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ENVIRONMENT
& HEALTH

Mr. Mostafa Mehran
Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, Arkansas 72118

Re: Response to ADEQ Correspondence Dated February 29, 2016
Fourth Quarter 2015 Progress Report – January 2016
Whirlpool Corporation
Fort Smith, Arkansas
EPA No. ARD042755389
AFIN No. 66-00048
CAO LIS 13-202-001

Dear Mr. Mehran:

Date April 8, 2016

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Ramboll Environ US Corporation (Ramboll Environ), on behalf of Whirlpool Corporation, is submitting this response to Arkansas Department of Environmental Quality's (ADEQ) February 29, 2016, comment letter on Ramboll Environ's Fourth Quarter 2015 Progress Report dated January 2016 (the ADEQ comment letter was received on March 4, 2016). ADEQ comments are provided in italics below and the respective Whirlpool response follows. We appreciate ADEQ granting the one week extension to respond to these questions. In addition, we have added at the end of this letter further clarification of trichloroethene (TCE) half-life values and the role of these values in the illustrative fate and transport model.

Fourth Quarter 2015 Progress Report

1. **Summary of Findings, Fifth Bullet:**
Whirlpool has done a commendable job estimating the quantity of trichloroethylene (TCE) in the groundwater at the site; however, to date no attempt has been made to estimate the quantity of TCE present sorbed onto or into the soil in the source area and the three plumes. As TCE concentrations in the groundwater are reduced in the source area, sorbed TCE in the soil is then able to dissolve into the groundwater to replenish the groundwater TCE concentration and produce rebound of constituents of concern (COC) concentrations in the source area groundwater. Please provide an estimate for the total TCE remaining in the subsurface at the site. Please provide this estimate in the section titled Quantity of TCE.

   Ramboll Environ Response: As described in Section 3.1 of the "Two Year Technical Review Report" (February 4, 2015) and in the "Response to ADEQ Comments on the Fourth Quarter 2014 Progress Report" (May 2015), the combined estimated quantity of TCE currently adsorbed in

unsaturated and saturated soil and the TCE dissolved in the three groundwater plumes is estimated to range from approximately 20 to 70 gallons based upon investigation and monitoring events at the Site. The combined estimated quantity of TCE ranging from approximately 20 to 70 gallons consists of:

- Six to 26 gallons of TCE in unsaturated soil (source area dimensions adjusted to 250 feet long, 10 feet wide and an average thickness of unsaturated soil of 18.5 feet);
- One to 8 gallons of TCE in saturated soil;
- Eight to 30 gallons of TCE in groundwater in the south plume;
- Less than 1 to 2 gallons of TCE in groundwater in the north plume; and
- Less than 1 gallon of TCE in groundwater in the northeast plume.

Future progress reports will include the estimated combined total quantity of TCE present at the site.

2. **Review of Activities Completed - Fourth Quarter 2015, Third Paragraph, Fourth Bullet:**
Based on the information presented, it is evident that chemical, geochemical and microbial data from the fourth quarter event are similar to the quarterly monitoring events in 2014 and 2015. The data obtained further demonstrates that reductive dechlorination is occurring in various locations both on and offsite and indicates that the primary route for dechlorination is through abiotic degradation. Abiotic degradation has produced relatively minor amounts of TCE daughter products such as cis- 1,2-dichloroethene, vinyl chloride and ethene. Therefore, the rate of degradation is insufficient to remediate the plumes within a reasonable time via the accepted remediation mechanism, monitored natural attenuation (MNA). Please explain how Whirlpool plans to deal with the slow COC degradation rates at the site.

Ramboll Environ Response: The chemical, geochemical and microbial results provide evidence that natural attenuation of TCE is occurring via various mechanisms in many areas of the northern, northeastern and southern plumes. Regression analysis was performed for the data from wells in the north and south plumes to estimate a representative regression slope that characterizes the 'average or representative' rate of reduction in the concentrations. The historical TCE concentration trends at a given location are a function of various factors: Groundwater velocity, flow direction, retardation, concentration distribution, reaction rates, etc. The regression lines were fit to the site data for the respective wells in each plume and the slopes reflect the combined influence of all these site-specific factors.

The average regression slope calculated for the north and south plumes was determined to be -0.15 yr-1. The average regression slope calculated for the source area was -0.04 yr-1. This is a conservative evaluation of the source area since the regression analysis excludes an alternate regression analysis for MW-25 based upon

evaluation of only the last approximate four years of data prior to performance of in-situ chemical oxidation (ISCO). As discussed in the "Response to ADEQ Questions Regarding the Fate and Transport Model" (March 3, 2016), the average regression slope of -0.04 yr-1 is significantly more conservative when compared with the regression slope at MW-25 of -0.67 yr-1 if only the data from November 2010 through May 2014 is evaluated (data immediately prior to performance of ISCO). The regression slope from late 2010 through mid-2014 indicates that significant reductions in TCE concentration trends was occurring at MW-25 prior to ISCO.

