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LETTER REGARDING RECOMMENDATIONS ON ANALYTICAL RESULTS FROM IN SITU GROUNDWATER TREATABILITY STUDY NTC ORLANDO FL
1/24/2001
HARDING LAWSON ASSOCIATES

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A MACTEC COMPANY

January 24, 2001

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Commanding Officer
Southern Division, Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, SC 29406

ATTN: Ms. Barbara Nwokike, Code 187300

SUBJECT: Analytical Results of Downgradient Well Samples
Operable Unit 4, Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study
Naval Training Center, Orlando, Florida
Contract No. N62467-89D-0317/135

Dear Barbara:

The pilot study evaluating in-situ chemical oxidation using potassium permanganate ($KMnO_4$) as a groundwater source area technology was begun at Naval Training Center (NTC), Orlando Operable Unit (OU) 4 on February 14, 2000. Sixteen rounds of groundwater sampling occurred to monitor the performance of the chemical oxidation. The final round of sampling occurred during the first week of August 2000.

In accordance with the pilot study work plan, two groundwater monitoring points (GMP-17, shallow; and OLD-13-46B, deep) were installed approximately 20 feet west of the pilot study extraction wells, located at the downgradient end of the treatment cell (Figure 1). These wells were installed to monitor for $KMnO_4$ that may have escaped containment during the pilot study, and also to monitor the quality of groundwater migrating away from the treatment cell after the pilot study was concluded. To date, HLA has sampled these wells prior to $KMnO_4$ injection in February 2000, again during the sixteenth round of pilot study sampling in August 2000, and a third time in early January 2001. OLD-13-46B was also sampled in April 2000 to look for evidence of $KMnO_4$ that might be escaping from the bottom of the treatment cell (none was found). Analyses were primarily for inorganics (filtered) and various field parameters; VOCs were not sampled at either of these locations.

Shallow Groundwater (GMP-17)

Analytical data for shallow downgradient groundwater is included as Table 1. Initial data from February 9, 2000 represents baseline conditions prior to injection of $KMnO_4$. These results are typical of baseline conditions in the vicinity of the treatment cell. Baseline samples were generally clear with low turbidity (less than 1 NTU). Inorganic concentrations were all very low or non-detect. Total dissolved solids (TDS) ranged between 100 to 150 mg/L.

Based on the results of the pilot study, the advance of $KMnO_4$ through the treatment zone is indicated by gradual changes in groundwater quality. Total dissolved solids (either measured directly or monitored through groundwater conductivity) increase. Groundwater color progresses from clear, to pale yellow, to amber, to brown, to purple. Potassium concentrations increase, as do concentrations of chromium (occasionally), aluminum, and often mercury. Manganese is usually only present as MnO_2 solids, and is therefore filtered out. However, manganese detected at

significant concentrations (above 100 mg/L) is generally an indication that unconsumed permanganate is present in solution, and groundwater has a definite purple hue.

Some of these changes were becoming apparent in GMP-17 during the August 2, 2000 sampling event. Treatment cell containment was lost on June 21, when the system was apparently struck by lightning and damaged. Hydraulic containment of the treatment cell was lost at this time, and natural gradient flow was re-established through the treatment cell area. Some slight color was observed in the August 2 samples, and conductivity and turbidity had increased from baseline. Mercury was now detected, but at a concentration well below drinking water standards. Potassium concentrations were essentially identical to baseline, as was chromium (non-detect).

By the January 5, 2001 sampling, groundwater conditions continued to exhibit evidence of $KMnO_4$. Groundwater color had changed to a yellowish brown. Conductivity and TDS had increased, as had concentrations of aluminum, potassium, chromium, and mercury. No primary standards were exceeded, but secondary standards for color, TDS and aluminum were exceeded (although aluminum concentrations remained below background screening).

Deep Groundwater (OLD-13-46B)

Analytical data for deep downgradient groundwater is included as Table 2. As was the case in the shallow downgradient well, initial data from February 9, 2000 represents baseline conditions prior to injection of $KMnO_4$. Baseline samples were somewhat cloudy, with turbidity above 25 NTUs and color above secondary standards. These conditions are occasionally observed in wells at OU 4, even after development and low-flow sampling. Inorganic concentrations were all very low or non-detect, with the exception of iron present at higher concentrations than in shallow groundwater, above Florida secondary standards, but consistent with other deep groundwater data at OU 4. TDS was only 80 mg/L.

