A Department of Ecology Report

Saginaw Mill (Aberdeen) Groundwater Monitoring Results, April and August 2006

Abstract

During April and August 2006, groundwater samples to be analyzed for formaldehyde were collected from seven monitoring wells at the former Saginaw Mill site. The mill was located in Aberdeen, Washington, on the south shore of the Chehalis River where the river enters Grays Harbor.

Samples were collected to assess the progress of ongoing phytoremediation (poplar trees) to reduce formaldehyde concentrations at the site.

- Formaldehyde was detected in groundwater samples collected from on-site monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7 at concentrations ranging from an estimated 13 to 65 ug/L.
- Formaldehyde was detected in groundwater samples collected from the off-site monitoring well MW-3 at estimated concentrations of 22 and 12 ug/L, in April and August, respectively.
- Formaldehyde concentrations in the seven monitoring wells were below the Model Toxics Control Act (MTCA) Method B non-carcinogenic cleanup level of 1,200 ug/L.
- Formaldehyde concentrations appear to have leveled off since the decrease in concentrations from 1993 to 1999. Concentrations are similar to those reported in August 2000, a year after the poplar trees had been planted.

A sample to be analyzed for total petroleum hydrocarbons as diesel (TPH-Dx) was collected from well MW-1 in April 2006. TPH-Dx was not detected in this sample at the reporting limit of 0.05 mg/L.

Since formaldehyde concentrations in the groundwater are below the current MTCA Method B cleanup level and are near the analytical reporting limit, it is recommended that no further monitoring is needed at this site.

Well MW-5 was damaged sometime between the April and August 2006 sampling. This well should be decommissioned.

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This report was prepared by a licensed hydrogeologist. A signed and stamped copy of the report is available upon request.

Background

The former Saginaw Mill site is located in Aberdeen, Washington on the south shore of the Chehalis River where the river enters Grays Harbor (Figure 1). The former mill manufactured treated shingles. The mill consisted of a saw building, treatment chemical tanks, drip pad/retort area, kiln and treated shingle storage area, as well as a fueling area, boilers, and maintenance buildings.

In April 1993, a Site Hazard Assessment (SHA) of the property was prepared for Grays Harbor County. Diesel, heavy-oil-range total petroleum hydrocarbons (TPH), and formaldehyde were detected in soil at concentrations above their respective Model Toxics Control Act (MTCA) cleanup levels. Formaldehyde also was detected in groundwater from two of the three monitoring wells on-site at concentrations of 2020 ug/L (MW-2) and 600 ug/L (MW-3) (CH2M Hill, 2000). Based on the SHA, the Washington State Department of Ecology (Ecology) ranked the site a "1" (representing "most threat" on a scale of 1 to 5) under the Washington Ranking Method, and placed it on Ecology's Hazardous Site List.

At the time of the SHA, formaldehyde concentrations in the groundwater were above the MTCA Method B cleanup levels as reported in Ecology's Cleanup Level and Risk Calculation (CLARC) database. The cleanup levels for formaldehyde were 1.46 ug/L (carcinogenic) and 1,600 ug/L (non-carcinogenic). Cleanup levels in CLARC were revised in August 2006. The current MTCA Method B groundwater cleanup level for formaldehyde as a non-carcinogen is 1,200 ug/L (CLARC, 2006). The formaldehyde cleanup levels were revised because they were originally extrapolated from inhalation data. It has since been concluded that because of the route-specific and site-specific response associated with formaldehyde, a route-to-route (i.e., inhalation – oral) extrapolation is unsuitable (McCormack, 2007).

Between 1996 and 1999, two site characterization studies were conducted, and site cleanup was initiated. All structures were removed except for the footings of former tanks in the treatment chemical tank area. Cleanup activities at the site also included removal of the most highly TPH-contaminated soils (CH2M Hill, 2000). Small structural debris (wood and concrete fragments) remains in some places on the site.

Samples collected during the 1999 site characterization found that remnant soil contamination appeared to be limited to localized areas around the former fueling and boiler areas, as well as the treatment chemical tank and kiln areas. Formaldehyde concentrations in on-site groundwater declined considerably between 1993 and 1999. In 1999 concentrations in the three wells were near or below the laboratory reporting limit of 20 ug/L.

As part of a continued site cleanup, in 1999 the University of Washington planted poplar trees (phytoremediation) in the central and southwestern portions of the site in an attempt to contain and remediate the formaldehyde-contaminated groundwater.

