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Response and Remediation Program

amec foster wheeler

October 15, 2015

Mr. Larry Kloet
Georgia Environmental Protection Division
Land Protection Branch
2 Martin Luther King Drive S.E.
Suite 1054, East
Atlanta, GA 30334

Subject: CSR Addendum
Southern Metal Finishing Company, LLC
1575 Huber Street Parcel, Atlanta, Fulton County, GA
HSI No. 10689
Tax Parcel No. 17-0187-LL-059-6
Amec Foster Wheeler Project No. 6122130015

Dear Mr. Kloet:

On behalf of Southern Metal Finishing Company, LLC, Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) is pleased to submit this Compliance Status Report (CSR) Addendum to the Georgia Environmental Protection Division (EPD). A Voluntary Remediation Program (VRP) CSR for the property was submitted to the Georgia Environmental Protection Division (EPD) on December 17, 2014. In a meeting with EPD in May 2015, EPD requested the following revisions to the groundwater model presented in the CSR:

- Provide both input and output model parameters, and all model files on a CD;
- Include a quantitative sensitivity analysis instead of the discussion provided;
- Provide both a shallow and bedrock F&T model with Woodall Creek as the point of exposure;
- Use the highest recent measured concentrations as the source term ("worst case conditions");
- Use the model to develop a site-specific groundwater cleanup level for comparison to current site concentrations;
- Consider averaging hydraulic parameters; and,
- Clarify the calibration process.

The updated modeling results discussion is presented as Attachment A. The associated model files are provided on a compact disc included as Attachment B.

Amec Foster Wheeler Environment & Infrastructure, Inc.
1075 Big Shanty Road, Suite 100
Kennesaw, Georgia 30144
Tel: (770) 421-3400
www.amecfw.com

Thank you for your assistance with this project. Please feel free to call either of us at 770-421-3400 if you have any questions regarding this submittal.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure, Inc.

GJW For Tim Glover with permission

Tim Glover
Senior Scientist II

Gregory J. Wrenn, PE
Project Manager

Attachments: A – Updated Modeling Discussion
B – CD with Modeling Files

cc: James McClatchey, Southern Metal Finishing
Scott Laseter, Kazmarek, Mowrey, Cloud, Laseter LLP

4.2 MODEL FOR VRP PROPERTY

The PCE concentration distribution associated with the VRP Property was modeled using BIOCHLOR version 2.2. Two BIOCHLOR models were created, one for shallow overburden groundwater and one for fractured bedrock groundwater. These models assume a single plume originates on the VRP Property in the vicinity of well SMFMW-3 and extends down gradient into the vicinity of DPMW-2S and DPMW-3S. While it is possible that pre-remediation source conditions on the VRP property may have contributed to a contiguous plume that historically discharged to Woodall Creek, current, post-remediation data shows the VRP property is not presently contributing to a plume capable of migrating that far because concentrations further down gradient are higher than the current source area concentrations. The goal of the BIOCHLOR analysis is to further evaluate this hypothesis by modeling the migration potential of residual, post-remediation concentrations on the VRP property. The BIOCHLOR model domain for both overburden and fractured bedrock ends at a point 1500 feet down gradient of the source in the vicinity of Woodall Creek. This is assumed to be the point of groundwater discharge, based on topography, potentiometric measurements, and inferred direction of groundwater flow at the site.

The BIOCHLOR simulations were run for 50 years to evaluate future migration potential from the VRP Property. The 50 year timeframe is long enough to obtain a steady-state plume distribution down gradient of the constant-concentration source.

4.2.1 Source Area

To maintain a conservative simulation representing worst-case conditions, the overburden model incorporates a continuing on-Site shallow source area 200 feet wide (approximate property width) by 22 feet deep (the approximate saturated aquifer thickness at MW-3) with a constant PCE concentration of 0.133 mg/L. The bedrock model source area is of an equivalent size with a constant PCE concentration of 0.236 mg/L. These concentrations are based on March 2015 data from overburden well SMFMW-2 and deep bedrock well SMFDR-3, and are assumed to be uniformly representative of current groundwater conditions across the former source area. This represents a worse-than-known-case assumption because existing measured concentrations in other source area wells are lower.