The average degradation rate calculated for the north plume based upon regression analysis indicates that the maximum contaminant levels (MCLs) are expected to be achieved within timeframes considered appropriate by USEPA (i.e. 30 to 35 years) and the south plume is anticipated to remain on the Whirlpool property. The fate and transport modeling was performed to illustrate and depict visually these prospective conditions based upon the regression analysis. Supplemental remedial actions will be proposed if future monitoring data unexpectedly indicates that these project conditions and specific objectives for the north and south plumes will not be achieved (see discussion of Action Plan below).

Based upon existing groundwater monitoring data for each of the plumes, we expect the predominant number of wells within these plumes to continue to exhibit stable to decreasing TCE concentration trends. Degradation rates at specific well locations vary and we agree that the average rate may require tens of years to achieve the MCLs for the north plume. We conclude the timeframe to achieve MCLs in the north plume is reasonable based upon:

- USEPA guidance;
- Demonstrated plume stability in a majority of the monitoring wells (see response to Comment 4 for further discussion of plume stability supporting a remedial decision for monitoring natural attenuation);
- Lack of complete exposure pathways regarding the north plume (monitoring is proposed to continue to confirm incomplete exposure pathways);
- Filing of deed restrictions precluding use of shallow groundwater for the north plume;
- Settlements with residential property owners regarding decreases in property values, according to the County appraiser, as a result of the TCE impacts in groundwater; and
- Commitment by Whirlpool to continue appropriate groundwater monitoring at the site with corresponding review and oversight of the monitoring results by ADEQ.

Groundwater monitoring is proposed to continue for all of the plumes (north, south and northeast) to re-affirm on an ongoing basis the plume stability, plume boundaries and future temporal trends compared with historic data. A groundwater monitoring plan will be submitted under separate cover which will include an Action

Plan as requested in the initial ADEQ comments on the "Two Year Technical Review Report." The Action Plan consists of preparation of a work plan for review by ADEQ to implement additional monitoring, investigation and/or supplemental remediation as necessary in the event significant, unexpected changes occur in the groundwater plume boundaries (at any of the three plumes) or other unanticipated changed groundwater conditions give rise to potential human health risks associated with a complete exposure pathway that presently does not exist. The Action Plan is triggered in the event that plume expansion is confirmed by increasing constituent concentrations at a boundary well location exceeding the removal action levels (RALs) during two consecutive monitoring events; or other unanticipated changed condition that occurs during two consecutive monitoring events that may cause potential human health risks associated with a newly complete exposure pathway.

Attachment A: Fourth Quarter 2015 Groundwater Monitoring Report

3. **3.1 Hydrogeology, Shallow Monitoring Wells, Second Paragraph, First Bullet:** *Please include numerical value for the downward vertical gradient at well grouping MW-178/MW-83.*

   Ramboll Environ Response: The first bullet of the second paragraph as noted in the comments could be revised as follows:

   - Downward vertical gradient (-0.38 feet/foot) at the western well grouping MW-178/MW-83;

   This information is also provided on Table 5 and Figure 1B of Attachment A.

4. **3.3.2 Monitored Natural Attenuation Results, Third Paragraph:** *This section of the report cites the United States Environmental Protection Agency (USEPA) documents "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater" (USEPA, 1998) and "An Approach for Evaluating the Progress of Natural Attenuation in Groundwater" (USEPA, 2011). These reports recognize three lines of evidence used to establish MNA as a viable remediation method:*

   First, historical groundwater and/or soil chemistry data clearly demonstrate a trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring points.

   Historical groundwater data from the site does indicate a majority of monitoring wells display decreasing mass and/or concentrations over time. However, the historical data also indicates the presence of six (6) wells in the northern plume and two (2) wells in the southern plume which continue to display increases in contaminant concentrations.

   Ramboll Environ Response: The referenced documents and the original Office of Solid Waste and Emergency Response (USEPA) (OSWER) Directive 9200.4-17 (1997) (referenced in the "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater") indicate that historical data demonstrating

decreasing concentration trends is sufficient to support a decision for monitored natural attenuation (MNA). The other two supplemental criteria including rates of natural attenuation and microcosm studies are explicitly not necessary if the historical data suggests a "majority of the monitoring wells display decreasing mass and/or concentrations over time;" although these supplemental criteria help support a "weight of evidence" conclusion regarding the appropriateness of the MNA remedy. We conclude the TCE concentrations in a predominant number of wells in each plume indicate that either little to no TCE exists or a stable or decreasing statistical concentration trend exists.

As of the fourth quarter of 2015, 86% of the wells in the northern plume and 89% of the wells in the southern plume indicate little to no TCE or a stable or decreasing statistical trend. Of the few wells which do indicate an increasing statistical trend for the north plume:

- MW-56R had maintained somewhat stable TCE concentrations including a high of 590 micrograms per liter (µg/L) in October 2013 to a first quarter 2016 result of 408 µg/L;
- MW-61R TCE concentrations have decreased from a high of 16.5 µg/L in September 2015 to 3.9 µg/L in the first quarter of 2016;
- MW-66 has TCE concentrations that are fairly stable, ranging from a high of 3.5 µg/L in March 2014 to a three year low of 0.53 µg/L in the first quarter of 2016;
- MW-67R has mainly had TCE concentrations that were at non-detect levels, with three current quarters (July 2015 through January 2016) of non-detected values;
- MW-55 has shown continued decrease in TCE concentration since 2013 (13 µg/L). The current concentration in the first quarter of 2016 is 0.26 µg/L; and
- MW-57 appears to be stabilizing with TCE concentrations ranging from 400 to 422 in the time period of July 2015 through January 2016.

