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A total of twenty-two groundwater samples were collected including the six supply wells for VOCs analysis. Table 4-11 summarizes the VOCs chemical test result. VOCs were detected above the reporting limit from all the groundwater samples analyzed. A total of twenty-six chemical components of VOCs were reported from the samples. Groundwater samples from the six supply wells contained thirteen chemical components of VOCs. A majority of groundwater samples including those of the supply wells contains cis-1,2-Dichloroethene, Methylene chloride, Tetrachloroethene, Toluene and Trichloroethene. A couple of more VOC components appear during the 2nd or 3rd sampling event in the cases of B03-465MW and B03-466MW. Figures 4-7, 4-8 and 4-9 present the distribution of Toluene, PCE, and TCE.

4.4. Hydrologic Characteristics of the Site

Figure 4-10 presents the groundwater monitoring well locations used for air permeability and hydrologic field test.

4.4.1. Slug Test

Six slug tests were performed at the LF-Area D. The monitoring wells selected for slug testing was subject to its relative location within the LF-Area D area. Measurements of water level versus time, along with other relevant aquifer and well characteristics were then used to determine a value for hydraulic conductivity of the site. The calculations were performed with Aqtesolv aquifer test analysis software. An anisotropy ratio (Kz/Kr) was assumed in the analysis and the analytical solution developed by Bouwer and Rice (1976) for an unconfined aquifer system was used to calculate the hydraulic conductivity. Hydraulic conductivity (K) was obtained by manual fitting using AQTESOLV.

The calculated K values for the monitoring wells were similar between injection and withdrawal. The K values ranged from 1.7E-05 to 7.70E-04 cm/sec for inserting the slug and from 1.90E-05 to 7.60E-04 cm/sec for withdrawal the slug from the monitoring wells. Table 4-12 presents the hydraulic parameters obtained from the slug test.

4.4.2. Pumping Test

A review of the pumping test results indicates that the calculated transmissivity (T) values ranged from 0.07 cm^2/sec to 9.03 cm^2/sec. The T value is generally higher during water level drawdown than recovery. The K values during pumping test obtained ranging from 9.81E-05 cm/sec to 5.28E-02 cm/sec, with an average of 1.29E-02 cm/sec. The K values obtained during pumping test were quite higher than those during slug test. This high K value during pumping test might reflect the existence of high K interval within the well screened interval during pumping test. Table 4-13 presents the result of pumping test.

4.4.3. Air Permeability Test

An air permeability test were conducted on 17 March 2010, to evaluate subsurface air flow patterns and radius of influence at LF-Area D of the Camp Carroll. The layout of the permeability test was determined based on the location of existing groundwater monitoring wells and the pre-installed air permeability test well. Air permeability test was conducted at four wells

1501

(as a set) consisting of one air extraction well (B03-465MW) and three observation wells (B03-464MW, B09-195, B03-466MW). Figure 4-10 presents the well layout of air permeability test at LF-Area D.

The extraction well was attached to a vacuum pump to control the air extraction rate. The extraction valves and measurement devices were securely attached and sealed at the top of each well pipe to prevent introducing any ambient air. Upon starting the vacuum pump for subsurface air extraction, field measurement data was collected from both extraction and observation wells. During the entire air permeability test, the extraction vacuum was maintained at a constant rate and the monitoring wells' down pressure was monitored indications in change of pressure. Conclusively, the observation wells (B09-195, B03-466MW and B03-464MW) did not respond during the permeability test probably due to the well locations are beyond the radius of influence.

4.4.4. Nutrient and Microbial Sampling

All soil samples were analyzed for their heterotrophic bacteria content. The following chemical parameters were also measured on these soils: Total Carbon, Total Nitrogen and Total Phosphorous (Total C/N/P). The average ratio of Total C/N/P at LF-Area D project site of Camp Carroll appears to be 83: 8: 9. Fuel disintegration bacteria were counted up to 517,000 Most Probable Number (MPN)/g in soil, but some samples were not identified. The presence of fuel disintegration bacteria and the C/N/P ratio suggest a certain degree of biodegradation could positively occur within the contaminated soil formation. The biological and chemical parameters measured on these soil samples are summarized in Table 4-14.

4.5. Summary of Laboratory Experiments for removal of VOCs and OC-Pesticides in Soil for LF-Area D

A laboratory scale experiments were conducted to assess the removal efficiencies by various methods for VOCs and OC-Pesticides in soil samples of Area D. The laboratory experimental process and the results are presented in Appendix #.

4.5.1. Kinetic tests for VOCs.

Conceptually the VOCs in soil can remove via air injection, which means the VOCs removal rate can be proportional to the exposure time to the air (see detail at Appendix #, Section 3-3). The result is shown in Figure 4-11. VOCs concentration decreased according to time elapsed. During 10 hours from the begging of the experiment, VOCs concentration was distinctly decreased to about 1 mg/kg till 24 hrs. After 24 hours, the variation is very limited.

4.5.2. Fenton Oxidation for OC-Pesticides

There were two comparisons to apply Fenton oxidation methods in terms of controlling pH of the solution at 3 and non-adjusted in order to remove OC-Pesticides in soil. Also there was a comparison for the variable concentration of Fe^{2+} at an identical concentration of hydrogen peroxide. Table 4-15 summarizes the experimental result. The addition of 1.5mMol

Fe^{2+}/1.0%H_2O2 solution without pH control was the best for OC-Pesticides removal, also injection of H_2O_2 without pH control can be effective as well.

Table 4-16 shows the result of column experiment for OC-Pesticides contaminated soil by 1% of H_2O_2. The experimental condition was based on the batch experiment which is no pH control and only H_2O_2 injection. According to this experiment, approximately 2 pore volume of H_2O_2 injection was most effective at this experiment.

4.5.3. Surfactant Flushing

Surfactant flushing is a technology to remove the adsorbed contaminants in the soil by transferring to a free-phase (micelle) and then the contaminants can be easily degraded by physico-chemical and biological processes. Surfactants used in this study were Tween 80, Triton X-100, SDS (Sodium Dodecyl Sulfate). Ethanol was also used for comparison.

Table 4-17 summarizes the removal efficiencies by each surfactant. SDS showed 88% of OC-Pesticides removal efficiency, which was more effective than those of Triton X-100, Tween-80 and Ethanol.

4.5.4. Zero Valent Iron (ZVI) Treatment

To test the removal efficiency of OC-Pesticide in soil ZVI dosage was used. The removal efficiency was the highest at 0.4g ZVI/g-soil (about 89%), which was close to those by Fenton oxidation and surfactant flushing. Table 4-18 presents the result of ZVI treatment for OC-Pesticides removal.

Table 4-1. Soil Sample Information versus the Chemical of Concern from each Borehole.

Borehole ID	Sample ID	Sample Depth	VOCs	OC-pest	Dioxins	TPH-D	SVOC	PCB	Metals
B09-192	S1	0~2m	O	O	O*	O	O	O	O
	S2	2~4m	O	O	O	O	O	-**	-
	S3	4~6m	O	O	-	-	-	-	-
B09-193	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-194	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-195	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-196	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-197	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-198	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-199	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-200	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-201	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-220	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-221	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-
B09-222	S1	0~2m	O	O	O	O	O	O	O
	S2	2~4m	O	O	O	O	O	-	-
	S3	4~6m	O	O	-	-	-	-	-

*- indicates sample was collected for the analysis, ** not collected.

Table 4-2. TPH Chemical Test Results for Soil Samples at LF-Area D.

BH_ID	Sample ID	Sample Interval	unit	Diesel range ($C_{10\sim24}$)	Residual oil range ($C_{24\sim40}$)	PID
B09-192	S1	0~2 m	mg/kg	ND	ND	6.8
	S2	2~4 m	mg/kg	ND	ND	3.4
B09-193	S1	0~2 m	mg/kg	55.4	171	3.6
	S2	2~4 m	mg/kg	ND	ND	3
B09-194	S1	0~2 m	mg/kg	ND	ND	4.6
	S2	2~4 m	mg/kg	ND	ND	11.7
B09-195	S1	0~2 m	mg/kg	ND	ND	1.4
	S2	2~4 m	mg/kg	ND	ND	2.3
B09-196	S1	0~2 m	mg/kg	12.1	ND	3.5
	S2	2~4 m	mg/kg	ND	19	391
B09-197	S1	0~2 m	mg/kg	ND	ND	2.8
	S2	2~4 m	mg/kg	ND	ND	1.9
B09-198	S1	0~2 m	mg/kg	ND	ND	1.8
	S2	2~4 m	mg/kg	ND	ND	2.4
B09-199	S1	0~2 m	mg/kg	ND	ND	1.9
	S2	2~4 m	mg/kg	ND	ND	7.9
B09-200	S1	0~2 m	mg/kg	ND	ND	3.6
	S2	2~4 m	mg/kg	ND	ND	1.9
B09-201	S1	0~2 m	mg/kg	ND	ND	0.5
	S2	2~4 m	mg/kg	ND	ND	0.9
B09-202	S1	0~2 m	mg/kg	ND	ND	21.5
	S2	2~4 m	mg/kg	ND	ND	2.5
B09-221	S1	0~2 m	mg/kg	ND	30.7	1.9
	S2	2~4 m	mg/kg	ND	ND	2.2
B09-222	S1	0~2 m	mg/kg	ND	ND	2.2
	S2	2~4 m	mg/kg	ND	ND	3.2
ND- not detected						

Table 4-3 VOCs Chemical Test Results for Soil Sample at LF-Area D.

Chemicals (µg/kg)	B09-192			B09-193			B09-194			B09-195			B09-196		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S
2-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	160J	27
4-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	440	89
cis-1,2-Dichloroethene	-	-	18J	-	14J	21J	-	-	-	-	-	-	-	150J	-
1,1-Dichloroethene	-	-	-	-	7.7J	12J	-	9.9J	-	-	-	-	-	-	-
Ethylbenzene	32J	21J	24J	33J	27J	20J	25J	20J	25J	19J	21J	-	28J	-	-
Methylene chloride	61J	33J	44J	52J	38J	33J	37J	34J	36J	30J	42J	41J	47J	52J	-
Naphthalene	-	2.8J B	-	-	-	-	-	-	-	-	-	-	-	-	-
Styrene	-	-	-	-	-	-	-	-	-	-	1.6J	-	-	-	-
Tetrachloroethene	6.4J	12J	57	-	20J	36J	110	41J	45J	-	-	-	58	350	24
Toluene	87	14J	34J	70	100	110	23J	89	51	83	27J	6400	48J	16000	130
1,2,4-Trichlorobenzene	-	10J B	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene	-	-	9.9J	-	26J	70	27J	14J	-	-	-	-	-	76J	-
m-Xylene & p-Xylene	94J	51J	63J	80J	60J	51J	55J	59J	58J	47J	52J	67J	74J	68J	-
o-Xylene	7.8J	-	7.1J	7.9J	6.3J	-	5.7J	-	-	-	-	-	7.5J	-	-

B-The analyte was found in a blank associated with the sample.

J- Estimated result. Result is less than reporting limit.

Q- Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

G- Elevated reporting limit. The reporting limit is elevated due to matrix interference.

Table 4-3 VOCs Chemical Test Results (Continued).

Chemicals (µg/kg)	B09-198			B09-199			B09-200			B09-201			B09-220			
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S
2-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
cis-1,2-Dichloroethene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1,1-Dichloroethene	-	-	-	-	9.5J	-	-	-	-	8.3J	-	-	-	5.2J	-	
Ethylbenzene	35J	27J	31J	26J	27J	32J	28J	27J	25J	22J	24J	33J	21J	26J	21J	2
Methylene chloride	61J	43J	45J	47J	48J	51J	49J	39J	42J	40J	42J	54J	31J	41J	46J	4
Naphthalene	-	-	-	-	-	4.9J B	-	-	-	-	-	-	-	-	-	6.

Tetrachloroethene	-	5.5J	8J	-	6.1J	-	-	-	-	-	-	-	-	-	7.7J	
Toluene	9.4J	54	45J	42J	250	110	42J	64	43J	63	68	39J	49J	42J	72	3
1,2,4-Trichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Trichloroethene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
m-Xylene & p-Xylene	83J	70J	77J	68J	73J	75J	81J	68J	62J	63J	61J	82J	51J	66J	66J	7
o-Xylene	7.9J	7.3J	-	7.8J	6.1J	8J	9.6J	7.1J	-	5.8J	6.1J	7.9J	-	6.6J	6.7J	9

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Chemicals (µg/kg)	B09-192		B09-193		B09-194		B09-195		B09-196		B09-197		B09-198		B09-199		B09-200		B09-201	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
bis(2-Ethylhexyl) phthalate	-	-	-	-	-	-	-	-	-	-	-	-	120J	-	-	-	300J	-	-	-

J- Estimated result. Result is less than reporting limit.

Chemical (mg/kg)	AreaD-BG$^{\&}$	B09-192	B09-193	B09-194	B09-195	B09-196	B09-197	B09-198	B09-199	B09-200	B09-201	B0 20
		S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S
Arsenic	7.3	8.7	3.2B*	5.5	8.3	8	6.9	7.2	3.7B	6.7	7.5	1
Barium	98.2	105	65	71.4	102	71.9	86.6	88.5	61.6	98.7	85.3	99
Cadmium	0.51	0.86	0.28B	0.48	0.33	0.17B	0.43	0.39	0.46	0.63	0.54	0.
Chromium	3.8	4.4	5.1	3.4	3.2	4.5	3.3	4.9	5.2	3.5	2.3	3.
Lead	18.7	22	14.6	23.7	12.6	8.9	15.4	14.6	18.3	20.5	20.4	19
Selenium	-**	-	-	-	-	-	-	-	-	-	-	-
Silver	-	-	-	-	-	-	-	-	-	0.14B	-	-
Mercury	0.011B	-	0.05	-	-	-	0.044	-	-	-	-	-

&- Background data of Area D, *- the analyte is found in a blank associated with the sample, **- not

Chemical (µg/kg)	B09-192			B09-193			B09-194			B09-195				B
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3		S1
alpha-BHC	-	-	-	0.71J	-	-	-	-	-	-	-	-	-	-
gamma-BHC (Lindane)	-	1.5J	-	**11**	-	0.7J	**6.4**	3.4J	0.29J	-	-	-	-	**4300**
beta-BHC	-	0.74J	-	-	-	0.86J	-	-	0.59J	-	-	-	-	-
delta-BHC	-	1J	-	1.6J	-	0.29J	-	-	0.35J	-	-	-	2.2J	-
Heptachlor epoxide	-	1.1J PG	2.9J PG	-	-	-	-	-	-	-	-	-	-	260J PG
gamma-Chlordane	6.2J PG	1.9J	10PG	-	-	-	-	-	-	-	-	-	-	-
alpha-Chlordane	-	2.9PG	8.5J PG	2.3J	-	-	-	-	-	-	-	-	-	-
4,4'-DDE	37J	7.5	**37**	11	-	0.35J	**3.9**	**27**	-	2.9J	12J	-	15J	730J
Dieldrin	4.5J	1.6J	7J	0.39J	-	0.42J	-	-	-	-	1.8J	-	1.3J	-
4,4'-DDD	15J	6.4	18J	**40**	1.1J	1.2J	0.64J	**37**	-	0.49J	7.2J	-	**22**	**24000**
4,4'-DDT	**740**	**47**	**280**	**130**	1.9J	2.6J	**28**	**120**	-	**15**	**240**	-	**260**	**54000**

B-The analyte found in a blank associated with the sample.

J- Estimated result. Result is less than reporting limit.

Q- Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

G- Elevated reporting limit. The reporting limit is elevated due to matrix interference.

PG: The percent difference between the original and confirmation analyses is greater than 40%.

1052
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Chemical (µg/kg)	B09-198			B09-199				B09-200			B09-201			B09-220			B09-221			B09-222		
	S1	S2	S3	S1	S2	S3	S4	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
alpha-BHC	-	-	0.47J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gamma-BHC (Lindane)	-	-	**8.6**	-	2.8J	**7.1**	1.3J	-	-	-	-	4.5J	-	-	-	-	-	-	-	-	-	-
beta-BHC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
delta-BHC	-	-	0.67J	-	-	0.46J	0.46J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor epoxide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gamma-Chlordane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
alpha-Chlordane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDE	**3.8**	28J	0.53J	4.1J	**12**	**8.1**	-	0.33J	**9.6**	240J	**4**	35J	80J	-	**13**	**44**	**29**	0.52J	-	1.6J	-	-
Dieldrin	-	2J	-	-	-	1.1J	-	-	-	-	-	-	-	-	0.24J	-	-	-	-	-	-	-
4,4'-DDD	0.41J	**300**	**4.1**	-	**24**	**48**	-	-	1.4J	**670**	-	17J	**250**	-	**3.7**	19J	13J	0.44J	-	3.5J	-	-
4,4'-DDT	**9.7**	**360**	**12**	**8.9**	**72**	**220**	0.68J	0.53J	**30**	**7300**	**4**	**300**	**4400**	0.63J	**85**	**460**	**190**	2J	0.65 J	1.8J	-	-

Table 4-7. Dioxin-Furan Chemical Test Results for Soil of LF-Area D.

Borehole ID	Sample ID	Sample interval (m)	Method	International-89 Toxicity Equivalent Quantity*
B09-192	S1	0~2	SW8290	0.050972
	S2	2~4	SW8290	0.10939
B09-193	S1	0~2	SW8290	0.088955
	S2	2~4	SW8290	0.32696
B09-194	S1	0~2	SW8290	0.053555
	S2	2~4	SW8290	0.074065
B09-195	S1	0~2	SW8290	0.0600195
	S2	2~4	SW8290	0.0575675
B09-196	S1	0~2	SW8290	1.9045
	S2	2~4	SW8290	0.044716
B09-197	S1	0~2	SW8290	0.0855335
	S2	2~4	SW8290	0.0735295
B09-198	S1	0~2	SW8290	0.051275
	S2	2~4	SW8290	0.058031
B09-199	S1	0~2	SW8290	0.061283
	S2	2~4	SW8290	0.0562345
B09-200	S1	0~2	SW8290	0.077417
	S2	2~4	SW8290	0.057267
B09-201	S1	0~2	SW8290	0.0575452
	S2	2~4	SW8290	0.051621
B09-220	S1	0~2	SW8290	0.052821
	S2	2~4	SW8290	0.04320945
B09-221	S1	0~2	SW8290	0.132052
	S2	2~4	SW8290	0.0236826
B09-222	S1	0~2	SW8290	0.0745945
	S2	2~4	SW8290	0.052043

* I-TEQ value calculated using International-89 Toxicity Equivalent Factors based on 2,3,7,8-TCDD

1512

Table 4-8 Water Level Measurement Result at LF-Area D

Proj_ID	Sites	MW_ID	Well Depth (m)	Top of Pipe (m)	Water Level					
					28-Feb-09		4-Sep-09		16-Dec-09	
					Bgs*	Amsl^	bgs	amsl	bgs	amsl
08-035E	Area D	303-463MW	11.8	48.55	9.0	39.6	7.97	40.6	8.8	39.8
		303-464MW	13.0	49.79	9.1	40.7	8.59	41.2	8.9	40.9
		303-465MW	13.0	50.90	10.2	40.7	9.65	41.3	10.0	40.9
		303-466MW	12.3	49.58	8.0	41.6	7.85	41.7	7.7	41.9
		303-467MW	12.3	49.79	9.2	40.6	8.64	41.2	9.0	40.8
		303-468MW	13.4	51.41	10.1	41.3	9.42	42.0	9.8	41.6
		309-193MW	15.5	49.28	9.1	40.2	8.00	41.3	8.8	40.5
		309-221MW	11.8	43.22	5.1	38.1	6.10	37.1	4.9	38.3
08-034E	Land Farm	307-217MW	11.4	50.92	3.7	47.2	3.28	47.6	4.0	46.9
		307-218MW	12.3	51.77	10.8	41.0	9.27	42.5	9.8	42.0
		307-219MW	11.7	55.41	7.3	48.1	7.04	48.4	7.7	47.7
		307-220MW	9.2	49.73	3.1	46.6	2.57	47.2	3.3	46.4
		307-221MW	11.7	54.59	6.9	47.7	6.1	48.5	7.3	47.3
		309-176MW	40.0	44.27	8.5	35.8	8.87	35.4	8.4	35.9
		309-177MW	42	47.19	9	38.2	9.04	38.2	9	38.3
		309-178MW	41	49.09	9	40.2	8.87	40.2	8	40.9
Supply Wells		12-247	70		Not measured !					
		13-279	73							
		14-283	80							
		15-286	77							
		16-289	85							
		20-575	184							

*- below ground surface; ^- above mean sea level.

