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January 15th, 2014

TO: John Mefford, LG, TCP-CRO

FROM: Charles San Juan, LHG, TCP-HQ *Charles San Juan*

SUBJECT: Smitty's Conoco (Kennewick) Plume Stability Assessment

Executive Summary

Per request, this report provides the results of a plume stability assessment (remnant gasoline) for the subject site. *Results* - although the gasoline footprint mass has decreased over the last 5 years (2008-13), the trends for area and concentration are unknown. However, the start of a remediation system (May-2009) has affected the historical concentration v. time monitoring data. Based on the historical gasoline footprint center mass points and pre-remediation ground water flow direction, it appears that this plume has migrated north-northeast. However, the Columbia River irrigation canal, which parallels the river, is located just north of this site. Based upon the historical monitoring data, it appears likely that gasoline has migrated either into or underneath this canal. Average ground water elevations for this site range from about 337-341 feet, with land surface at about 395 feet. The depth of this canal is unknown, however, it is probably no more than 20 feet. Either way, there is likely some interaction between shallow ground water and this canal. Likewise, review of the Ecology well log database found that there are two private water wells (Franchino Stove & Tile and SCS Cold Storage) about 0.5 miles NE. A check of reported hydraulic conductivity (K) values for the Pasco gravels found a range of about 1,000 – 2,000 ft/day. Thus, ground water flow rates for this area are probably in the neighborhood of several feet per day (~ 4-5 ft/day). If this is correct, then it would take about 1-3 years for the most mobile components of gasoline (benzene and MTBE) to reach the Franchino well. However, the higher flow rates also imply more dilution. If you average the historical source area (MW-2) ground water gasoline levels and assume first order decay, then target levels (1,000 ug/L) should be achieved in a year or so. However, although the source area levels appear to be declining, there has been rebound and oscillation in gasoline levels. This may be an artifact of the treatment system. Lastly, an assessment of source area gasoline mass / volume found that in all likelihood, there has been a release of approximately 5,000 – 10,000 gallons. Given the depth to water table (> 50 ft) and dry climate, there must have been a fairly significant release to create fairly high (up to 100 ppm) source area ground water gasoline levels.

Recommendations

A check of whether gasoline has impacted the canal needs to be made. This would be easy enough to do, e.g. with shallow piezometers and perhaps some canal bottom sediment samples. Aside from the canal issue, this site is a good candidate for monitored natural attenuation (MNA). The source area levels appear to be declining. However, as long as the source area remains above target levels, monitoring of the downgradient (MW-6 and MW-7) wells should continue. In other words, you should not monitor the source and not check downgradient. There is a residual gasoline mass beneath this site. Likewise, starts / stops in the treatment system may have caused levels to rebound or oscillate. Consequently, it may take some time for this residual gasoline mass to fully dissipate. Therefore, until this happens, monitoring should continue. Lastly, if this site is redeveloped and remnant gasoline exists, then a check for subsurface vapors should be made.

Action Items

- Check downgradient well screen depths. Do they intersect the gasoline plume? Is there an upward / downward vertical gradient? Is the current well configuration adequate?

- Check and find out the degree of hydraulic interaction between the canal and any shallow perched zones (e.g. transducer study). If the canal has been impacted, then notify appropriate parties (e.g. Columbian Irrigation District, etc.).

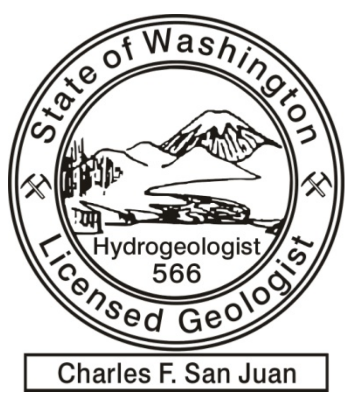
- Check and find out what analytical method was used for MTBE (EPA 8021 v. 8260) and EDB / EDC. If EPA 8021 was used for MTBE, then re-test by EPA 8260. Likewise, if 8260 (or 8021) was used for EDB / EDC, then retest by EPA 8011.

- Re-start testing of downgradient wells (MW's 6 & 7) and continue testing until source (MW-2 and MW-3) decays to acceptable levels.

- If the results of the additional monitoring indicate that gasoline has continued to migrate downgradient (MW's 6 & 7), then drill a new well equidistant between MW-6 and MW-7. Use field screening methods to locate the well screen depth.

- Check the status of the Franchino well (downgradient). Is it still being used? Is it operational? If yes, then assess the need for gasoline testing (BTEX, MTBE and EDB / EDC).

- Assess the need for a restrictive land covenant. If this site is ever redeveloped, then vapor intrusion testing should probably be considered.



Tables

Figures

Plume Stability Analysis

The Ricker (2008) method was used to evaluate plume stability. Here's how this method works: you can use the Surfer (Golden Software) contouring package to calculate plume footprint volumes. You can also use Surfer to calculate the planar area (square feet) of the plume footprint. In other words, if you know X and Y in feet units, then you can then use Surfer to map Z (g.w. concentration) in ug/L units. You can therefore use Surfer to calculate the grid volume, which has units of ug/L*ft2. If you divide the Z ug/L*ft2 units by footprint area (ft2), then it results in average concentration (ug/L). The advantage of the Ricker method is that it accounts for the entire plume footprint, as opposed to individual points.

Here are the steps that were used for this analysis:

1. Assemble the data. Historical g.w. monitoring data, from 2008-2011, was used.

2. Select target analytes. For this analysis, TPH analysis by the gasoline range organics (GRO) was used.

3. Calculate the average measured TPH-gasoline (GRO) for each year (2008, 2009, 2010 and 2011).

4. Use the Surfer grid-volume command to calculate average predicted TPH-gasoline concentrations for each year: grid volume (ug/L*f2) divided by grid plan area (ft2). Use 1,000 ug/L (cleanup level) as the Z lower surface for TPH-gasoline. Add the Z-value to the average concentration (for each year).

5. Calculate the mass (kg) and area (acres) for each year. Use the Surfer grid planar area (ft2) to calculate area (acres). Use Equation 1 to calculate mass:

   Equation 1: $\mathbf{M} = \frac{\mathbf{A*b*C*}\boldsymbol{n}\mathbf{*UCF1}}{\mathbf{UCF2}}$

   M = plume mass (kg)
   A = plume footprint area (ft2)
   b = aquifer thickness (20 ft)
   C = average TPH-gasoline concentration (ug/L)
   n = soil porosity (0.43 dimensionless)
   UCF1 = unit conversion factor (28.3 L/ft3)
   UCF2 = unit conversion factor (1E9 ug/kg)

6. Calculate the TPH-gasoline center points (center mass). Export the Surfer grid file in X,Y,Z (.dat) format). For each point, multiply the X and Y coordinates by the corresponding Z (concentration) value. Sum the X,Y and Z values. Derive the footprint center point: X-coordinate is sum (X*Z) / sum Z and Y-coordinate is sum (Y*Z) / sum Z. Calculate center points for 2008, 2009, 2010 and 2011.

7. Use the GIS (ArcMap) spatial analyst tool to determine the directional distribution of the gasoline footprint center points. Note: the output of this function is a directional distribution ellipse polygon[1]. This ellipse maps the direction of the center points.

8. Use the Excel regression package to calculate the regression line slope and lower / upper 95% confidence levels for average concentration, mass and area over time.

9. Use the following criteria to interpret the data: if the confidence interval of the regression line slope contains a zero-value, then unknown trend. Likewise, if the confidence interval of regression line slope contains either all positive or negative values, then significant increasing or decreasing trend (EPA, 1992).

Plume Stability Analysis Results

For gasoline, the trend for mass was decreasing, with unknown trends for both area and concentration (Table 2). However, the average predicted gasoline concentration has decreased by factor of about seven (from 13 to 2 ppm) over a three year period (2008-11; Table 1, Figure 4). Analysis of the gasoline center mass over time (2008-11) found that points align along a N-S axis (Figure 8). This indicates that the gasoline plume has likely migrated north-northeast (in the direction of the Columbia River).

Land Surface / Topography

Land surface elevations from the Ecology statewide ArcMap (DEM-generated 40 ft contours) were converted to points. These points (X,Y and Z-elevation) were then used to construct a 3D land surface (from Surfer, Figure 2). *Result*s – the Smitty's Conoco service station is located along what appears to be an ancestral stream bench (former Colombia River shoreline). The land surface elevation is about 390 ft. and drops off gradually down to the river (~ 360 ft. elevation).

Ground Water Flow Direction

Water table maps were calculated using the average ground water elevations for 2008 and 2009 (Figure 9). Historical ground water elevation data (2008-13) was also used to construct box plots (Figure 10). *Results* – for 2008, there was very slight gradient (about 0.2 ft) to the north-northeast from MW-3. This site is located along the flat part of the ancestral river bench. Therefore, the gradient probably increases north of the site (to the river). In May of 2009, some type of ground water treatment system was initiated. This action reversed the gradient, from east (MW-6) to west (MW-4), by about 1 ft. (Figure 9).

Columbia River Canal

An irrigation canal (Columbia River Irrigation District (CID)) is located just north of this site. The depth of this canal is unknown, however, it's likely no more than 20 feet. Also, information on the flow rate and stage heights for this canal were not available. Either way, it's likely that this canal is recharging shallow ground water and there's likely some degree of interaction thereof. Although site ground water elevations

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[1] A common way of measuring the trend for a set of points or areas is to calculate the standard distance separately in the x and y directions. These two measures define the axes of an ellipse encompassing the distribution of features. The ellipse is referred to as the standard deviational ellipse, since the method calculates the standard deviation of the x coordinates and y coordinates from the mean center to define the axes of the ellipse. The ellipse allows you to see if the distribution of features is elongated and hence has a particular orientation (Source: ESRI ArcMap Help).

(337 – 341 ft) are likely well below this canal, one of the boring logs (B-1) indicates that ground water was encountered at 17 ft. Therefore, it's unclear is this was just a shallow perched zone, etc. According to the boring log for one of the remediation wells, ground water was detected at 63 feet. Again, this is consistent with the historical ground water elevation data provided to Ecology.

