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ENVIRONMENT
& HEALTH

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

RE: Methods for Assessment of Constituent Concentration Rebound
Whirlpool Corporation
Fort Smith, Arkansas
EPA No. ARD042755389
AFIN No. 66-00048
CAO LIS 13-202

Dear Mr. Mehran:

Date June 29, 2015

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Ramboll Environ US Corporation (Ramboll Environ), on behalf of Whirlpool Corporation (Whirlpool), is submitting this letter to describe the methods proposed for assessment of rebound for constituents of concern (COCs) in groundwater following prior discussions with the Arkansas Department of Environmental Quality (ADEQ) concerning rebound. Although the potential occurrence of rebound has been previously discussed, to date no clear method for rebound assessment has been presented to the ADEQ for review. As described in more detail below, we are proposing an accepted method for rebound assessment for use at the Whirlpool site to reach closure on this issue.

Rebound is a term used when concentrations of a COC in groundwater are observed to decrease following the implementation of a remediation technology and then increase at a later time. Rebound may be the result of back diffusion of COCs out of low permeability media; incomplete treatment of sorbed trichloroethene (TCE) followed by re-equilibration with the aqueous phase; or other processes[1].

Rebound is an expected condition for the site and a common occurrence when using in-situ chemical oxidation (ISCO) as a source remedy. A rebound condition, if one may occur, is not synonymous with failure of an ISCO injection event or the remedy in general. In fact, rebound is an indication of the positive effects of the transfer of contaminants to the more treatable aqueous phase. The use of ISCO should be viewed as an ongoing, iterative process (adaptive remedy) that will take advantage of

[1] ISCO for Groundwater Remediation: Analysis of Field Applications and Performance; Krembs, Siegrist, Crimi, Furrer and Petri; Groundwater Monitoring and Remediation 30, No. 4, Fall 2010, pages 42–53(Peer reviewed reference).

contaminant rebound rather than view it as an indication that the technology was inappropriate or ineffective. The original work plan (July 2013); December 2013 Remedial Action Decision Document (RADD); February 2014 Adaptive Remedy Work Plan; and the September 2014 Supplement to the February 2014 Final Remedy Work Plan, Area 1 Work Plan for the Whirlpool site all considered sequential ISCO treatments to address remedy effectiveness, including rebound. The installation of permanent injection wells as outlined in ADEQ approved work plans and 2013 RADD allow for efficient, multiple deployments of additional oxidant in the defined treatment areas when warranted.

The potential for rebound should only be assessed over a suitable period of time after the oxidant injection has taken place in the target treatment areas. Prior to assessing rebound conditions, contaminant concentrations, oxidant concentrations and field parameters must stabilize to within a range of variability of 10% or less over three consecutive monitoring events post oxidant injection before assessing rebound conditions[2]. If rebound is assessed prematurely incorrect conclusions and recommendations could result.

Groundwater conditions at the Whirlpool Site have not stabilized in all treatment areas to facilitate proper assessment of rebound in treatment areas. Persulfate concentrations and pH measurements indicate the oxidant is active in several locations (see attached tables depicting current oxidant concentrations – April 2015 data).

We propose that rebound at a specific monitoring well be assessed after groundwater conditions stabilize based upon whether or not the increase in the concentration of total COCs in groundwater during the post-ISCO monitoring period was greater than 25% of the pre-ISCO baseline value. This is consistent with the treatise referenced earlier. We further propose the following calculation as the basis for assessment of rebound at the Whirlpool site.

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

- Pre ISCO baseline: Highest pre-ISCO groundwater monitoring results collected prior to ISCO implementation.
- Lowest post ISCO: Lowest recorded total COC concentration in groundwater collected within one year after the end of ISCO application.
- One year post ISCO: Is a groundwater monitoring result reported from approximately one year after the end of reagent delivery.