Table 4-9 Groundwater Sampling Strategy at LF-Area D.

Proj_ID	Sites	BH_ID	Well Dpth (m)	Water level	VOCs	OC Pest
08-035E	Area D	B03-463MW	12.4	7.97	O	O
		B03-464MW	13.1	8.59	O	O
		B03-465MW	13.1	9.65	O	O
		B03-466MW	17.9	7.85	O	O
		B03-467MW	12.4	8.64	O	O
		B03-468MW	13.5	9.42	O	O
		B09-193MW	15.0	8.00	O	O
		B09-221MW	12.4	6.10	O	O
08-034E	Land Farm	B07-217MW	12.0	3.28	O	
		B07-218MW	12.7	9.27	O	
		B07-219MW	12.3	7.04	O	
		B07-220MW	9.7	2.57	O	
		B09-176MW	40.0	8.87	O	
		B09-177MW	40	9.04	O	
		B09-178MW	40	8.87	O	
Supply Wells		12-247	70		O	
		13-279	73		O	
		14-283	80		O	
		15-286	77		O	
		16-289	85		O	
		20-575	184		O	

Chemicals (µg/L)	B03-463MW			B03-464MW			B03-465MW			B03-46	
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2n
alpha-BHC	0.34	0.53J G	0.37	-	-	-	0.14PG	- G	0.057 PG	0.07PG	0.06
gamma-BHC	3.5q	4.9	3.3	0.01J	-	-	0.069	0.022J	0.039 J	0.17	0.21
Heptachlor	-	-	-	-	-	-	0.031J	-	-	-	-
beta-BHC	0.73	0.76J PG	0.52	0.0047J	-	-	0.53PG	0.27PG	0.26 PG	0.66	0.75
delta-BHC	1	1.1	0.98	0.0073J	-	-	-	-	0.024J PG	0.57	0.
Heptachlor epoxide	-	-	-	-	-	-	-	-	0.019J PG	-	-
Endosulfan I	-	-	-	-	-	-	-	-	-	0.017J PG	-
gamma-Chlordane	-	-	-	-	-	-	-	-	-	-	-
alpha-Chlordane	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDE	-	-	-	-	-	-	-	-	-	-	-
Dieldrin	0.007J	-	-	-	-	-	0.048J PG	-	0.037J PG	0.028J PG	0.0
Endrin	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDD	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDT	-	-	-	-	-	-	-	-	-	-	-
Endosulfan sulfate	-	-	-	-	-	-	-	-	-	-	-
Endrin ketone	-	-	-	-	-	-	-	-	-	-	-

Sampling at 1st: May 11~15, 2009: at 2nd August 31~Sep 2, Sep14~16, 2009: at 3rd: Dec 12~15, 2009

PG- the percent difference between the original and confirmation analyses is greater than 40%.

J- Estimated result. Result is less than reporting limit.

Q- Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

G- Elevated reporting limit. The reporting limit is elevated due to matrix interference.

Chemicals (µg/L)	B03-467MW			B03-468MW			B07-217MW			B	
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2r
alpha-BHC	0.033J PG	- G	0.038J PG	-	-	-	0.028J	-	0.024J	-	0.
gamma-BHC	0.05PG	0.6	0.24 PG	0.043J	-	-	0.06	0.018J	0.033J	0.016J	
Heptachlor	-	-	-	-	-	-	-	-	0.0076J PG	-	-
beta-BHC	0.14PG	0.19J PG	0.072	-	-	-	-	-	-	0.025J PG	0.
delta-BHC	0.3	0.11J	0.22	-	-	-	-	-	-	-	0.
Heptachlor epoxide	-	-	-	-	-	-	-	-	-	0.01J	0.
Endosulfan I	-	-	-	-	-	-	-	-	-	-	-
gamma-Chlordane	-	-	-	-	-	-	-	-	-	0.015J PG	0.
alpha-Chlordane	-	-	-	-	-	-	-	-	-	0.022J PG	0.
4,4'-DDE	-	-	-	-	-	-	-	-	-	0.0095J	0.
Dieldrin	-	-	-	-	-	-	0.0096J	-	0.019J	0.04J	0.
Endrin	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDD	-	-	-	-	-	-	-	-	-	0.1	0.
4,4'-DDT	-	-	-	-	-	-	-	-	-	0.017J	0.
Endosulfan sulfate	-	-	-	-	-	-	-	-	-	-	0.
Endrin ketone	-	-	-	-	-	-	-	-	-	-	-

Chemicals (µg/L)	B07-219MW			B07-220MW			B07-221MW		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
alpha-BHC	0.041J PG	0.043J	0.046	-	0.025J	0.032J	0.018J	-	-
gamma-BHC	0.054	0.15	0.098	0.021J	0.15	0.2	0.016J	0.012J	0.014J
Heptachlor	-	-	-	-	-	-	-	-	-
beta-BHC	0.16	0.35	0.27	0.017J	0.19	0.26	-	0.035J PG	0.0077.
delta-BHC	0.065	0.047	0.059	-	0.012J	0.024J	0.016J	-	-
Heptachlor epoxide	-	-	0.0054J	-	-	0.012J	-	-	-
Endosulfan I	-	0.0061J PG	0.049 PG	-	-	0.02J	-	-	-
gamma-Chlordane	-	-	-	-	-	0.018J PG	-	-	-
alpha-Chlordane	-	-	0.011J PG	-	-	-	-	-	-
4,4'-DDE	-	-	-	-	-	-	-	-	-
Dieldrin	0.12	0.28	0.44	-	-	0.062J	-	-	-
Endrin	-	0.0054J	0.013J PG	-	-	-	-	-	-
4,4'-DDD	-	-	-	-	-	0.006J	-	0.011J	0.013J
4,4'-DDT	-	-	-	0.0079J	-	0.1	-	0.017J	0.01J
Endosulfan sulfate	-	-	-	-	-	0.0067J PG	-	-	-
Endrin ketone	-	0.038J	0.055J	-	-	-	-	-	-

Table 4-10 VOCs Chemical Test Result for Groundwater of LF-Area D.

Component (μg/L)	B03-463MW			B03-464MW			B03-465MW			B03-466MW			B03-467MW		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Acetone	-	-	- q	3.4J	-	-	-	-	-	4.4J	-	- q	15	11	-
Benzene	0.97J	-	1.1J	0.45J	-	-	9.8J	11	9.3	0.98J	4.2	1.7J	4.3	8	7.2
2-Butanone (MEK)	-	-	-	0.6J	-	-	-	-	-	-	-	-	0.77J	0.38J	-
Carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24J
Chlorobenzene	4.9J	3.5J	7.9	-	-	-	-	5.4	5.3	2.8	15	5.9J	6.1	3	11
Chloroethane	-	-	-	-	-	-	-	4.4	3.4	-	-	-	7.6	7.9	7.1
Chloroform	1.9J	1.4J	1.4J	0.39J	0.22J	0.48J	-	0.42J	0.47J	0.68J	1.2	1.6J	0.62J	0.23J	0.29J
Chloromethane	-	-	-	-	-	-	-	-	-	-	0.28J	-	-	0.3J	-
2-Chlorotoluene	-	-	0.39J	-	-	-	9.2J	19	14	0.099J	1.9	-	0.73J	0.085J	0.46J
4-Chlorotoluene	-	-	-	-	-	-	-	0.7J	0.54J	-	0.89J	-	0.53J	-	0.14J
1,2-Dichlorobenzene	-	-	0.72J	-	-	-	-	-	-	-	0.28J	-	-	-	-
1,3-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	0.28J	-	-	-	0.13J
1,4-Dichlorobenzene	-	1J	0.95J	-	-	-	-	0.26J	0.29J	0.2J	0.73J	-	0.34J	0.4J	0.59J
Dichlorodifluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	2J	2.5J	1.7J	-	-	-	11J	11	12	0.3J	0.42J	-	7.4	5.6	18
1,2-Dichloroethane	-	-	-	-	-	-	-	-	0.98J	-	-	-	-	-	0.31J
cis-1,2-Dichloroethene	95q	98	160E	0.21J	0.5J	0.63J	1100q	1100E	1100E	15	54	26	7.7	7.7	29
trans-1,2-Dichloroethene	-	-	0.65J	-	-	-	18J	28	24	-	0.52J	-	0.24J	0.49J	0.92J
1,1-Dichloroethene	-	-	0.3J	-	0.16J	0.37J	-	4.7	3.3	-	-	-	-	-	0.21J
1,2-Dichloropropane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19J
Ethylbenzene	-	-	-	0.32J	-	-	-	-	-	0.27J	1.9	-	0.71J	0.12J	0.26J
Isopropylbenzene	-	-	-	-	-	-	-	-	-	0.47J	0.57J	-	-	-	-
p-Isopropyltoluene	-	-	-	-	-	-	-	-	-	-	0.73J	-	-	-	-
Methylene chloride	-	-	1.5J	1.2	1	1.3	-	3.4	3	0.61J	1.6	-	0.92J	1.7	1.7
Naphthalene	-	-	-	0.35J	-	-	-	-	-	-	5.3	-	-	-	-
Tetrachloroethene	110G	120	160E	23	40	30	23J	27	21	13	200E	180	2.2	0.94J	0.21J
Toluene	33	1.5J	8.1	21	0.7J	6.9	49J	9.2	22	14	480E	8.8J	34B	1.4	7.3
1,2,3-Trichlorobenzene	-	-	-	-	-	-	-	-	-	-	0.41J B	-	-	-	-
1,2,4-Trichlorobenzene	-	-	0.4J	-	-	-	-	-	-	-	0.53J B	-	-	-	0.19J
1,1,1-Trichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene	62G	58	89	1.2	12	15	100	210E	150E	20	50	29	2.3	16	1.3
Trichlorofluoromethane	-	-	0.62J	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4-Trimethylbenzene	-	-	-	0.32J	-	-	-	-	-	-	7.1	1.4J	0.14J	-	0.44J
1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	1.8	-	-	-	-
Vinyl chloride	-	-	2.6	-	-	-	18J	57	32	-	5.2	-	2.8	2.6	6.7
m-Xylene & p-Xylene	-	-	-	0.9J	-	-	-	-	-	0.2J	1.6	-	0.22J	-	0.28J
o-Xylene	-	-	-	0.37J	-	-	-	-	-	0.18J	0.87J	-	0.13J	0.11J	0.33J
Sampling at 1st: May 11~15, 2009: at 2nd August 31~Sep 2, Sep14~16, 2009: at 3rd: Dec 12~15, 2009															

PG- the percent difference between the original and confirmation analyses is greater than 40%.

J- Estimated result. Result is less than reporting limit.

Q- Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

G- Elevated reporting limit. The reporting limit is elevated due to matrix interference.

Table 4-10 VOCs Chemical Test Result (Continued).

Component (μg/L)	B03-468MW			B07-217MW			B07-218MW			B07-219MW			B07-220MW		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Acetone	-	-	-	2.6J	-	- q	2.3J	-	- q	-	-	- q	- q	-	- q
Benzene	-	-	-	0.34J	-	-	0.23J	-	-	-	-	-	-	-	-
2-Butanone (MEK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	-	-	-	0.35J	-	-	-	-	-	-	0.52J	-	-	-	-
Chloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	0.86J	0.23J	0.6J	3.7	2.7J	3.7J	0.48J	-	-	-	0.49J	-	4.3	1.8J	1.2J
Chloromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	0.23J	-	-	-	-
Dichlorodifluoromethane	-	-	-	0.53J	-	-	-	-	-	-	-	-	0.65J	-	-
1,1-Dichloroethane	-	-	-	0.15J	0.14J	-	-	-	-	-	-	-	-	-	-
1,2-Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cis-1,2-Dichloroethene	-	0.11J	0.57J	84E	110E	120	32	42q	71	84	75	96	35	190	120
trans-1,2-Dichloroethene	-	-	-	1.3	2.9	3.7J	0.19J	0.38J	-	-	6.1	6.3J	0.53J	1.1J	1.9J
1,1-Dichloroethene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichloropropane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	0.2J	-	-	0.21J	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	-	-	-	0.47J	-	-	-	-	-	-	-	-
p-Isopropyltoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	-	1.9	1.7	1.5	-	-	1.6	2.3	-	-	1.9	-	1.7J	-	-
Naphthalene	-	-	-	0.27J	-	-	0.4J	-	-	-	-	-	-	-	-
Tetrachloroethene	140q	70	160E	130E	180	280	32	78	210	590q	270E	410	86	41	32
Toluene	11	0.95J	5.8	17	-	7.7J	17	0.62J	7.7J	11J	2.2	6.3J	19	-	5.3J
1,2,3-Trichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.1J B
1,1,1-Trichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene	6.1	1.7	11	210E	350	460	3.4	2.5	5.3J	150	80	120	110	230	340
Trichlorofluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4-Trimethylbenzene	-	-	-	0.17J	-	-	0.26J	-	-	-	-	-	-	-	-
1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
m-Xylene & p-Xylene	-	-	-	0.52J	-	-	0.61J	-	-	-	-	-	0.4J	-	-
o-Xylene	-	-	-	0.24J	-	-	0.23J	-	-	-	-	-	-	-	-

1122 **Table 4-10 VOCs Chemical Test Result (Continued).**

Component (µg/L)	B07-221MW			B07-222MW			B09-176MW			B09-177MW			B09-178MW		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Acetone	- q	-	-	- q	-	-	2.1J	-	-	-	-	-	2.6J	-	- q
Benzene	-	-	-	-	-	-	-	-	-	0.23J	-	-	0.27J	-	-
2-Butanone (MEK)	-	-	-	-	-	-	-	-	-	-	-	-	0.52J	-	-
Carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	5.2	-	0.45J	5.3	0.27J	-	0.21J	0.18J	0.37J	0.4J	0.17J	0.37J	0.19J	-	-
Chloromethane	-	0.28J	-	-	0.26J	-	-	-	-	-	-	-	-	-	-
2-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cis-1,2-Dichloroethene	52	0.58J	3.7	51	1.2	4J	0.17J	0.15J	0.12J	-	-	-	0.13J	-	-
trans-1,2-Dichloroethene	0.97J	-	0.14J	1.2J	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethene	-	-	-	0.29J	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichloropropane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	0.22J	-	-	0.47J	-	-
Isopropylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
p-Isopropyltoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	1.2J	1.5	1.4	1.2J	1.3	-	1.5	1.3	1.1	1.2	0.79J	1.1	0.54J	0.8J	-
Naphthalene	-	-	-	-	-	-	-	-	-	0.29J	-	-	-	-	-
Tetrachloroethene	74	0.22J	8.8	71	8.6	9.3J	0.74J	1.2	1.7	1.1	-	-	1.8	2.1	170
Toluene	23	2.7	6.6	21	1	6J	11	1	5.6	9.6	0.64J	6.6	19B	1.8	6.3J
1,2,3-Trichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	-	-	-	-	-	-	-	-	0.31JB	-	-	0.32JB	-	0.22JB	-
1,1,1-Trichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene	99	0.37J	7.1	96	5.1	7.3J	0.68J	0.96J	0.99J	0.6J	-	-	0.51J	-	-
Trichlorofluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-	-	0.27	-	-	-	-	-

										J					
1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
m-Xylene & p-Xylene	0.37 J	-	-	-	-	-	-	-	-	0.59 J	-	-	0.23 J	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	0.24 J	-	-	-	-	-

Table 4-10 VOCs Chemical Test Result (Continued).

Component (μg/L)	B09-193MW			B09-221MW			12-247			13-279		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Acetone	-	-	- q	-	-	-	-	5.1J	-	-	4.5J	-
Benzene	-	-	-	0.25J	-	-	-	-	-	-	-	-
2-Butanone (MEK)	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	-	0.22J	-	-	-	-	-	-	-	-	-	-
Chloroethane	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	3.3J	2.3	2.4J	0.57J	0.32J	0.24J	1.1	0.65J	0.35J	1.8	1.2	1.1
Chloromethane	-	-	-	-	-	-	-	3.9	-	-	9.6	-
2-Chlorotoluene	-	-	-	0.38J	-	-	-	-	-	-	-	-
4-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	-	0.33J	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	-	0.12J	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	-	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	-	0.17J	-	-	-	-	0.5J	1	0.17J	0.3J	-	0.15J
1,2-Dichloroethane	-	-	-	-	-	-	0.37J	-	-	1.1	0.93J	0.79J
cis-1,2-Dichloroethene	130	130E	140	8.3	1.3	0.58J	8	19	8.7	29	9.1	16
trans-1,2-Dichloroethene	1.3J	0.91J	1.3J	0.22J	-	-	0.75J	0.34J	-	1.2	0.53J	0.5J
1,1-Dichloroethene	-	0.27J	-	-	-	-	1.8	4.4	2.5	2.3	0.29J	1.5
1,2-Dichloropropane	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	0.11J	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	-	-	-	-	-	-	-	-	-
p-Isopropyltoluene	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	-	2.2	-	0.41J	1.4	1.5	1.8	-	0.97J	1.4	-	1.2
Naphthalene	-	-	-	-	-	-	-	-	-	-	-	0.29J B
Tetrachloroethene	29	110E	98	1.7	8.7	0.21J	5.8	16	2.6	12	4.5	9.6
Toluene	28	2	6.1J	12	1.6	6	30	1.6	9.5	25	1.3	8.2
1,2,3-Trichlorobenzene	-	-	-	-	-	-	-	-	0.26J B	-	-	-
1,2,4-Trichlorobenzene	-	-	-	-	-	-	-	-	0.34J B	-	-	-
1,1,1-Trichloroethane	-	-	-	-	-	-	0.36J	1.6	0.5J	0.65J	-	0.27J
Trichloroethene	170	260E	240	2.7	4.8	-	69	21	59	100E	23	39
Trichlorofluoromethane	-	-	-	-	-	-	0.26J	-	-	-	-	-
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-
1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	-	-	-	-	-	-	-	-	-	-	-	-
m-Xylene & p-Xylene	-	-	-	0.27J	-	-	-	-	-	-	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-10 VOCs Chemical Test Result (Continued).