Private Water Wells

Per the Ecology well log database, there is a private water well (Franchino Stove & Tile, 223 N Benton; Figure 14) about 0.4 miles NE (Figure 3). According to the Ecology records, this well is 38 feet deep and the reported water depth (Sept-2001) was 24 feet. If you assume land surface for this location is 360 feet (Figure 3), then the Franchino well ground water elevation is about 336 feet. This elevation (336 feet) is within the range of elevations reported for the Smitty's site.

Another private water well is located about one block to the west of the Franchino well (SCS Cold Storage, 411 W Railroad Avenue). This well was drilled to 105 feet below ground surface (bgs); however, casing only extends to 60 feet bgs and the casing is perforated from 30 to 60 feet bgs. The reported groundwater static level (July-1978) was 21 feet bgs. Assuming the land surface is approximately 361 feet (Figure 3), then the SCS Cold Storage well ground water elevation is about 340 feet.

Reported hydraulic conductivity (K) values for the Pasco gravels range from 880 ft/day (Ecology, 2003) up to 1,300 ft/day (Chern, 1989). If you assume an average gradient of 0.0016 ft/day (Table 7), then ground water velocity for this area is about 3.3-4.9 ft/day. If you calculate retardation for benzene and MTBE, then that results in contaminant velocities of about 2.6-3.8 ft/day (Table 8). Therefore, it's estimated that for benzene / MTBE, it would take about 1-3 years (or thereabouts) to travel from Smitty's to Franchino. This estimate does not take into account biodegradation. According to the historical monitoring data, all of the Smitty's Conoco site wells were tested for MTBE, as well as lead scavengers (EDB / EDC). However, it's unknown if EPA 8260 was used for MTBE (EPA 8021 is less reliable). Likewise, EDB, which has a drinking water MCL of 0.05 ug/L, presents analytical challenges as well. Therefore, for lower detection, it's recommended that EPA Method 8011 be used (Falta, 2005).

Gasoline Rate Constants and Half Lives

The gasoline degradation rate constant and half-life were calculated using Equations 1 and 2. Due to the impact of the treatment system, the average annual gasoline concentrations from MW-2 were used.

Equation 1: $\mathbf{C = C_0 e^{-kt}}$

C = predicted concentration at time t (ug/L)
C_0 = initial measured concentration (ug/L)
-k = rate constant (days or years-1)
t = time (days or years)

Equation 2: $\mathbf{t = \frac{\ln\left(\frac{C}{C_0}\right)}{-k}}$

t = time to cleanup level (days or years)
C = predicted concentration at time t (ug/L)
C_0 = initial measured concentration (ug/L)
-k = rate constant (days or years-1)

Results – if you use the average annual gasoline concentrations from MW-2, then it results in a slope / degradation constant (k) of -0.5183 yrs-1 (-0.0014 days-1) and a gasoline half life (t ½) of 1.3 yrs (Figure 9, Table 7). If you use 1,000 ug/L as the gasoline cleanup level, then the predicted restoration timeframe (from 2008) is 6.7 yrs. Therefore, if you assume first order decay, then the gasoline plume should reach the 1,000 ug/L target level within a year or so (by December, 2014).

Source Area Soil Gasoline Mass / Volume

The source area soil gasoline mass / volume was estimated. Here's why this is important: the depth to ground water (about 55-58 ft.) for this site is deeper than many other typical gas station sites. However, the 2008 source area ground water gasoline levels were fairly high (up to 100 ppm and free product detected at MW-3). Therefore, given these conditions, it implies that a significant volume of gasoline was likely released.

In order to estimate mass, you need to know soil gasoline levels. Therefore, Ecology's MTCATPH (petroleum 4-phase) spreadsheet was used to estimate soil gasoline concentrations (from measured ground water levels). A weathered gasoline soil profile was used to predict ground water concentrations. Soil gasoline levels were then varied to predict ground water gasoline levels. Predicted ground water gasoline levels (dilution factor = 1) were compared against the average measured levels for MW-2 (2008).

Results – if you assume a slightly weathered soil gasoline profile and a soil gasoline concentration of 750 mg/kg, then it results in a predicted total gasoline level of about 40 mg/L (benzene = 1.6 mg/L). If you compare these results to the average measured levels for MW-2 (for 2008), then there's a good correlation (Table 4).

Soil gasoline mass / volume – if you assume a 1.2 acre source area (Table 1) and subdivide the vadose zone into four layers 10, 25, 25 and 15 feet thick, then that results in a total thickness of 75 feet (gasoline impact zone). If you assign gasoline concentrations of 50, 100, 250 and 750 mg/kg to these four layers, then that results in a total predicted gasoline mass of about 20,000 kg, which equates to about 7,300 gallons of gasoline.

Key point – given the deeper depth to ground water and dryer climate, there must have been a fairly significant release of gasoline to impact ground water in this way. Based on these calculations, it's estimated that anywhere from 5,000 to 10,000 gallons of gasoline were released (over some unknown period of time).

Vapor Intrusion

The average measured gasoline level from MW-2 for 2013 (2,280 ug/L, Table 3) and a weathered composition (Table 4) was used to predict the total source area gasoline vapor phase. *Results* – if you assume the source area still has about 3 mg/L of total gasoline, then that equates to about 2.5 million ug/m3 of total gasoline vapor phase (benzene @ 13,000 ug/m3). This vapor phase level results in a Hazard Index (HI) of about 25,000. Therefore, to reach HI of 1, you would need a vapor attenuation factor (VAF) of about 25,000. This is beyond Ecology's current guidelines of 10 and 100 fold attenuation factors for shallow (< 15 feet) and deep (> 15 ft) soil gas. However, given the depth to water table (> 50 ft) for this site and dry climate, it seems unlikely that at depth vapors would migrate to land surface and create problems. Nevertheless, if this site is redeveloped and remnant gasoline exists, then vapors should be checked.

Concentration vs. Elevation

A concentration vs. elevation plot was constructed from MW-2 historical monitoring data. *Results* – prior the start of the remediation system (Apr-2008 to May-2009), there appeared to be a trend of increasing gasoline concentrations with higher ground water elevations. However, once the treatment system came on-line (May-2009), this trend appeared to reverse back to higher gasoline concentrations with lower ground water elevations (Figure 12). Typically, a falling water table results in more product draining into a well, which results in higher concentrations and increased LNAPL thickness (Kemblowski and Chiang, 1990). In this case, however, prior to the treatment system, gasoline concentrations did appear to be increasing with increasing ground water elevation.

Geochemical

Source area (MW-2 and MW-4) ground water is highly reduced (< -50 mV), with perimeter downgradient wells less reduced (Figure 13). In other words, as the source gasoline biodegrades, it has created geochemically reduced conditions.

Analytical Issues

Analysis for oxygenates (MTBE), lead scavengers (EDB / EDC) and total naphthalenes was performed.

Conclusion

Based on the weight of evidence, it appears that the Smitty's Conoco gasoline plume has migrated off site to the north-northeast. The Columbia River is about 0.8 miles north of this service station and the land surface slopes off in that direction. Therefore, it appears that this gasoline release has impacted a shallow unconfined water table that discharges to the river. Per the plume stability (Ricker, 2008) method, the concentration and area trends were unknown (based on 95% confidence levels of the regression line). However, this unknown trend may simply be an artifact of the treatment system and subsequent impacts on concentration v. time data. Likewise, if you use average annual gasoline concentrations, then there appears to be good evidence of a declining concentration trend (MW-2).

References

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Kemblowski, M.W. and Chiang, C.Y. (1990). Hydrocarbon Thickness Fluctuations in Monitoring Wells. GROUND WATER, Vol. 28, No. 2, pp. 244-252.

Ricker, J.A. (2008) A Practical Method to Evaluate Ground Water Contaminant Plume Stability. Ground Water Monitoring and Remediation 28, No. 4 (Fall, 2008), pp. 85-94.

Surfer (Golden Software). Surfer v.11.

Figure 1 - Smitty's Conoco, Kennewick, WA.