4.3 INPUT AND ASSUMPTIONS

Under the VRP, "point of exposure" means the nearest of the closest existing down gradient drinking water supply well, the likely nearest future location of a drinking water well, or a hypothetical point of drinking water exposure located at a distance of 1000 feet down gradient from the delineated site contamination. The VRP point of exposure would therefore be 1000 feet beyond Woodall Creek itself, which represents the delineated down gradient extent of contamination. However, to be conservative, the model was set to determine whether detectible impacts from the VRP property would ever reach the creek based on current, post-remediation VRP property conditions. As explained further, below, the model predicts the maximum extent of detectible impacts to be approximately 900 feet from the VRP Property (i.e., roughly 600 feet short of Woodall Creek). Therefore, it is unnecessary to model to any theoretical point beyond Woodall Creek.

The VRP calls for the establishment of a "point of demonstration well" located such that measurements from that well allow prediction of concentrations at the down-gradient Point of Exposure. For purposes of the model, well MW-3 and SMFDR-3 located at the southwestern corner of the VRP Property were selected as the representative point of demonstration wells.

The groundwater flow direction affecting contaminant migration across the SMF and Woodall Creek sites was measured to be generally toward the southwest. The results of the groundwater assessment indicate that the horizontal and vertical extent of TCE and PCE in groundwater has been delineated and extends along the west-southwest end of the VRP Property near SMFMW-3.

The BIOCHLOR model is a screening level model and requires some simplifying assumptions: homogeneous hydrogeologic parameters across the entire domain, a homogeneous decay rate (for CEs) throughout the model; and (in these models) a continuing, constant concentration (no future mass reduction) at the source.

4.3.1 Input Parameters

Table 7 presents a summary of the key parameters of the BIOCHLOR simulation prepared for the VRP Property. Pertinent details for selected parameters appear below.

Seepage velocity *(feet per year (ft/yr))* – a function of the hydraulic conductivity, effective porosity of the materials, and hydraulic gradient across the modeled area. At most sites, these factors can vary greatly both horizontally and vertically, and are normally adjusted during the calibration process. The current shallow model incorporated the seepage velocity of 300 ft/yr identified in the VRP Application (Peachtree, 2013) and adjusted it as a calibration value to 66 ft/yr. The deep seepage velocity of 302 ft/yr was set based also on the VRP Application (Peachtree, 2013).

Dispersion *(ft)* – the BIOCHLOR documentation (BIOCHLOR 2000, BIOCHLOR 2002) describes dispersion as "the process whereby a dissolved solvent will be spatially distributed longitudinally (along the direction of ground-water flow), transversely (perpendicular to ground-water flow), and vertically (downward) because of mechanical mixing and chemical diffusion in the aquifer." The longitudinal dispersivity ("X") is used to derive the transverse ("Y" or across the plume) and vertical ("Z" or depth-wise) dispersivities using the following relationships: Y = 0.1*X and Z = 0.01 *X. "X" was determined using BIOCHLOR's built-in dispersion calculator using an estimated plume length of 1000 feet.

Soil bulk density *(kg/L)* – soil bulk density is the mass of a volume of dry aquifer material. A value of 1.5 kg/L was used based on the previous S&ME 2004 model value. This value is slightly less than the BIOCHLOR default value of 1.6 kg/L.

Fraction organic carbon *(dimensionless)* – because no site-specific value was available and to help ensure a conservative approach, the current model incorporates the default BIOCHLOR value of 0.001.

***Simulation time** (yr)* – duration of model simulation, set at 50 years into the future based on iterative testing indicating a stable-state plume prior to that point in time.

Modeled area width (ft) – estimated value, assumed to be larger than the maximum width attained by the plume within the length of the model domain. Estimate is based on two-thirds of the model length.