Component (μg/L)	14-283			15-286			16-289			17-290			20-575		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Acetone	2.2J	-	-	-	-	- q	2.3J	4J	-	2.5J	7.1J	-	-	-	-
Benzene	-	-	-	-	-	-	0.14 J	-	-	-	-	-	-	-	-
2-Butanone (MEK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	-	-	-	0.12 J	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	0.37 J	0.73 J	0.46J	0.83 J	0.76 J	0.5J	0.58 J	0.57 J	0.5J	0.58 J	0.54 J	0.51 J	0.56 J	0.77 J	0.7J
Chloromethane	-	61	-	-	15	-	-	20	-	-	26	-	-	-	-
2-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24 J
4-Chlorotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15 J
1,2-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	0.24 J	0.18 J	0.22J	9.5	5.7	7.4	9.2	0.54 J	0.94J	9.3	0.52 J	0.84 J	-	-	-
1,2-Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cis-1,2-Dichloroethene	12	9.3	9.4	160 E	110 q	150	150 E	13	20	150 E	13	20	1.7	1.7	1.7
trans-1,2-Dichloroethene	0.22 J	0.12 J	-	1.1	1.3J	1J	3.7	0.18 J	0.21J	2.7	0.29 J	1.1	0.19 J	0.12 J	0.27 J
1,1-Dichloroethene	3.4	3.2	2.5	17	7.7	18	17	4.5	5.4	18	3.9	1.1	-	-	-
1,2-Dichloropropane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
p-Isopropyltoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	1.3	-	1.1	1.9	-	1J	1.5	-	1.2	2	-	0.9J	1.4	3.1	1.2
Naphthalene	-	-	0.29J B	-	-	-	0.29 J	-	-	0.19 J	-	-	-	-	-
Tetrachloroethene	3.6	2.4	2.2	67	39	77	73	11	19	71	11	20	-	-	0.1J
Toluene	32	2.6	9.1	30	2.9J	7.5	30	1.9	8.4	32	2	8.5	26	1.3	1.3
1,2,3-Trichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	-	-	-	-		0.7J B	0.15 J	-	0.33J B	0.15 J	-	-	-	-	-
1,1,1-Trichloroethane	0.72 J	0.58 J	0.58J	13	6.3	11	12	1.4	1.7	12	1.3	1.8	-	-	-
Trichloroethene	77	66	63	80E	53	96	83E	19	22	82E	18	23	16	16	15
Trichlorofluoromethane	-	-	-	0.25 J	-	-	0.3J	-	-	0.28 J	-	-	-	-	-
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	-	-	-	0.36 J	-	0.49 J	-	-	-	0.43 J	-	-	-	-	-
m-Xylene & p-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-12 Slug Test Result at LF-Area D.

Well_ID	Activity	Bouwer and Rice (1976)	
		K(m/sec)	Average K (cm/sec)
B03-464	Injection	7.70E-04	7.65E-04
	Withdrawal	7.60E-04	
B03-465	Injection	5.60E-04	5.10E-04
	Withdrawal	4.60E-04	
B03-466	Injection	3.30E-04	2.75E-04
	Withdrawal	2.20E-04	
B07-217	Injection	6.80E-05	7.70E-05
	Withdrawal	8.60E-05	
B07-218	Injection	1.70E-05	1.80E-05
	Withdrawal	1.90E-05	
B07-219	Injection	1.30E-04	2.05E-04
	Withdrawal	2.80E-04	

Table 4-13 Pumping Test Result at LF-Area D.

Monitoring Well		Status	Level of Displacement (m)	Q	Slop	T (cm2/sec)	K (cm/sec)	Average K
				(m^3/day)	(Δs)			(cm/sec)
Pumping welll	B07-217	Drawdown	1.956	1.704	0.088	0.41	5.44E-04	3.21E-04
		Recovery		1.704	0.486	0.07	9.81E-05	
Observation Well 1	B07-218	Drawdown	0.031	1.704	0.007	5.02	2.87E-02	2.87E-02
Observation Well 2	B03-465	Drawdown	0.096	1.704	0.004	9.03	5.28E-02	5.28E-02
Observation Well 3	B07-220	Drawdown	0.022	1.704	0.056	0.64	7.42E-04	1.19E-03
		Recovery		1.704	0.026	1.41	1.63E-03	
Observation Well 4	B07-221	Drawdown	0.164	1.704	0.014	2.53	5.85E-03	5.85E-03
K = hydraulic conductivity [m/day], T= transmissivity[m2/day],Q = pumping capacity [m3]								
Δs= Slope of the straight part of the drawdown on a semi-logarithmic graph (m)								

Table 4-14 Microbe and Total CNP Analytical Result of Soil at LF-Area D.

BH_ID	Total Microbe (CFU*/g)	Oil Disintegrated Microbe (MPN**/g)	Total Carbon (%)	Total Nitrogen (%)	Total Phosphorous (mg/kg)
B09-192-S3	$1.99\text{x}10^{6}$	$2.58\text{x}10^{2}$	0.25	0.0323	222.3
B09-193-S2	$3.12\text{x}10^{5}$	$3.12\text{x}10^{4}$	0.08	0.0106	263.24
B09-194-S1	$5.35\text{x}10^{5}$	$5.91\text{x}10^{4}$	0.01	0.0062	332.36
B09-195-S3	$4.50\text{x}10^{5}$	not detected (ND)	0.03	0.0081	197.7
B09-196-S3	$1.18\text{x}10^{6}$	$2.84\text{x}10^{2}$	0.1	0.0106	173.32
B09-197-S1	$5.22\text{x}10^{5}$	ND	0.07	0.0065	265.24
B09-198-S3	$8.00\text{x}10^{4}$	$3.30\text{x}10^{4}$	0.18	0.0115	81.72
B09-199-S1	$8.28\text{x}10^{5}$	$4.49\text{x}10^{5}$	0.17	0.0151	276.08
B09-200-S1	$1.67\text{x}10^{6}$	$5.22\text{x}10^{3}$	0.34	0.0221	353.89
B09-201-S1	$3.39\text{x}10^{6}$	$5.17\text{x}10^{5}$	0.64	0.0507	322.35
B09-220-S3	$2.13\text{x}10^{5}$	$4.40\text{x}10^{2}$	0.23	0.0221	136
B09-221-S2	$1.49\text{x}10^{6}$	$4.75\text{x}10^{3}$	0.18	0.0133	59.16
B09-222-S2	$3.27\text{x}10^{6}$	$2.88\text{x}10^{4}$	0.2	0.0294	100.37
* CFU-colony forming unit, ** MPN- most probable number					

Table 4-15 Fenton Oxidation Batch Test Result for Soil at LF-Area D.

Condition	Initial concentration (182.3 mg/kg)	Fe^{2+} (mMol):H$_2$O$_2$ (%)			
		0:01	1.0:1	1.5:1	2.0:1
Controlled at pH 3	Concentration	38.85	40.12	42.39	42.75
	Removal efficiency (%)	78.7	78	76.7	76.5
pH not controlled	Concentration	41.47	29.78	28.2	35.78
	Removal efficiency (%)	77.3	83.7	84.5	80.4

Table 4-16 Fenton Oxidation Column Experimental Result for Soil at LF-Area D.

Initial conc. (55.87 mg/kg)	1 pore volume	2 pore volume	3 pore volume
Concentration measured	13.74	1.95	2.05
Removal efficiency (%)	75.4	96.5	96.3

Table 4-17 Surfactant Removal Experimental Result for Soil at LF-Area D.

Site	Initial concentration (182.3 mg/kg)	Triton X-100	SDS	Tween-80	Ethanol
		(0.01M)	(0.01M)	(0.01M)	-1%
Area D	concentration extracted	62.16	21.29	40.21	25.91
(OC-Pesticide)	Removal efficiency (%)	65.9	88.32	77.94	85.79

Table 4-17 Removal Experimental Result for Soil at LF-Area D.

Site	Initial Conc. (mg/kg)	ZVI dosage (g/g-soil)				
		0	0.1	0.2	0.3	0.4
Area D	182.3	130.17	51.04	37.27	31.16	21.04
(OC-Pesticide)	Removal efficiency (%)	28.6	72	79.6	82.9	88.5

Figure 4-1. Toluene Concentration in Soil at LF-Area D of Camp Carroll.

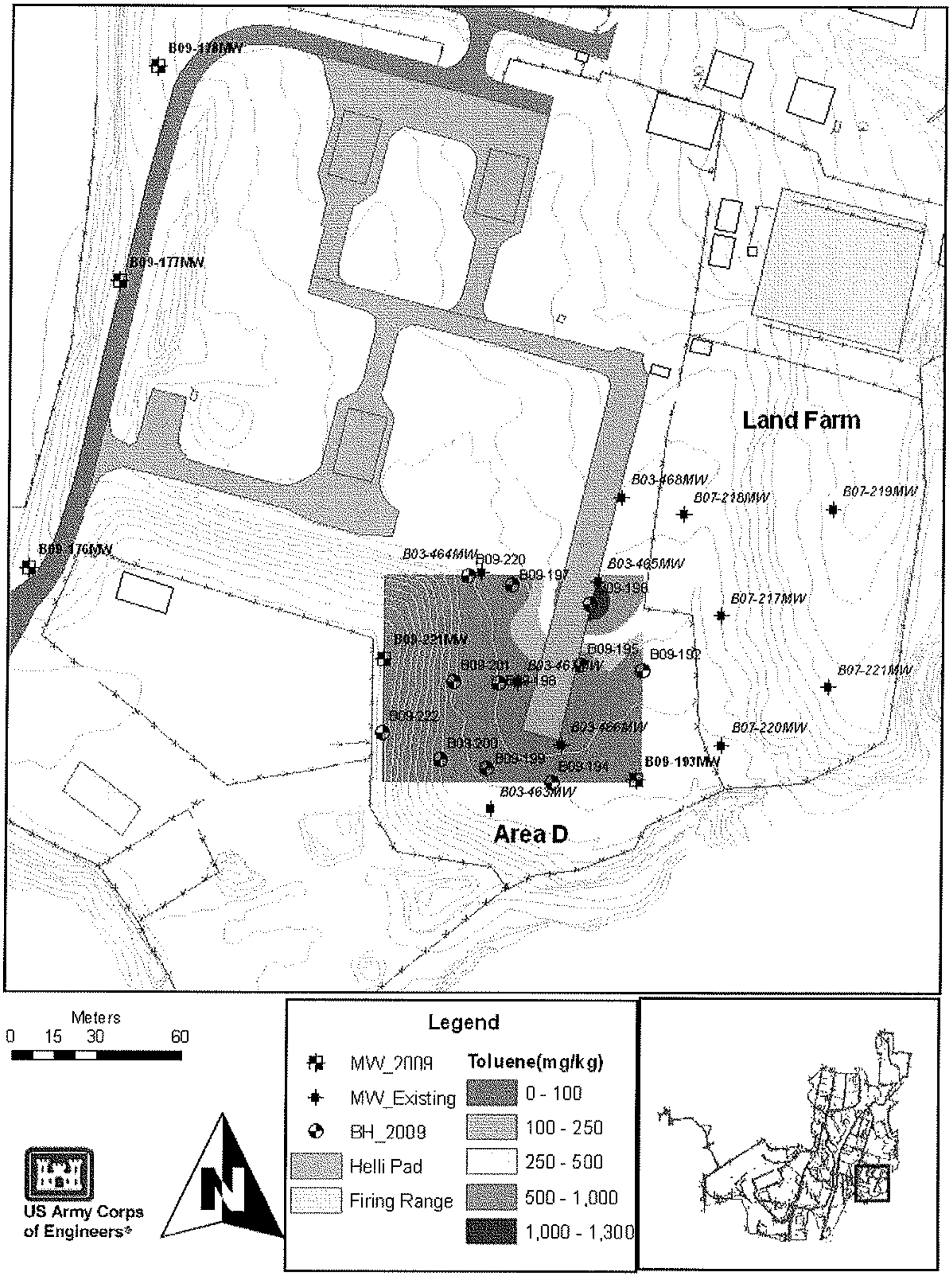

Figure 4-2. PCE Concentration in Soil at LF-Area D of Camp Carroll.

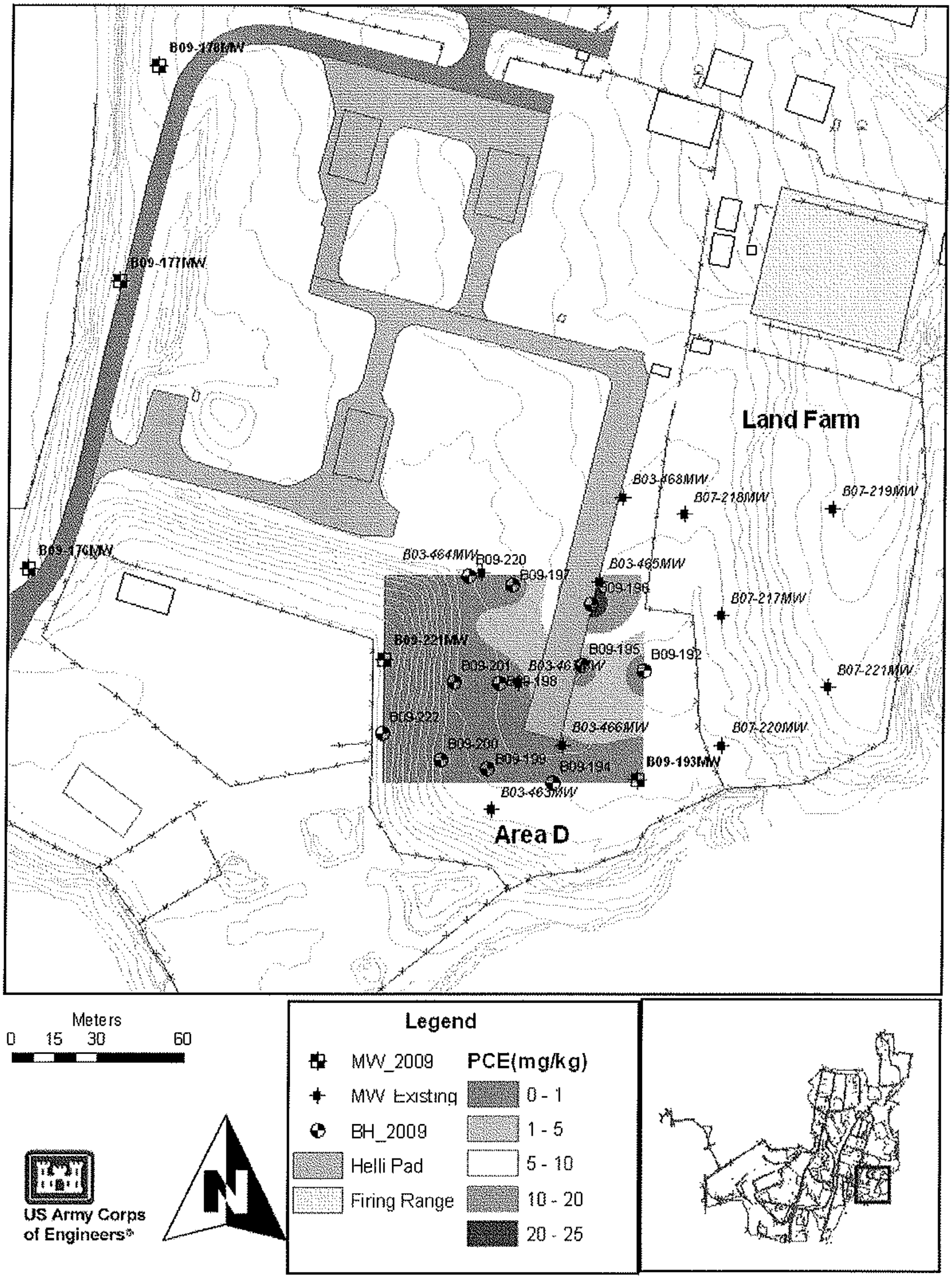

Figure 4-3 4',-4 DDT in Soil at LF-Area D of Camp Carroll.

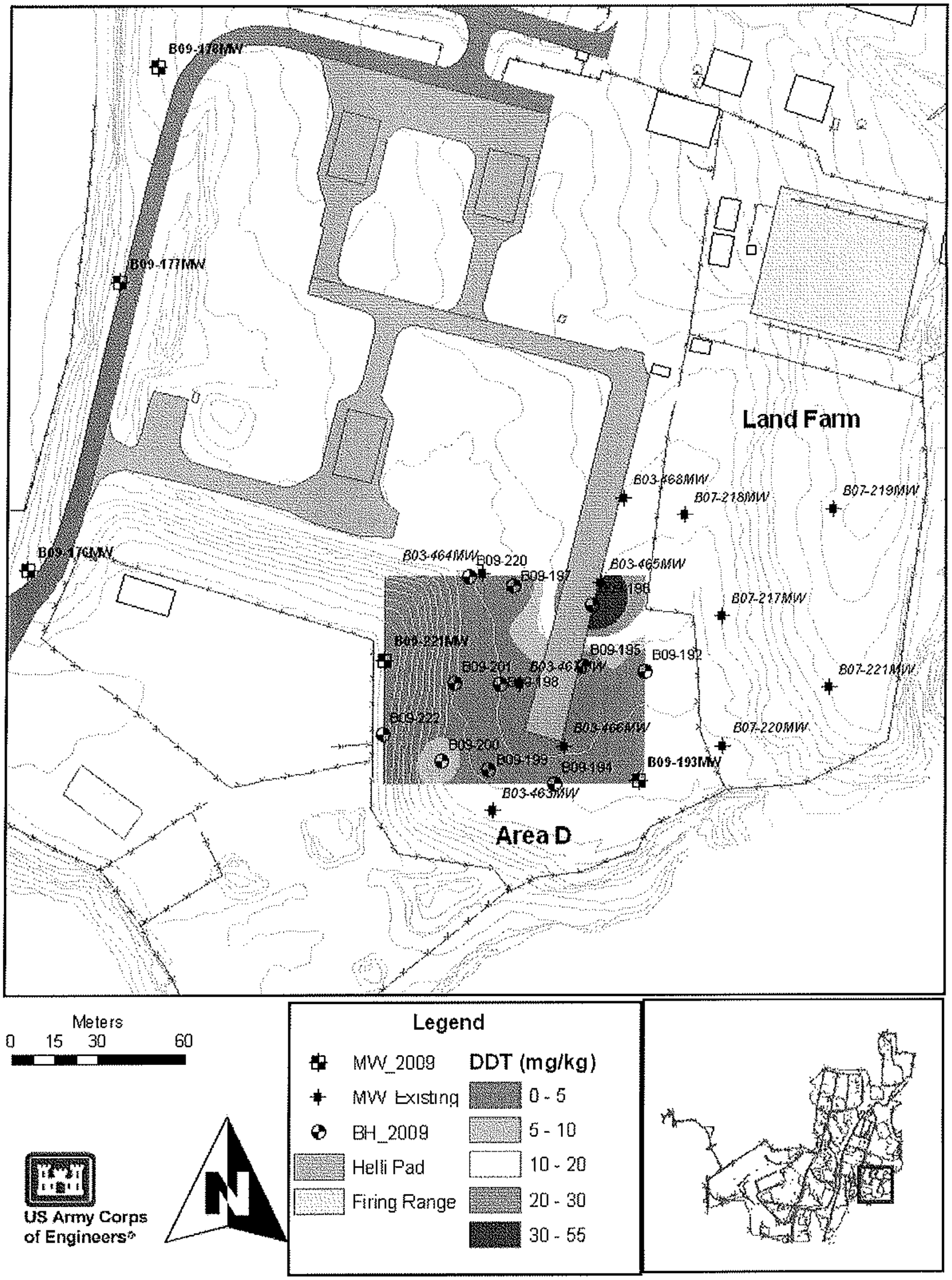

Figure 4-4. Supply Well and Groundwater Monitoring Well Locations in the Vicinity of LF-Area D of Camp Carroll.