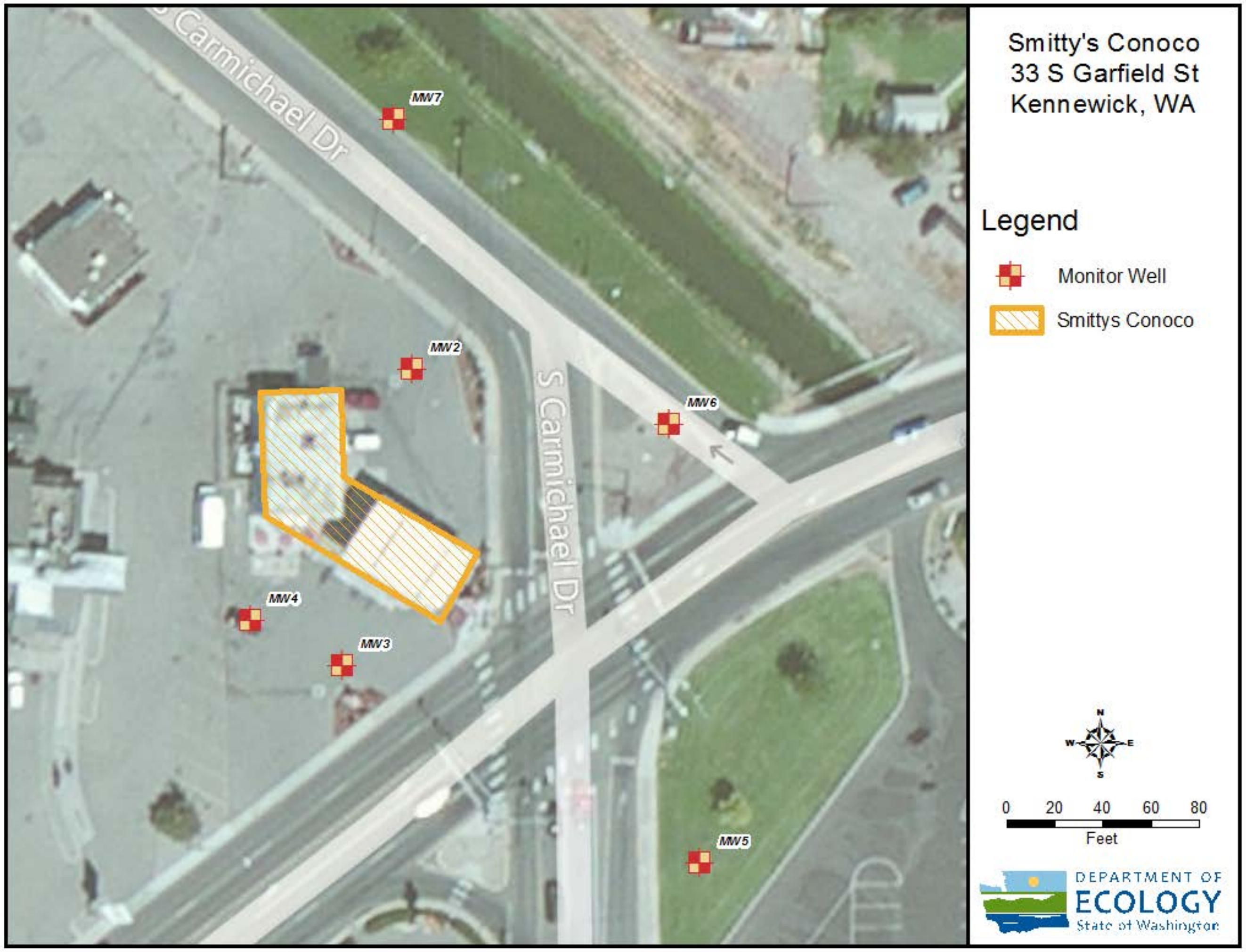


Figure 2 - 3D Land Surface.

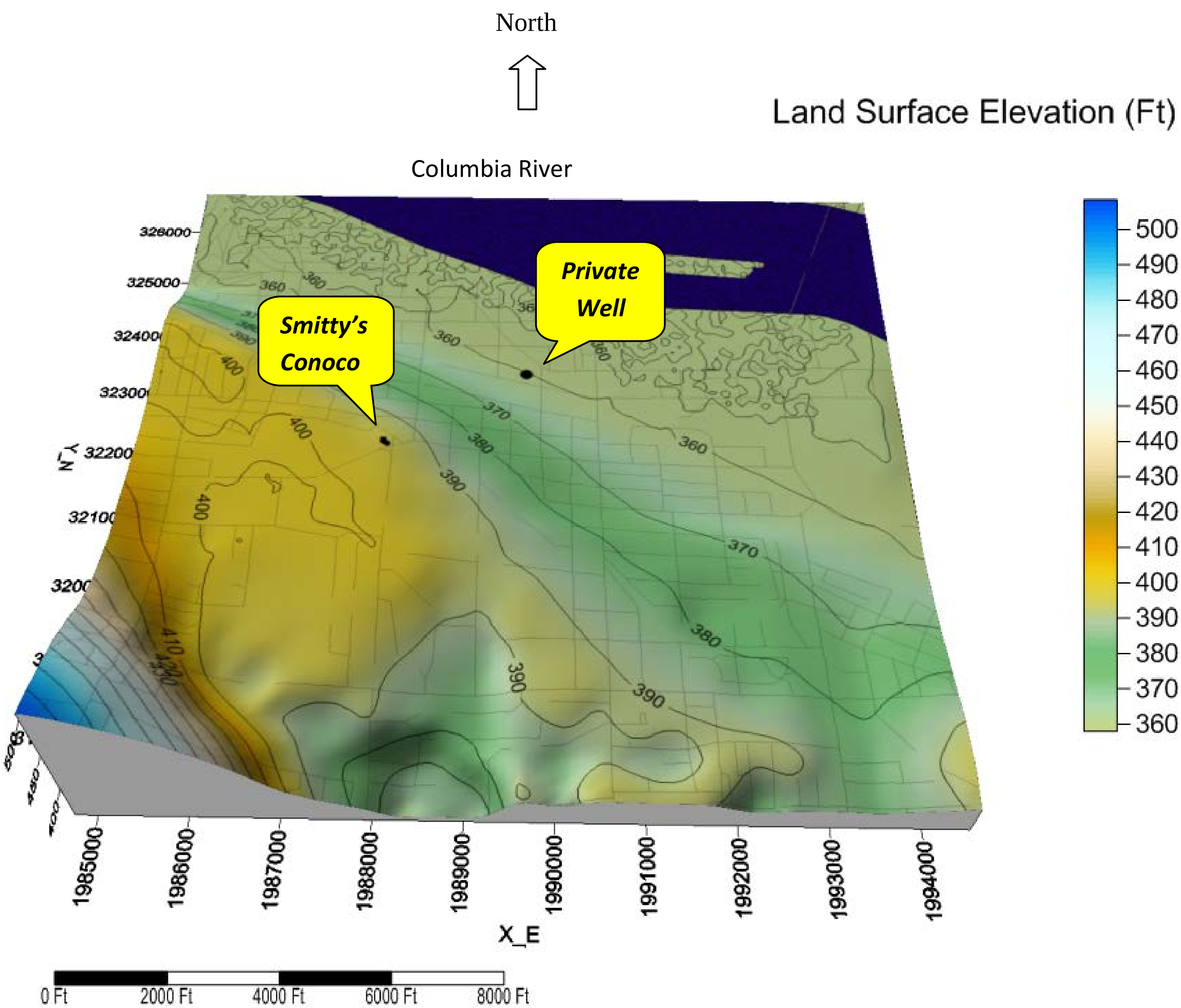


Figure 3 – Smitty's Conoco and Nearby Private Wells.

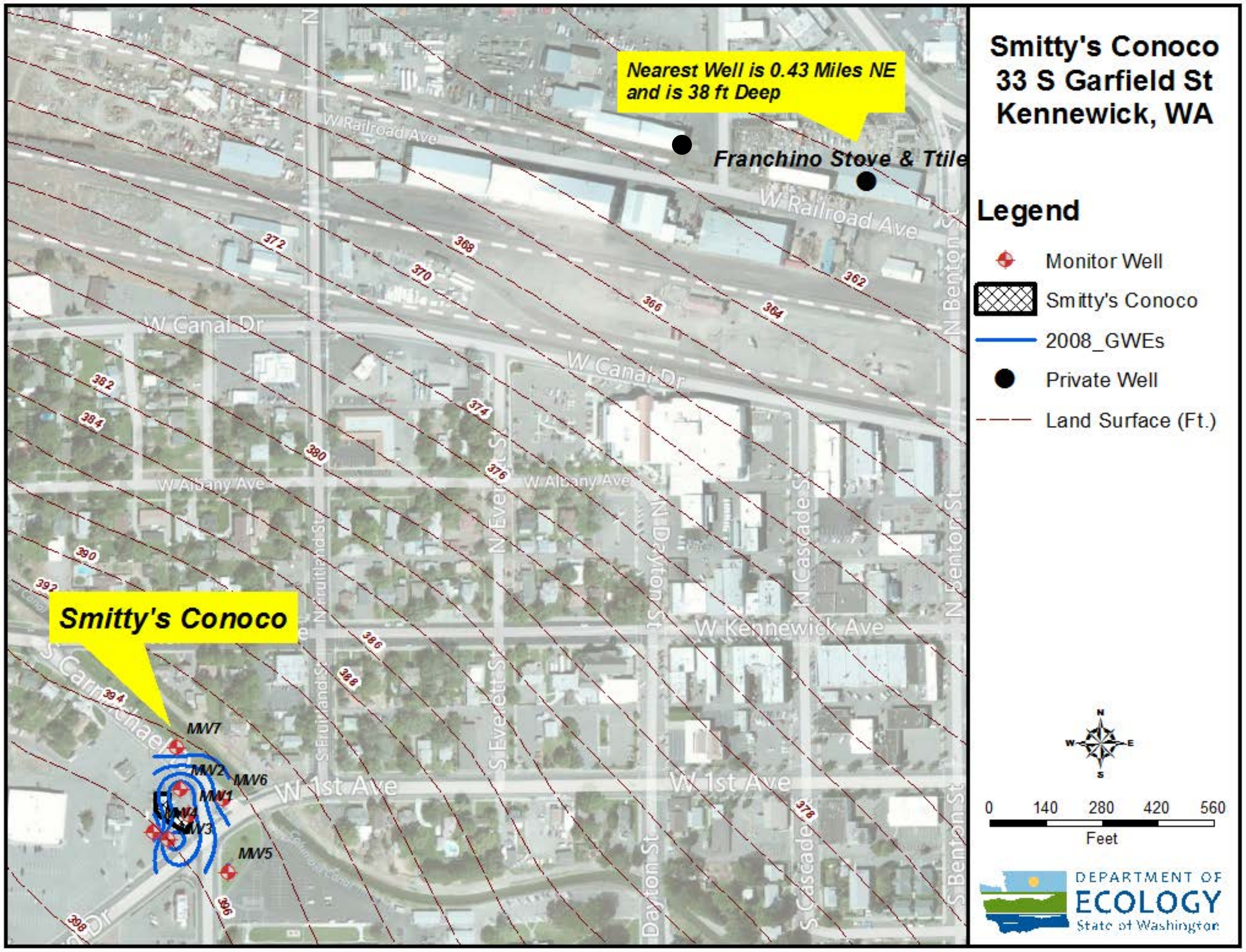


Table 1 – Gasoline Mass, Concentration and Area (2008-2011).

	Units	2008	2009	2010	2011
Positive Volume (Cut)	ft3	658,647,966	343,834,826	71,604,452	4,916,276
Positive Planar Area (Fill)	ft2	53,676	52,064	10,835	5,098
Planar Area	Acres	1.2	1.2	0.25	0.12
Average Predicted GRO	ug/L	13,271	7,604	7,608	1,964
Average Measured GRO	ug/L	11,190	6,119	9,048	1,050
Aquifer Thickness	ft	20	20	20	20
Aquifer Porosity	Unitless	0.43	0.43	0.43	0.43
Unit Conversion	L/ft3	28.3	28.3	28.3	28.3
Unit Conversion	ug/kg	1.00E+09	1.00E+09	1.00E+09	1.00E+09
Mass	**kg**	**173**	**96**	**20**	**2**

Table 2 - Gasoline / Diesel Fuel Plume Stability Regression Results (2008-11).