As stated in the 2013 RADD, the goal of ISCO is to significantly reduce the TCE concentrations in groundwater to allow monitored natural attenuation (MNA) to be effective. Peer reviewed literature documents the median reduction in total chloroethene concentrations in groundwater to range from 60% to 80% as a result of ISCO to deplete

[2] In-Situ Chemical Oxidation, Chlorinated Solvent Source Zone Remediation, B.H. Kueper, Chapter 9, 2014.

source areas[3]. To date the reduction of TCE concentrations in source area wells MW-25, MW-85 and MW-86 is currently greater than 80% demonstrating a highly successful ISCO event at the source area (January 2015 data). Oxidant is still present at the source and other treatment areas based upon preliminary April 2015 field data; therefore, further treatment may yet occur. Assessment of TCE concentration reductions in the source area, remedy effectiveness and rebound will continue.

We look forward to ADEQ's review of our proposed assessment of rebound conditions. Additional correspondence will follow discussing other issues of concern to ADEQ. If you have any further questions or comments, please feel free to contact me.

Yours sincerely,

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Principal

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[3] Chlorinated Ethene Source Remediation: Lessons Learned (Environmental Science & Technology, Stroo, et. al., May 2012)

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TABLES

TABLE 1
SUMMARY OF TCE CONCENTRATIONS (AREA 1)
SEPTEMBER 2014 - JANUARY 2015
Whirlpool Facility - Fort Smith, Arkansas

	TCE Concentrations (µg/L)																
Date(s)	**MW-25**	**MW-38**	**MW-85**	**MW-86**	**MW-92**	**MW-93**	**MW-94**	**MW-95**	**MW-172**	**ITMW-11**	**ITMW-12**	**ITMW-15**	**ITMW-17**	**ITMW-18**	**ITMW-19**	**Total TCE Reduction (all wells)**	
9/11/2014	nm	nm	5820	129000	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	944213	
10/15/2014	nm	6750	nm	nm	nm	nm	nm	nm	nm	2050	2570	1490	3510	3540	12800		
10/23/2014	59800	nm	nm	nm	2160	18200	11100	22300	3010	nm	nm	nm	nm	nm	nm		
12/4/2014	2620	3190	27700	169000	2200	14600	9570	20900	1810	1530	468	63	4630	3690	33.5	431793	
1/15/2015	2510	5440	5940	81200	1410	18000	9530	21100	3600	68.3	57.1	56.5	3840	488	17.4	323046	
Percent Reduction	96%	52.7%	-375.9%	-31.0%	-2%	20%	14%	6%	40%	25.4%	81.8%	95.8%	-31.9%	-4.2%	99.7%	54.3%	**4th Quarter 2014**
	96%	19.4%	-2.1%	37.1%	35%	1%	14%	5%	-20%	96.7%	97.8%	96.2%	-9.4%	86.2%	99.9%	65.8%	**1st Quarter 2015**

Field Parameters April 2015

Sodium Persulfate (mg/L)	4200	70	4200	2800	210	0	70	0	1860	17500	nm	600	140	3400	2100	
pH	5.35	6.61	5.23	6.15	5.77	5.29	5.64	5.57	5.96	2.74	5.78	6.98	5.27	5.82	11.15	
Conductivity (µS/cm)	12454	784	5056	10951	2449	1094	631	1156	1649	22280	926	2452	1277	5836	5710	

Notes:
nd = Not detected
µg/L = Micrograms per liter
mg/L = Milligrams per liter
U = Not detected above noted method detection limit
µS/cm = Microsiemens per centimeter

TABLE 2
SUMMARY OF TCE CONCENTRATIONS (AREA1/MW-25)
MAY 2014 - JANUARY 2015
Whirlpool Facility - Fort Smith, Arkansas