No evidence of the presence of $KMnO_4$ was observed in data from the April 2000 sampling event. Conductivity remained unchanged from baseline, inorganic concentrations were essentially identical to baseline, and no color changes were observed. This was expected, as the pilot study was operating, and hydraulic control of the treatment cell was being maintained.

By August 2, 2000, initial signs of $KMnO_4$ were observed. Potassium had begun to increase, along with a slight increase in conductivity. Chromium and mercury were not detected, and aluminum was consistent with baseline. Groundwater color remained clear, with low turbidity.

On January 2, 2001, groundwater from OLD-13-46B was a pale yellow. Potassium concentrations and conductivity had increased further since August, and aluminum was now present above baseline (but still below background screening). Color was above secondary standards. Chromium and mercury were still not detected.

Conclusions and Recommendations

Groundwater downgradient from the KMnO4 pilot study now exhibits evidence of KMnO4 injection. This was to be expected, as termination of the pilot study eliminated the hydraulic control of the treatment cell, and allowed treated groundwater to move downgradient due to natural flow.

The presence of $KMnO_4$ is most evident in analysis of color, TDS, conductivity, and potassium. Exceedances of Florida secondary standards for color, TDS, and aluminum have occurred or are possible. However, these exceedances should reach a maximum and then decrease as the treated groundwater disperses.

Increases in groundwater concentrations of chromium and/or mercury were also observed. This is consistent with increases measured within the treatment cell itself. Both mercury and chromium excursions above Florida primary standards occasionally occurred. However, concentrations appeared to decrease after $KMnO_4$ injection ceased. Mercury is not present in $KMnO_4$ solutions, and some of the chromium concentrations observed in groundwater were much higher than the concentrations injected. It is possible that the $KMnO_4$ solution oxidized aquifer TOC, releasing soluble inorganic compounds that may have been sorbed onto soil particles. After oxidation ceased, the inorganics may have re-sorbed onto aquifer soils or MnO_2 particles. These possibilities are further discussed in the forthcoming final $KMnO_4$ pilot study report.

Additional sampling of downgradient wells GMP-17 and OLD-13-46B could be performed in another 3 months to monitor continued changes in water quality due to the $KMnO_4$ injection. Additional sampling of monitoring wells within the treatment cell itself might also be warranted to confirm continued decreases in chromium and mercury concentrations, as well as concentrations of other parameters with Florida secondary standards.

If you have any questions or comments, please contact me at (781) 213-5652 or John Kaiser at (407)522-7570.

Very truly yours,

HARDING LAWSON ASSOCIATES

R Allen for MJ Salvetti

Mark J. Salvetti, P.E.
Task Order Manager

Enclosures

cc:

W. Hansel (SDIV)	S. Tsangaris (CH2M HILL)	File
C. Casey (SDIV)	S. McCoy (TetraTech)	
D. Grabka (FDEP)	R. Allen (HLA)	
N. Rodriguez (USEPA)	J. Kaiser (HLA)	

Figure 1. Operable Unit 4 Groundwater Treatability Studies, In-Situ Chemical Oxidation Pilot Study