Substance	Parameter	Units	R2	Regression Line Slope	Lower 95% CL	Upper 95% CL	Trend
TPH-Gasoline (GRO)	Area	Acres	0.8592	-0.4292	-0.9577	0.099	Unknown
	Concentration	ug/L	0.8998	-3,392	-6,835	52.3	Unknown
	Mass	Kg	0.9430	-58.9	-103	-14.8	Decreasing

Table 3 – Average Measured Gasoline Levels (MW-2, 008).

Date	B	T	E	X	GRO	Naphthalene
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
9-Apr-08	780	2,890	521	5,940	22,800	44
7-Aug-08	2,910	7,220	72.2	6,140	35,200	66.9
25-Nov-08	6,060	23,500	680	11,400	88,000	620
30-Dec-08	1,500	3,700	270	2,700	36,000	--
Average	**2,813**	**9,328**	**386**	**6,545**	**45,500**	**244**

Table 4 – 4-Phase Modeling Results.

	*Predicted Soil GRO	%	*Predicted Ground Water GRO	**Average Measured Ground Water GRO
	(mg/kg)		(ug/L)	(ug/L)
AL_EC >5-6	11.3	1.5%	706	--
AL_EC >6-8	70	9%	646	--
AL_EC >8-10	72	10%	43	--
AL_EC >12-16	117	16%	5	
AR_EC >8-10	86	11%	7,270	--
AR_EC >10-12	171	23%	5,570	--
AR_EC >12-16	137	18%	951	--
Benzene	0.9	0.114%	1,640	2,813
Toluene	13.5	1.8%	10,300	9,328
Ethylbenzene	6.8	0.9%	1,770	386
Total Xylenes	38.2	5.1%	10,100	6,545
Naphthalene	27.0	3.6%	1,140	244
Total	**750**	**100%**	**40,141**	**45,500**

*Ecology 4-Phase solution (MTCATPH spreadsheet) with the following input parameters: dilution factor (DF) = 1, soil organic carbon = 0.1%, soil bulk density 1.5 L/kg, soil moisture content 0.3, soil air content 0.13 and soil porosity 0.43. ** MW-2 measured average (2008).

Table 5 – Source Area Estimated Soil Gasoline Mass and Volume.

Layer	Gasoline Volume gal	Gasoline Volume L	Gasoline Density (kg/L)	TPH (a) Mass (kg TPH / ft)	Estimated TPH (b) Concentration (mg/kg)	Start Elev. Ft	End Elev. Ft	Soil Bulk Density (kg/ft3)	Layer Thickness Ft	Soil (c) Volume (ft3)	Area (d) Acres
1	178	672	0.729	490	50	395	385	42	10	230,808	1.2
2	888	3,362	0.729	2,451	100	385	360	42	25	577,019	1.2
3	2,221	8,405	0.729	6,127	250	360	335	42	25	577,019	1.2
4	3,997	15,129	0.729	11,029	750	335	320	42	15	346,212	1.2
Total	**7,284**	**27,568**		**20,097**	**288**	**--**	**--**	**--**	**75**	**1,731,058**	**--**

(a) From Equation 1.
(b) From Table 4.
(c) Based on an assumed soil porosity (n) of 0.43
(d) From Table 1.

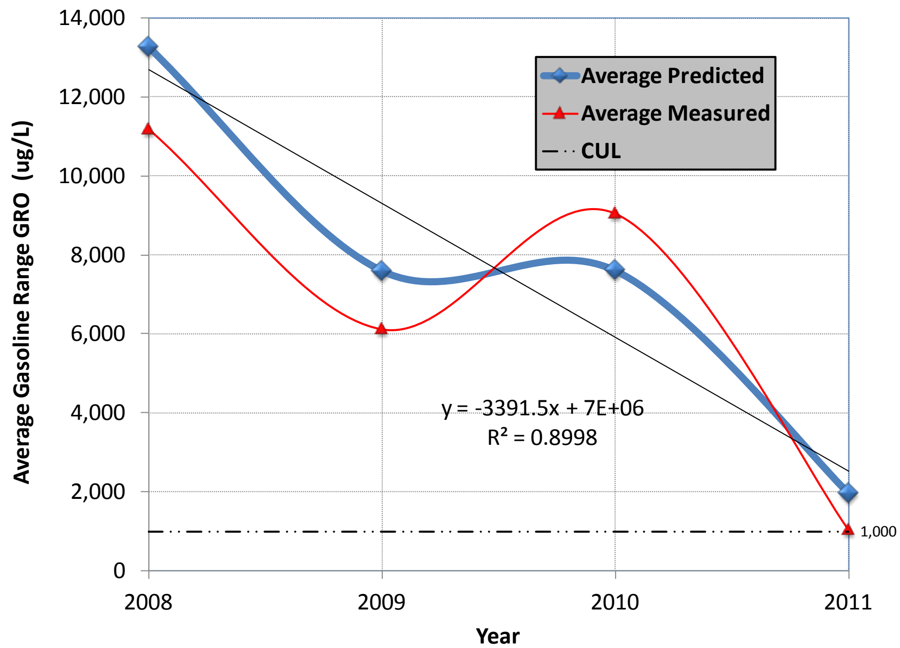
Table 6 – Vapor Intrusion.

Petroleum Fraction	%	*Average Measured Ground Water	**Adj HLC	***Predicted Vapor	Inhalation RFD	Hazard Index (HI)
		ug/L	unitless	ug/m3	mg/kg-day	unitless
AL_EC >5-6	2%	40	2.23E+01	895,593	1.7	329.3
AL_EC >6-8	2%	37	3.13E+01	1,149,457	1.7	422.6
AL_EC >8-10	0%	2	4.47E+01	109,951	0.085	808.5
AL_EC >10-12	0%	0	6.26E+01	16,281	0.085	119.7
AR_EC >8-10	18%	413	2.74E-01	113,033	0.114	619.7
AR_EC >10-12	14%	316	7.26E-02	22,956	0.00086	16,683.4
AR_EC >12-16	2%	54	2.66E-02	1,438	0.05	18.0
Benzene	4%	93	1.41E-01	13,173	0.00855	963.0
Toluene	26%	585	1.62E-01	94,534	1.4	42.2
Ethylbenzene	4%	101	1.84E-01	18,531	0.286	40.5
Total Xylenes	25%	574	2.28E-01	131,021	0.029	2,823.7
Total Naphthalenes	3%	65	1.39E-02	897	0.00086	652.2
Total		**2,280**		**2,566,867**		**23,523**

*Average MW-2 measured ground water (2013) and a weathered gasoline composition. **Henry's Law Constant (HLC) adjusted to ground water temperature (55 F). *** Predicted ground water vapor phase = HLC * measured ground water (ug/L) * UCF (1,000 L / m3)

Figure 4 – Average Predicted Concentration / Mass v. Time.

Concentration



Mass

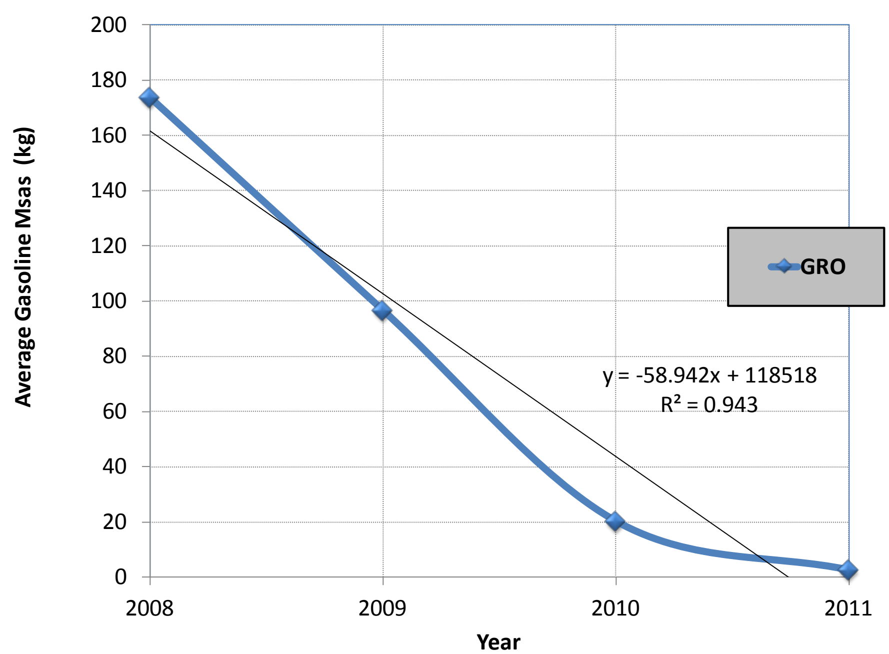


Figure 5 – Concentration vs. Time (Individual Wells).