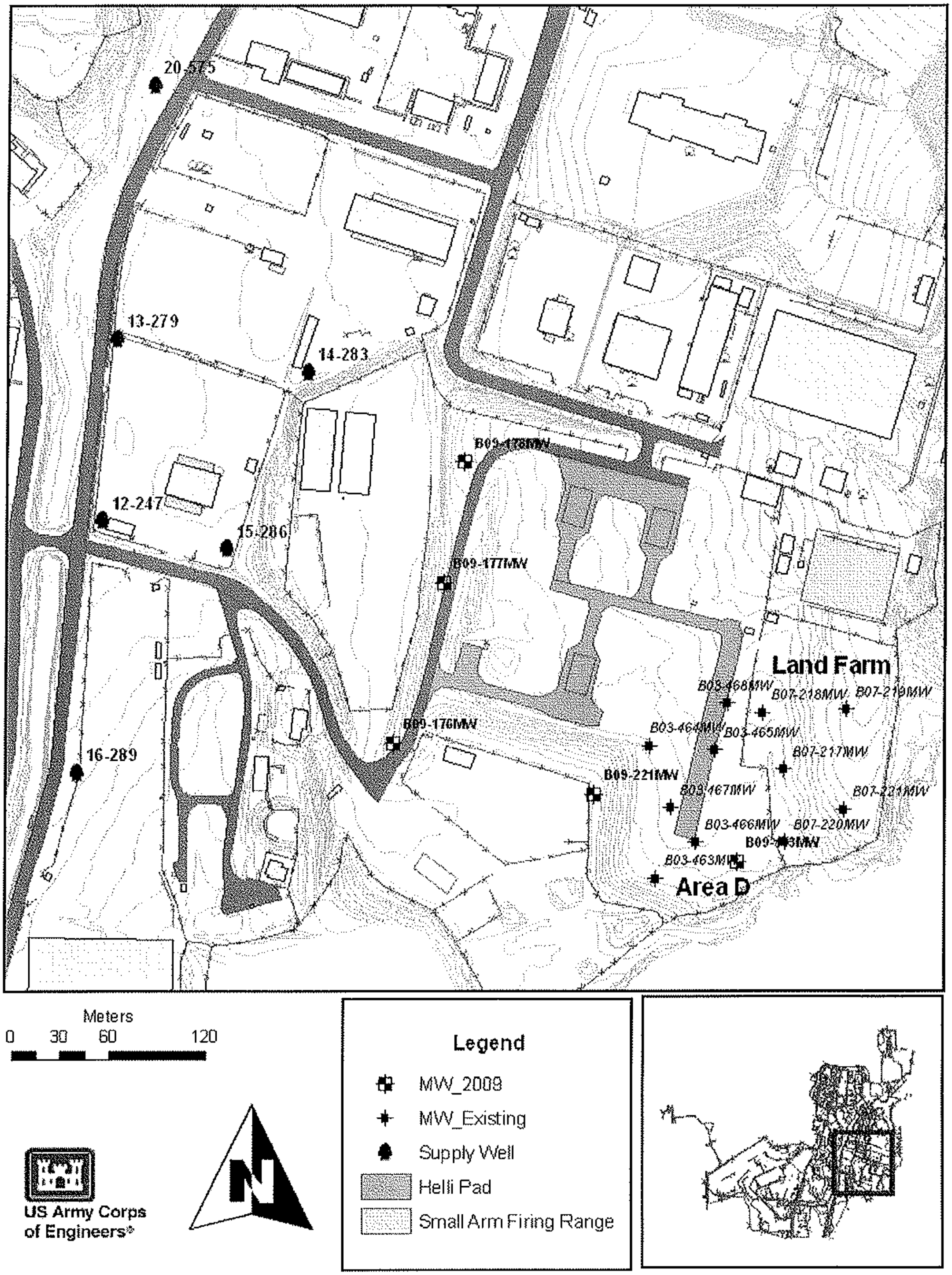

Figure 4-5 Correlation among the Groundwater Level Measurement Results at LF-Area D of Camp Carroll.

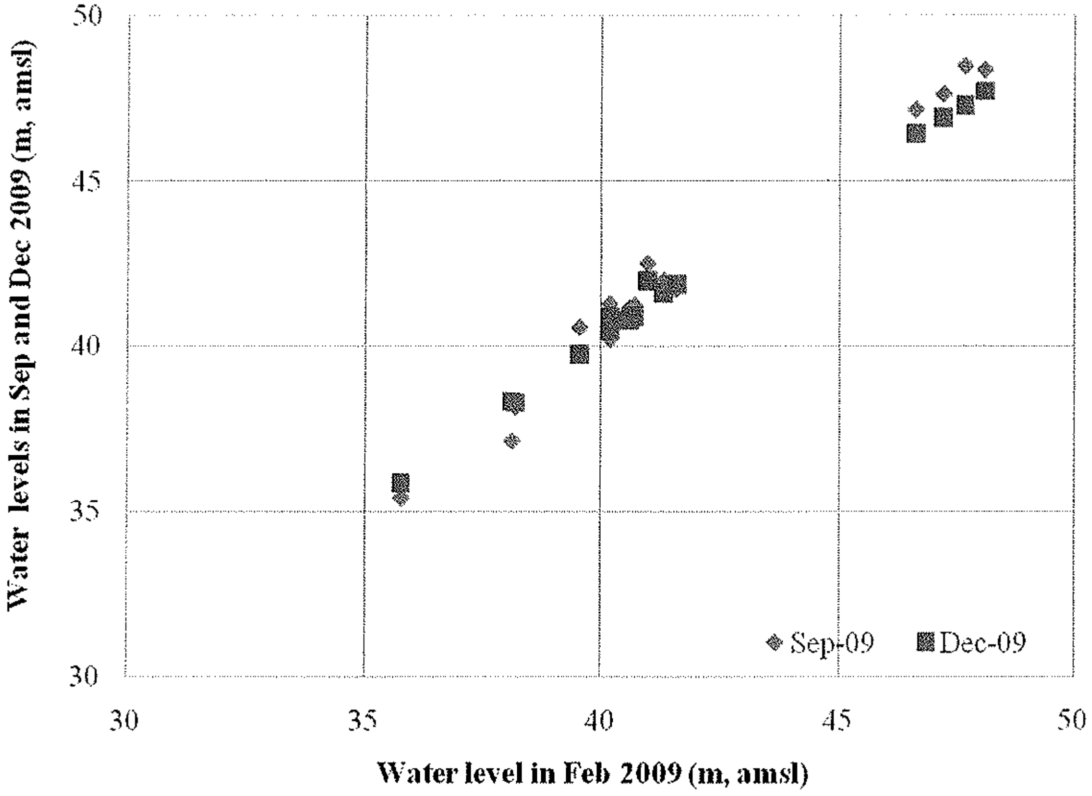

Figure 4-6 Groundwater Flow Direction at LF-Area D of Camp Carroll.

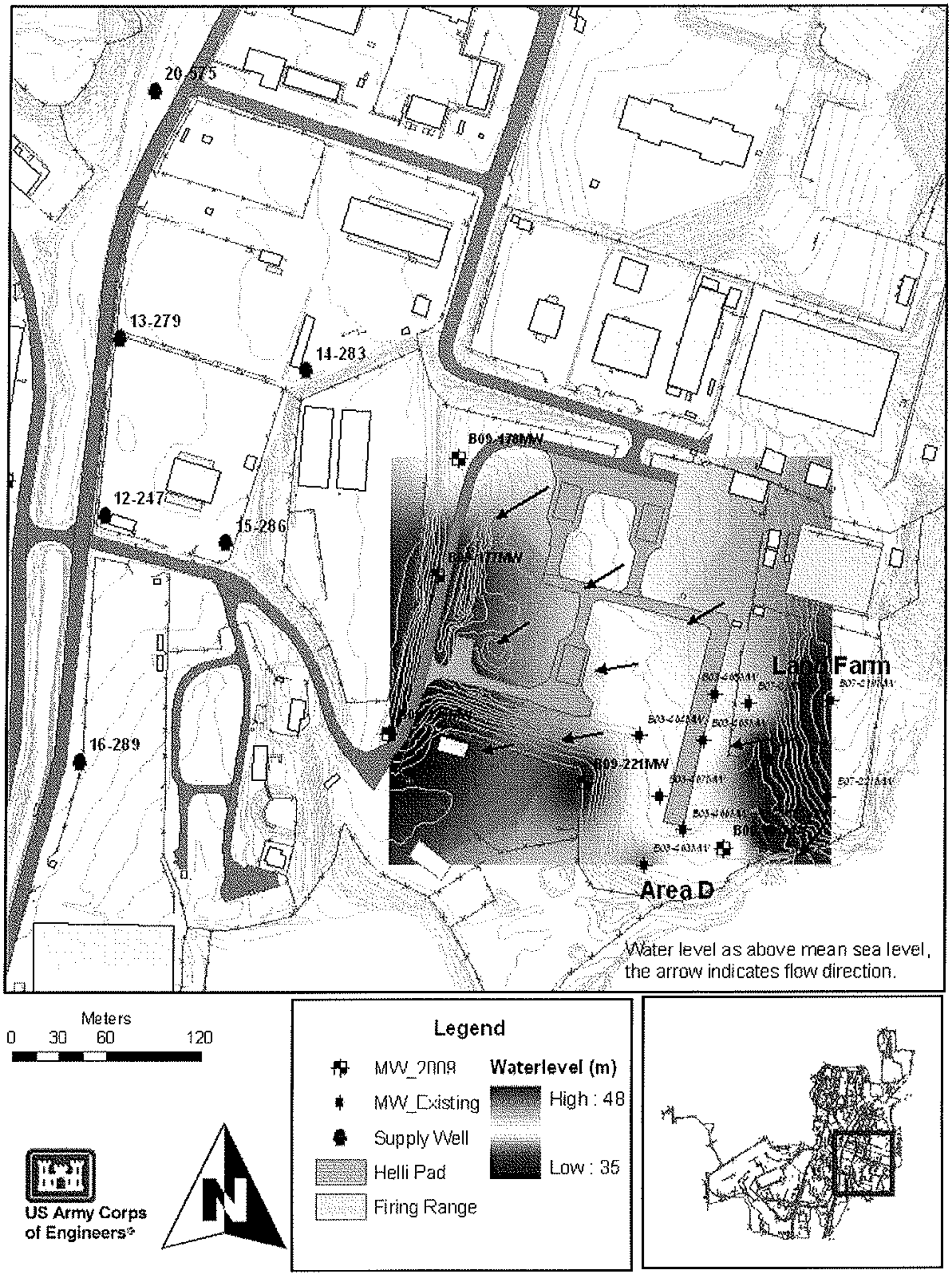

Figure 4-7 Toluene in Groundwater of LF-Area D of Camp Carroll.

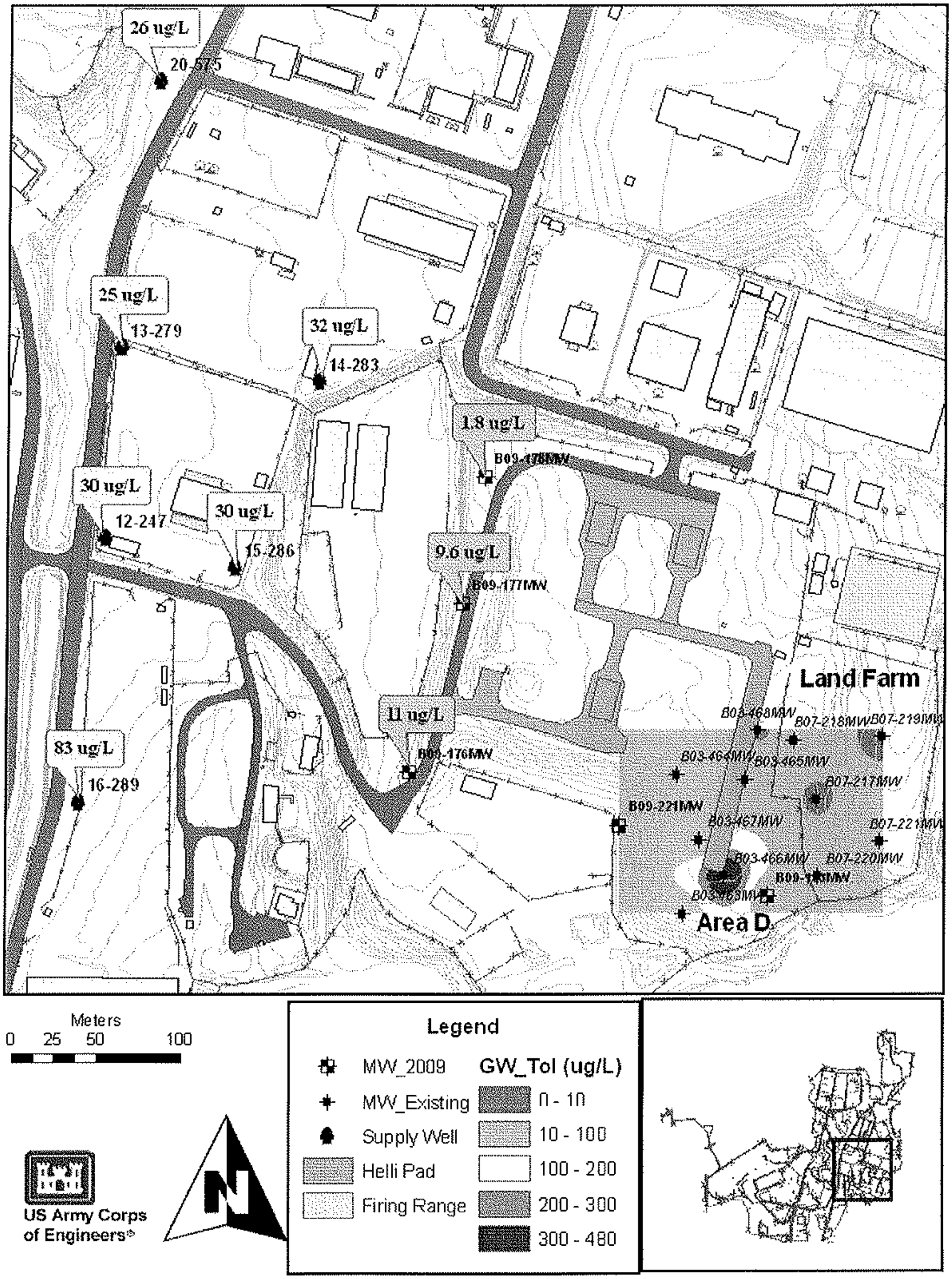

Figure 4-8 PCE in Groundwater of LF-Area D of Camp Carroll.

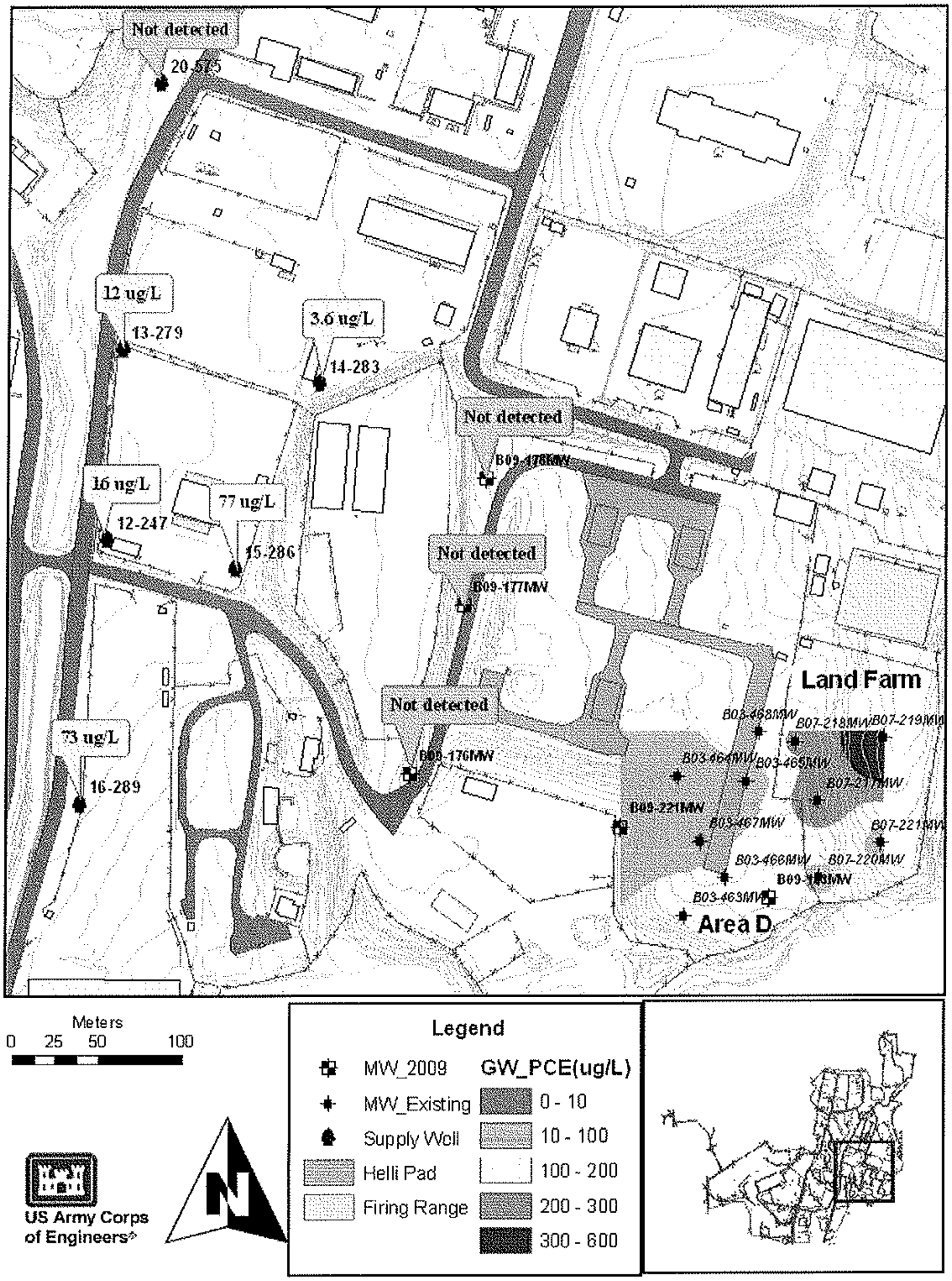

Figure 4-9 TCE in Groundwater of LF-Area D of Camp Carroll.