Modeled area length (ft) – length of the current model is defined as the map distance from the source to the expected groundwater discharge point at the creek, approximately 1500 feet from the source and includes the Point of Demonstration (POD

***Degradation zone length** (ft)* – the length of the zone within the plume in which degradation of CEs is assumed to take place with essentially the same mechanisms and rates of degradation. It is expressed as a distance along the modeled area length.

***Plume length** (ft)* – length of the plume as initially defined by the input data; for this model, this distance is measured from the source area (SMFMW-3) to the approximate point at which the plume emanating from the source area at SMF becomes indistinguishable from the larger plume in the area down-gradient from the VRP Property, approximately halfway between wells MW-26 and JPMW 21 (Figure 5).

***Source thickness in saturated zone** (ft)* – assumed to be the saturated thickness of the surficial aquifer (above the bedrock) in the source area. Value was estimated using information available from well SMFMW-3, and is based on the depth-to-water measurement made in this well during the 2014 sampling event and estimated depth to the confining unit below the surficial aquifer. As fractured bedrock thickness is unknown, this same source thickness was conservatively used for the bedrock model.

***Source width** (ft)* – cross-sectional width of model source area in a direction perpendicular to the direction of groundwater flow (across the source area). This is estimated to be the approximate distance across the VRP Property as measured perpendicular to the direction of groundwater flow. Because the size and location of possible PCE sources on the VRP Property are not known, a very conservative estimate is made in assigning the entire property as a source.

***PCE to DCE degradation lambda** (1/yr)* – an expression of the dechlorination rate of PCE to TCE. This is the decay constant for the reaction and can be converted to a half-life using the following equation:

$$t_{1/2} = \frac{\ln(2)}{\lambda}$$

Where:

$t_{1/2}$ is half life

ln(2) is the natural logarithm of 2

λ is the decay constant

Initially, the model default value of 2.0 was used. This value was adjusted in calibration to 0.6. This final value is still within the model's suggested range of 0.07 to 1.2 which the model documentation quotes from Weidemeier et al. 1999.

4.4 CALIBRATION

Model calibration is the process of finding a set of fate and transport parameters which produces a plume concentration distribution similar to field measurements. For the overburden model, groundwater seepage velocity and the PCE biodegradation rate were used as calibration parameters. The goal of the calibration was to approximate the PCE concentrations observed at MW-2S, MW-3S, and DPMW-3S during the 2015 sampling event. As stated in Section 4.2.1, the shallow overburden source zone was assigned a constant PCE concentration of 0.133 mg/L based on March 2015 data. This source concentration does not degrade over time in the model, representing a conservative, indeed worse-than-possible, condition of no further source attenuation.

The final groundwater seepage velocity after calibration was 60 feet per year (ft/yr), which is not unreasonable for soil and saprolite although this value is somewhat less than the previously proposed seepage velocity of 300 ft/year developed using results from slug testing in selected monitoring wells at the Woodall Creek site (Peachtree, 2013). The final PCE biodegradation rate constant (lambda) after calibration was 1.1 yr^{-1}, which is consistent with the default BIOCHLOR value. BIOCHLOR guidance suggests lambda should not be increased above 1.2. The default adsorption rate was used as no site-specific data were available for this parameter.

Comparisons between calibration runs were based on root-mean-square sums of errors (RMS) for the first three wells (SMFMW-2, DPMW-2S, and DPMW-3S), the source area well and the first two down gradient of the source well comparing model-predicted concentrations to measured concentrations. A summary of the calibration runs is included in the table below. The final calibration run parameters and RMS are highlighted in bold underline.

PCE concentrations (mg/L)	Seepage Velocity (ft/yr)	PCE Biodegradation Rate (yr^{-1})	SMFMW-2 concentration	DPMW-2S concentration	DPMW-3S concentration	RMS for 3 wells
Field Measurements	300	1.1	0.133	0.0173	0.0164	--
Run #1	150	1.1	0.133	0.0461	0.0148	0.029
Run #2: Final Calibration	**60**	**1.1**	0.133	0.0231	0.0037	**0.014**
Run #3	30	1.1	0.133	0.0102	0.0007	0.017

PCE concentrations (mg/L)	Seepage Velocity (ft/yr)	PCE Biodegradation Rate (yr^{-1})	SMFMW-2 concentration	DPMW-2S concentration	DPMW-3S concentration	RMS for 3 wells
Run #4	60	0.75	0.133	0.0323	0.0072	0.018
Run #5	60	1.15	0.133	0.0221	0.0034	0.014

The calibration results demonstrate that the model is reasonably able to predict recent PCE concentrations down gradient of the post-remediation VRP property. Therefore, the model is usable as a screening tool to evaluate the overall extent of the plume that could be generated in the future by the current residual source on the VRP property.

