expect to find gravel and fill in the upper five to fifteen feet in many locations at the site.

Surface and Groundwater Hydrology

The northern boundary of the site is Goose Creek, which is a perennial stream that flows to the west: although during summer months the creek can become stagnant. Groundwater in the area is generally found in fractured basalt at depths over 100 feet below ground surface. Groundwater at the site is shallow and locally perched on basalt. There may be some connectivity of groundwater between monitoring wells during times of high water table. During summer months, wells are commonly dry as the wells do not penetrate the underlying basalt. Water levels are influenced by localized infiltration and the adjacent Goose Creek.

Groundwater elevations measured during 2011 are presented on the attached Groundwater Elevation Maps for each quarter (See Figure 3). The water levels are erratic and discontinuous. We have drawn simplified contours and illustrated the direction of flow generally on each map. During the first two quarterly sampling events, groundwater flow was towards Goose Creek, with a relatively shallow gradient. Groundwater flow was generally away from Goose Creek during the third and fourth quarter. Seasonal fluctuation of the water table ranged between 2 and 9 feet. The depth to water in the monitoring wells was within 5 to 10 feet of the surface in most of the wells.

Field Sampling Methods

Samples were obtained from monitoring wells (MW) using a peristaltic pump and low flow sampling techniques. Dates of quality monitoring and sampling were March 24-25, June 21-22, November 22, and December 22 for the 2011. Water levels were measured in each well using a standard water level indicator. The wells were purged for a minimum of 3 well volumes and hydro-chemical parameters stabilized to ensure that samples were representative of the surrounding groundwater.

During the November sampling event, the water table was deeper then MW8 and MW9. During the December sampling event, the water table was deeper than MW8, and MW9 was inaccessible due to a parked vehicle.

Field parameters such as dissolved oxygen (mg/L), oxidation reduction potential (REDOX, mV), conductivity (micro Siemens/cm), pH (pH units, 0-14), and temperature (degrees Celsius) were measured using a hand-held YSI multi-meter. Turbidity (NTU) was measured in the field using a HACH Ratio Turbidimeter. Ferrous Iron (mg/L) was also measured in the field using a colorimetric CHEMets Ferrous Iron K-6210 kit. A summary of field measurements at the time of sampling is presented in Table 2. Other non-petroleum parameters include Nitrites (NO2/N), Nitrates (NO3/N) and Sulfates. These parameters were analyzed to help evaluate natural attenuation. Results are also presented on Table 2. Nitrites were not detected in any of the samples analyzed.

Results of Chemical Analyses

Results of chemical analysis from each of the wells are discussed below, including a comparison to field parameters and previous results. The regulatory limits referenced are default Washington State Model Toxics Control Act (MTCA) Method A cleanup levels based on unrestricted site use and protection of drinking water supplies. The samples were analyzed to determine concentrations of gasoline range petroleum hydrocarbons (GRPH), benzene, toluene, ethyl-benzene, total xylenes (BTEX), diesel range petroleum hydrocarbons (DRPH), and oil range petroleum hydrocarbons (ORPH).

The term ND (Not Detected) indicates that the concentration was below the quantification limit of the Analytical Laboratory for the specific analysis. Detection limits are designed to be below the regulatory limit. In some cases, a petroleum related constituent may be present, but below a quantifiable level. The laboratory reports indicate ND, whereas our laboratory summaries present the results as "less than (<)" the detection limit for the parameter tested.

Monitor Well # 1

This well is located between the UST cleanup area and Goose Creek. Historical results from chemical analyses have ranged from moderately high to below diction limits. Measurable GRPH were reported in each of the 4 quarters and exceeded regulatory limits in the 2nd quarter. Benzene concentrations marginally exceeded regulatory limits in June. Other BTEX constituents and DRPH were detected during the first 2 quarters, but were below regulatory limits. Samples from this well have otherwise been below regulatory limits since June of 2008.

In 2011, measured groundwater levels fluctuated between 6 and 9 feet below ground surface, or approximately 3 feet. Dissolved oxygen (DO) levels from this well have generally been very low, but were somewhat higher (1 ppm) in November and December; sulfate concentrations were also higher. Ferrous iron (Fe^{2+}) was between 2 and 14 ppm.

Monitor Well #2

This well is located very near the UST cleanup area. Historical results of GPRH have been very high, ranging between of 10-20 ppm. This is above the normal solubility concentration of gasoline in water, and suggests that free product is present. During sampling events, purge water from this well had a distinct petroleum odor and an occasion iridescent sheen. Concentrations for the first 3 quarters of 2011 were below 10 ppm. DRPH was also detected during the 1st and 2nd quarter event, and ORPH was detected in the 1st quarter. Benzene concentrations exceeded regulatory limits; other BTEX constituents are present, but at relatively low concentrations.

In 2010, measured groundwater levels in MW2 fluctuated between 7 and 12 feet below ground surface, or approximately 5 feet. DO levels from this well have generally been low. Measured pH levels in the groundwater have been near neutral. Ferrous iron (Fe^{2+}) has been relatively high in this well,

approximately 10 ppm. Sulfate levels in this well fluctuated from 60 ppm in March to 0.4 ppm in October.