And for the south plume located on the Whirlpool property:

- MW-38 is a source area well with a high TCE concentration of 6,970 µg/L in October of 2014 and since that time concentrations have fluctuated as would be expected given the in-situ chemical oxidation (ISCO) injections in this area but TCE concentrations have decreased overall with a current first quarter concentration of 3,680 µg/L.
- ITMW-6 TCE concentrations have been primarily non-detect at less than 5 µg/L and when detections have been reported, they have ranged from 2.7 to 4.7 µg/L over the time period of October 2013 through January 2016. The current TCE concentration for the first quarter of 2016 is 4.2 µg/L.
- ITMW-10 will continue to be monitored regarding increasing TCE trends.

We conclude based upon the statistical trend analysis performed quarterly in 2014 and 2015 and based upon the regression analysis that the vast majority of the monitoring wells display decreasing TCE mass and/or concentrations over time in the north and south plumes in accordance with the OSWER Directive for MNA and USEPA documents "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater" (USEPA, 1998) and "An Approach for Evaluating the Progress of Natural Attenuation in Groundwater" (USEPA, 2011) that MNA is not only viable by appropriate for the site.

Second, hydrogeologic and geochemical data that can be used to establish indirectly the type(s) of natural attenuation processes occurring at the site and at the rate at which the processes will reduce contaminant concentrations to the cleanup goal.

Hydrogeologic and geochemical data establish the primary natural attenuation process at the site to be abiotic degradation which will not reduce contaminant concentrations to the cleanup goal in a reasonable time frame. The calculated half-lives for TCE concentrations, especially in the northern plume, are on the order of years to ten(s) of years as opposed to days.

Ramboll Environ Response: Regression analysis was performed for the data from wells in the north and south plumes to estimate a representative slope that characterizes the 'average or representative' rate of reduction in the concentrations so that the representative slope can be used to determine a TCE degradation rate constant or half-life. The TCE chemical reaction process half-life used for the model in the northern plume is 110 days whereas the observed half-life value (output from the model) is based upon a resulting modeled future TCE concentration degradation rate/slope of -0.14 yr. -1, which corresponds to an observed half-life value of approximately of 1,800 days. These half-life values (chemical reaction process half-life and observed half-life) in the illustrative model project a time frame of 30 to 35 years to achieve the MCLs for the north plume; therefore, we agree the TCE observed half-life value is on the order of years. Further discussion of TCE half-life values is provided at the end of this letter.

Third, data from field or microcosm studies which directly demonstrate the occurrence of a specific natural attenuation process at the site and its capacity to degrade the contaminants of concern.

Data from the field demonstrates abiotic degradation is occurring over most of the site. Although this abiotic degradation has the capacity to degrade the contaminants of concern, the rate of degradation is insufficient to degrade the COCs in a timely manner sufficient for MNA to be considered a valid remediation method.

Please include a discussion explaining how Whirlpool plans to deal with the slow COC degradation rates at the site and how this slow degradation rates effect plume stability.

Ramboll Environ Response: Microcosms of various natural attenuation processes are present at the site to support the third line of evidence to establish MNA as a

viable remedial alternative. For example, 17 wells were identified with dehalococcoides (DHC) concentrations detected at concentrations greater than 30 cells/milliliter (mL) at any time during the past two years. The presence of DHC demonstrates microcosms of biological activity (capable of degrading TCE) are present at certain locations.

Management of slow degradation rates is discussed in the response to Comment 2. Plume instability has not been indicated based upon the monitoring performed to date based upon the predominant number of wells exhibiting little to no TCE or a stable or decreasing statistical trend. Consistent with the response regarding slow degradation rates in Comment 2, groundwater monitoring will continue for the north, south and northeast plumes to confirm on an ongoing basis plume stability, plume boundaries and future temporal trends and the Action Plan will be implemented if plume expansion occurs.

5. **3.3.2.1 Chemical Lines of Evidence, Second Paragraph:**
Abiotic reductive dechlorination is capable of eventually completely degrading the chlorinated ethenes; however, an excessive length of time would be required. Please include a discussion explaining how Whirlpool plans to deal with the slow COC degradation rates at the site.

   Ramboll Environ Response to Comment #5: The plan for management of slow degradation rates is discussed in the response to Comment 2.

6. **3.3.2.3 Microbial Lines of Evidence, Last paragraph, Last Sentence:**
The report states that the lower levels of reductive dechlorination are likely due to low levels of Total Organic Carbon (TOC) and elevated Dissolved Oxygen (DO) levels in the groundwater. Please explain how Whirlpool plans to deal with the low levels of TOC and elevated DO levels in the groundwater which inhibits bio-reductive dechlorination.