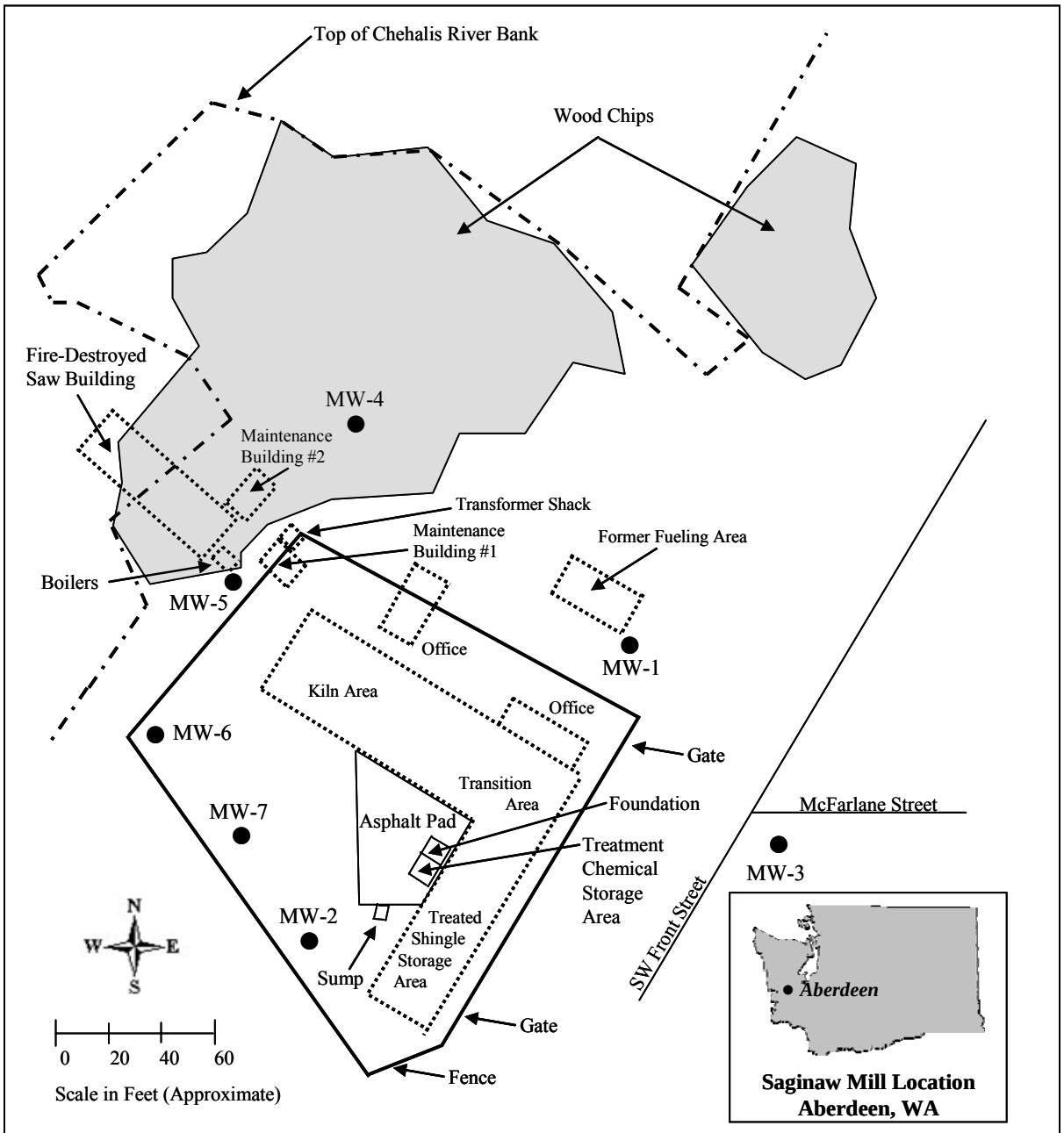

Figure 1: Saginaw Mill Sample Locations

In 2000 Grays Harbor County had four new wells installed (MW-4 thru MW-7) along the north and west perimeters of the site. All of the wells were sampled in August 2000 to provide additional formaldehyde data prior to the potential remedial effects of the newly planted poplar trees (phytoremediation plot). The new wells were also installed to gain a better understanding of groundwater elevations and flow directions at the site. The monitoring results showed that overall formaldehyde concentrations were near the reporting limit of 20 ug/L (CH2M Hill, 2000).