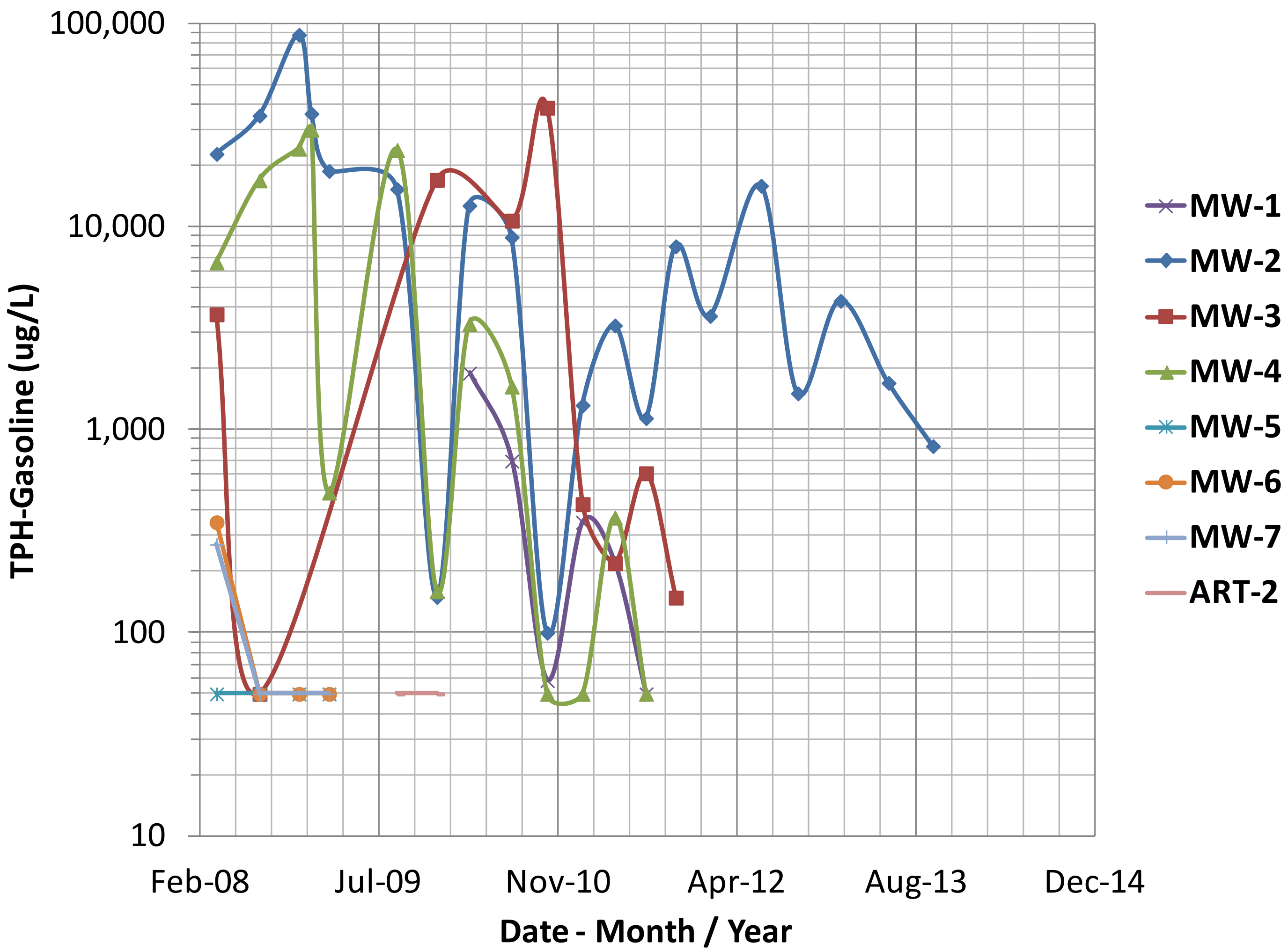


Table 7 – Estimated Hydraulic Gradient (from Smitty's Site to Downgradient Well).

	*Smitty's	Downgradient Well	Change	**Distance	Gradient (i)
	Ground Water Elevation ft	Ground Water Elevation ft	ft	ft	ft/ft
Min	338.35	336	2.4	2,350	0.0010
Average	339.84	336	3.8	2,350	0.0016
Max	340.92	336	4.9	2,350	0.0021

*From all site wells for the time period April 9th, 2008 up through February 17th, 2009 (prior to the start of the treatment system).
**Distance from Smitty's site to Franchino well (223 North Benton).

Table 8 – Estimated Contaminant Travel Times.

Contaminant	Time	Vc	Vgw	K	i	R	ρ	θw	Koc	foc	Kd	η
	Yrs	ft/day	ft/day	ft/day	ft/ft	unitless	kg/L	mL/ mL	ml/g	%	L/kg	dimensioness
Benzene	1.0	3.8	4.9	1,300 (a)	0.0016	1.3	1.5	0.3	62	0.1%	0.062	0.43
Benzene	2.5	2.6	3.3	880 (b)	0.0016	1.3	1.5	0.3	62	0.1%	0.062	0.43
MTBE	1.4	4.7	4.9	1,300 (a)	0.0016	1.1	1.5	0.3	11	0.1%	0.011	0.43
MTBE	2.0	3.2	3.3	880 (b)	0.0016	1.1	1.5	0.3	11	0.1%	0.011	0.43

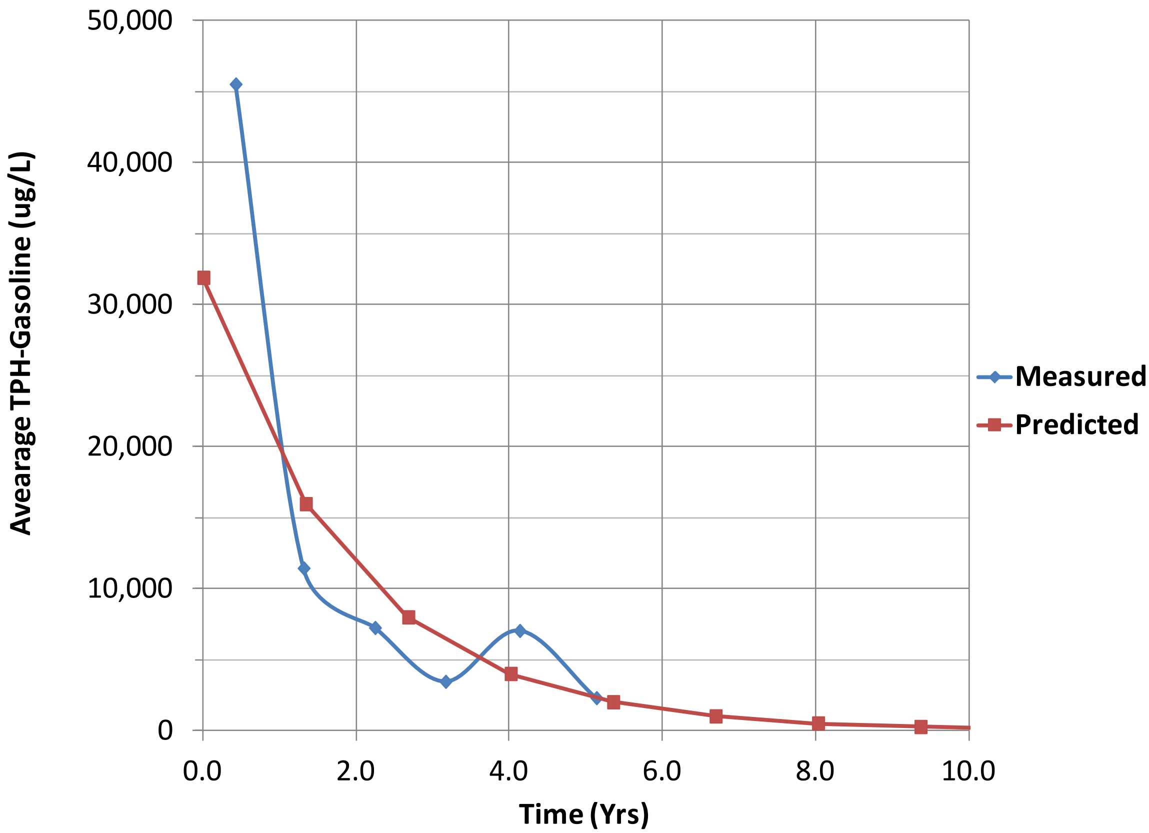
Time = contaminant travel time (yrs)
Vc = contaminant velocity (ft/day)
Vgw = ground water velocity (v = Ki / n)
K = hydraulic conductivity (ft/day; (a) Chern (1989) (b) Ecology (2003))
i = average hydraulic gradient (ft/ft; Table 7)
R = retardation factor (unitless)
ρ = dry soil bulk density (kg/L)
θw = soil moisture content (mL water / mL soil)
Koc = soil organic carbon-water portioning coefficient (mL/g)
Kd = distribution coefficient (L/kg)
η = soil porosity (dimensionless)

Table 9 – Gasoline Rate Constant (k), Half Life and Restoration Timeframe.

Year	*Average TPH-GRO (ug/L)	Ln TPH-GRO (ug/L)	Slope K (Yrs-1)	t 1/2 (Yrs)	*TOR (Yrs)	Estimated Date
0.4	45,500	10.7	-0.5183	1.3	6.7	December 12, 2014
1.3	11,417	9.3				
2.2	7,223	8.9				
3.2	3,430	8.1				
4.1	7,013	8.9				
5.1	2,280	7.7				

*Average annual gasoline concentrations from MW-2 (Apr-2008 to Sept-2013).
**TOR = time of remediation (restoration timeframe) to 1,000 ug/L TPH-GRO cleanup level.

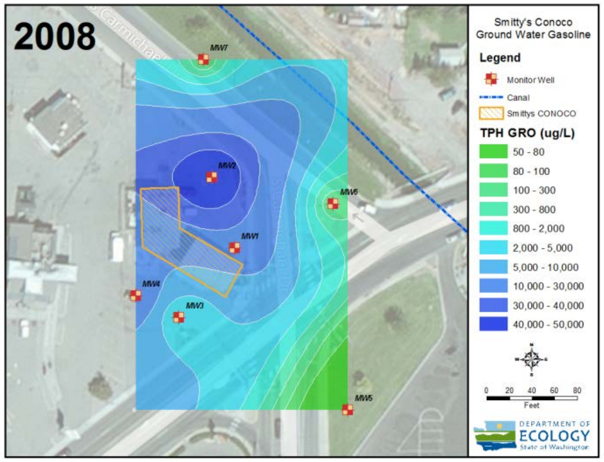
Figure 6 – Gasoline Concentration v. Time (MW-2).



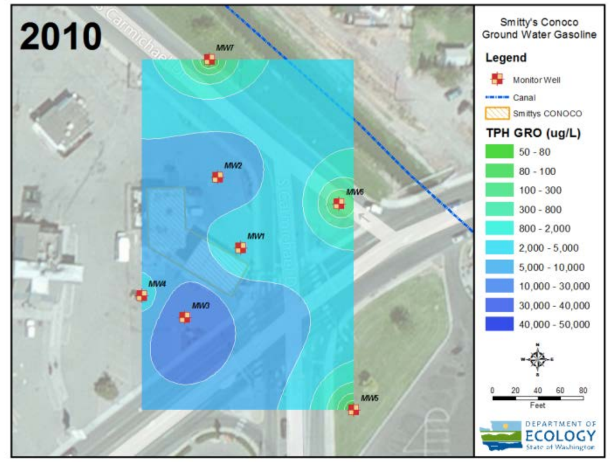
Note: predicted ground water gasoline concentrations from Eq. 1 and Table 4 rate constant. Measured gasoline concentrations are from Table 4 (average annual).