   Ramboll Environ Response to Comments #6: As discussed above, microcosms of biological activity are present in the north, south and northeast plumes. Although low levels of TOC or elevated DO levels may exist in groundwater inhibiting biodegradation in certain locations, other chemical, geochemical as well as microbial natural attenuation processes will be relied upon to continue to demonstrate continued results providing strong evidence that natural attenuation of VOCs is occurring in the plumes. Consistent with previous responses to comments regarding slow degradation rates which may be attributable to low levels of TOC and elevated DO levels, groundwater monitoring will continue for the north, south and northeast plumes to assess plume stability, plume boundaries and future temporal trends and the Action Plan will be implemented if plume expansion occurs.

7. **4.1.1 Statistical Analysis of Temporal Trends, Sixth Paragraph, First Bullet (Northern Plume Wells), Third Paragraph, Last Sentence:**
Of the six wells with increasing trends in the northern plume, three are located to the extreme northeast at the leading edge of the plume. One is located at the northern lateral edge of the plume and two are located along the centerline of the plume closer to the leading edge than to the source area. Please include a discussion referencing the locations of the wells with increasing trends and their impact on the determination of plume stability.

   Ramboll Environ Response: The temporal trends for these six wells in the northern plume are discussed in the response to Comment 4.

   The monitoring well at the northern lateral edge of the northern plume is MW-61R. Since September 2015 TCE concentrations have decreased from a high of 16.5 µg/L to 3.9 µg/L in the first quarter of 2016. The in-situ chemical reduction (ISCR) injection activities have continued to decrease TCE concentration in this area, therefore proving a positive impact on plume stability and reducing TCE concentrations at MW-61R to less than the MCL.

   The other two wells referenced in the comment are MW-56R and MW-57. The current concentration of TCE at MW-56R (408 µg/L in the first quarter of 2016) has decreased from a high of 590 µg/L in October 2013. Concentrations of TCE at MW-57 appear to be stabilizing with concentrations over the last three quarters (third and fourth quarters of 2015 and first quarter of 2016) as 409, 400 and 422 µg/L. Since MW-61R at the northern lateral edge of the plume is below the MCL and the other two wells (MW-56R and MW-57) include TCE concentrations that are less than historic maximums or appear to be stabilizing and both wells are located more than 450 feet from the plume boundary; therefore, plume stability is not currently threatened based upon the data from these three wells.

   In addition and consistent with previous comments, groundwater monitoring will continue to assess plume stability and the Action Plan will be implemented if plume expansion occurs.

8. **4.1.1 Statistical Analysis of Temporal Trends, Sixth Paragraph, Third Bullet (Southern Plume Wells), First Paragraph, Third (-), Last Sentence:**
The report states that two source area wells (MW-85 and MW-86) displayed dramatic increases in TCE concentration from July 2015 to October 2015. These increases in TCE concentration appear to be the result of rebound following ISCO treatments of the area.

   Please include a discussion explaining the effect a continuing source area of elevated TCE concentrations will have on the stability of the southern plume.

   Ramboll Environ Response: As discussed in the June 29, 2015, letter submitted to ADEQ titled “Methods for Assessment of Constituent Concentration Rebound” by Ramboll Environ, rebound is an expected condition and is known to be a common occurrence when using ISCO as a source area remedy. A rebound condition does not necessarily mean that the ISCO injection event has failed. Rebound can be an

indication of the positive effects of the transfer of contaminants to the more treatable aqueous phase.

It is premature to assess rebound in any of the source area wells noted by ADEQ given that groundwater conditions have not yet stabilized (sodium persulfate concentrations, contaminant concentrations and certain field parameters have not stabilized to within a range of variability of 10% or less over three consecutive monitoring events) in source area wells MW-85, MW-86, ITMW-11 and MW-25. Stabilization is a key component of the "Methods for Assessment of Constituent Concentration Rebound."

The source area and south plume monitoring well data have been included in the statistical trend analysis, regression analysis and the illustrative fate and transport model. The statistical analysis indicates a majority of the TCE concentration trends are stable to decreasing; and therefore, no effects from an area exhibiting higher TCE concentrations or a source area are expected to impact the stability of the plume. Consistent with previous responses, groundwater monitoring will continue to assess plume stability, and the Action Plan will be implemented if plume expansion occurs.

Attachment C: Fourth Quarter 2015 Oxidant Injection Summary Report

9. **General Comment:**
Area I (Source Area) was not included as a treatment area during the 4th phase of ISCO injections. Monitoring wells MW-85, MW-86, ITMW-11 and MW-25 appear to show rebound following the third ISCO treatment. Please add a section describing any rebound observed in the source area (Area 1), neck area, or Area 2 and 3 wells.

Additionally, in June 2015 Whirlpool submitted a report titled "Methods for Assessment of Constituent Concentration Rebound". At that time it was decided that a discussion of the method for assessing rebound would be addressed at the two year review. Please include a discussion summarizing the methodology Whirlpool would propose to use to determine when additional ISCO treatments are required based on COC rebound.