Well logs indicate that the geology of the site consists primarily of a thick layer of fine-to-medium silty sand to at least 25 feet. A mixture of topsoil, rubble fill, and wood chips a few feet thick overly the layer of silty sand. Well MW-4 is the exception; it has an upper layer of wood chips and logs about 10 feet thick. Depth to groundwater ranges from approximately 1 to 9 feet below the ground surface. In 2000 groundwater levels in the south and southwest parts of the site showed groundwater flow direction toward the Chehalis River and Grays Harbor to the northwest. Groundwater levels at the east edge of the site indicate that groundwater in this part of the site flows to the southeast. Groundwater flow on-site may be influenced by the tidal cycles of Grays Harbor.

To assess the progress of the phytoremediation, Ecology collected groundwater samples from the seven monitoring wells in April 2005. The wells were to be purged and sampled using a stainless steel submersible pump at a flow rate of 0.5-liter/minute or less. The pump was used at two of the wells. Both wells purged dry after a few gallons. Groundwater in the wells was very slow to recover. Samples that were eventually collected from these wells were very turbid. Because of the difficulty in collecting samples with the submersible pump, the remainders of the wells were sampled with decontaminated bailers with little or no purging. Formaldehyde concentrations in these samples were exceedingly high (400 to 8000 ug/L) compared to results from 2000. Because of the length of time between the sample events (2000 to 2005) and sample methods used, the results from 2005 were not considered to be representative of the actual groundwater conditions and were rejected.

Methods

Groundwater Sampling

Groundwater samples were collected in April and August 2006 from all seven wells to assess the progress of ongoing phytoremediation to reduce the concentrations of formaldehyde at the site.

The seven wells are constructed in 2″ PVC, and range in depth from 11 to 29 feet. The wells have 10-foot screen lengths from the base of the completion depths. They are screened in a fine-to-medium sand with silt to a very fine silty sand. Most of the wells are low yielding. Wells MW-1, MW-4, MW-6 and MW-7 have been purged dry in the past.

Static water levels were measured in all wells using a Solinst water level meter prior to well purging and sampling. Measurements were recorded to 0.01 foot and are accurate to 0.03 foot. The probe was rinsed with deionized water between measurements.

To minimize drawdown in the wells as they were being purged and sampled, a mechanical bladder pump was used to sample the wells in 2006. The pump body is stainless steel with a corrugated teflon bladder. Dedicated teflon tubing was used for each well. Because the wells have been purged dry in the past, the pump intake was placed near the bottom of the screened interval and purged at a rate of 0.1 to 0.5-liter/minute. Wells were purged until pH, specific conductivity, and temperature readings stabilized. At the completion of purging, samples were collected from the monitoring wells directly from the dedicated pump discharge tubing into laboratory supplied containers. The pump was decontaminated between each well by circulating laboratory grade detergent/water through the pump followed by a clean water rinse, with each cycle lasting a minimum of 100 pumps.

Formaldehyde samples were collected in three 40-mL amber glass bottles with teflon-lined septa lids. Total petroleum hydrocarbons as diesel (TPH-D) samples were collected in 1-gallon glass jars with Teflon lined caps. After sample collection and proper labeling, all samples were stored in an ice-filled cooler. The formaldehyde samples were delivered to FedEx for next day shipping to the contract laboratory because of the analytical methods short holding time (3 days). The TPH-D samples were transported to Ecology's Operation Center in Lacey. These samples were kept in the walk-in cooler until picked up by the courier and transported to the Ecology/EPA Manchester Environmental Laboratory in Manchester, Washington. Chain-of-custody procedures were followed according to Manchester Laboratory protocol (Ecology, 2005).

Analysis

Analytes, analytical methods, and reporting limits for both field and laboratory parameters are listed in Table 1. The analytical method used for formaldehyde was the same as that used for the 1996, 1999, and 2000 studies to allow a direct comparison of the data sets.