Figure 7 - Gasoline Plume Footprints (2008 - 2011).

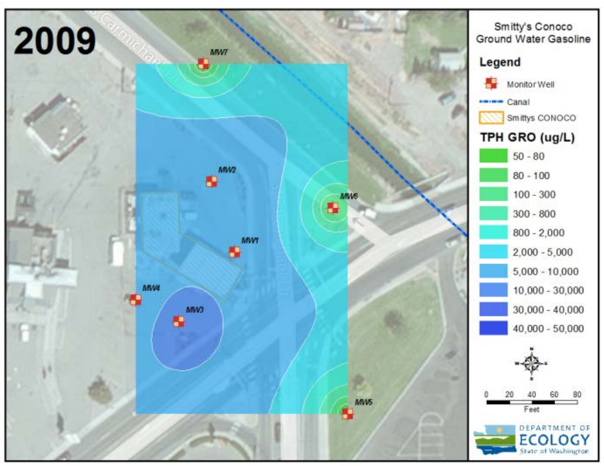
2008



2010



2009



2011

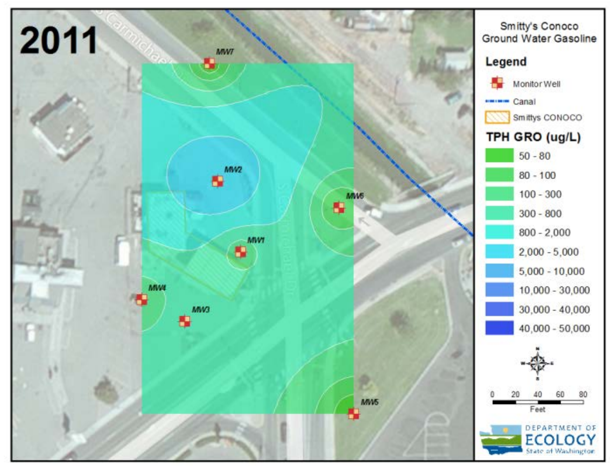


Figure 8 – Gasoline Plume Footprint Center Mass (2008-11).

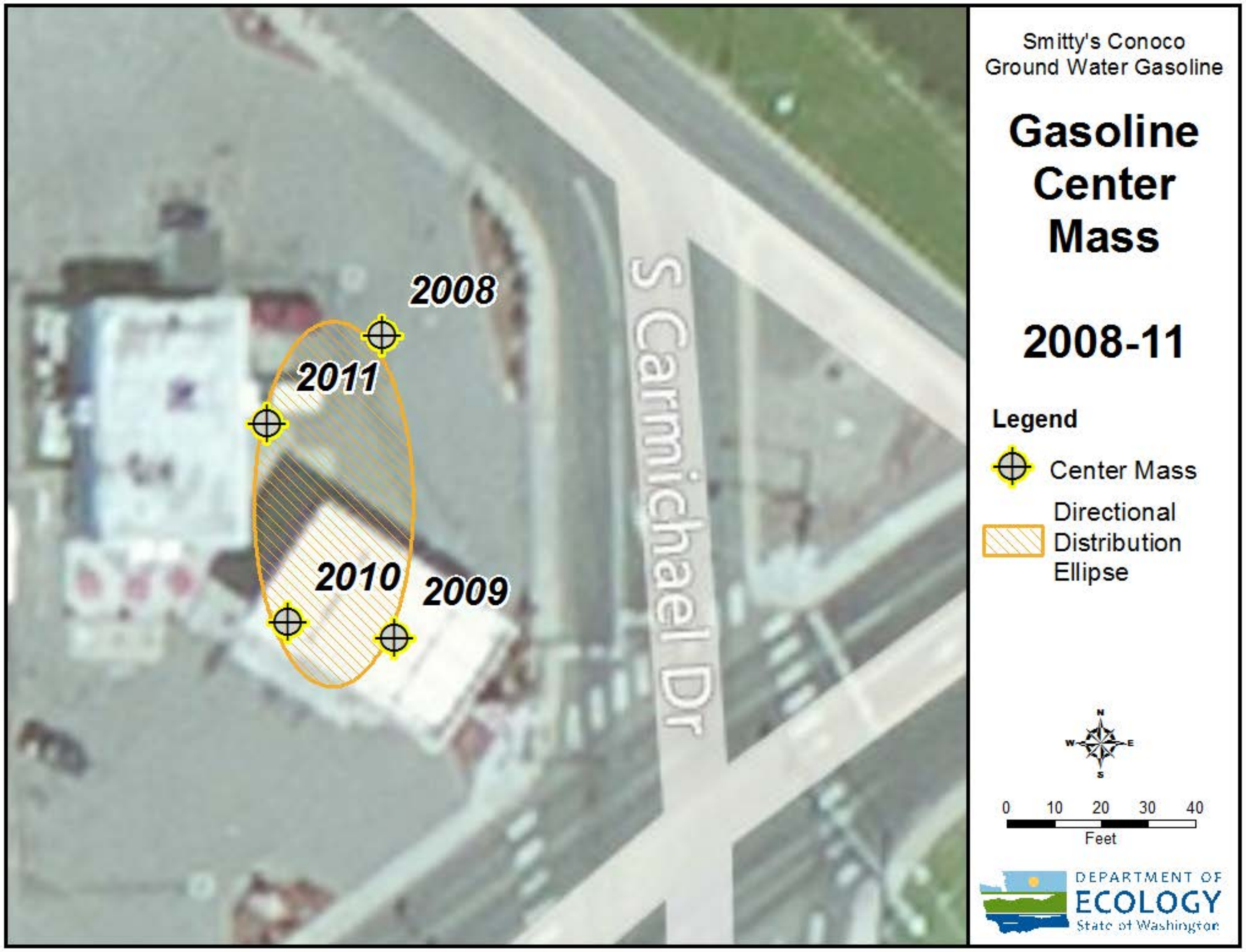
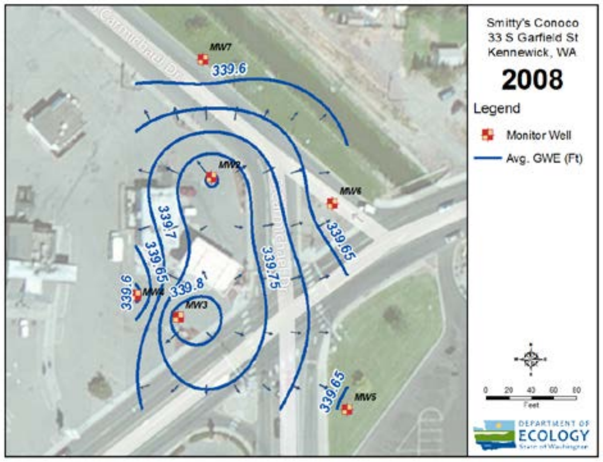
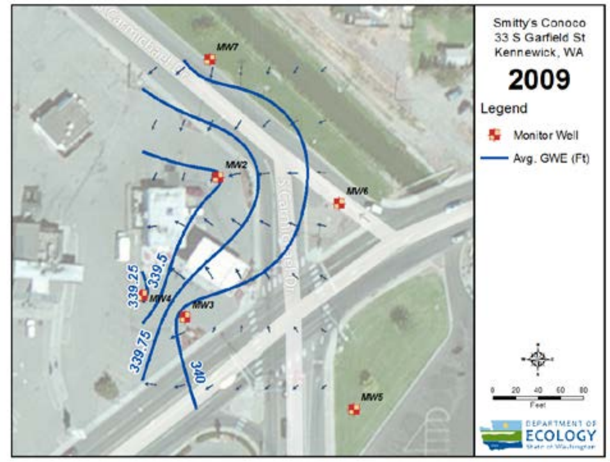


Figure 9 - Average Ground Water Elevations (2008-09).