Monitor Well #3

This well is near the center of the UST cleanup area. It is periodically dry, but samples generally contained GRPH concentrations in the range of 3-8 ppm. 2011 results were similar to previous results. Benzene concentrations have also historically been above MTCA Method A cleanup levels; other BTEX constituents were present at low concentrations. DRPH and ORPH concentrations have occasionally been above cleanup levels.

In 2011 measured groundwater levels in MW3 fluctuated between 5 and 10 feet below ground surface, or approximately 5 feet. DO levels from this well have generally been well below ppm. Measured pH values in the groundwater have been near neutral. Ferrous iron (Fe^{2+}) has been relatively high in this well, approximately 8 to more than 10 ppm. Sulfate levels ranged from 0.7 to 36 ppm.

Monitor Well #4

This well is located to the southwest of the UST cleanup area. Test results of GRPH have sporadically ranged from 3 to 17 ppm during 2011. These concentrations are similar to previous test results and suggest free product is in the vicinity of the well. Benzene concentrations have been above regulatory limits; other BTEX constituents were present at concentrations that are below cleanup levels.

In 2011, measured groundwater levels in MW4 fluctuated between 5 and 10 feet below ground surface, or approximately 5 feet. DO levels from this well have generally been low. Measured pH values in the groundwater have been near neutral. Ferrous iron (Fe^{2+}) values have ranged from approximately 0.8 to 10 ppm. Sulfate levels in this well have generally been between 2 and 15 ppm.

Monitor Well #5

-No Longer Present

Monitor Well #6

This well should be upgradient of the UST cleanup area, but is within the general vicinity. Historical and current GRPH results were generally above 10 ppm, very high with one exception (12/19/05), when they were below detection limits. 2011 results for GPH ranged from 22 to 24 ppm. BTEX concentrations exceeded regulatory limits with the exception of Toluene, which was present at low concentrations. DRPH were also measured at levels above cleanup levels. ORPH concentrations exceeded regulatory limits in the first quarter results. DRPH concentrations exceeded regulatory limits during the first 2 quarters, and were below detection limits in the 3rd and 4th quarter.

In 2011, measured groundwater levels in MW 6 ranged from 9 to 13 feet below ground surface, or approximately 4 feet. DO levels from this well have generally been relatively low ranging from 0.2 to 2 ppm. Ferrous iron (Fe^{2+}) values have ranged from 5 to 10 ppm. Sulfate levels in this well were moderate in the spring (14 ppm) and very low in the fall (<1 ppm).

Monitor Well #7

This well is to the southeast and upgradient from the UST cleanup area. Historical GRPH results were generally below detection limits, but were occasionally at detectable levels. GRPH and BTEX concentrations have been below detection limits with occasional detections. 2011 results were below detection limits. ORPH was detected in the first quarter sample and the last quarter sample of 2010, but

has been below detection limits since. DRPH was detected at a low concentration in the 1st quarter sample.

In 2011, measured groundwater levels in MW 7 fluctuated between 5 and 12 feet below ground surface, or approximately 7 feet. DO levels from this well have been relatively high, ranging from 5 to 12 ppm, higher than most other results from the site. Ferrous iron (Fe^{2+}) values have ranged from approximately 2 to 25 ppm. Sulfate levels in this well have ranged from 10 to 36 ppm.

Monitor Well #8

This well was dry during the 3rd and 4th quarter sampling event, and contained barely enough water to sample (without purging) in March. Groundwater was present and sampled in June. We did not observe evidence of petroleum odor or discoloration to suggest contamination in this location. GRPH and BTEX constituents were not detected. DRPH and ORPH were detected at low concentrations in the March sample.

Dissolved oxygen was present at low concentrations. Ferrous iron (Fe^{2+}) was not detected, and sulfate concentrations were relatively high, ranging with, with values of 134 and 99 ppm.

Monitor Well #9

This well is up gradient of the UST cleanup area. Historical results are below regulatory limits or below detection limits with the exception of the June 2009 sampling event. 2011 results for this well were below detection limits for GRPH and BTEX. DRPH was detected at low concentrations in the 2nd quarter samples. The well was dry during the 3 quarter event and inaccessible during the 4th quarter event.

In 2011, measured groundwater levels in MW9 fluctuated between 4 feet to more than 12 feet below ground surface, or over 8 feet. The first two quarters recorded the highest water levels for this well. DO levels from this well have are relatively high and range from 5 to 7 ppm. Measured pH values in the groundwater have been near neutral. Ferrous iron (Fe^{2+}) values have been below the detection limit of 0.1 ppm. Sulfate levels in this well have been relatively high, between 32 and 50 ppm.

Monitor Well #10

This well should be up gradient but is proximal to the UST cleanup area. Historical and current results of chemical analyses are moderately high and above regulatory limits. GRPH ranged from 2 to 5 ppm during the 2011 sampling events. BTEX constituents were present at low concentrations, below regulatory limits. DRPH was reported at moderately low concentrations but below regulatory limits. ORPH was not detected.