	TCE Concentrations (µg/L)				
Date(s)	**MW-25**	**MW-85**	**MW-86**	**Total TCE Reduction (all wells)**	
5/15/2014	18500	nm	nm	553470	
5/29/2014	nm	1970	533000		
7/8/2014	49900	3780	nm		
7/31/2014	71700	nm	nm		
9/11/2014	nm	5820	129000		
10/24/2014	59800	nm	nm		
12/5/2014	2620	27700	169000	199320	
1/15/2015	2510	5940	81200	89650	
Percent Reduction	85.8%	-1306.1%	68.3%	64.0%	**4th Quarter 2014**
	86.4%	-201.5%	84.8%	83.8%	**1st Quarter 2015**

Field Parameters April 2015

Sodium Persulfate (mg/L)	4200	4200	2800
pH	5.35	5.23	6.15
Conductivity (µS/cm)	12454	5056	10951

Notes:
nm = not measured
µg/L = Micrograms per liter
mg/L = Milligrams per liter
µS/cm = Microsiemens per centimeter

TABLE 3
SUMMARY OF TCE CONCENTRATIONS (SUPPLEMENTAL NECK AREA)
MAY 2014 - JANUARY 2015
Whirlpool Facility - Fort Smith, Arkansas

	TCE Concentrations (µg/L)				
Date(s)	**MW-24**	**MW-83**	**MW-84**	**Total TCE Reduction (all wells)**	
5/22/2014	79.7	470	214	1296	
5/23/2014	nm	nm	nm		
7/8/2014	102	nm	nm		
9/12/2014	55.7	213	0.93	572	
10/23/2014	33.1	210	0.68		
1/14-15/2015	26.9	101	0.5 U	382	
Percent Reduction	58.5%	55.3%	99.7%	55.9%	**4th Quarter 2014**
	66.2%	78.5%	99.8%	70.5%	**1st Quarter 2015**

Field Parameters April 2015

Sodium Persulfate (mg/L)	1400	280	7000
pH	4.23	6.32	9.59
Conductivity (µS/cm)	2775	2231	8756

Notes:
nm = Not measured
µg/L = Micrograms per liter
mg/L = Milligrams per liter
U = Not detected above noted method detection limit
µS/cm = Microsiemens per centimeter

TABLE 4
SUMMARY OF TCE CONCENTRATIONS (AREAS 2 AND 3)
MAY 2014 - JANUARY 2015
Whirlpool Facility - Fort Smith, Arkansas

	TCE Concentrations (µg/L)									
Date(s)	**MW-82**	**IW-77**	**IW-78**	**MW-34**	**MW-35R**	**MW-36**	**MW-65**	**IW-80**	**Total TCE Reduction (all wells)**	
5/13-14/2014	nm	1460	nm	19.9	183	0.5 U	195	24.2	3864	
5/28-30/2014	285	nm	255	nm	nm	nm	nm	nm		
7/8-7/9/2014	48.2	1200	nm	nm	nm	nm	nm	nm		
7/29-30/2014	nm	1540	nm	78.2	64.7	0.61	17.1	25.6		
9/11/2014	50	nm	39.6	nm	nm	nm	nm	nm	1736	
10/14-15/2014	nm	741	nm	47.7	79.2	0.5 U	30.8	11.8		
10/23/2014	nm	554	nm	nm	nm	nm	nm	nm		
1/12-14/2015	66	201	nm	22	10.9	0.5 U	19.2	7.1	1211	
Percent Reduction	82.5%	62.1%	84.5%	-139.7%	56.7%	-	84.2%	51.2%	55.1%	**4th Quarter 2014**
	76.8%	86.2%	-	-10.6%	94.0%	-	90.2%	70.7%	68.7%	**1st Quarter 2015**

Field Parameters April 2015

Sodium Persulfate (mg/L)	700	2800	nm	nm	16800	560	3500	420
pH	5.82	5.59	nm	4.62	6.74	4.88	10.65	5.72
Conductivity (µS/cm)	1388	5108	nm	1745	15767	1398	10973	1295

Notes:
nm = Not measured
µg/L = Micrograms per liter
mg/L = Milligrams per liter
U = Not detected above noted method detection limit
µS/cm = Microsiemens per centimeter