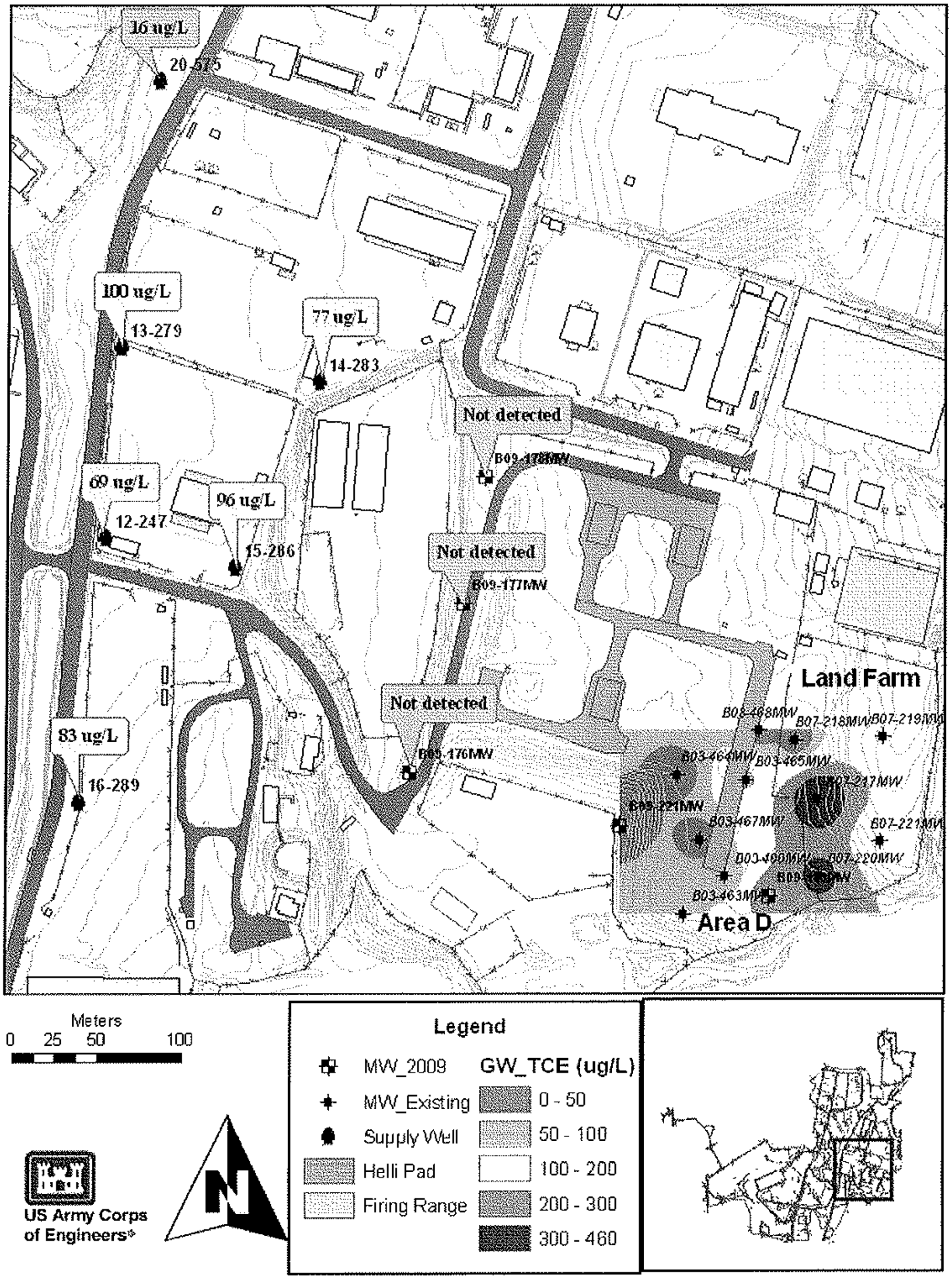

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Figure 4-10 TCE in Groundwater of LF-Area D of Camp Carroll.

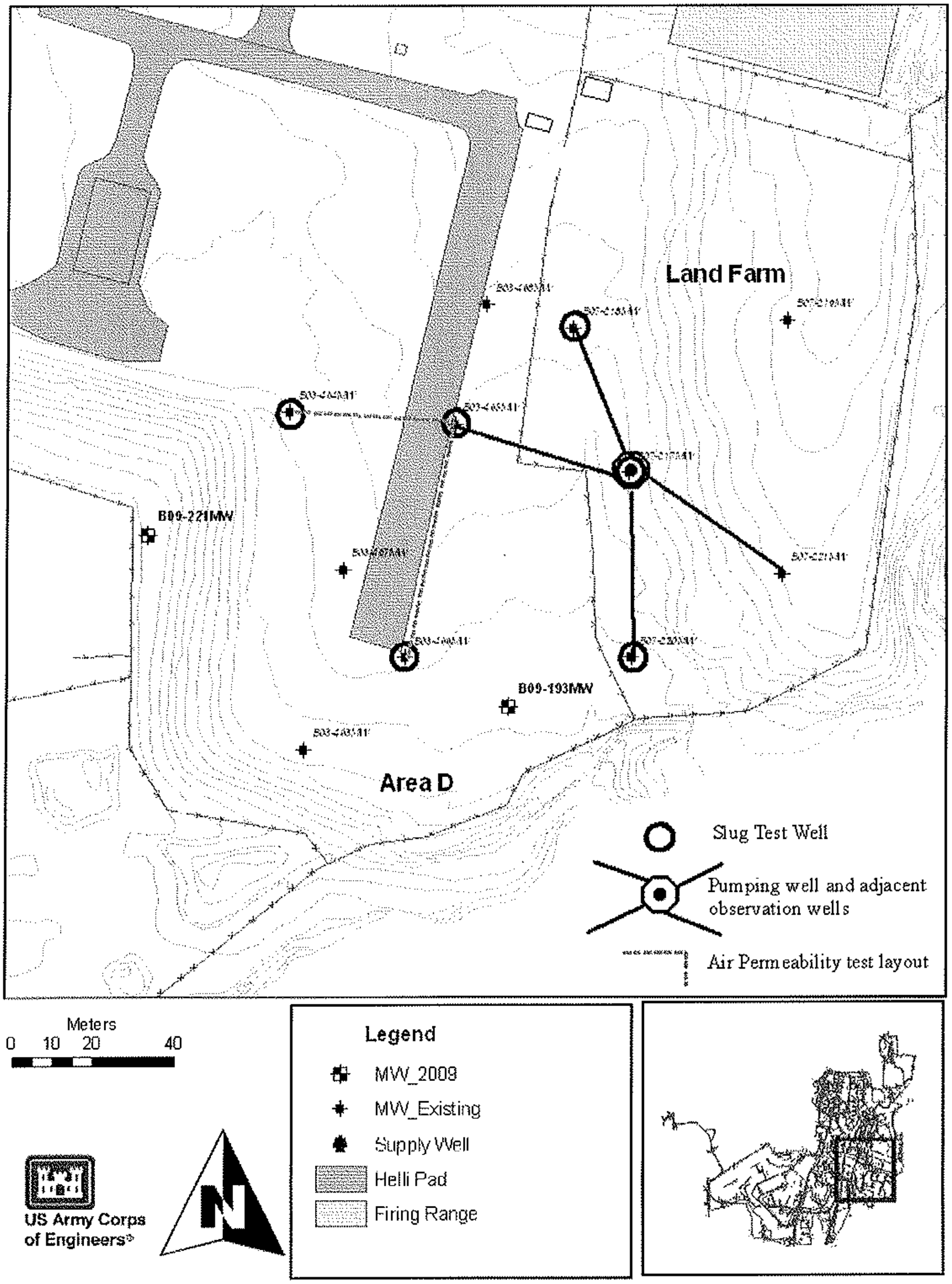
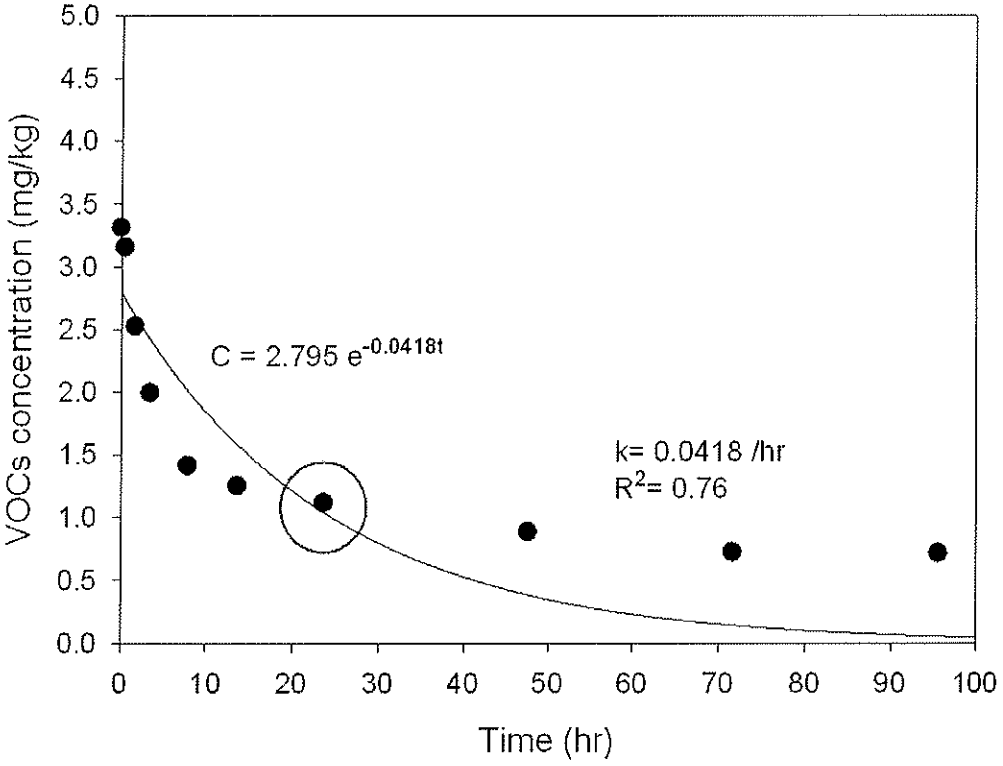


Figure 4-11 Kinetic Aeration Experiment for VOCs of LF-Area D of Camp Carroll.


5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
VOCs concentration (mg/kg)
C = 2.795 e$^{-0.0418t}$
k= 0.0418 /hr
R^2= 0.76
0
10
20
30
40
50
60
70
80
90
100
Time (hr)

5. Environmental Hazard Evaluation

An environmental hazard evaluation is presented for LF-Area D of Camp Carroll. The risk assessment utilizes soil and groundwater analytical data collected between February 2009 to March 2010. The risk analysis utilizes Environmental Screening Levels (ESLs) found in the Pacific Basin Edition of the document titled Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater which was last updated in October 2008 (Guam EPA, 2008; http://hawaii.gov/health/environmental/hazard/pacificbasin.html). Table 5-1 presents the maximum concentration detected in the site soil samples with comparison to the Pacific Basin ESL criteria, and Table 5-3 for groundwater sample result.

The ESL values were determined largely based upon published USEPA toxicity factors, water standards and recently promulgated Regional Screening Levels (RSLs). These screening levels are appropriate for future unrestricted land use of sites containing shallow (<3 meters) or deep (>3 meters) contaminated soils that are underlain by groundwater that is a potential source of drinking water. The detection of a chemical in soil and groundwater at concentrations below the corresponding Tier 1 ESL can be assumed to not pose a significant long-term or "chronic" threat to human health and the environment.

A more detailed Tier 2 screening analysis was conducted by the project scientist for those analytes that exceeded the Tier 1 ESL. For soil contamination, the construction worker scenario was evaluated during the Tier 2 analysis due to the specific site characteristics of the LF-Area D site. Generally, the project site is covered with asphalt or uncovered dirt area, therefore the outdoor worker considered in the commercial/industrial land use scenario would have a limited contact with surface soils. In such cases, the more relevant commercial receptor who may come in direct contact with contaminated soils is the construction/trench worker.

5.1. Summary of Environmental Findings from Investigations

The site characterization data obtained from LF-Area D site during the current investigation was previously provided. The findings during the current RI can be summarized as followings:

1) Boreholes were drilled in a roughly 20,000 square meters area in the vicinity of the LF-Area D at Camp Carroll.
2) The soil and groundwater samples were collected and analyzed. TPH, VOCs, metals and OC-Pesticides were reported from soil samples: TPH up to 236 mg/kg, Toluene up to 1,300 mg/kg, PCE up to 24 mg/kg and TCE up to 0.07 mg/kg; 4,4'-DDD up to 24 mg/kg and 4,4'-DDT up to 54 mg/kg, etc.
3) VOCs were detected in the groundwater samples; cis-1,2-DCE up to 1,100 μg/L, PCE up to 590 μg/L, Toluene up to 460 μg/L, etc. The VOCs were also reported from the samples collected from the supply wells.
4) OC-Pesticides were detected in the groundwater samples: alpha-BHC up to 0.37 μg/L, Lindane up to 4.9 μg/L, beta-BHC up to 0.73 μg/L, delta-BHC up to 1.1 mg/L and Dieldrin up to 0.44 mg/L, etc.
5) The average groundwater level during the investigation was about 7.8 m bgs, and about 1 meter variation among the measurement events.

Other relevant information other than investigation findings about the LF-Area D site includes:

- There are supply wells located within Camp Carroll Facility, six of those are located approximately 500 m from the LF-Area D.
- There are no documented sensitive ecological habitats at or adjacent to the Site.

5.2. Conceptual Site Model for LF-Area D

DPW's suspicions are based on the fact that contaminated soil and waste materials, such as one-gallon cans were uncovered during excavation and construction of Land Farm Bed #1 in 1995 (northwest corner of Bed #1). The Land Farm is also located very close to Area D. Area D is a site identified as a landfill where hazardous waste from Area #41 was disposed of between the years of 1977 and 1982, but reportedly removed between 1982 and 1983. In 2008 approximately 2,200 cubic meters of contaminated soils with various chemicals were excavated and stockpiled within the Land Farm Facility. In association with the contaminated soil, tons of buried materials were uncovered such as 55gallon drums, 5 gallon cans and construction debris.

Environmental concerns resulting from the historic use of the site include following:

- The origin of the environmental contamination present at the site is believed to be from the buried waste either on the Land Farm or the Area D, evidenced by uncovered buried wastes in 2008.
- Reported VOCs identification at the supply wells in the early 1990 is also believed to add environmental contamination to subsurface and groundwater from the LF-Area D.
- The very high concentration of various VOCs such as Toluene and PCE at LF-Area D (B09-196) is likely to be a burial point of associated wastes.
- Workers at the site may be exposed to elevated levels of soil gas present in the vadose zone at the site.

Current use of the project site is an open storage container yard and contaminated soil treatment facility, and the potentially exposed populations include soldiers and excavation workers at LF-Area D. The conceptual site model (CSM) of exposure routes for the LF-Area D project site is presented in Figure 5-1.

Surface soil was not affected by the contaminants, so the exposure pathway thru the surface soil is unlikely. Other than excavation scenarios for installing underground utilities or for construction purpose, the exposure to the contaminated subsurface soil is very limited. Soldiers are generally not involved in site excavation works, so the military activities are not affected by the subsurface contamination. Potential exposure routes include a construction or trenching scenario: the construction worker (adult) who is exposed to the COC in (1) subsurface soil via direct ingestion and dermal contact, (2) subsurface soil particles and vapors via inhalation of outdoor air, (3) groundwater via direct ingestion and dermal contact. There are the supply wells on base; therefore exposure to groundwater is considered a complete pathway for soldiers and civilians utilizing groundwater at Camp Carroll.

5.3. Target Constituents

The results from the current and the previous investigations (FED 2003; 2007; 2008) determined that VOCs and OC-Pesticides are present in the site subsurface of the LF-Area D. This Environmental Hazard Evaluation evaluated the risk posed by concentration of the COCs detected in site soils and groundwater.

5.4. RI Results Compared to Tier I Environmental Action Levels

The soil and groundwater collected during the project period were used to evaluate the existing environmental conditions of the site. The analytical results from soil and groundwater samples collected during this RI are summarized in Section 4-2 and included in the separate CD in this report. The maximum concentration of the various analytes detected in near (< 3 meters) and deep (> 3 meters) soil and groundwater collected from LF-Area D are summarized in Tables 5-1 and 5-3 respectively. The maximum values detected at the site were initially screened against the Tier 1 ESL.

The Tier I ESLs for an unrestricted land use scenario were selected for the initial screening evaluation. Based on the characteristics of the site, the ESL table associated with "Groundwater is a current or potential drinking water resource, and surface water body is not located within 150 meters of release site" was used.

Soil screening can derive up to four ESL endpoints with assumption of an excavation scenario. Two are human health impacts, including direct exposure to soils and vapor during trenching and soil excavation. The other impacts are gross contamination, and leaching to groundwater sources. Intrusion of vapor into buildings is considered as an exposure pathway, but currently there are no permanent buildings and residence within the project site.

Groundwater screening can derive up to three ESL endpoints with assumption of an excavation scenario. Direct exposure to groundwater during for construction and trench workers are incorporated into the Tier 1 ESLs. Two human health impacts are direct contact with contaminated groundwater and inhalation of vapor during excavation. The other impact is gross contamination including a presence of free phase product. The Tier I ESL screening compares the maximum concentrations to the ESL values without consideration of site-specific conditions. Table 5 3 summarizes the potential environmental hazards by site contamination at LF-Area D with assumption of trenching or site excavation.

5.4.1. Tier I ESL Screening Result of Soil at LF-Area D

The maximum soil concentrations summarized in Table 5-1 were compared to their corresponding ESL criteria of the Pacific Basin (Guam EPA, 2008). The chemical results detected were compared the results with shallower than 3 meter and deeper than 3 meter with potential drinking water concern for both unrestricted land use and commercial/industrial land use purposes. Four out of the total chemical components in the Table such as PCE, Toluene, DDD and DDT exceeded the ESL screening level and require additional site specific evaluation.

The soil screening results are summarized in Table 5-2. A "yes" in the table denotes that the maximum soil concentration measured during this RI exceeded the associated Tier I ESL.

5.4.2. Tier I ESL Screening Result of Groundwater at LF-Area D

1543

The maximum groundwater concentrations summarized in Table 5-3 were compared to their corresponding ESL screening criteria of the Pacific Basin (Guam EPA, 2008). The table divided results into groundwater samples from monitoring wells and the supply wells. Six chemical components of the monitoring well samples exceeded the Tier 1 ESL, and six chemical components of the supply well samples exceeded the criteria. The 1,1-Dichloroethane and cis-1,2-Dichloroethene commonly exceeded the criteria in the samples both monitoring well and the supply well. The six VOC components that exceeded the ESL screening endpoints require further evaluation. The groundwater screening results are summarized in Table 5-4. A "yes" in the table below denotes that the maximum groundwater concentration measured during this RI exceeded the associated Tier 1 ESL.

5.5. Site Specific Environmental Hazard Evaluation

The following section provides a more detailed environmental hazard evaluation for this RI site based upon the site specific conditions present at the site.

5.5.1. Site Specific Environmental Hazard Evaluation for LF-Area D

Based on the data collected during the RI, the initial conservative Tier 1 screening identifies potential hazards related to the soil and groundwater concentrations measured at the site. Four chemical components including PCE, Toluene, DDD and DDT in site soils exceeded Tier I screening levels, while total ten components including benzene, PCE, cis-1,-2 Dichloroethene and Toluene and etc exceeded the groundwater Tier I screening levels. Therefore, unrestricted future use of the site, for example for residential land development, would require a remedial effort to be conducted at the site in order to mitigate or remove the risk posed by the reported chemicals.

- The site is partly paved, mostly open dirt and grass field, but the current site is being used a container yard and contaminated soil treatment facility, which is likely to minimize the potential for direct dermal contact or ingestion of contaminated soil for outdoor soldiers and workers unless an excavation is ongoing.