Ramboll Environ Response: It is premature to assess rebound in any of the source area wells noted by ADEQ given that groundwater conditions have not yet stabilized as discussed in the response to Comment 8.

We will add a discussion regarding rebound in constituent concentrations in groundwater observed in future progress reports. However in terms of Area 1 and the source area, although it is premature to assess rebound and TCE concentrations increased in October 2015 over those observed in July 2015, the concentrations do not represent rebound (except at well MW-85) as explained/defined in our June 2015 letter as illustrated in the following table.

Well ID	TCE (µg/L)			
	Pre-ISCO Baseline	One Year Post ISCO	Lowest Post ISCO	
ITMW-11	19,000	721	0.5	0.04
MW-25	270,000	68,700	2,510	0.25
MW-85	5,820	12,000	132	**2.04**
MW-86	533,000	131,000	46700	0.16

$$\frac{\text{One year post ISCO} - \text{lowest post ISCO}}{\text{Pre-ISCO baseline}} \geq 0.25$$

The pre-ISCO treatment concentration of TCE in well MW-85 was very low (5,820 µg/L) as compared to other source area wells even though MW-85 is in close proximity to MW-25 and MW-86; therefore it appears that the ISCO treatment in the area has liberated TCE bound to the surrounding soil into the aqueous phase. As stated above in our response to Comment 8, rebounding fluctuations in TCE concentration in the groundwater can be viewed as a positive effect due to contaminants being much more treatable in the aqueous phase.

The "Fourth Quarter 2015 Oxidant Injection Summary Report" described increases in TCE concentrations as rebound in the neck area and Areas 2 and 3 in the Summary Section (Page 9). Specifically the report indicated, "Minimal rebound in TCE concentrations was observed over the fourth injection event period and were observed in MW-24 (fourth injection event and since May 2014) at the Supplemental Neck Area and in IW-77 at Areas 2 and 3." Actual rebound has not occurred in Areas 2 and 3 and the neck area (excluding MW-24); however, TCE concentrations in select wells increased during the fourth quarter of 2015 (the TCE concentration in groundwater at MW-24 was 84.1 µg/L in December 2015 and was 79.7 µg/L in May 2014; even though, these concentrations are essentially the same). The TCE concentration in MW-24 in January 2016 is 49.3 µg/L.

Consistent with previous responses, groundwater monitoring will continue to assess plume stability, plume boundaries and future temporal trends which we expect to continue to exhibit stable to decreasing trends based upon the existing groundwater monitoring data base and the ISCO and ISCR efforts performed to date. The Action Plan is triggered in the event that unanticipated changed conditions are confirmed during two consecutive monitoring events that may cause potential human health risks associated with a complete exposure pathway (the Action Plan also addresses plume stability and boundary conditions as noted in previous responses).

Attachment D: Fourth Quarter 2015 In-Situ Chemical Reduction Pilot Study Report

10. **Section 5.3 Field Water Quality Parameters, First Paragraph, Fifth Bullet:** *Ferrous iron results are not included in Table 2. Please revise Table 2 to include ferrous iron results.*

    Ramboll Environ Response: Ferrous iron data has been included in the attached revised Table 2.

Discussion of Observed Half-Life and Chemical Reaction Process Half-Life Values

The following provides clarification for the observed half-life and chemical reaction process half-life values used in the *Two Year Technical Review Report*. We believe there may be some confusion here, and we acknowledge the *Two Year Technical Review Report* and other submittals may not have been sufficiently clear on this point. The observed half-life value describes the overall rate of change in TCE concentrations which includes the influence of all fate and transport processes or mechanisms. The chemical reaction process half-life is specific only to the chemical transformation of TCE in the dissolved phase and excludes consideration of all other fate and transport processes. Those other processes considered in the observed half-life value must be taken into account in order to determine historical and projected TCE degradation rates.

Observed Half-life

The observed half-life reflects the combined effect of all fate and transport processes affecting TCE concentrations (advection, sorption, dispersion, biodegradation, etc.). This reflects the fact that certain processes will be removing contaminant mass and other processes may be simultaneously adding contaminant mass. The observed half-life describes the resultant trend from these processes and can be calculated based upon the following formula:

$$\text{Observed Half-life} = \text{LN}(2)/\text{slope}$$

The “slope” in the above formula is the regression slope value (i.e. attenuation rate) of a constituent as measured at site. In the instance of the Fort Smith site, for the north plume, the average regression slope value for TCE (i.e. attenuation rate) was determined to be 0.15 yr-1. Using the formula from above, this corresponds to an observed half-life of 4.6 years or roughly 1,700 days.

Chemical Reaction Process Half-life

The chemical reaction process half-life value only addresses the rate of degradation of TCE in the dissolved phase. As dissolved TCE concentrations in groundwater are reduced by natural attenuation processes, the model reflects that additional TCE will continue to be released into groundwater to maintain equilibrium between the sorbed and dissolved phases

of TCE. The mass of sorbed TCE effectively acts as a reservoir that releases TCE into solution to maintain equilibrium with the dissolved phase.