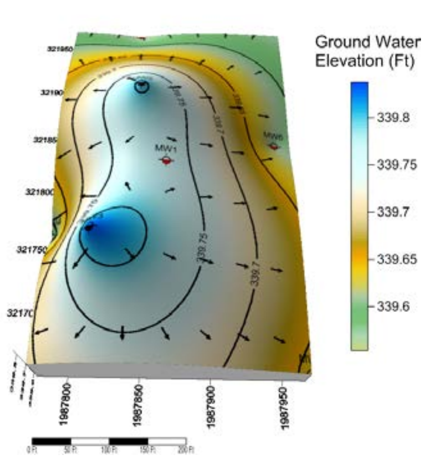
Plan View



Plan View



3D



3D

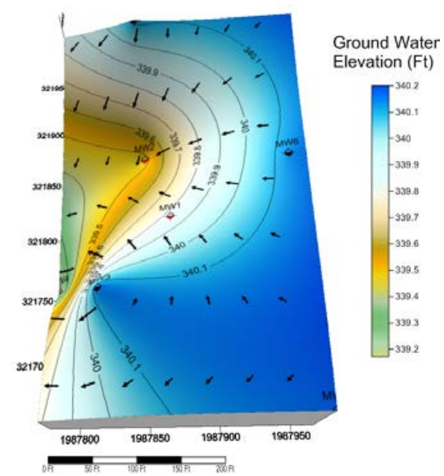
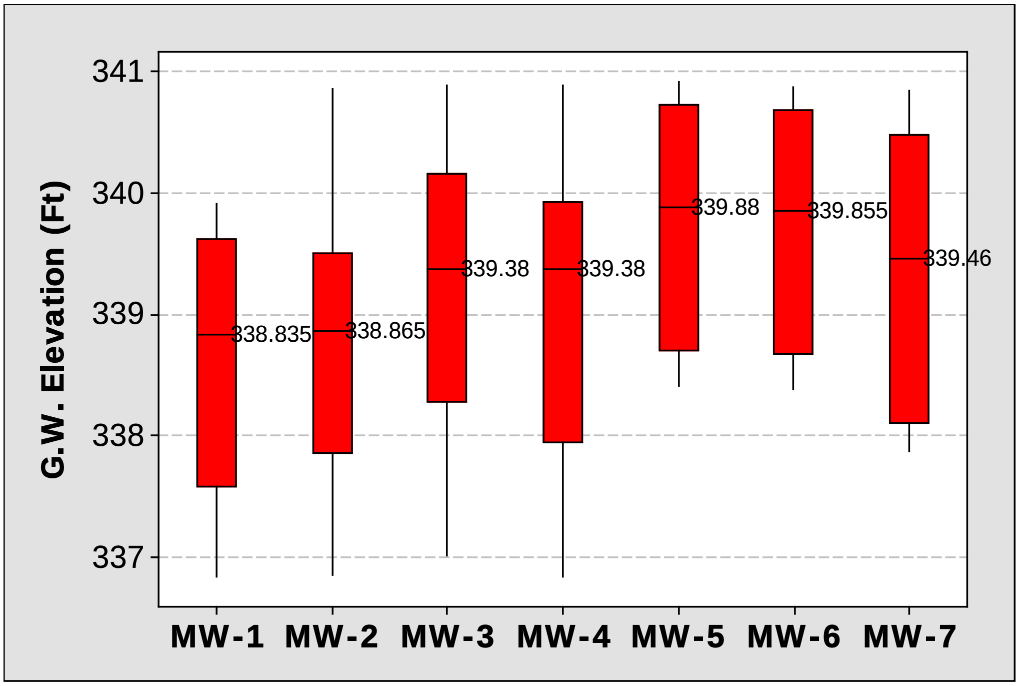


Figure 10 - Ground Water Elevation Box and Interval Plots.

Box Plot (With Median Elevations)



Interval Plot (With Average Elevations)

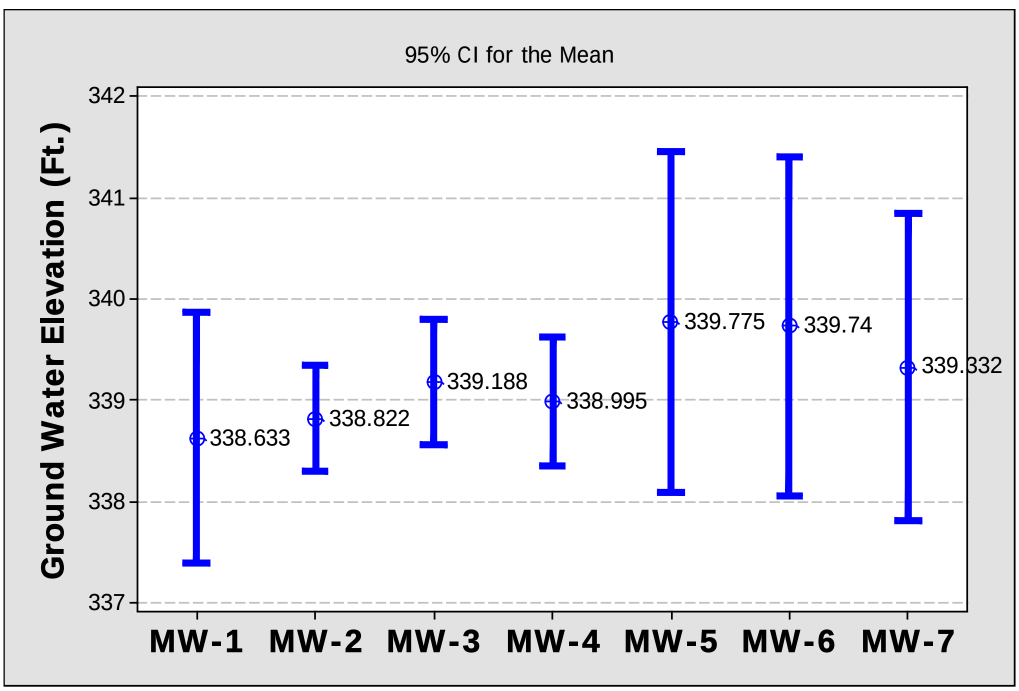


Figure 11 – Hydrograph.

Average Monthly Ground Water Elevations (2008-11)

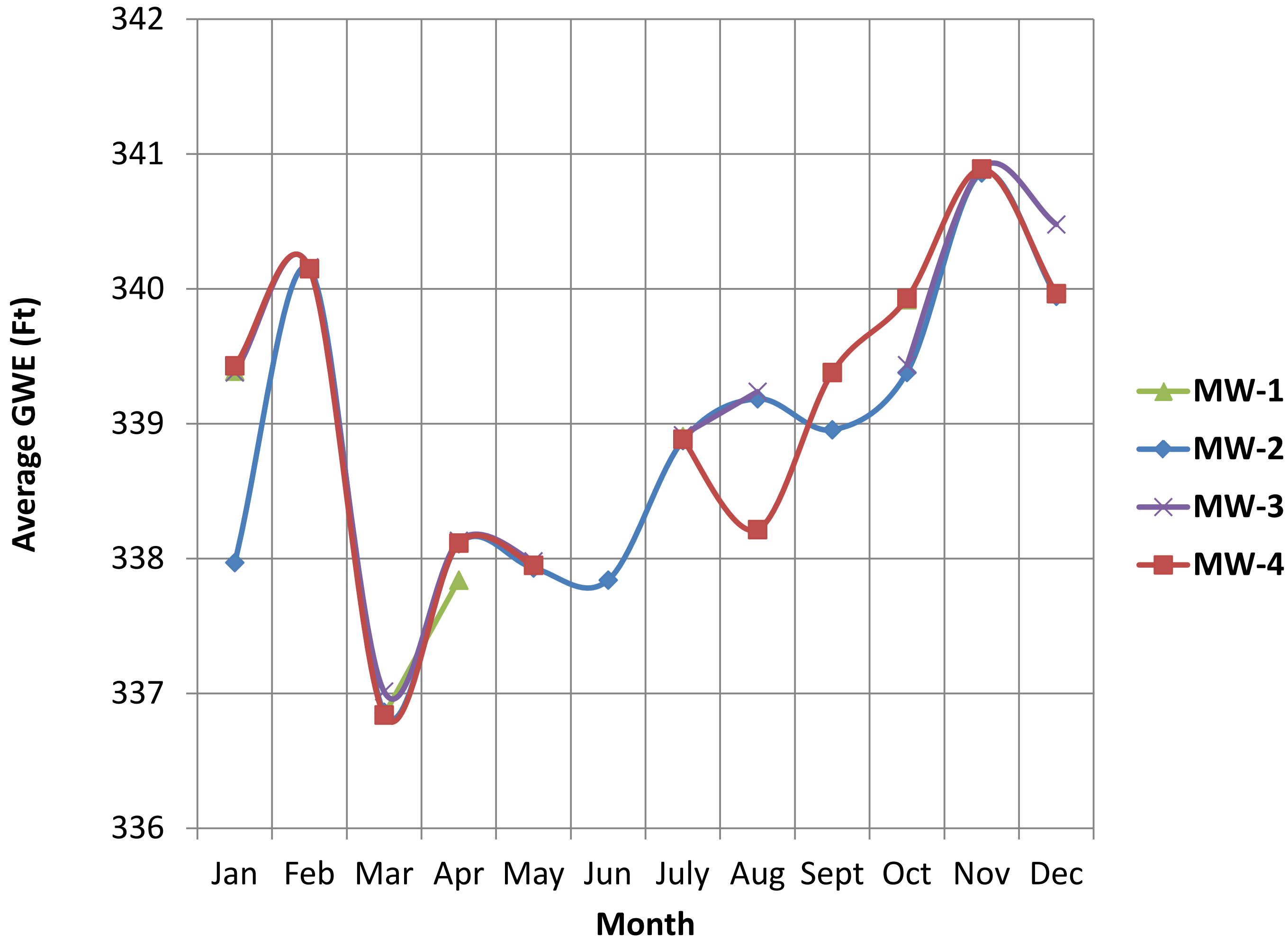


Figure 12 – Gasoline Concentration v. Ground Water Elevation (MW-2).