- LF-Area D is an open area and no permanent residential facility so exposure to soil gas for soldiers/workers is not considered unless an excavation is ongoing.

- There are six known extraction wells to be utilizing within approximately 500 meters distance from the investigation site, which could be a direct exposure to the dissolved phase contamination present within the groundwater system at the site.

The most likely future exposure pathway to site subsurface soil contamination would be related to installation of underground utilities or a construction required excavation at the site. For instance, future construction work at the site could involve some form of trenching or excavation work in conjunction with putting building foundation, replacement or repair of the storm drain, sewer, electrical or cable utilities that run through or adjacent to the property. For this reason, the ESLs developed for the construction/trench worker exposure scenario (Table K-3 in the ESL Surfer at http://hawaii.gov/health/environmental/hazard/pacificbasin.html) were deemed most relevant for use in the Tier 2 ESL soil evaluation.

5.5.2. Tier 2 ESL Soil Evaluation for LF-Area D

The initial Tier 1 ESL screening indicated that direct exposure and leaching were potential hazards associated with the chemicals detected above the Tier 1 in the site soil. The soil contamination that exceeded Tier 1 ESLs was encountered both shallow and deep according to the ESL category. The maximum soil concentrations summarized in Table 5-5 are compared to the corresponding construction/trench worker exposure scenario final screening level (FSL at Table K-3 in the Pacific Basin Surfer spreadsheet). The FSL in Table K-3 is the lowest of individual screening levels for carcinogenic effects and non-carcinogenic effects. The saturation limit for the carcinogenic effects are not available was used as the upper limit for VOCs that are liquid at ambient conditions.

Note the trench/construction worker FSL for Toluene is based on the saturation limit, not health risks. The maximum Toluene concentration measured at LF-Area D site is higher than the trench/construction worker FSL. The presence of Toluene above the saturation limit indicates that there may be an inhalation risk to free product that cannot be accurately predicted with the EPA's soil exposure model.

5.5.3. Tier 2 Groundwater Evaluation at LF-Area D of LF-Area D

The initial Tier 1 ESL screening indicated that thermal contact, direct vapor ingestion and gross contamination were potential hazards associated with the chemicals detected in the groundwater. There are six supply wells within 500 meters away from the site, and Camp Carroll utilizes the groundwater for multipurpose uses such as taking shower, cleaning, washing car and etc. Thus, there are viable exposure pathways for personnel utilizing the groundwater from the supply wells, and for site workers involved an excavation work at LF-Area D site as well.

Table 5 6 presents the summary of the chemical data comparison result with the Guam Criteria for drinking water quality for human toxicity. Also the primary maximum contaminant levels (MCL) for each chemical are presented together for comparison. A total of nine chemicals out of VOCs exceeded the drinking water screening for human toxicity, and six chemicals are exceeding the primary MCL.

The depth to groundwater of 2.6 to 10.8 meters bgs (seasonal variation and variation due to the site topography) of the site suggests that the risk of exposure due to vapors originating from volatilization of contaminants in the shallow groundwater is minimal. Potential direct exposure to groundwater for construction/trench workers should be addressed and safety controls should be implemented to avoid direct contact with groundwater during a construction scenario.

5.6. Summary of Risk Assessments Results

The subsurface soil contamination present at the LF-Area D of Camp Carroll does not pose an immediate risk to human if left undisturbed. The Tier 1 screening identified potential hazards related to the subsurface soil and groundwater measured at the LF-Area D site. Specifically, for soil concentrations of PCE, Toluene and DDT exceeded the Tier 1 ESLs for both the unrestricted land use and the commercial/industrial land use. Therefore, future land use of the site would require soil excavation and treat contaminated groundwater.

Several constituents of concern in groundwater exceed the ESLs and drinking water for human toxicity and the primary MCL such as benzene, cis-1,2-DCE, PCE and Toluene, etc, this assessment determined that groundwater is a complete exposure pathway because there are known supply water wells in the area. The findings of VOCs constituents in the groundwater both groundwater monitoring well and the supply wells strongly suggest that the LF-Area D can be a very possible continuing source of VOCs contamination.

Table 5-1. Tier 1 Comparison with the Maximum Concentration detected in Soil Sample at LF-Area D of Camp Carroll according to the Guam EPA in 2008.

Chemical Parameter	Maximum Sample concentration (mg/kg)	BH_ID	Depth	Shallow <3 m, GW is potential drinking water		Deep >3 m, GW is potential drinking water	
				[1]Unrestricted Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[2]Unrestricted Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)
TPH Diesel	55.4	B09-193	0-2 m	1.0E+02	1.0E+02	1.0E+02	1.0E+02
TPH oil	171	B09-193	0-2 m	5.0E+02	1.0E+03	1.0E+03	1.0E+03
Tetrachloroethylene	**24***	B09-196	4-6 m	7.0E-02	2.5E-01	7.0E-02	2.5E-01
Toluene	**1300**	B09-196	4-6 m	3.4E+00	3.4E+00	3.4E+00	3.4E+00
DDD	**24**	B09-196	0-2 m	2.0E+00	7.2E+00	8.2E+01	8.2E+01
DDE	0.044	B09-220	4-6 m	1.4E+00	4.0E+00	3.7E+01	3.7E+01
DDT	**54**	B09-196	0-2 m	1.7E+00	4.0E+00	7.3E+00	7.3E+00
Arsenic	8.7	B09-192	0-2 m	2.0E+01	2.0E+01	8.9E+01	8.9E+01
Barium	105	B09-192	0-2 m	7.5E+02	1.5E+03	2.5E+03	4.3E+03
Cadmium	0.87	B09-202	0-2 m	1.2E+01	1.2E+01	3.7E+02	3.7E+02
Chromium	5.4	B09-221	0-2 m	6.5E+01	6.5E+01	6.5E+01	6.5E+01
Lead	22	B09-192	0-2 m	2.0E+02	8.0E+02	8.0E+02	8.0E+02
Mercury	0.05	B09-193	0-2 m	4.7E+00	1.0E+01	1.3E+02	1.3E+02
1- Residential area assumed that groundwater is a potential source of drinking water.							
2- Industrial area assumed that groundwater is a potential source of drinking water.							
* Highlighted ones denote that EXCEED the associated criteria.							

Table 5-2. Tier 1 ESL Screening Summary of Subsurface Soil at LF-Area D.

Analyte	Human Health		Gross Contamination	Terrestrial Habitats
	Direct Exposure	Vapor Intrusion		
TPH Diesel	-	-	-	-
TPH oil	-	-	-	-
Tetrachloroethylene	yes	yes	yes	-
Toluene	yes	yes	yes	-
DDD	yes	yes	yes	-
DDE	-	-	-	-
DDT	yes	yes	yes	-
Arsenic	-	-	-	-
Barium	-	-	-	-
Cadmium	-	-	-	-
Chromium	-	-	-	-
Lead	-	-	-	-
Mercury	-	-	-	-

"yes" indicates "exceeding" the Tier 1 ESL criteria.

Table 5-3. Tier 1 Comparison with the Maximum Concentration Detected in Site Groundwater at LF-Area D of Camp Carroll according to the Guam EPA in 2008.

Chemical parameter	Highest Detect*(µg/L)	Monitoring Well_ID	Highest Detect** (µg/L)	Supply Well_ID	Screening Level (µg/L)
Acetone	15	B03-467MW	-		1.5E+03
Benzene	**11**	B03-467MW	-		5.0E+00
Bromomethane	-		1.6	14-283	8.7E+00
Chlorobenzene	15	B03-466MW	-		2.5E+01
Chloroethane	8	B03-467MW	-		3.9E+00
Chloroform	5	B07-221MW	1.8	13-279	7.4E+01
Chloromethane	-		**61.0**	14-283	1.8E+00
1,1-Dichloroethane	**18**	B03-467MW	**9.5**	15-286	2.4E+00
1,2-Dichloroethane	-		1.1	13-279	5.0E+00
cis-1,2-Dichloroethene	**1100**	B03-465MW	**160.0**	15-286	7.0E+01
trans-1,2-Dichloroethene	28	B03-465MW	3.7	16-289	1.0E+02
1,1-Dichloroethene	5	B03-465MW	**18.0**	15-286	7.0E+00
Ethylbenzene	2	B03-466MW	-		3.0E+01
Methylene chloride	3	B03-465MW	3.1	20-575	4.8E+00
Naphthalene	5	B03-466MW	-		1.7E+01
1,1,2,2-Tetrachloroethane	-		**18.0**	12-247	6.7E-02
Tetrachloroethene	**590**	B07-219MW	77.0		5.0E+00
Toluene	**480**	B03-466MW	32.0	14-283	4.0E+01
1,1,1-Trichloroethane	-		13.0	15-286	6.2E+01
Trichloroethene	460	B09-193MW	**100.0**	13-279	5.0E+02
Vinyl chloride	57	B03-465MW	-		2.0E+00

*- highest concentration from the monitoring wells, **- those from the supply wells.

Table 5-4. Tier 1 ESL Screening Summary of Groundwater at LF-Area D.

Analyte	Human Health		Gross Contamination	Terrestrial Habitats
	Direct Exposure	Vapor Intrusion		
Acetone	-	-	-	-
Benzene	yes	yes	yes	-
Bromomethane	-	-	-	-
Chlorobenzene	-	-	-	-
Chloroethane	yes	yes	yes	-
Chloroform	-	-	-	-
Chloromethane	yes	yes	yes	-
1,1-Dichloroethane	yes	yes	yes	-
1,2-Dichloroethane	-	-	-	-
cis-1,2-Dichloroethene	yes	yes	yes	-
trans-1,2-Dichloroethene	-	-	-	-
1,1-Dichloroethene	yes	yes	yes	-
Ethylbenzene	-	-	-	-
Methylene chloride	-	-	-	-
Naphthalene	-	-	-	-
1,1,2,2-Tetrachloroethane	yes	yes	yes	-
Tetrachloroethene	yes	yes	yes	-
Toluene	yes	yes	yes	-
1,1,1-Trichloroethane	-	-	-	-
Trichloroethene	-	-	-	-
Vinyl chloride	yes	yes	yes	-
"yes" indicates "exceeding" the Tier 1 ESL criteria.				

Table 5-5. Tier 2 Screening by Final Screening Level (FSL) for Subsurface Soil Data Exceeding the Tier 1 ESL.

Component	Highest hit (mg/kg)	BH_ID	Depth	Final Screening Level (mg/kg)	
				Concentration	**Basis**
Tetrachloroethylene	24	B09-196	4-6 m	32	carcinogenic effects
Toluene	1300	B09-196	4-6 m	**925**	saturation limit
DDD	24	B09-196	0-2 m	604	carcinogenic effects
DDT	54	B09-196	0-2 m	191	noncarcinogenic effects
Final Screening Level published by Guam EPA in 2008 based on the excavation work scenario.					

Data for Exceeding the Tier 1 ESL.

Component (µg/L)	Monitoring Well		Supply Well		*Drinking Water for Human Toxicity	**Primary MCL	Toxicity
	µg/L	ID	µg/L	ID			
Benzene	**11**	B03-467MW	-		5.0	5.0	Drinking Water
Chloromethane	-		**61.0**	14-283	1.8		Drinking Water
1,1-Dichloroethane	**18**	B03-467MW	**9.5**	15-286	2.4		Drinking Water
1,2-Dichloroethane	-		1.1	13-279	5.0	5.0	Drinking Water
cis-1,2-Dichloroethene	**1100**	B03-465MW	**160.0**	15-286	70.0	70.0	Drinking Water
trans-1,2-Dichloroethene	28	B03-465MW	3.7	16-289	100.0	100.0	Drinking Water
1,1-Dichloroethene	5	B03-465MW	**18.0**	15-286	7.0	7.0	Drinking Water
1,1,2,2-Tetrachloroethane	-		**18.0**	12-247	0.1		Drinking Water
Tetrachloroethene	**590**	B07-219MW	**77.0**		5.0	5.0	Drinking Water
Toluene	480	B03-466MW	32.0	14-283	1000.0	1000.0	$^{\$\$}$Gross Contam
Trichloroethene	**460**	B09-193MW	**100.0**	13-279	5.0	5.0	Drinking Water
Vinyl chloride	**57**	B03-465MW	-		2.0	2.0	Drinking Water

* Lowest of groundwater Gross Contamination, Vapor Intrusion and Aquatic Habitat screening levels. Used to develop soil leaching leve protection of groundwater quality.

*Human Toxicity: Based on primary maximum concentration levels (MCLs), or equivalent. Considered protective of human health.

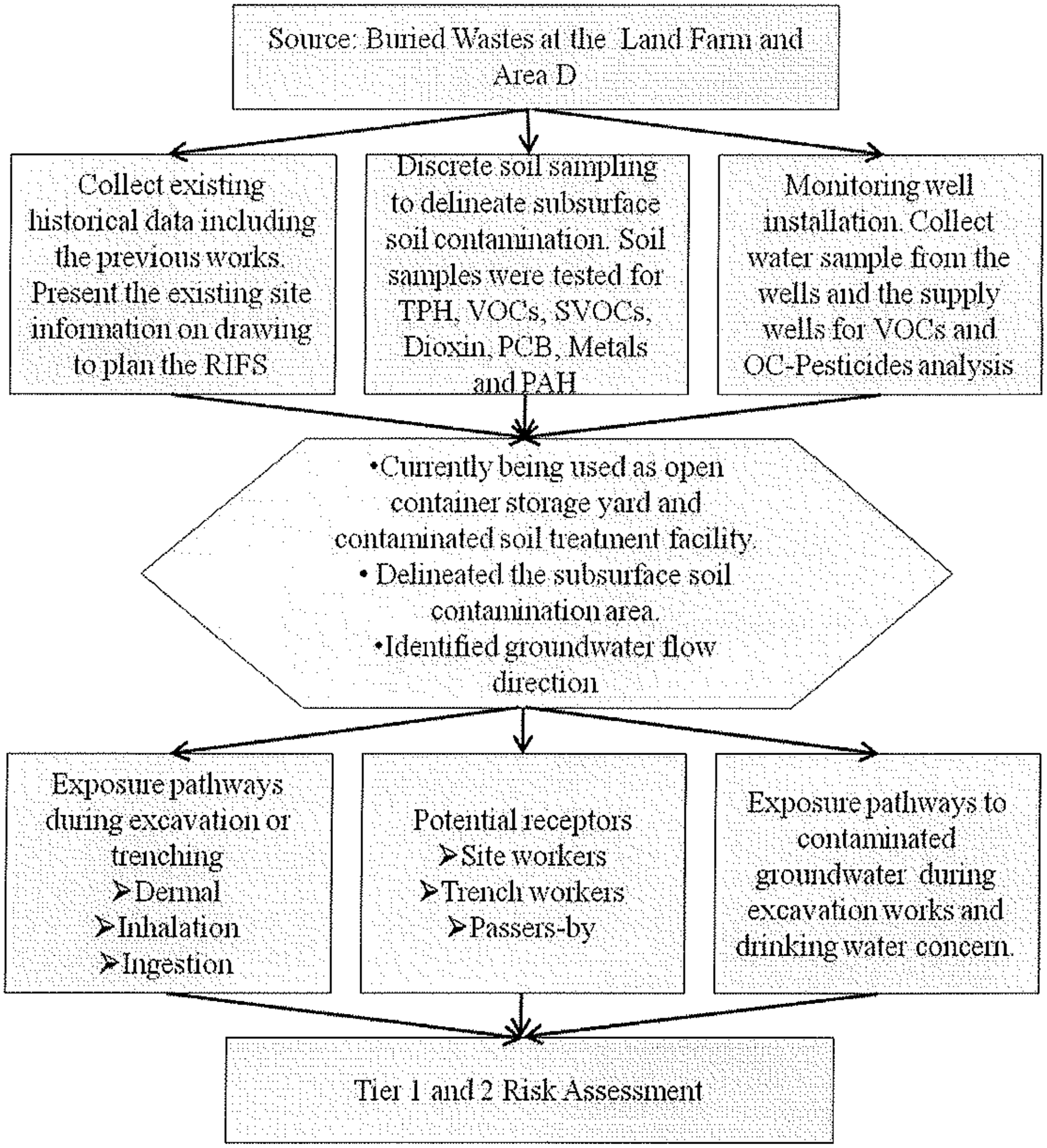
** Maximum concentration level (MCLs) by EPA 2006.

$^{\$}$Aquatic Habitat Goal: Addresses potential discharge of groundwater to estuarine aquatic habitat and subsequent impact on aquatic life.

$^{\$\$}$Gross Contamination: Odor threshold, 1/2 solubility or 50000 µg/L maximum, whichever is lower. Intended to limit general groundwat resource degradation.

The highlighted ones indicate the concentration exceeds the drinking water for human toxicity concentration

Figure 5-1. Conceptual Site Model based on the currently available site information.



6. Screening of Potential Remedial Alternatives

In this Chapter, potential remedial options are addressed for VOCs and OC-Pesticides contaminated soils and groundwater present at the LF-Area D site. The overall levels of contamination measured in soils and groundwater at the site varies over the project site from having greater than the Tier 1 and 2 screening concentrations to non-detected. The limited lateral extent of the site subsurface soil contamination is likely due to the waste burial point might not be associated directly with groundwater. However, the limited spreading over the area occurred over the year, probably by precipitation passing through the wasted burial point due to unpaved the site ground condition. A leaching process by the precipitation or the elevated of groundwater level during monsoon season is likely to affect the site groundwater quality, even to the supply well systems over the year.

A conservative remedial action scenario would be to initiate clean-up all soils and/or groundwater that exceed the Tier I and Tier II ESLs as identified in this report. The efficacy of various remedial alternatives for treating VOCs and OC-Pesticides contamination addresses in this Chapter. As discussed in the environmental hazard evaluation, the site subsurface soil contains chemicals that exceed the Tier I and II ESLs, but not poses a risk to site workers or passers-by due to site-specific conditions (i.e. depth to contamination and current site use, etc.) unless the site is determined to excavate. By the health evaluation, the groundwater was identified the VOCs concentration exceeding Tier I and II ESLs, and drinking water standards as well which could cause a direct exposure to human being to utilize the groundwater at Camp Carroll unless the source is completely removed or the groundwater is treated before distributing to the buildings.

6.1. Remedial Action Objectives

Remedial action objectives serve as remedial technologies established for protecting human health and the environment at the site. The objective of any remedial action undertaken is to reduce risks to human health to acceptable levels for the current and reasonably anticipated land use. As discussed above, the conservative Pacific Basin Tier 1 and Tier ESLs (Guam, 2008) were used as the criteria for determining the extent of soil and groundwater contamination at this RI site that may potentially require remediation.

6.2. Identification of General Response Actions

General Response Actions are those actions that can potentially achieve the Remedial Action Objectives as described in the Project objective of this project. The remedial actions are intended to: (1) mitigate potential exposure to, (2) control the migration of, and/or (3) remediate the VOCs and OC-Pesticides contamination present at the site.

6.3. Screening of Remedial Action Alternatives

The preliminary Tier land Tier II environmental hazard evaluation conducted for the site suggests that some remedial actions are required at the site due to potential risk to human receptors. If there are no time constraints on remediation of the project site, the site would be good location for evaluation of monitoring natural attenuation to degrade the contaminants present at the site. Other conventional remedial approaches that would be appropriate for the site would include excavation and off-site disposal and surface capping of the sites. These technologies could be protective of human health by providing an effective means of reducing future exposure to the contamination at the site. The following section evaluates a series of potential remedial alternatives for the LF-Area D site. The presence of containers and underground utilities at the project site may present certain logistical challenges with respect to applying remedial technologies to the site.