Table 1: Field and Laboratory Methods

Analytes	Method	Reference	Accuracy
Field			
Water Level	Solinst Water Level Meter	NA	±0.03 feet
pH	Orion 25A Field Meter	NA	±0.1 std. units
Temperature	YSI 3510 Temperature Probe	NA	±0.1 C
Specific Conductance	YSI 3520 Conductivity Cell	NA	±10 umhos/cm
Laboratory			*Reporting Limit*
Formaldehyde	EPA Method 8315A	U.S. EPA 1996	50 ug/L
Total Petroleum Hydrocarbons as Diesel and Heavy Oil	NWTPH-Dx	Ecology 2005	0.05 mg/L

The quality of the data is acceptable. Quality control samples collected in the field consisted of blind replicate samples, which were obtained from well MW-6 in April 2006 and well MW-1 in August 2006. The numeric comparison of replicate results is expressed as the relative percent difference (RPD). The RPD is calculated as the difference between sample results, divided by the mean and expressed as a percent. The RPD for formaldehyde in April could not be calculated because both analytical results are qualified as estimates at concentrations of 50J and 49J ug/L. In August, the RPD for formaldehyde was 11%.

A review of the data quality control and quality assurance from laboratory case narratives indicates that analytical performance was good. The reviews include descriptions of analytical methods, holding times, instrument calibration checks, blank results, surrogate recoveries, and laboratory control samples. A small amount of formaldehyde appeared to be present in the method blanks in both April and August, but at levels below the method detection limit. This did not appear to compromise the usefulness, or validity, of the sample results. Formaldehyde is a common interferent in laboratory reagent water (EPA, 1996). No data were rejected, and all results were usable as qualified. Quality assurance case narratives and laboratory reporting sheets are available upon request.

All field measurements and analytical result data are available in electronic format from Ecology's EIM data management system: www.ecy.wa.gov/eim/index.htm at study ID, PMART003.

Results

Field Observations

Table 2 lists total depth, depth-to-water, and water table elevation for each monitoring well. Completion depths for the seven monitoring wells ranged from 11.24 to 28.50 feet. Depth-to-water was measured prior to purging each well and ranged from 2.05 to 12.73 feet below the measuring point in April, and 3.08 to 13.75 feet in August. Water table elevation ranged from 3.27 to 10.87 feet below the ground surface in April, and 3.97 to 7.96 feet in August.

Table 2: Groundwater Elevation Data for April 18-19 and August 15-16, 2006

Monitoring Well	Casing Rim Elevation (feet)	Total Depth (feet)[1]	Date	Time	Depth-to-Water (feet)[1]	Water Table Elevation (feet)	Date	Time	Depth-to-Water (feet)[1]	Water Table Elevation (feet)
MW-1	12.5	13.75	4/18/06	09:35	2.59	9.91	8/16/06	10.55	4.97	7.53
MW-2	15.19	15.34	4/18/06	12:35	4.32	10.87	8/15/06	09:30	7.23	7.96
MW-3	8.69	11.24	4/19/06	09:10	2.05	6.64	8/15/06	13:15	3.08	5.61
MW-4	18.63	28.50	4/19/06	12:40	12.73	5.9	8/15/06	11:15	13.75	4.88
MW-5	14.75	27.99	4/19/06	11:00	11.13	3.62	--	--	--	--
MW-6	13.01	25.65	4/19/06	14:00	9.74	3.27	8/16/06	09:30	8.63	4.38
MW-7	13.21	17.43	4/18/06	15:40	5.61	7.6	8/15/06	14:30	9.24	3.97

[1] Measured from surveyed top of PVC casing.
-- Not Measured.

Figures 2 and 3 show the tidal phase when water levels were measured and samples collected. Samples were primarily collected during the low or rising tide in April 2006 and the low and falling tide in August.