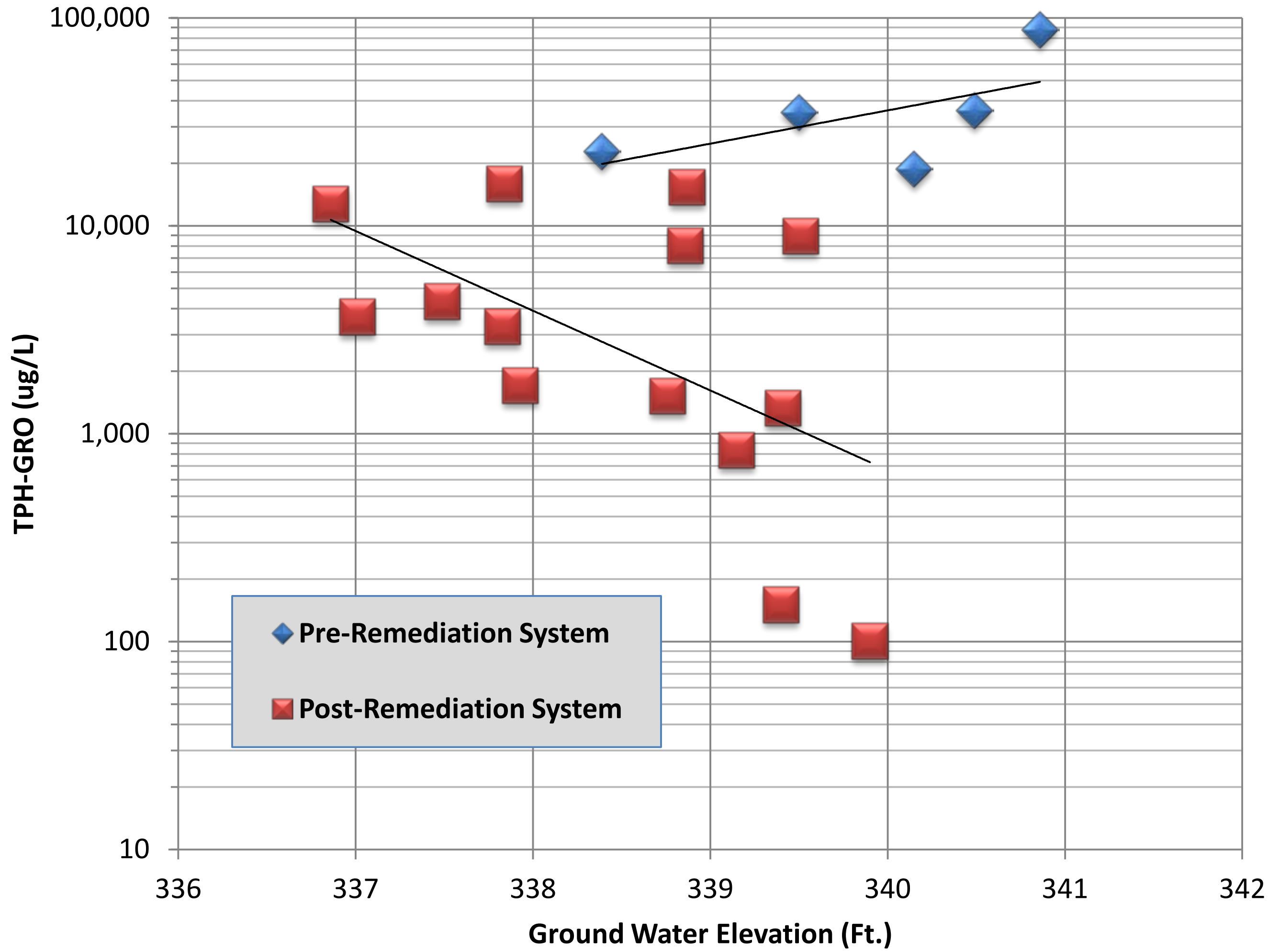


Figure 13 – Ground Water Oxidation Reduction Potential (ORP).

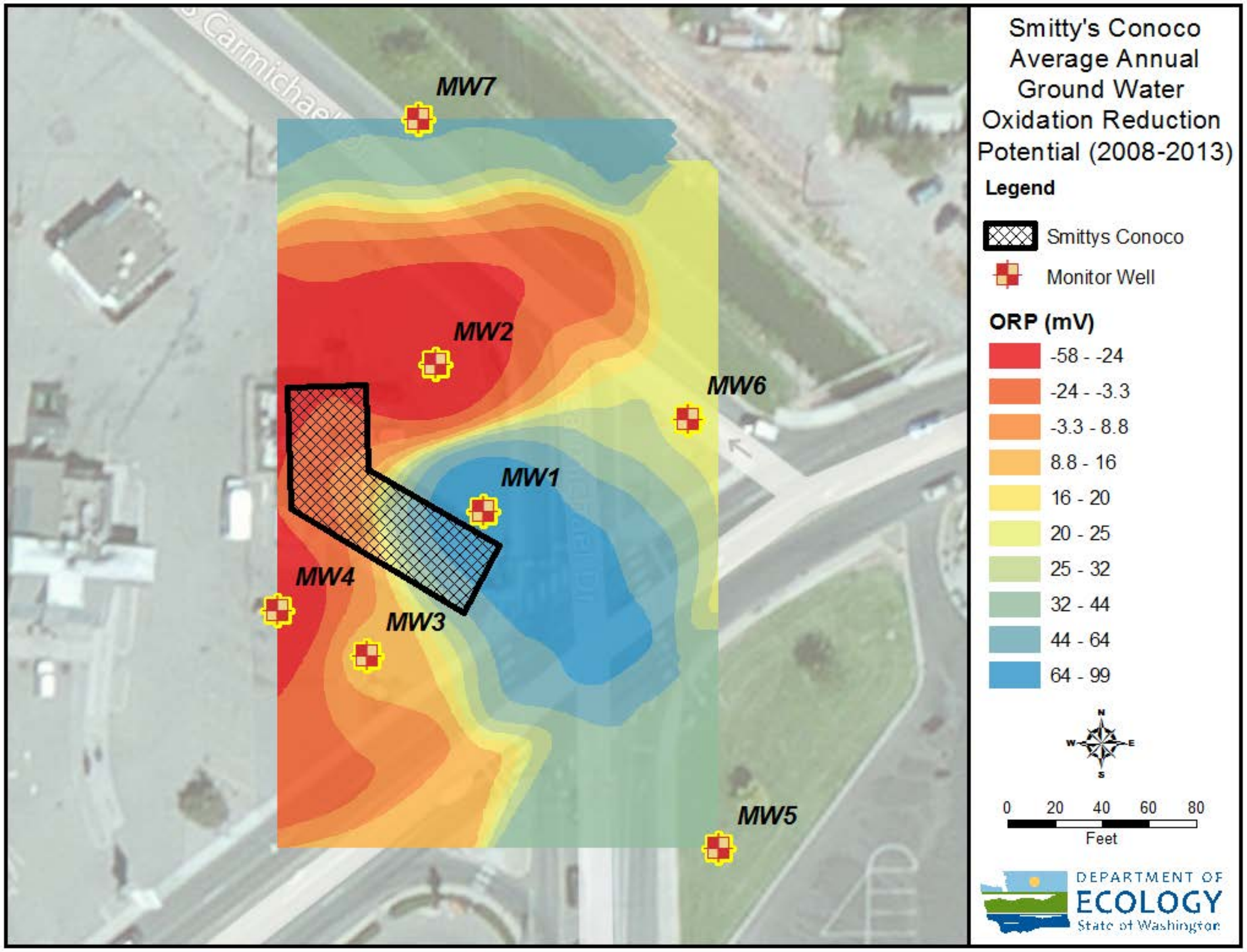


Figure 14 – Franchino Stove and Tile and SCS Cold Storage Well Logs (2001).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy 106774

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W148953
UNIQUE WELL I.D. # AGM105
Water Right Permit No

(1) OWNER: Name Franchino Stove+tile Address 223 N Benton Kena

(2) LOCATION OF WELL: County Benton NE 1/4 NE 1/4 Sec 1 T 8 N R 29E WM

(2a) STREET ADDRESS OF WELL: (or nearest address) 223 N Benton

TAX PARCEL NO.

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (if more than one) ☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method: ☐ Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 36 feet Depth of completed well 37 ft

(6) CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam from +1 ft to 32 ft
☐ Liner installed " Diam from ft to ft
☐ Threaded " Diam from ft to ft

Perforations: ☐ Yes ☒ No
Type of perforator used
SIZE of perforations in by in
perforations from ft to ft

Screens: ☒ Yes ☐ No ☐ K-Pac Location 31
Manufacturer's Name Cook
Type Stainless Model No
Diam 6" Slot Size 12 from 32 ft to 37 ft
Diam Slot Size from ft to ft

Gravel/Filter packed: ☐ Yes ☐ No ☐ Size of gravel/sand
Material placed from ft to ft

Surface seal: ☒ Yes ☐ No To what depth? 18 ft
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H P

(8) WATER LEVELS: Land-surface elevation above mean sea level ft
Static level 24 ft below top of well Date 9-11-01
Artesian pressure lbs per square inch Date
Artesian water is controlled by (Cap, valve, etc)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)
Time Water Level Time Water Level Time Water Level

Date of test
Bailer test gal /min with ft drawdown after hrs
Airtest 30 gal /min with 1 ft drawdown after 2 hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? ☐ Yes ☐ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered.

MATERIAL	FROM	TO
Cobbles, gravel sand Black	0	17
Gravel, sand Black Water @ 23 feet	17	35
Gravel, sand Black	35	37
Sand Tan Gravel	37	38

DEPT OF ECOLOGY Received OCT 25 2001 CENTRAL REGION OFFICE

Work Started 9-11 2001 Completed 9-11 2001

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Type or Print Name Jim Nelson License No. 361
(Licensed Driller/Engineer)
Trainee Name License No
Drilling Company Nelson Well Drilling Inc
(Signed) Jim Nelson License No 361
(Licensed Driller/Engineer)
Address 3200 W Argent Pasco
Contractor's Registration No NELSOWD198CQ Date 9-11 2001

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (360) 407-6600. The TDD number is (360) 407-6006.

ECY 050-1-20 (11/98)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No
Permit No 24-25263P

(1) OWNER: Name Thomas J. Skelly, John H. Chapman & Maloy Sensney, DBA SCS Storage & Distribution Center Address 99 Lee Blvd. Richland, Wash

(2) LOCATION OF WELL: County Benton — N ½ NE ¼ Sec. 1 T. 8 N., R. 29E. W.M.
Bearing and distance from section or subdivision corner Lot 28 - Block A N½ NE ¼

(3) PROPOSED USE: Domestic ☒ Industrial ☒ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☒ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.
Drilled 100 ft. Depth of completed well 105 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 12" Diam. from 0 ft. to 60 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ 12" Diam. from 0 ft. to 60 ft.

Perforations: Yes ☒ No ☐
Type of perforator used Side
SIZE of perforations 1/8 in. by 1/8 in.
50 perforations from 30 ft. to 60 ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 6' ft.
Material used in seal Concrete
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name To be determined
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 21 ft. below top of well Date 7-20-78
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Basin Pump
Yield: 1750 gal./min. with 26 ft. drawdown after 96 hrs.
"Pump set at 85 ft – at 1610
GPM 41' of water over bowls"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	21'	4hrs.	47'	-0-	21'

"Recovery after Shut off Immeditly"

Date of test ....
Bailer test — gal./min. with — ft. drawdown after — hrs.
Artesian flow 5000+ g.p.m. Date ....
Temperature of water 59 Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Well drilled in 1938 – Used for human consumption & food processing. Consumption rate approx 1.5 million gals per day	1938	1965
Feb 1977 well was tested by US Dept of Health & US Testing Co in Richland Wash. Under both tests well proved to be soft water – bacteria free and certified by both agencies for human consumption & or food processing.		

RECEIVED
JUL .. 1978
DEPARTMENT OF ECOLOGY

Work started 3, 1935 Completed 11-16-, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Basin Pump Service (Person, firm, or corporation) (Type or print)
Address Kennewick Washington
(Signed) [illegible] (Well Driller)
License No. G4-25263P Date 7-21, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20