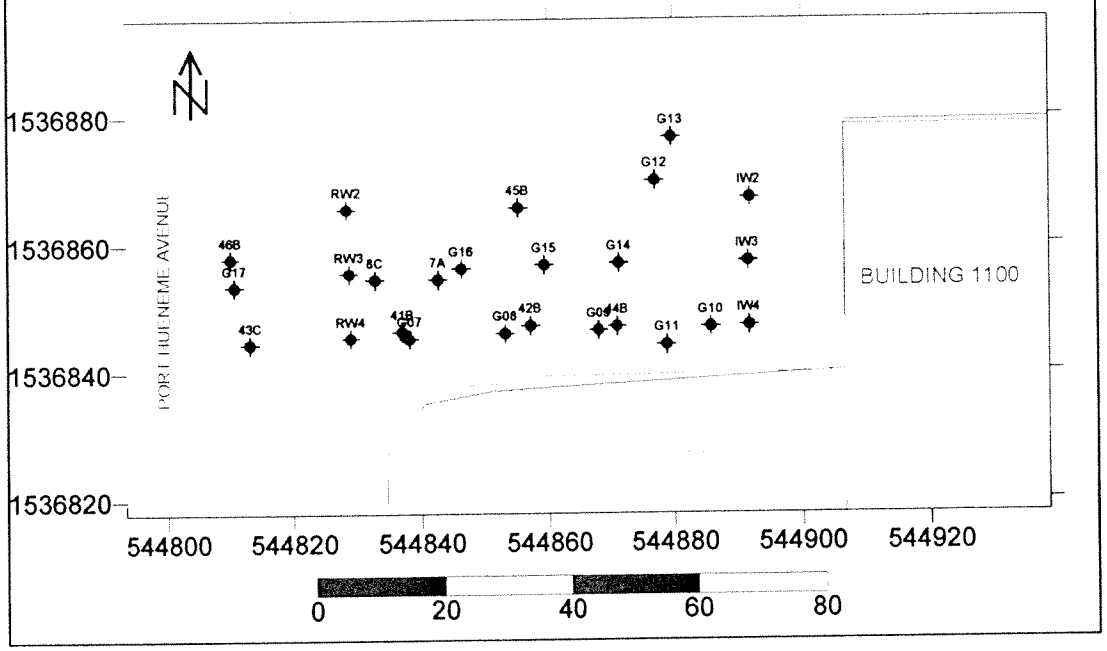

Table 1. Summary of Groundwater Analytical Results
Shallow Downgradient TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-17				GMP-17	
Sample ID	FDEPGCTL		U4H17GBL		U4HGMP-17-16		U4HGMP-17-17	
Sampling Date			9-Feb-00		2-Aug-00		5-Jan-01	
Inorganics, mg/L								
Aluminum	**0.2**	S/	0.05	U	0.05	U	**1.0**	
Antimony	**0.006**	P/ST	0.005	U	0.006	U	0.006	U
Arsenic	**0.05**	P/C	0.01	U	0.01	U	0.01	U
Barium	**2**	P/ST	0.1	U	0.1	U	0.1	U
Beryllium	**0.004**	P/C	0.001	U	0.001	U	0.001	U
Cadmium	**0.005**	P/C	0.001	U	0.001	U	0.001	U
Calcium			30		69		18	
Chromium	**0.1**	P/	0.01	U	0.01	U	0.016	
Cobalt	**0.42**	MC/ST	0.05	U	0.05	U	0.05	U
Copper	**1**	S/ST	0.05	U	0.05	U	0.05	U
Iron	**0.3**	S/	0.05	U	0.05	U	0.05	U
Lead	**0.015**	P/ST	0.005	U	0.005	U	0.005	U
Magnesium			**5.1**		**12**		**2.8**	
Manganese	**0.05**	S/ST	0.01	U	0.01	U	0.01	U
Mercury	**0.002**	P/ST	0.0002	U	0.00035		0.00079	
Molybdenum	**0.035**	MC/ST			0.01	U	0.01	U
Nickel	**0.1**	P/ST	0.01	U	0.01	U	0.01	U
Potassium			1.8		2.0		370	
Selenium	**0.05**	P/ST	0.01	U	0.01	U	0.01	U
Silver	**0.1**	S/ST	0.01	U	0.01	U	0.01	U
Sodium	**160**	P	7.2		6.9		5.3	
Thallium	**0.002**	P/	0.002	U	0.002	U	0.002	U
Vanadium	**0.049**	MC/ST	**0.02**		0.01	U	0.01	U
Zinc	**5**	S/ST	0.1	U	0.1	U	0.1	U
RSK 175, mg/L								
Methane			0.0039		0.004			
Ethane			0.001	U	0.001	U		
Ethene			0.001	U	0.001	U		
Water Quality, mg/L								
Alkalinity								
Alk-P			0					
Alk-T			8.16					
COLOR (CU)	**15**		10				**500**	
CO2			30					
Chloride	**250**		20				11	
Fe2+			0					
Fe Total			0					
Hardness			114.9					
Nitrite-N			0.005		0.01	U		
Nitrate-N			0		0.02	U		
Nitrate-Nitrite-N					0.02	U		
Sulfate			0.021		11			
Sulfide			0					
TDS	**500**		150				**750**	
TOC			6.0					
pH	**6.5 to 8.5**		6.26		5.65		6.63	
Temp (degrees C)			22.8		27.4		22.8	
Conductivity			205		440		1200	
Turbidity (NTUs)			0.64		7.7		18	
Oxygen Reduction Potential (mv)			-53.8		-58.4		189.9	
Dissolved Oxygen			0.3		0.81		0.2	