The chemical reaction process half-life value is determined through an iterative process such that the future overall decay rate of the plume matches the calculated historical trend determined from the regression-based trend analysis (see *Fate and Transport Model Inputs* submitted February 25, 2106). The chemical reaction process half-life value in the model was adjusted (as is customary and necessary) until the projected trend (i.e. slope of trend line fit to model results) at the representative location (MW-46R) matched the average, historical regression trend. The best fit to historical trends for the north plume was observed when setting the chemical reaction process half-life value to 110 days. The slope of trend line fit to the model results (i.e. projected trend) indicates a slope value of -0.14 yr-1 calculated as an observed TCE half-life value of approximately 1,800 days (i.e. observed half-life = LN (2)/slope). This chemical reaction process half-life value was applied throughout the model domain, so the modelled attenuation rates are matched to the overall trend, but do not necessarily incorporate local variability. This approach is best suited to illustrating the fate of the entire plume over time. There will, of course be some variability in future trends at individual locations; that is axiomatic in groundwater plumes of this nature in this environmental setting. The foregoing approach was followed for the south plume as discussed in the “Two Year Technical Review Report.”

It is important to emphasize that the chemical reaction process half-life value of 110 days for the north plume does not reflect the continual regeneration of dissolved TCE from the equilibrium reaction and thus appears rapid relative to the observed half-life value of 1,700 days, which incorporates all processes including desorption.

For the north plume, the 30 to 35 year timeframe to achieve the MCLs is based upon the TCE observed half-life value of 1,700 days based upon regression analysis of the historical data and is supported by the TCE observed half-life value of 1,800 days from the illustrative model based upon the projected TCE concentration trends.

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We appreciate this continuing effort to come to a shared understanding of the technical issues presented in the “Two Year Technical Review Report.” We hope this is responsive to the Department’s comments and we look forward to our next opportunity to discuss with ADEQ any further technical issues regarding the “Two Year Technical Review Report” or the model.

Yours sincerely,

Michael F. Ellis, PE
Principal

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LIST OF ATTACHMENTS

Table 2: Summary of Monitoring Well Groundwater Sample Analytical Results

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TABLE

TABLE 2
SUMMARY OF MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
Whirlpool Facility - Fort Smith, Arkansas