Because there are few fractured bedrock wells and because the first well down gradient from the source area has a higher concentration than the source area, it is not possible to calibrate the fractured bedrock model in the same manner. Instead, the calculated seepage velocity for the fractured bedrock was used with the degradation and sorption parameters used in the shallow overburden model.

4.5 RESULTS AND DISCUSSION

The calibrated BIOCHLOR overburden model predicts center-of-plume, steady-state PCE concentrations of less than 1 ppb (<0.001 mg/L) at approximately 900 feet from the source after a period of 50 years. Since the source area is near the boundary of the site, the maximum extent of detectable PCE predicted by the overburden model is less than 900 ft down gradient of the VRP property. The fractured bedrock BIOCHLOR model predicts a concentration expected to be <5 ppb (<0.005 mg/L) at 1400 ft distance. The maximum extent of detectable PCE predicted by the bedrock model is also approximately 1400 ft down gradient of the VRP property.

It is reiterated that the BIOCHLOR models are based on highly conservative (worst-case) assumptions, including:

- The VRP property residual source experiences zero attenuation in the future;
- The VRP property residual source is uniformly assigned the highest concentration measured in 2015 in both the overburden and bedrock; and
- The model does not account for any added biodegradation or adsorption that will take place as contaminated groundwater moves through relatively organic-rich soil and alluvial deposits in the floodplain adjoining Woodall Creek;

Even when applying these conservative assumptions, the model shows that concentrations beneath the VRP Property meet all Risk Reduction Standards as derived under the VRP. The steady-state plume lengths predicted for the overburden and bedrock are both approximately 900 ft down gradient of the VRP Property. This indicates the post-remediation residual source on the VRP Property is not capable of producing a plume that will reach Woodall Creek at detectable levels.

The calibrated BIOCHLOR models were used to back-calculate source concentrations that would generate detections of PCE at Woodall Creek above surface water criteria (X mg/L). Even with source concentrations indicative of NAPL in the source area (1% of PCE solubility or 1.5 mg/L), do not extend to the creek. This suggests conservative site-specific target levels (SSTL) of 1% of aqueous solubility (1.5 mg/L) for the overburden and for bedrock are appropriate. As current concentrations are significantly below these SSTLs, remedial goals have been met and confirmation monitoring can continue under the VRP, in conjunction with continued implementation of the monitored natural attenuation CAP for the broader Woodall Creek site.

4.6 SENSITIVITY ANALYSIS

Sensitivity analysis seeks to determine which parameter values supplied to the model, when varied slightly, causes the largest changes in model predictions. There is some overlap between the model calibration step and model sensitivity analysis. If a parameter value is attempted to be used in calibration, yet great changes in that value do not affect the model calibration, then that parameter is not particularly sensitive. On the other hand, if small changes to a parameter in calibration make great changes in the model results that is likely a sensitive parameter.

For the BIOCHLOR PCE models, major contributors of variability include source strength, foc and organic carbon partitioning coefficient (which together determine the retardation factor for adsorption/advection), seepage velocity (which drives advection), and degradation constant (which determined degradation rate). The sensitivity analysis involved changing these parameters and comparing the resulting predicted plume length with the calibrated model. The overburden model was used for the sensitivity analysis as historically overburden groundwater has been the driver of plume delineation and response actions.