In 2011, measured groundwater levels in MW10 fluctuated between 7 and 9 feet below ground surface, or approximately 2 feet. The 2011 water levels were generally higher than most previous levels. DO levels from this well were relatively low.. Ferrous iron (Fe^{2+}) values ranged from 2 to 20 ppm. Sulfate levels in this well fluctuated significantly, from 0.2 ppm to 43 ppm.

Monitor Well #11

This well is near the UST cleanup area and Grouse Creek. Current and historical results have generally been below detection limits with few exceptions. GRPH and Ethyl-benzene were detected in the 2nd quarter sample at low concentrations, below regulatory limits. DRPH was detected in the first and second quarter samples at relatively low concentrations. ORPH was detected in the first quarter sample, but below detection limits in subsequent samples.

In 2011, measured groundwater levels in MW11 fluctuated between 7 to 9 feet below ground surface, or approximately 2 feet. DO levels from this well were relatively low. Measured pH values in the groundwater have been slightly acidic, an lower than the other wells, ranging from 6.01 to 6.23. Ferrous iron (Fe^{2+}) values ranged from 2 to 20 ppm. Sulfate levels in this well were relatively high, ranging from 66 to 144 ppm.

Monitor Well #12

This well is down gradient, but may not be within the area of influence. Current and historical results have generally been below detection limits and well below cleanup levels. Trace concentrations of Benzene and Xylenes were detected in the first quarter sample event. The other results were below detection limits for 2011.

In 2011, measured groundwater levels in MW12 fluctuated between 6 to 9 feet below ground surface, or approximately 3 feet. DO levels from this well ranged from1 to 6 ppm, and are somewhat higher than previous results. Measured pH values in the groundwater were generally neutral. Ferrous iron (Fe^{2+}) values were below detection limits of 0.1 ppm. Sulfate levels in this well were between 31 and 85 ppm.

EVALUATION OF NATURAL ATTENUATION

In-situ degradation of petroleum related compounds by biological activity is generally referred to as *natural attenuation*. Biological activity in groundwater conditions generally consumes DO while processing, or degrading, petroleum constituents. We believe that natural attenuation is occurring at the site. For example MW 2, 3, 4, 6, and 10 contain low DO concentrations, and are anaerobic. MW 7, MW 9 and MW 12, which generally contain low to non-detectable levels of petroleum constituents generally have DO values over 1 mg/L and may be considered aerobic. MW 1, 11, and 12 generally contain lower levels of DO, possibly associated with biodegradation of low-level petroleum constituent is occurring in the soil, or upgradient contamination.

Other indicators for natural attenuation are increased concentrations of ferrous iron and decreased sulfate levels in the groundwater. This is due to the reduction of ferric iron by microbes and conversion from sulfates to sulfides. These other indicators are observed in many of the wells. For example MW 2 and 3, two of the more severely contaminated wells, contain relatively high concentration of ferrous iron and low concentrations of sulfate when compared to cleaner wells, such as MW 9.

Groundwater in the vicinity of MW 9 and MW 12 does not appear to be influenced by the release(s). Groundwater in the vicinity of MW 7 shows occasional influence, but is mostly unaffected. These are the only wells with significant Nitrate concentrations, They also have moderately high sulfate concentrations and more DO than the other wells. The low concentrations of DO and nutrients in the affected area is likely due to biodegradation of petroleum constituents in the soil and groundwater.

Attenuation or mass reduction by evaporation or migration does not seem to be occurring quickly enough to reduce groundwater concentrations. This suggests that there is enough petroleum in the soil and rock to replace that which is degraded or transported by groundwater. The rate and volume of groundwater movement through the site is limited, and it does not appear that petroleum is leaving the site at a significant rate, as evidenced by test results from the downgradient wells.

CONCLUSIONS

Groundwater levels, field parameters, and chemical analyses from 2011 are similar to past sampling events. Natural attenuation, if active, is very slow. We believe that this is limited by the amount of oxygen and other nutrients available as these appear to be depleted by degradation of petroleum in surrounding soils and groundwater. It appears that levels of petroleum constituents vary as the water table moves up and down across areas of contaminated soils. Possible increases in contamination in monitoring well #7 may indicate that some migration is occurring, but does not appear to be migrating very far from the original UST sites. We believe that the petroleum constituents will eventually degrade.

LIMITATIONS

We endeavored to conduct this study in accordance with generally accepted environmental engineering practices in this area. This report presents our professional interpretation of investigation data developed, which we believe meets the standards of the environmental profession in this area; we make no other warranties, express or implied. The findings in this report are based upon our professional judgment. Groundwater samples are discreet. Interpolation between these discreet locations is made for illustrative purposes only, but should be expected to vary. If a greater level of detail is desired, the client should request an increased scope of exploration. Due to low water table or obstruction of well heads we may not be able to sample each of the wells described in the scope during each quarterly monitoring event.

REFERENCES

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