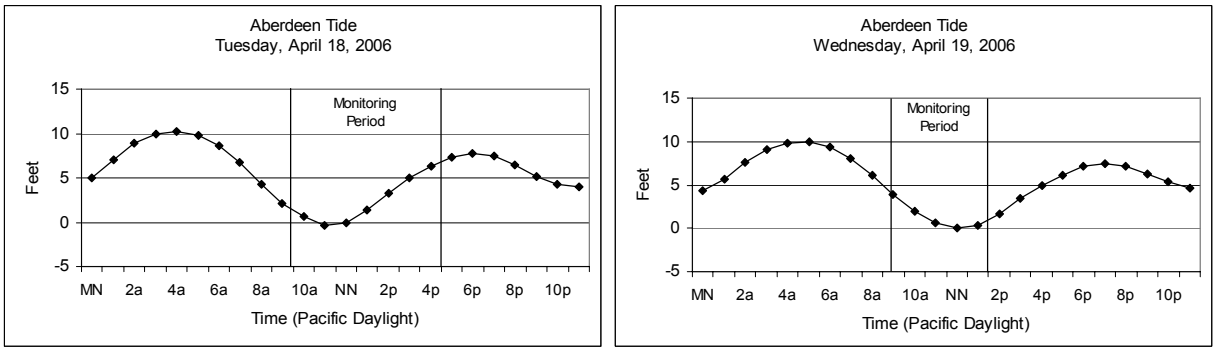

Figure 2: Tide Phase for Monitoring Period in April 2006

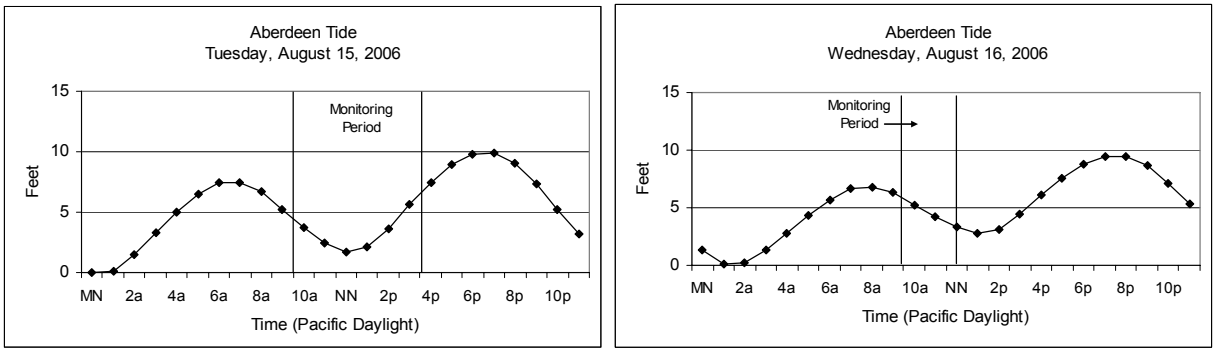

Figure 3: Tide Phase for Monitoring Period in August 2006

Although water levels were measured throughout the monitoring period, a groundwater contour map constructed from the April 2006 measurements (Figure 4) is similar to the August 2000 contour map when water levels were measured during a one-hour period. The location of the April 2006 water-table contours was determined using a kriging algorithm in the Surfer software program. The groundwater flow direction is approximately perpendicular to the contours. Groundwater levels for most of the site show that the flow direction is to the west and northwest, toward the Chehalis River and Grays Harbor. Groundwater flow direction in the southeast part of the site appears to flow to the southeast, away from the Chehalis River. Given the site's location near Grays Harbor, groundwater flow direction may be influenced by the tidal cycles.

pH, temperature, specific conductivity, and turbidity readings measured at the time of sampling, as well as the total purge volume, are listed in Table 3.

Table 3: Summary of Field Parameter Results for April 18-19 and August 15-16, 2006

Monitoring Well	pH (standard units)		Temperature (degrees C)		Specific Conductivity (umhos/cm)		Turbidity (NTU)		Purge Volume (gallons)	
	4/06	8/06	4/06	8/06	4/06	8/06	4/06	8/06	4/06	8/06
MW-1	6.2	6.5	11.9	16.1	--	4,890	4.5	48	2.5	2
MW-2	6.5	6.8	11.1	14.9	--	2,160	4	3.1	1.5	2
MW-3	6.8	6.9	11.1	15.7	777	396	2.3	6	1.5	2
MW-4	6.2	7.1	14.3	15.5	11,400	12,000	33	13	2	2
MW-5	7.3	--	12.5	--	3,800	--	10	--	2.5	--
MW-6	5.4	6.8	13.1	12.0	4,600	7,820	90	130	2.5	2.5
MW-7	5.6	6.9	11.6	12.8	--	3,730	5.6	17	2	2

-- Not Measured.

During the monitoring period, the pH of groundwater ranged from an average of 6.1 to 7.3. Groundwater temperatures in April ranged from 11.1 to 14.3ºC, increasing to 12.0 to 16.1ºC in August. Specific conductivity measurements ranged from 396 to 12,000 umhos/cm. Specific conductivity values are typically higher for water from fine-grained units. Turbidity measurements ranged from 2.3 to 130 NTUs, with well MW-6 representing the higher end. Turbidity measurements in some wells increased during purging, even with the very low flow rate. This is probably also related to the fine silty materials in the screened interval.