Foc and retardation factor

Since available site-specific data did not address foc, the model default value was used. As can be seen from the equation defining the retardation factor (BIOCHLOR manual) this parameter has a definite effect on the retardation factor:

$$R = 1 + \frac{K_{oc} * f_{oc} * \rho_b}{n}$$

Where

R is the retardation factor

Koc is PCE organic carbon partitioning coefficient

foc is the fraction organic carbon

ρb is the bulk density

n is the effective porosity

For the sensitivity analysis, the model-default foc value of 0.001 was adjusted an order of magnitude larger and smaller (0.01 and 0.0001). These simulations enable assessment of how the predicted plume changes in length and concentration with changing retardation.

Seepage velocity

Seepage velocity was used as a calibration parameter. During the calibration, it was apparent that changing seepage velocity while holding other parameters constant could change the plume length prediction greatly. However, it is unlikely that the entire modeled area has a single seepage velocity (as assumed by BIOCHLOR) so a sensitivity analysis on seepage velocity is warranted.

As determined in calibration, a seepage velocity of 60 ft/yr gives the smallest RMS error for the first three wells for the values tested. For the sensitivity analysis, the seepage velocity was increased and decreased by a factor of 10 to evaluate resulting changes in plume magnitude.

Degradation constant for PCE to TCE

The calibration process indicates the degradation constant is also a sensitive parameter since small changes in it created relatively large changes in the predicted concentrations along the plume.

As determined in calibration, a degradation constant (lambda) of 1.1 yr^{-1} gives the smallest RMS error for the calibration wells for the values tested. For the sensitivity analysis, the degradation constant was increased and decreased by a factor of 2 to evaluate resulting changes in plume magnitude.

Finally, a bounding case – a source concentration equal to 1% of PCE solubility (1% of 150 mg/L or 1.5 mg/L) was used. This condition is often considered a de facto indication of the presence of NAPL – a condition that may have been present at the site before remediation measures were undertaken but do not appear to be present now.

Source Concentration

The highest measured concentrations in 2015 were used to specify source concentrations in the BIOCHLOR models. This source concentration is constant and is a major determinant of the resulting steady-state plume length. For the sensitivity analysis, the source concentration was set to 1% of aqueous solubility for PCE (1% of 150 mg/L or 1.5 mg/L) to evaluate resulting changes in plume magnitude for the bounding case of NAPL present in the source area. .

Sensitivity Analysis Results and Conclusions

A summary of sensitivity runs and their RMS are included in the following table

Shallow Sensitivity Summary

		Distance in feet from Source								
		0	153	306	459	918	1071	1224	1377	1530
	RMS - first three wells	Concentration of PCE in mg/L								
Nearest field measurement	--	0.133	0.0173	0.0164	0.212	0.178	0.188	0.336	0.226	--
Initial model	0.014	0.133	0.0231	0.0037	0.001	0.000	0.000	0.000	0.000	0.000
seep = 600	0.064	0.133	0.0768	0.0410	0.024	0.007	0.005	0.003	0.002	0.002
seep = 6	0.024	0.133	0.0003	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
seep = 60, foc = 1e-4	0.014	0.133	0.0231	0.0037	0.001	0.000	0.000	0.000	0.000	0.000
seep = 60, foc = 1e-2	0.014	0.133	0.0231	0.0037	0.001	0.000	0.000	0.000	0.000	0.000
seep = 60, lambda = 0 (no degradation)	0.095	0.133	0.0977	0.0663	0.049	0.026	0.021	0.017	0.013	0.010
seep = 60, lambda = 2.2	0.017	0.133	0.010	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Initial model with 1.5 mg/L PCE source	1.389	1.500	0.2610	0.0420	0.007	0.000	0.000	0.000	0.000	0.000

References

BIOCHLOR
Natural Attenuation Decision
Support System
User's Manual
Version 1.0
Carol E. Aziz, Charles J. Newell, James R. Gonzales, Patrick Haas,T. Prabhakar Clement, and Yunwei Sun
Office of Research and Development
United States Environmental Protection Agency
EPA/600/R-00/008
January 2000

BIOCHLOR
Natural Attenuation
Decision Support System
Version 2.2
User's Manual Addendum
Carol E. Aziz, Charles J. Newell, and James R. Gonzales
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