Location	Remedial Action Levels per ADEQ RADD Issued Dec 2013	MW-61R	MW-61R	MW-61R	MW-61R	MW-61R	MW-61R	TMW-10	TMW-10	TMW-10	TMW-10	TMW-11	TMW-11	TMW-11	TMW-11
ENVIRON Sample ID		MW-61R-201507	MW-61R-GW-091815	MW-61R-201510	DUP-02-201510	MW-61R-201511	MW-61R-201512	TMW-10-GW-091815	TMW-10-201510	TMW-10-201511	TMW-10-201512	TMW-11-GW-091815	TMW-11-201510	TMW-11-201511	TMW-11-201512
Lab Sample ID(s)		60198937025, 161940005, 057MG030	60203213003, 167200003	60204767001, 169690006, 169980020, 086MJ09	60204767002	60206665003	60208468003	60203213002, 167200002	60204791002	60206665001	60208468001	60203213001, 167200001	60204791001	60206665002	60208468002
Sample Date		7/21/2015	09/18/2015	10/08/2015	10/08/2015	11/04/2015	12/1/2015	09/18/2015	10/08/2015	11/04/2015	12/1/2015	09/18/2015	10/08/2015	11/04/2015	12/1/2015
Sample Method		Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow	Low Flow
Comments					Field Duplicate										
Volatile Organic Compounds															
Acetone	12000	U (1.9)	U (1.9)	U (1.9)	U (1.9)	58.1 (1.9)	148 (1.9)	U (1.9)	3.4 J (1.9)	8.4 J (1.9)	2.0 J (1.9)	U (1.9)	104 (1.9)	636 (1.9)	1420 (9.4)
Benzene	5.0	U (0.060)	U (0.060)	0.099 J (0.060)	0.11 J (0.060)	U (0.060)	0.10 J (0.060)	U (0.060)	U (0.060)	U (0.060)	U (0.060)	U (0.060)	0.27 J (0.060)	U (0.060)	0.15 J (0.060)
Bromodichloromethane	80	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)	U (0.19)
Bromoform	80	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)	U (0.070)
Bromomethane	7.0	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	1.8 J (0.16)	U (0.16)
2-Butanone	4900	U (0.59)	U (0.59)	243 (0.59)	269 (0.59)	155 (0.59)	233 (0.59)	U (0.59)	3.6 J (0.59)	8.6 J (0.59)	U (0.59)	U (0.59)	135 (0.59)	810 (0.59)	1410 (3.0)
Carbon Disulfide	720	U (0.12)	U (0.12)	0.34 J (0.12)	0.59 J (0.12)	0.49 J (0.12)	0.27 J (0.12)	U (0.12)	U (0.12)	0.31 J (0.12)	U (0.12)	U (0.12)	0.92 J (0.12)	2.6 J (0.12)	0.38 J (0.12)
Carbon Tetrachloride	5	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)
Chlorobenzene	100	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)
Chloroethane	12000	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	0.48 J (0.15)
Chloroform	80	0.45 J (0.14)	0.18 J (0.14)	0.20 J (0.14)	0.26 J (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)
Chloromethane	190	U (0.080)	U (0.080)	U (0.080)	U (0.080)	U (0.080)	0.52 J (0.080)	U (0.080)	U (0.080)	U (0.080)	0.29 J (0.080)	U (0.080)	U (0.080)	U (0.080)	0.46 J (0.080)
Dibromochloromethane	80	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)	U (0.21)
1,1-Dichloroethane	2.4	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)	U (0.050)
1,2-Dichloroethane	5.0	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)
1,1-Dichloroethene	7.0	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	0.26 J (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)
cis-1,2-Dichloroethene	70	U (0.080)	U (0.080)	U (0.080)	U (0.080)	1.1 (0.080)	4.6 (0.080)	1.9 (0.080)	1.1 (0.080)	0.72 J (0.080)	0.88 J (0.080)	0.15 J (0.080)	U (0.080)	2.5 (0.080)	5.8 (0.080)
trans-1,2-Dichloroethene	100	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	0.36 J (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	0.64 J (0.20)
1,2-Dichloropropane	5.0	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)	U (0.16)
1,3-Dichloropropene (total)	0.41	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	NM	U (0.14)	U (0.14)	U (0.14)	NM	U (0.14)	U (0.14)	U (0.14)	NM
cis-1,3-Dichloropropene	NE	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)	U (0.14)
trans-1,3-Dichloropropene	NE	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)
Ethyl Benzene	700	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)	U (0.18)
2-Hexanone	34	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	U (1.2)	3.6 J (1.2)	5.3 J (1.2)
4-Methyl-2-pentanone	1000	U (0.42)	U (0.42)	1.5 J (0.42)	1.5 J (0.42)	U (0.42)	0.61 J (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	4.0 J (0.42)	2.0 J (0.42)	1.6 J (0.42)
Methylene Chloride	5.0	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	0.26 J (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	0.66 (0.15)	U (0.15)	0.30 J (0.15)
Styrene	100	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)	U (0.12)
1,1,2,2-Tetrachloroethane	0.066	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)	U (0.15)
Tetrachloroethene	5.0	U (0.10)	U (0.10)	U (0.10)	U (0.10)	U (0.10)	0.16 J (0.10)	U (0.10)	U (0.10)	U (0.10)	U (0.10)	U (0.10)	U (0.10)	U (0.10)	U (0.10)
Toluene	1000	U (0.17)	U (0.17)	0.22 J (0.17)	0.32 J (0.17)	U (0.17)	0.46 J (0.17)	U (0.17)	U (0.17)	U (0.17)	U (0.17)	U (0.17)	0.46 J (0.17)	U (0.17)	0.57 J (0.17)
1,1,1-Trichloroethane	200	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)	U (0.11)
1,1,2-Trichloroethane	5.0	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)	U (0.20)
Trichloroethene	5.0	14.7 (0.17)	16.5 (0.17)	11.7 (0.17)	13.3 (0.17)	9.2 (0.17)	5.0 (0.17)	190 (0.17)	102 (0.17)	120 (0.17)	114 (0.17)	31.1 (0.17)	14.3 (0.17)	6.3 (0.17)	0.63 J (0.17)