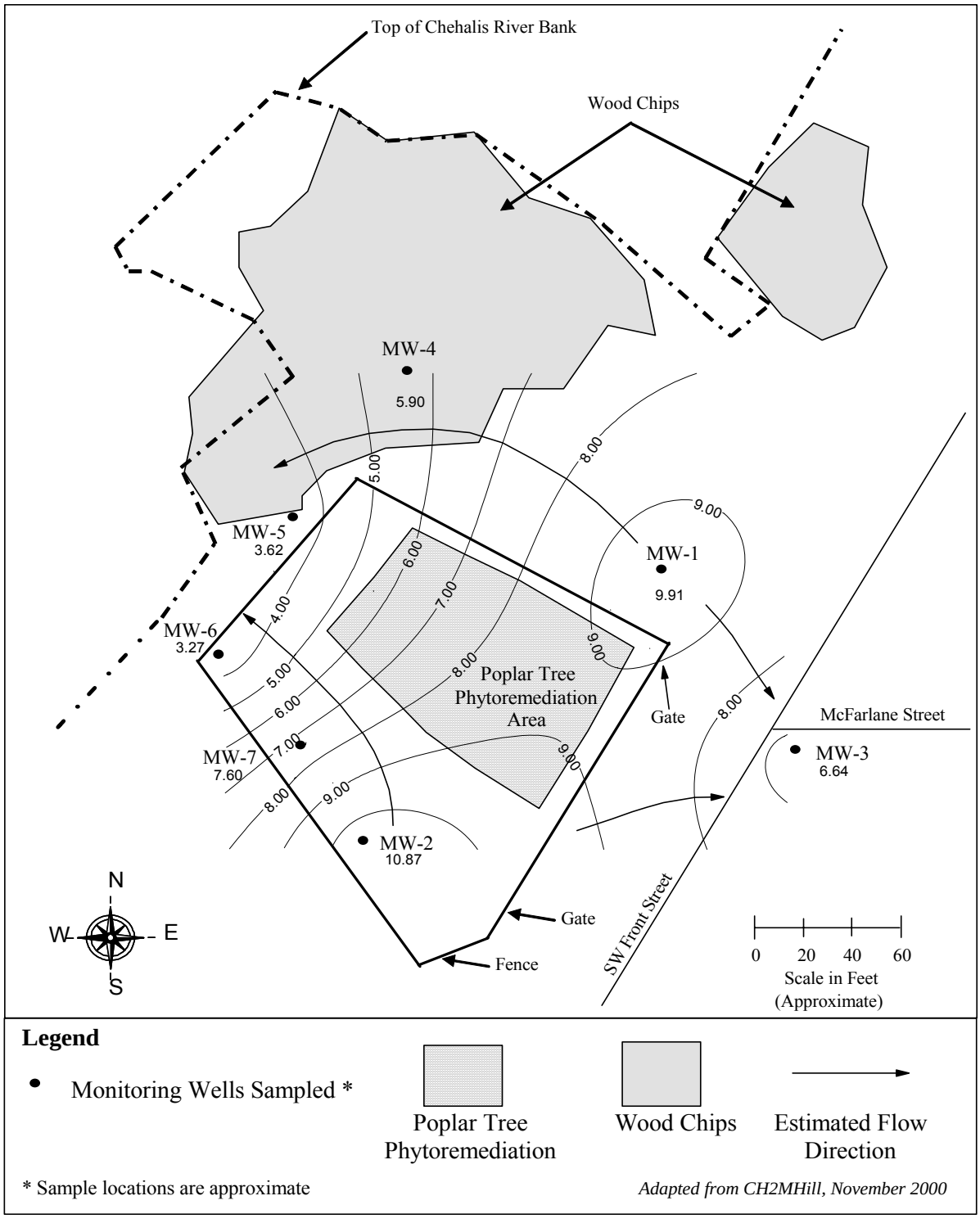

Figure 4: Saginaw Mill Groundwater Contour Map - April 2006

Analytical Results

Analytical results for formaldehyde are summarized in Table 4 and presented in Figure 5.