6.3.1. No Action Alternative

The No Action Alternate assumes that no remedial activities will be conducted at the project site. Under this alternative, no effort would be made to reduce or remove the contaminant that is present in soils and groundwater at the project site. Advantages and disadvantages are summarized as below when no action was selected.

Contaminants:

- Non-halogenated volatiles and semi-volatiles, pesticides, PCBs.
- Less effective for some halogenated volatiles and pesticides.

Advantages:

- Involves no handling of contaminated materials which could put workers at risk.
- No site disturbance, no capital costs.

Disadvantages:

- Degradation contaminants may be more mobile and toxic than the original contaminant.
- Risk that contaminants may migrate to sensitive receptors before being attenuated.
- Regulatory and public acceptance is low due to perception of "do-nothing" option.
- May significantly increase the treatment cost when it is necessary due to a migration of contaminants over to the adjacent area.
- Cannot be a permanent solution.

6.3.2. Monitoring Natural Attenuation (Intrinsic Bioremediation)

Natural attenuation (also known as Intrinsic Bioremediation) is the conversion of environmental pollutants into harmless forms through the innate capabilities of natural site processes. These processes may include dilution, volatilization, biodegradation, adsorption, and chemical reactions. The intrinsic ability of the *in-situ* biologic community to metabolize the site contamination needs to be further evaluated at the laboratory and at field scale before the use of this technology can be implemented. The bioremediation is one of the most commonly implemented innovative treatment technologies at National Priority List (NPL) sites of EPA, and there is increasing interest in using intrinsic bioremediation following more active actions, such as source removal and soil vapor extraction. Bioremediation has been successfully implemented at sites containing petroleum related contamination throughout the US. The petroleum hydrocarbon contaminant acts as an electron donor and naturally occurring groundwater constituents such as oxygen, nitrate, sulfate, and methane act as electron acceptors in a respiratory process. In order for this technology to be effective, hydrogeologic conditions must exist that degrade contaminants quickly enough to prevent them from spreading without human intervention. The effectiveness of this remediation technology is typically established by implementing a long-term monitoring plan for a given project site. The contaminants for which this technology can be applied as well as this technology's advantages and disadvantages are summarized below:

Contaminants:

- Non-halogenated volatiles and semi-volatiles, fuel hydrocarbons.
- Less effective for some halogenated volatiles, semi-volatiles, pesticides and PCBs.

Advantages:

- Involves no handling of contaminated materials which could put workers at risk.
- No site disturbance, no capital costs.
- Limiting contaminant migration.
- Reducing long term risks.
- Can be a permanent solution.

Disadvantages:

- Modeling for contaminants fate-transport and long term monitoring generally required.
- Degradation products may be more mobile and toxic than the original contaminant.
- Risk that contaminants may migrate to sensitive receptors before being attenuated.
- Regulatory and public acceptance is low due to perception of "do-nothing" option.
- May require implementation of some form of institutional control to prevent inappropriate future use of the site.

6.3.3. Excavation and Off-site Disposal Alternative

All of the soil in the contaminated area would be excavated and transported off-site for disposal or treatment at an appropriate facility under this alternative. Because all of the material within the disposal area would physically be removed from the impacted area, no Institutional Controls or long-term monitoring would be required. The contaminants for which this technology can be applied as well as this technology's advantages and disadvantages are summarized below:

Contaminants:

- Non-halogenated volatiles and semi-volatiles, fuel hydrocarbons, halogenated volatiles, semi-volatiles, pesticides and PCBs.

Advantages:

- Facilitates unrestricted future use of site
- Eliminates contaminant migration.
- No long term risks.
- Can be a permanent solution.

Disadvantages:

- Involves handling of contaminated materials which could put workers at risk.
- High cost
- Does not directly address the existing groundwater contamination at each site.
- Require proper facility to dispose of contaminated soil excavated.
- Require an installation of water treatment facility in the case of encountering contaminated groundwater.

6.3.4. Bioslurping Alternative

Bioslurping involves the simultaneous application of vacuum enhanced extraction/recovery, vapor extraction, and bioventing to address light non-aqueous phase liquid (LNAPL) contamination. Vacuum extraction/recovery is used to remove free product along with some groundwater, vapor extraction is used to remove high volatility vapors from the vadose zone, and bioventing is used to enhance aerobic biodegradation in the vadose zone and capillary fringe.

The bioslurping system is made up of a well into which an adjustable length “slurp tube” is installed. The slurp tube, connected to a vacuum pump, is lowered into the LNAPL layer, and pumping begins to remove free product along with some groundwater vacuum enhanced extraction/recovery). The vacuum-induced negative pressure zone in the well promotes LNAPL flow toward the well and also draws LNAPL trapped in small pore spaces and bedrock fractures above the water table. When the LNAPL level declines slightly in response to pumping, the slurp tube begins to draw in and extract vapors (vapor extraction). This removal of vapors promotes air movement through the unsaturated zone, increasing oxygen content and enhancing aerobic bioremediation (bioventing).

When mounding due to the introduced vacuum causes a slight rise in the water table, the slurp cycles back to removing LNAPL and groundwater. This cycling minimizes water table fluctuations, reducing “smearing” associated with other recovery techniques. Liquid (product and groundwater) removed through the slurp tube is sent to an oil/water separator, and vapors are sent to a liquid vapor separator.

Aboveground water and vapor treatment systems may also be included, if required. However, in some cases, system design modifications have allowed discharge of groundwater and vapor extracted via bioslurping without treatment. Results of field tests of bioslurping systems have shown that LNAPL and vapor recovery are directly correlated with the degree of vacuum. A comparison of bioslurping to conventional methods of LNAPL recovery reported that bioslurping achieved the greater recovery rates than either skimming or dual-pump methods. In order for this technology to be effective, the site should have fine to medium grained overburden materials; however, has also been effective at some sites with medium to coarse grained material and in fractured rock. The ability of this technology to remediate the contamination present at the site is typically evaluated by conducting a pilot scale demonstration project. The contaminants for which this technology can be applied as well as this technology’s advantages and disadvantages are summarized below:

Contaminants:

- Oil and gasoline hydrocarbons (LNAPL).
- Chlorinated solvents.

- Trichloroethylene.

Advantages:

- Lower project cost than excavation due to minimization of storage, treatment, and disposal costs.
- Allows direct discharge without treatment by keeping extraction rates to a minimum by maintaining vapor concentrations below regulatory limits.
- Fluctuations in the elevation of the water table, and associated smearing, are minimized since product moves horizontally toward bioslurping wells.
- Recovery of residual hydrocarbons in the vadose zone is enhanced by the partial vacuum induced during bioslurping.
- Limit plume migration through hydraulic lift.
- Can easily be converted for standard bioventing activities following free product removal and groundwater remediation activities.
- Well design can be modified to expose contamination below water table.
- Bioslurping technology can minimize disruption of the gas station operation during technology implementation.

Disadvantages:

- High-velocity pump systems tend to form emulsions, especially when diesel is part of recovered fluids.
- Biofouling of well screens is possible due to active aeration of bioslurping wells.
- Bioslurping does not treat residual contamination in saturated soils.
- Fuel extraction efficiency strongly depends on the bedrock fracture system and hydrologic connectivity.

6.3.5. Soil Vapor Extraction Alternative

Soil vapor extraction (SVE), also known as "soil venting" or "vacuum extraction", is an *in situ* remedial technology that reduces concentrations of volatile constituents adsorbed to soils in the unsaturated (vadose) zone. In this technology, a vacuum is applied through wells near the source of contamination in the soil. Volatile constituents of the contaminant mass "evaporate" and the vapors are drawn toward the extraction wells. Extracted vapor is then treated as necessary (commonly with carbon adsorption) before being released to the atmosphere. The increased air flow through the subsurface can also stimulate biodegradation of some of the contaminants, especially those that are less volatile. In areas of high groundwater levels, water table depression pumps may be required to offset the effect of upwelling induced by the vacuum. High moisture content in soils can reduce soil permeability and, consequently, the effectiveness of SVE by restricting the flow of air through soil pores. In order for this technology to be effective, hydrogeologic conditions, soil structure and stratification need to be evaluated. The ability of this technology to remediate the contamination present at the site is typically evaluated by conducting a pilot scale demonstration project. The contaminants for which this technology can be applied as well as this technology's advantages and disadvantages are summarized below:

Contaminants:

- VOCs and certain semi-volatile organic compounds (SVOCs) found in petroleum products.
- Not effective for diesel fuel, heating oils, and kerosene, which are less volatile than gasoline, or non-volatile lubricating oils.

Advantages:

- Proven performance; readily available equipment; easy installation.
- Minimal site operations disturbance.
- Can be applied at sites with free product, and can be combined with other technologies.

Disadvantages:

- Concentration reductions greater than 90% are difficult to achieve.
- Effectiveness less certain when applied to sites with low-permeability soil or stratified soils.
- May require costly treatment for atmospheric discharge of extracted vapors.
- Air emission permits generally required.
- Only treats unsaturated-zone soils.
- SVE generally not appropriate for sites with a groundwater table located less than three feet below the land surface.

6.3.6. *Ex-Situ* Treatment of Excavated Soil

This remediation alternative involves excavation and on- or off-site treatment of the contaminated media present at the property. Examples of potential ex-situ treatment technologies include the construction of vented biopiles, thermal desorption, enhanced biodegradation, and phytoremediation. The ability of these technologies to remediate the contamination present at the site is typically evaluated by conducting a pilot scale demonstration project.

Contaminants:

- Non-halogenated volatiles and semi-volatiles, fuel hydrocarbons.
- Less effective for some halogenated volatiles, semi-volatiles, and pesticides.

Advantages:

- Better oxygen delivery to less permeable formations.
- Easier to track progress of remediation.
- Allows the use of a number of innovative remediation technologies.

Disadvantages:

- Extensive site disturbance, moderate capital costs.
- Need to isolate contaminated soils being treated from coming into human contact.
- Not effective in highly layered, clay, or bedrock sub-surfaces.
- Not effective at sites with high concentrations of heavy metals, inorganic salts, or chlorinated organic.
- Remediation may take several months to years.

6.3.7. Surface Capping (Encapsulation)

This technology involves construction of a surface cap at the project site. An impermeable ground cover is constructed in order to isolate the contaminants from the surface (and potential exposure to human receptors) and redirect surface water and resulting percolation away from the contaminated soil.

Surface caps are typically made of synthetic membranes, soil-bentonite mixtures, clay, asphalt or concrete. An extension of surface capping is encapsulation where impermeable barriers are extended vertically around and sometimes underneath the contaminated soils to redirect groundwater around the contaminated soils.

Contaminants:
- All types.

Advantages:
- Easily installed.
- Reduces exposure/contact of public to contaminants.
- Low operation/maintenance (O/M) costs.

Disadvantages:
- Long term liability.
- Periodic maintenance and monitoring may be required.
- Vapor controls built-up may be needed.
- Groundwater controls may be needed.
- Not a permanent solution.

6.3.8. Pump and Treat for Contaminated Groundwater

When contaminated groundwater is extracted from the subsurface by pumping, it needs to be treated before it is discharged. Hence this method is referred to as pump-and-treat. This is the most common form of groundwater remediation. It is often associated with treatment technologies such as Air Stripping and Liquid-phase Granular Activated Charcoal. Treatment systems are described separately.

The well design, pumping system, and treatment are dependent on the site characteristics and contaminant type. It is not uncommon to find many wells extracting groundwater at the same time. These wells may be screened at different depths to maximize effectiveness. A major component of any groundwater extraction system is a ground water monitoring program to verify its effectiveness. Monitoring the cleanup allows the operator to make adjustments to the system in response to changes in subsurface conditions.

A major issue for a pump-and-treat system is determining when to turn the system off. For contaminants regulated by the EPA, levels established under the Safe Drinking Water Act are usually the prevailing levels that groundwater has to meet. Termination requirements are based on the cleanup objectives defined in the initial stage of the remedial process, combined with site-specific aspects revealed during remedial operations.

Contaminants:

- Non-halogenated volatiles and semi-volatiles, fuel hydrocarbons, explosive compounds and dissolved metals.

Advantages:

- Proved technology for contaminated groundwater treatment
- One of the known most efficient to remediate contaminated groundwater.
- Easier to track progress of remediation.
- Enhance biodegradation process by dewatering and supplying oxygen to the capillary fringe.

Disadvantages:

- Normally take a very long time to meet cleanup goals depending upon the extent of area of concern and the hydraulic properties of the aquifer.
- Pumping depresses the groundwater level, leaving residuals sorbed to the soil.
- After the groundwater level returns to its normal level, contaminants sorbed onto soil become dissolved (rebound effect).
- Should rebound tests be performed frequently after a system is turned off, and after major rain or flooding events.

6.4. Remedial and Monitoring Recommendations

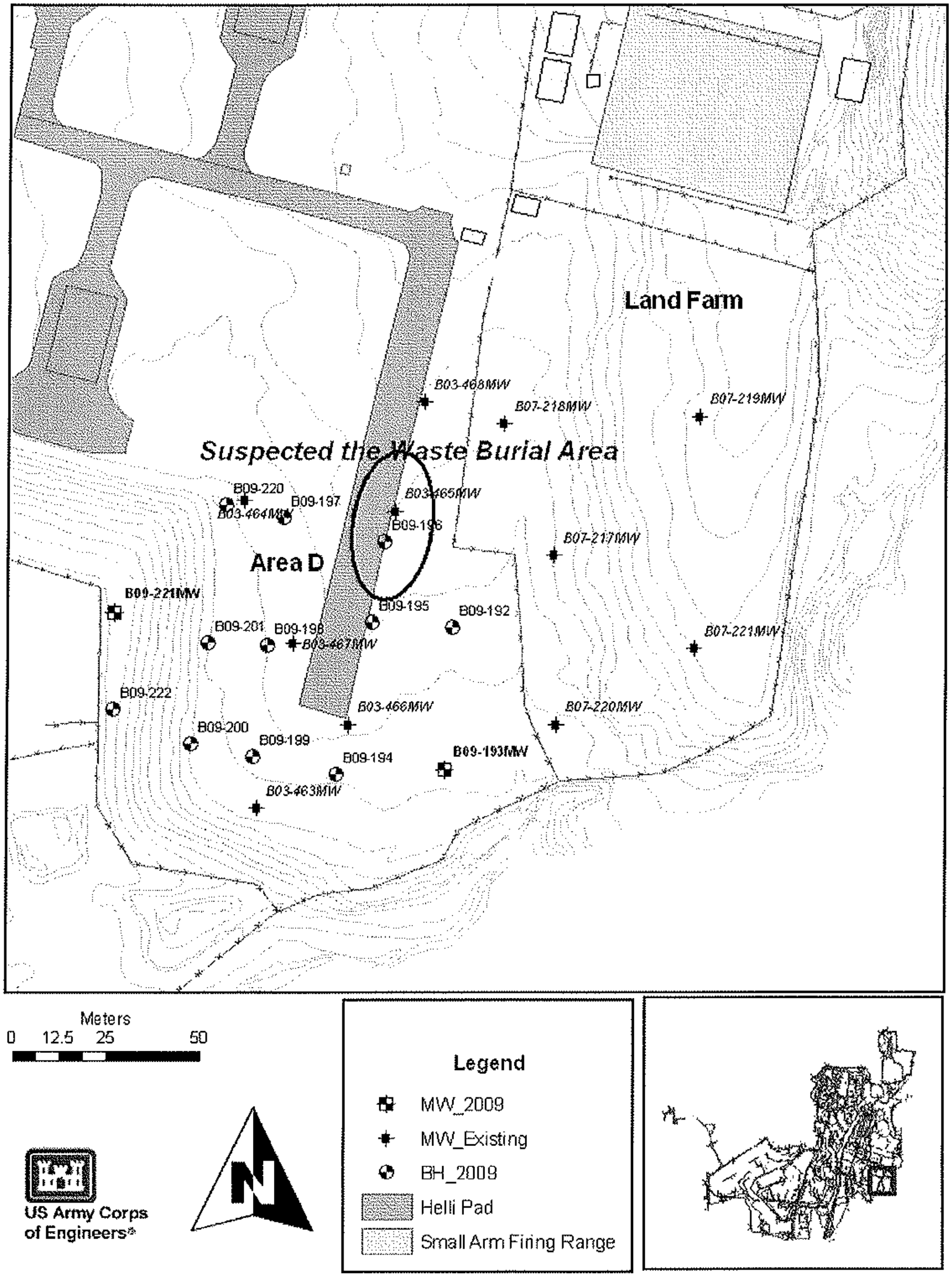
The recommended remedial and monitoring requirements for Camp Carroll installation are summarized in Table 6-1. The levels of contaminants in the site soil and groundwater do exceed the Tier I and II ESLs of Guam EAP Standards, which was identified exposure pathways to human being that could pose an imminent health risk since the camp utilizes the groundwater. As an initial remedial measure, it is recommended that a buried waste be removed from the site subsurface (Figure 6-1)

With respect to contaminant source removal, it is recommended that groundwater be treated prior to uptaking from the supply wells or before distributing to buildings. In addition, periodic groundwater and soil sampling at the site is recommended to evaluate whether natural attenuation and contaminant degradation is occurring.

Table 6-1. Recommended Remedial Approach and Site Monitoring at LF-Area D.

Recommended Remedial / Monitoring Approach	Rationale for Decision
Remove the source of soil and groundwater contamination, otherwise it's going to be a continuing source of contamination to subsurface soil and groundwater.	Allows the site can be utilized and help the installation mission gets succeed without any environmental concern. Removal activity should occur because the level of subsurface contamination exceeds the human health risk guideline by Guam EPA ESLs.
Treat the contaminated groundwater.	Tier I and II screenings indicate the site groundwater utilizing in the installation exceeds the level of human toxicity, and some chemicals exceed the drinking water standard by US EPA.
Plan on period groundwater and soil monitoring programs at LF-Area D	Evaluate the viability of biodegradation to reduce the concentration of residual contamination at the site, and to monitor if any further spreading of contamination.

Figure 6-1. The Suspected Waste Burial Area to Be Removed at LF-Area D of Camp Carroll.



Appendix I: Soil Borehole Logs

Appendix II: Monitoring Well Construction Logs

Appendix III: Slug Test Result

Appendix IV: Pumping Test Result

1567

Appendix V: Air Permeability Test Result

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, FAR EAST DISTRICT
Unit #15546
APO AP 96205-5546

REPLY TO
ATTENTION OF:

CEPOF-ED-GE

25 May 2011

MEMORANDUM FOR Deputy Commander, Eighth Army (Brigadier General David J. Conboy), APO AP 96204

SUBJECT: Review of Existing Dioxin Analytical Results in Soil and Groundwater Samples, Camp Carroll, Korea

1. Enclosed is the summary of historical test results for dioxin in soil and groundwater samples. Special attention is focused on 2,3,7,8-tetrachlorodibenzodioxin (TCDD) due to the very high toxicity of this compound. The results were excerpted from the previous and on-going investigation projects at Camp Carroll conducted from 2004 to 2011 by Geotechnical and Environmental Engineering Branch, US Army Corps of Engineers, Far East District (FED).