Vinyl Chloride	2.0	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)	U (0.13)
Xylenes (total)	10000	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)	U (0.42)
Metals															
Iron	NE	3790 (50.0)	4110 (50.0)	74000 (50.0)	NM	NM	52400 (50.0)	755 (50.0)	NM	NM	1730 (50.0)	5220 (50.0)	NM	NM	193000 (50.0)
Manganese	NE	1480 (5.0)	NM	20000 (5.0)	NM	NM	6320 (5.0)	NM	NM	NM	37.4 (5.0)	NM	NM	NM	35900 (50.0)
Monitored Natural Attenuation Parameters															
Acetic acid	NE	U (5000)	U (5000)	1800000 (100000)	NM	NM	13000 (5000)	U (5000)	NM	NM	U (5000)	U (5000)	NM	NM	1600000 (25000)
Acetylene	NE	U (0.50)	NM	U (0.50)	NM	NM	U (0.50)	NM	NM	NM	U (0.50)	NM	NM	NM	U (0.50)
Total Alkalinity	NE	124000 (20000)	NM	1190000 (40000)	NM	NM	862000 (20000)	NM	NM	NM	154000 (20000)	NM	NM	NM	2630000 (60000)
Ammonia	NE	U (100)	NM	8100 (500)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Bicarbonate Alkalinity	NE	124000 (20000)	NM	1190000 (40000)	NM	NM	862000 (20000)	NM	NM	NM	154000 (20000)	NM	NM	NM	2630000 (60000)
Butyric acid	NE	U (5000)	U (5000)	280000 (100000)	NM	NM	U (5000)	U (5000)	NM	NM	U (5000)	U (5000)	NM	NM	600000 (25000)
Carbon Dioxide	NE	265000 (20000)	NM	8230000 (20000)	NM	NM	1000000 (20000)	NM	NM	NM	294000 (20000)	NM	NM	NM	3270000 (20000)
Organic Carbon (total)	NE	U (1000)	U (1000)	1620000 (200000)	NM	NM	NM	U (1000)	NM	NM	NM	U (1000)	NM	NM	NM
Carbonate Alkalinity	NE	U (20000)	NM	U (40000)	NM	NM	U (20000)	NM	NM	NM	U (20000)	NM	NM	NM	U (60000)
Chloride	NE	110000 (10000)	108000 (10000)	130000 (20000)	NM	NM	NM	177000 (10000)	NM	NM	NM	149000 (10000)	NM	NM	NM
2-Chloroethanol	NE	U (10000)	U (10000)	U (10000)	NM	NM	NM	U (10000)	NM	NM	NM	U (10000)	NM	NM	NM
Iron, Ferric	NE	2000 (200)	4100 (200)	70700 (200)	NM	NM	NM	760 (200)	NM	NM	NM	5200 (200)	NM	NM	NM
Iron, Ferrous	NE	1.8	ND	>3.3	NM	>3.3	2.8	ND	>3.3	ND	1.4	ND	3.0	>3.3	4.4
Lactic Acid	NE	U (10000)	U (10000)	U (20000)	NM	NM	U (10000)	U (10000)	NM	NM	U (10000)	U (10000)	NM	NM	160000 (10000)
Nitrogen	NE	1300 M1 (100)	1400 (100)	110 (100)	NM	NM	NM	280 (100)	NM	NM	NM	U (100)	NM	NM	NM
Nitrogen, Nitrate (As N)	NE	1300 (100)	1400 (100)	110 (100)	NM	NM	U (1000)	280 (100)	NM	NM	1900 (1000)	U (100)	NM	NM	U (1000)
Nitrogen, Nitrite	NE	U (100)	U (100)	U (100)	NM	NM	U (1000)	U (100)	NM	NM	U (1000)	U (100)	NM	NM	U (1000)
pH [PH UNITS]	NE	6.2 (0.10)	NM	5.5 (0.10)	NM	NM	6.8 (0.10)	NM	NM	NM	6.3 (0.10)	NM	NM	NM	6.7 (0.10)
Phosphates (total)	NE	130 M1 (30)	NM	3600 (310)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Propionic Acid	NE	U (5000)	U (5000)	140000 (100000)	NM	NM	76000 (5000)	U (5000)	NM	NM	U (5000)	U (5000)	NM	NM	550000 (25000)
Pyruvic Acid	NE	U (5000)	U (5000)	U (10000)	NM	NM	U (5000)	U (5000)	NM	NM	U (5000)	U (5000)	NM	NM	U (5000)
Sulfide (total)	NE	U (50)	NM	21 J (50)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Sulfate	NE	14800 (1000)	11000 (1000)	79000 (5000)	NM	NM	7400 (1000)	2100 (1000)	NM	NM	3700 (1000)	3300 (1000)	NM	NM	910 J (1000)
Organic Carbon (dissolved)	NE	NM	U (1000)	NM	NM	NM	NM	U (1000)	NM	NM	NM	U (1000)	NM	NM	NM
Gases															
Methane	NE	4.5 (0.50)	2.1 (0.50)	4.3 (0.50)	NM	NM	10000 (0.50)	U (0.50)	NM	NM	1.3 (0.50)	0.57 (0.50)	NM	NM	12000 (0.50)
Ethane	NE	1.4 (0.10)	0.31 (0.10)	0.33 (0.10)	NM	NM	0.41 (0.10)	U (0.10)	NM	NM	U (0.10)	U (0.10)	NM	NM	0.16 (0.10)
Ethene	NE	1.1 (0.10)	0.48 (0.10)	1.2 (0.10)	NM	NM	2.7 (0.10)	U (0.10)	NM	NM	U (0.10)	U (0.10)	NM	NM	2.6 (0.10)
HYDROGEN (H2) [nM]	NE	2.0 (0.60)	NM	500 d (12)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Molecular Analyses															
3AV1 Vinyl Chloride Reductase [cells/mL]	NE	U (0.5)	NM	1.9 (1)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Dehalococcoides (DHC) [cells/mL]	NE	U (0.5)	NM	184 (1)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
tceA Reductase [cells/mL]	NE	U (0.5)	NM	U (1)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
inyl Chloride Reductase (vrcA) [cells/mL]	NE	U (0.5)	NM	0.3 J (1)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM

Notes:

1 All concentrations are presented in ug/L except where noted.
2 Only compounds with at least one detection are shown, with the exception of Monitored Natural Attenuation Parameters, for which all compounds are shown.
3 Concentrations that exceed the Remedial Action Levels per ADEQ RADD Issued Dec 2013 are double underlined.
U = Not detected
J = Estimated concentration
d = The analyte concentration was determined from a dilution.
( ) = Method detection limit for VOCs; reporting limit for all other parameters
* = Sampled on different day than other parameters with different method
RADD = Remedial action decision document
ADEQ = Arkansas Department of Environmental Quality
VOC = Volatile organic compounds
µg/L = Micrograms per Liter
mL = Milliliters
NE = Not established
NM = Not measured

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