Table 4: Summary of Analytical Results (ug/L) for April and August, 2006

Monitoring Well	Formaldehyde	
	4/06	8/05
MW-1	64	65
MW-2	50 U	27 J
MW-3	22 J	12 J
MW-4	17 J	13 J
MW-5	14 J	--
MW-6	50 J	47 J
MW-7	44 J	45 J

-- Well was damaged. No sample was collected.
U – Analyte was not detected at, or above, the reported value.
J – Analyte was positively identified. The associated numerical result is an estimate.

Formaldehyde was detected in all the sampled wells. In April 2006, results ranged from an estimated concentration of 14 to 64 ug/L. Analytical results for August 2006 were similar, with concentrations ranging from an estimated 12 to 65 ug/L. Most of the reported concentrations have been qualified as estimates because they are below the laboratory reporting limit of 50 ug/L.

Because of the low yielding wells and the low volume sampling method, samples for total petroleum hydrocarbons as diesel (TPH-Dx) were only collected from well MW-1 in April. TPH-Dx was not detected at the reporting limit of 0.05 mg/L.

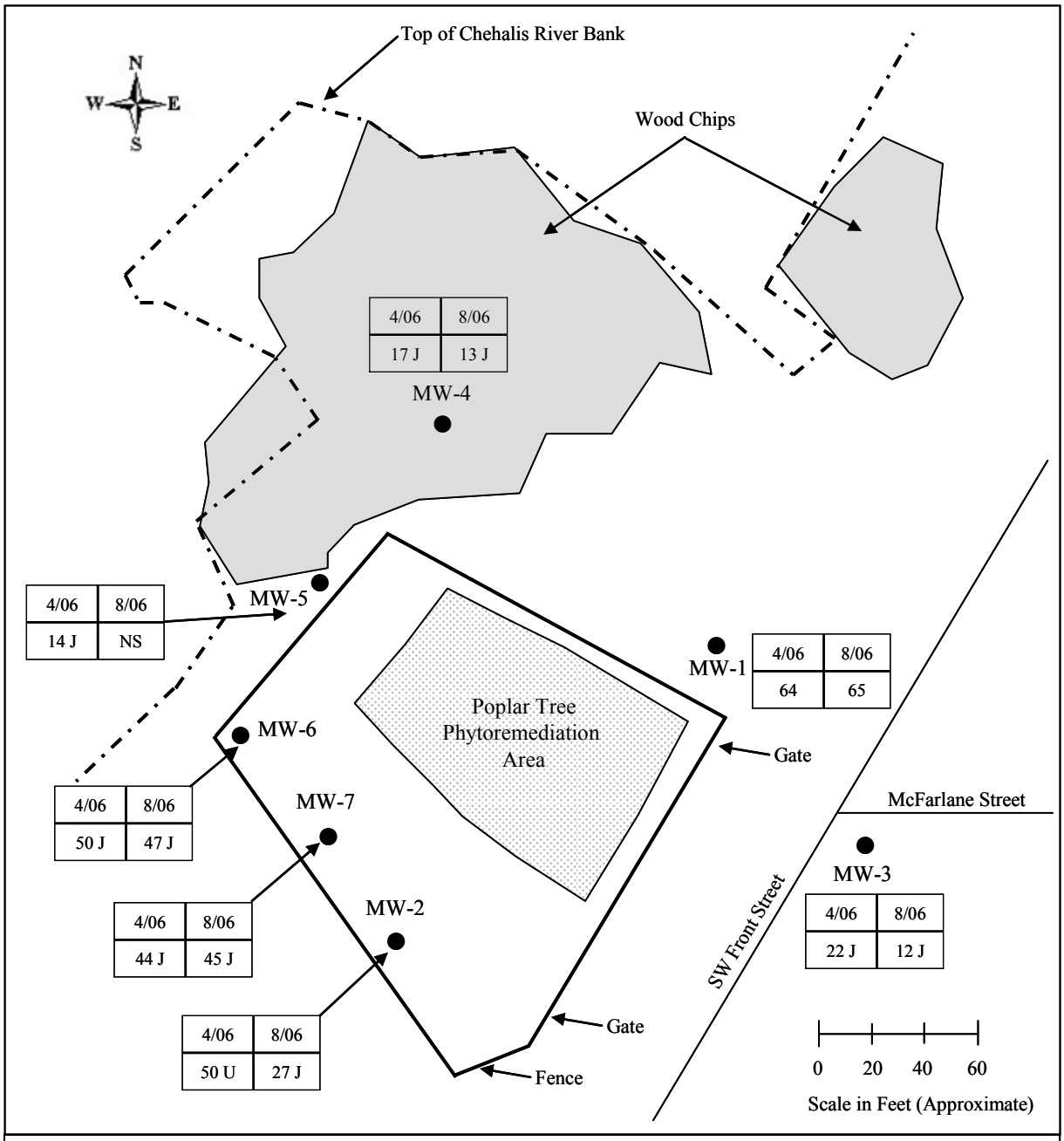

Figure 5: Saginaw Mill Formaldehyde Concentrations (ug/L)