Table 2. Summary of Groundwater Analytical Results
Deep Downgradient TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-46B			
Sample ID	FDEPGCTL		U4H46BBL	U4H46B06	U4HOLD-13-46B-16	U4HOLD-13-46B-17
Sampling Date			9-Feb-00	13-Apr-00	2-Aug-00	5-Jan-01
Inorganics, mg/L						
Aluminum	**0.2**	S/	0.078	0.19	0.05	**1.4**
Antimony	**0.006**	P/ST	0.005 U	0.005 U	0.006 U	0.006 U
Arsenic	**0.05**	P/C	0.01 U	0.01 U	0.01 U	0.01 U
Barium	**2**	P/ST	0.1 U	0.1 U	0.1 U	0.1 U
Beryllium	**0.004**	P/C	0.001 U	0.001 U	0.001 U	0.001 U
Cadmium	**0.005**	P/C	0.001 U	0.001 U	0.001 U	0.001 U
Calcium			9.3	8.8	26	30
Chromium	**0.1**	P/	0.01 U	0.01 U	0.01 U	0.01 U
Cobalt	**0.42**	MC/ST	0.05 U	0.05 U	0.05 U	0.05 U
Copper	**1**	S/ST	0.05 U	0.05 U	0.05 U	0.05 U
Iron	**0.3**	S/	**3.7**	**2.1**	**1.9**	**0.75**
Lead	**0.015**	P/ST	0.005 U	0.005 U	0.005 U	0.005 U
Magnesium			1.4	1.4	3.3	4.5
Manganese	**0.05**	S/ST	0.028	0.012	0.019	0.012
Mercury	**0.002**	P/ST	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Molybdenum	**0.035**	MC/ST			0.01 U	0.01 U
Nickel	**0.1**	P/ST	0.01 U	0.01 U	0.01 U	0.01 U
Potassium			1.2	NA	6.5	64
Selenium	**0.05**	P/ST	0.01 U	0.01 U	0.01 U	0.01 U
Silver	**0.1**	S/ST	0.01 U	0.01 U	0.01 U	0.01 U
Sodium	**160**	P	9.7	NA	11	15
Thallium	**0.002**	P/	0.002 U	0.002 U	0.002 U	0.002 U
Vanadium	**0.049**	MC/ST	0.01 U	0.01 U	0.01 U	0.027
Zinc	**5**	S/ST	0.1 U	0.1 U	0.1 U	0.1 U
RSK 175, mg/L						
Methane			0.012		0.012	
Ethane			0.001 U		0.001 U	
Ethene			0.001 U		0.001 U	
Water Quality, mg/L						
Alkalinity						
Alk-P			0			
Alk-T			3.4			
COLOR (CU)	**15**		25			**250**
CO2			55			
Chloride	**250**		25			16
Fe2+			2.76			
Fe Total			3			
Hardness			51.3			
Nitrite-N			0.037		0.01 U	
Nitrate-N			0		0.02 U	
Nitrate-Nitrite-N					0.02 U	
Sulfate			0.334		18	
Sulfide			0.5			
TDS	**500**		80			250
TOC			6			
pH	**6.5 to 8.5**		5.62	5.39	5.37	5.38
Temp (degrees C)			23.7	23.9	26	22.5
Conductivity			132	135	230	410
Turbidity (NTUs)			25.1	5.71	6.88	4.38
Oxygen Reduction Potential (mv)			-186.1	-130.6	-98.5	10.39
Dissolved Oxygen			8.4	--	0.55	0.2