Discussion

Formaldehyde was detected in the shallow groundwater at the site in April and August, 2006. Table 5 is a comparison of the 2006 results to the MTCA Method B cleanup level for formaldehyde in groundwater of 1,200 ug/L (non-carcinogen). A summary of historical data for this project is also included in Table 5.

Table 5: Formaldehyde Concentrations (ug/L) in Groundwater from 1993 to 2006

Monitoring Well	April 1993	August 1996	May 1999	August 2000	April 2006	August 2006
MW-1	--	140	28	61	64	65
MW-2	2020	1300	21	20 U	50 U	27 J
MW-3	600	66	20 U	29	22 J	12 J
MW-4	--	--	--	22	17 J	13 J
MW-5	--	--	--	35	14 J	--
MW-6	--	--	--	26	50 J	47 J
MW-7	--	--	--	35	44 J	45 J

Formaldehyde MTCA Method B Cleanup Level in Groundwater: Non-carcinogen, 1,200 ug/L
-- Not Sampled.
U – Analyte was not detected at, or above, the reported value.
J – Analyte was positively identified. The associated numerical result is an estimate.

Formaldehyde concentrations have decreased significantly from concentrations reported in 1993 and 1996, but are similar to those reported in August 2000, a year after the poplar trees were planted. Formaldehyde concentrations appear to have leveled off to concentrations near the available analytical reporting limits. Formaldehyde concentrations in the seven monitoring wells in April and August 2006 were below the current MTCA Method B non-carcinogenic cleanup level of 1,200 ug/L.

Formaldehyde is widely present in the environment as a result of natural processes and man-made sources. Formaldehyde, which has high water solubility and a low n-octanol/water partition coefficient, is not expected to adsorb to soil particles to a great degree. Because the soil adsorption coefficient is low, leaching occurs easily and mobility in soil is very high (IPCS INCHEM). Formaldehyde present in groundwater is commonly the result of leaching. Other parameters that affect leaching to groundwater include soil type, the amount and frequency of rainfall, the depth to groundwater, and the extent of degradation of the formaldehyde. Formaldehyde is susceptible to degradation by various soil microorganisms and biodegrades in a relatively short time.

Considering that this site is probably tidally influenced, the natural flushing of the groundwater could provide an opportunity for enhanced biodegradation and attenuation of the formaldehyde dissolved in the groundwater. This could explain the decrease in formaldehyde concentrations between 1993 and 1999.

Conclusions

Groundwater samples for formaldehyde were collected from seven monitoring wells during April and August 2006, at the former Saginaw Mill site. Samples were collected to assess the progress of ongoing phytoremediation to reduce the formaldehyde concentrations at the site.

At the time the poplar trees were planted in 1999, formaldehyde concentrations in groundwater were above the MTCA Method B cleanup level for formaldehyde as a carcinogen of 1.46 ug/L, as reported in Ecology's Cleanup Level and Risk Calculation (CLARC) database. In August 2006, the MTCA Method B cleanup level for formaldehyde was revised to 1,200 ug/L (non-carcinogenic).

Formaldehyde was detected in groundwater samples collected in 2006 from on-site monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7 at concentrations ranging from an estimated 13 to 65 ug/L. Formaldehyde was also detected in groundwater samples collected from the off-site monitoring well MW-3 at estimated concentrations of 22 and 12 ug/L in April and August, respectively. Formaldehyde concentrations detected in the seven monitoring wells in 2006 were below the current MTCA Method B cleanup level.

Recommendations

Since formaldehyde concentrations in the groundwater are below the current MTCA Method B cleanup level and are near the available analytical reporting limit, it is recommended that no further monitoring is needed at this site.

Well MW-5 was damaged sometime between the April and August 2006 sampling. This well should be decommissioned.

References

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