2. A total of 106 soil samples and 4 groundwater samples were tested for dioxins and furans using Method 8290 of United States Environmental Protection Agency (USEPA). The summary of analytical results is presented in the attached table. The attached figure shows the general location of samples with detected 2,3,7,8-TCDD in the Area 41, Area D, Landfarm, and BEQ Hill areas. There were two investigation events in both Area D and Area 41 where 2,3,7,8-TCDD was detected.

3. Summary of Findings:

a. The 2,3,7-8-TCDD was not detected in any of the groundwater samples.

b. Two (2) soil samples collected in 2004 were reported to have detectable concentrations of 2,3,7,8-TCDD. One sample collected at the Landfarm site had 0.304 pg/g of 2,3,7,8-TCDD, and the other sample collected at Area 41 had a concentration of 0.244 pg/g as an estimated maximum possible concentration (EMPC). EMPC is an estimated value provided when the target compound is mixed with other components, but estimated as maximum under the assumption that the concentration only originated from the target compound.

c. Three (3) soil samples collected in 2011 were reported to have 2,3,7,8-TCDD. There is one sample from Area 41 with a concentration of 0.070 pg/g, and two samples from Area D with 0.074 and 0.030 pg/g respectively. These detected levels were less than the quantitation limit of the testing laboratory. Consequently, the concentrations were reported as estimated values.

d. The International-Toxic EQuivalent (I-TEQ) scheme weighs the toxicity of the less toxic compounds as fractions of the toxicity of the most toxic TCDD. There are two methods for calculating the I-TEQs for soil samples using the I-Toxic Equivalent Factors (TEF). The first method uses the measured concentrations of dioxins and furans detected equal to or higher than the Method Detection Limit (MDL), and one-half the detection limit for the compounds not detected. For the second method, the I-TEQs can be calculated in a manner similar to the above, but uses a zero value for the compound if it was not detected. In the draft version of 2011 FED report, FED calculated the I-TEQ as 1.9 pg/g by using the first method for Area D samples, and recalculated the I-TEQ value as 1.7 pg/g using the second method.

4. Laboratory reports for the samples in which 2,3,7,8-TCDD was detected are attached. The POC for this matter is Ms. Sarah Woo at 721-7739.

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[redacted]70271285
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,
ou=USA, cn=[redacted]170271285
Date: 2011.05.25 19:00:11 +09'00' b6

Encl

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Chief, Geotechnical & Environmental Engineering
Branch

Table- Summary of Dioxin Test Results
-Soil and Groundwater Samples of Camp Carroll-

Project Year and Location		Number of Borehole	Samples for Dioxin analysis		Detection of 2,3,7,8-TCDD		I-TEQ *	
			Soil	Ground water	Number of Hit	Concentration (pg/g)	Soil (pg/g)	Groundwater (pg/g)
2004 FED	BEQ Hill	7	21	-	-	-	0.179 - 2.02	-
	Landfarm	6	18	-	1 sample	0.304	0.482-0.962	-
2004 Samsung	Area 41	4	4	2	1 sample	0.244 EMPC[$]	0.717 - 2.04	0.00017 - 0.00336
	Area D	No borehole	6**	2		-	0.0026 - 0.717	0.00001 - 0.00097
2011 FED	Area41	13	31		1 sample	0.070 JQ[$$]	0.001 - 1.33	-
	Area D	13	26		2 sample s	0.074 JQ	0.03 - 1.73	-
						0.030 JQB[$$$]		-

*International Toxic Equivalent calculated using International-89 Toxicity Equivalent Factors based on 2,3,7,8-TCDD.

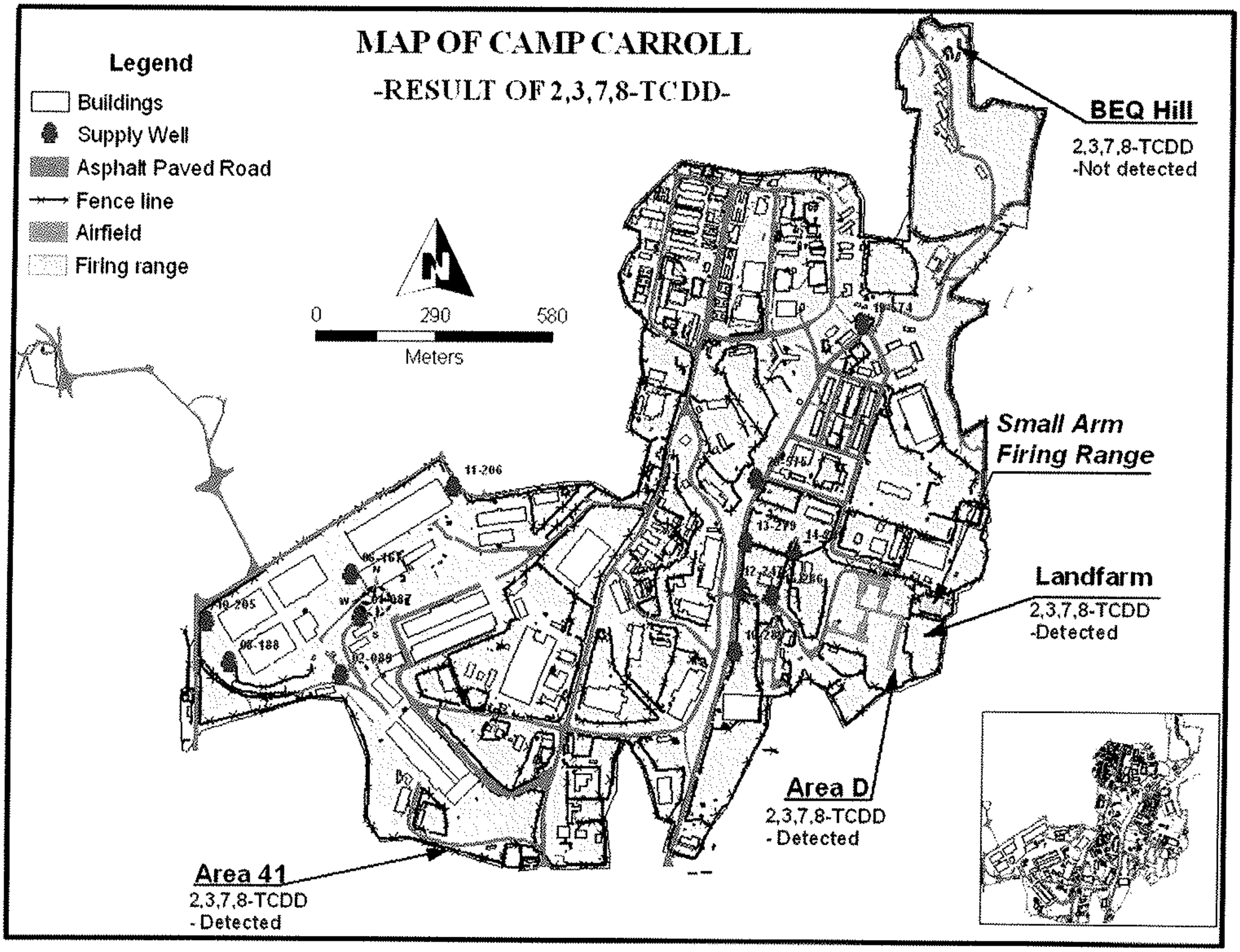
** samples were collected using a backhoe.

$ - Estimated Maximum Possible Concentration.

$$- J: the quantitation is estimated, Q: QC parameter out of acceptable range

$$$- B: Indicates the analyte is found in a blank associated with the sample

Figure - Summary of 2,3,7,8-TCDD Test Result.



APPENDIX

2,3,7,8-TCDD Data Sheet

1573

2004 Samsung - Area 41

Table 4-8
Summary of Dioxin Detections: Soil

Sample ID	CC051SS01	CC055SS01	CC066BS01	CC066SS01	CC067SS01	CC161BS01	CC001SS01	CC004SS01	CC006BS02
Lab ID	1033224003	1033224004	1032224002	1032224001	1033224005	1031902006	103182003	103182002	103182017
Location	Area 41	Area 41	Area 41	Area 41	Area 41	Area 41	Area D	Area D	Area D
Unit	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)
2,3,7,8-TCDD	ND	ND	ND	EMPC=0.244	ND	ND	ND	ND	ND
1,2,3,7,8-PeCDD	EMPC=0.268	ND	ND	EMPC=0.253	ND	ND	ND	ND	ND
1,2,3,4,7,8-HxCDD	EMPC=0.559	ND	ND	EMPC=0.278	ND	ND	ND	ND	ND
1,2,3,6,7,8-HxCDD	1.74	ND	ND	0.594	ND	ND	ND	ND	ND
1,2,3,7,8,9-HxCDD	1.1	ND	ND	EMPC=0.467	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-HpCDD	54.5	1.14	0.378	11.6	0.865	0.926	0.607	0.394	0.627
OCDD	793	40	4.15	111	30.2	51.7	26.1	18.7	38.5
2,3,7,8-TCDF	EMPC=0.318	ND	ND	0.235	ND	0.107	ND	ND	ND
1,2,3,7,8-PeCDF	0.493	ND	ND	0.131	EMPC=0.119	ND	ND	ND	ND
2,3,4,7,8-PeCDF	0.25	ND	ND	0.278	0.0956	ND	ND	ND	ND
1,2,3,4,7,8-HxCDF	0.766	ND	ND	0.393	EMPC=0.110	ND	ND	ND	ND
1,2,3,6,7,8-HxCDF	EMPC=0.555	ND	ND	EMPC=0.341	0.119	ND	ND	0.0522	ND
2,3,4,5,6,7-HxCDF	0.584	ND	ND	0.414	ND	ND	ND	ND	ND
1,2,3,7,8,9-HxCDF	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-HpCDF	10.5	0.312	ND	4.53	0.336	EMPC=0.118	EMPC=0.0883	0.106	0.0988
1,2,3,4,7,8,9-HpCDF	0.859	ND	ND	0.382	ND	ND	ND	ND	ND
OCDF	23.1	1.08	ND	11.3	EMPC=0.559	ND	EMPC=0.136	ND	ND
Total TCDDs	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PeCDDs	0.557	ND	ND	0.223	ND	ND	ND	ND	ND
Total HxCDDs	7.62	ND	ND	0.594	ND	ND	ND	ND	ND
Total HpCDDs	97.7	2.52	0.737	21.1	2	3.01	1.44	1.14	0.627
Total TCDFs	2.6	ND	ND	0.64	ND	0.186	ND	ND	ND
Total PeCDFs	4.55	ND	ND	2.4	0.0956	ND	ND	ND	ND
Total HxCDFs	11.8	ND	ND	7.14	0.224	ND	ND	0.0522	ND
Total HpCDFs	28.2	0.312	ND	13	0.732	ND	ND	0.106	0.186
ITEF TEQ (ND = 0)	2.04	0.0556	0.00793	0.596	0.102	0.0717	0.0322	0.0289	0.0458
ITEF TEQ (ND = 1/2)	2.34	0.584	0.436	0.825	0.492	0.362	0.331	0.293	0.323

Notes:
pg/g = picograms per gram
ND = not detected
na = not analyzed

Method 8290

1042930024

SGS Environmental

Analytical Data Summary Sheet

Analyte	Amount (pg/g)	EDL (pg/g)	EMPC (pg/g)	RT (min.)	Ratio	Qualifier
2,3,7,8-TCDD	0.304			31:17	0.82	A
1,2,3,7,8-PeCDD	0.240			34:07	1.37	A
1,2,3,4,7,8-HxCDD	0.232			36:42	1.13	A
1,2,3,6,7,8-HxCDD	EMPC	0.500	0.732	36:47	1.02	A
1,2,3,7,8,9-HxCDD	EMPC	0.500	0.388	37:02	1.60	A
1,2,3,4,6,7,8-HpCDD	21.0			40:06	1.02	
OCDD	339			44:23	0.85	
2,3,7,8-TCDF	1.47			30:36	0.79	A
1,2,3,7,8-PeCDF	0.851			33:19	1.53	A
2,3,4,7,8-PeCDF	0.628			33:56	1.57	A
1,2,3,4,7,8-HxCDF	1.55			35:59	1.15	A
1,2,3,6,7,8-HxCDF	EMPC	0.500	0.915	36:06	1.05	A
2,3,4,6,7,8-HxCDF	0.748			36:35	1.21	A
1,2,3,7,8,9-HxCDF	ND	0.500				
1,2,3,4,6,7,8-HpCDF	6.84			38:51	1.06	
1,2,3,4,7,8,9-HpCDF	0.787			40:48	0.97	A
OCDF	28.2			44:41	0.81	
Total TCDDs	1.52		2.66			
Total PeCDDs	1.71					
Total HxCDDs	4.29		6.33			
Total HpCDDs	42.1					
Total TCDFs	7.68		12.8			
Total PeCDFs	7.27		8.46			
Total HxCDFs	9.25		10.2			
Total HpCDFs	17.0					
ITEF TEQ (ND=0)	1.83		2.04			
ITEF TEQ (ND=½)	1.93		2.06			

Client Information

Project Name:	Cp Carroll 03-079e
Sample ID:	1042930024

Laboratory Information

Project ID:	G552-81	
Sample ID:	G552-81-20B	
Collection Date/Time:	17-May-04	12:50
Receipt Date:	29-May-04	
Extraction Date:	03-Jun-04	
Analysis Date:	10-Jun-04	

Sample Information

Report Basis:	Dry Weight	
Matrix:	Soil	
Weight / Volume:	05.52	g
Solids / Lipids:	90.6	%
Original pH :	NA	
Batch ID:	WG10361	
Filename:	a07jun04b_7-8	
Retchk:	a07jun04b_6-14	
Begin ConCal:	a07jun04b_6-14	
End ConCal:	a07jun04b_7-14	
Initial Cal:	m8290-122203b	

NCA Labs Korea Co, Ltd.

Sample ID: B09-191-S2

Trace Level Organic Compounds

SW846 8290

Lot - Sample #....:	G9J100225 - 018	**Work Order #....:**	LMD842AG	**Matrix....:**	SOLID
Date Sampled....:	10/07/09	**Date Received....:**	10/14/09	**Dilution Factor:**	0.98
Prep Date....:	11/05/09	**Analysis Date....:**	11/07/09	**Percent Moisture:**	13
Prep Batch # ....:	9309558	**Instrument ID....:**	3D5		
Initial Wgt/Vol :	10.21 g	**Analyst ID....:**	Grandfield S. Virginia		

PARAMETER	RESULT		REPORTING LIMIT	ESTIMATED DETECTION LIMIT	UNITS
2,3,7,8-TCDD	**0.070**	**J Q**	**1.1**	**0.036**	**pg/g**
Total TCDD	**0.070**		**1.1**	**0.036**	**pg/g**
1,2,3,7,8-PeCDD	ND		5.6	0.057	pg/g
Total PeCDD	ND		5.6	0.057	pg/g
1,2,3,4,7,8-HxCDD	**0.054**	**J Q**	**5.6**	**0.039**	**pg/g**
1,2,3,6,7,8-HxCDD	**0.059**	**J Q**	**5.6**	**0.032**	**pg/g**
1,2,3,7,8,9-HxCDD	**0.040**	**J**	**5.6**	**0.033**	**pg/g**
Total HxCDD	**0.22**		**5.6**	**0.034**	**pg/g**
1,2,3,4,6,7,8-HpCDD	**0.70**	**J B**	**5.6**	**0.058**	**pg/g**
Total HpCDD	**1.4**		**5.6**	**0.058**	**pg/g**
OCDD	**10**	**J B**	**11**	**0.15**	**pg/g**
2,3,7,8-TCDF	**0.096**	**J**	**1.1**	**0.026**	**pg/g**
Total TCDF	**0.17**		**1.1**	**0.026**	**pg/g**
1,2,3,7,8-PeCDF	ND		5.6	0.041	pg/g
2,3,4,7,8-PeCDF	ND		5.6	0.043	pg/g
Total PeCDF	ND		5.6	0.043	pg/g
1,2,3,4,7,8-HxCDF	**0.068**	**J**	**5.6**	**0.023**	**pg/g**
1,2,3,6,7,8-HxCDF	**0.031**	**J Q**	**5.6**	**0.020**	**pg/g**
2,3,4,6,7,8-HxCDF	**0.056**	**J**	**5.6**	**0.022**	**pg/g**
1,2,3,7,8,9-HxCDF	**0.046**	**J**	**5.6**	**0.024**	**pg/g**
Total HxCDF	**0.29**		**5.6**	**0.022**	**pg/g**
1,2,3,4,6,7,8-HpCDF	**0.21**	**J**	**5.6**	**0.036**	**pg/g**
1,2,3,4,7,8,9-HpCDF	**0.055**	**J Q**	**5.6**	**0.043**	**pg/g**
Total HpCDF	**0.42**		**5.6**	**0.039**	**pg/g**
OCDF	**0.081**	**J Q**	**11**	**0.079**	**pg/g**

1576 [redacted] 1/30/2009

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NCA Labs Korea Co, Ltd.

Sample ID: B09-198-S1

Trace Level Organic Compounds

SW846 8290

Lot - Sample #....:	G9I240378 - 020	**Work Order #....:**	LLF3Q2AQ	**Matrix....:**	SOLID
Date Sampled....:	09/22/09	**Date Received....:**	09/25/09	**Dilution Factor:**	0.95
Prep Date....:	10/21/09	**Analysis Date....:**	10/29/09	**Percent Moisture:**	8.1
Prep Batch # ....:	9294334	**Instrument ID....:**	3D5		
Initial Wgt/Vol :	10.5 g	**Analyst ID....:**	Sonia Ouni		

PARAMETER	RESULT		REPORTING LIMIT	ESTIMATED DETECTION LIMIT	UNITS
2,3,7,8-TCDD	**0.030**	**J Q B**	**1.0**	**0.026**	**pg/g**
Total TCDD	**0.030**		**1.0**	**0.026**	**pg/g**
1,2,3,7,8-PeCDD	ND		5.2	0.057	pg/g
Total PeCDD	ND		5.2	0.057	pg/g
1,2,3,4,7,8-HxCDD	ND		5.2	0.027	pg/g
1,2,3,6,7,8-HxCDD	**0.036**	**J Q**	**5.2**	**0.022**	**pg/g**
1,2,3,7,8,9-HxCDD	**0.079**	**J Q**	**5.2**	**0.023**	**pg/g**
Total HxCDD	**0.17**		**5.2**	**0.024**	**pg/g**
1,2,3,4,6,7,8-HpCDD	**0.56**	**J B**	**5.2**	**0.043**	**pg/g**
Total HpCDD	**1.6**		**5.2**	**0.043**	**pg/g**
OCDD	**26**	**B**	**10**	**0.12**	**pg/g**
2,3,7,8-TCDF	**0.14**	**J B**	**1.0**	**0.023**	**pg/g**
Total TCDF	**0.22**		**1.0**	**0.023**	**pg/g**
1,2,3,7,8-PeCDF	ND		5.2	0.031	pg/g
2,3.4,7,8-PeCDF	ND		5.2	0.032	pg/g
Total PeCDF	ND		5.2	0.033	pg/g
1,2,3,4,7,8-HxCDF	**0.067**	**J Q**	**5.2**	**0.015**	**pg/g**
1,2,3,6,7,8-HxCDF	**0.048**	**J Q**	**5.2**	**0.014**	**pg/g**
2,3,4,6,7,8-HxCDF	**0.036**	**J Q**	**5.2**	**0.014**	**pg/g**
1,2,3,7,8,9-HxCDF	**0.044**	**J**	**5.2**	**0.016**	**pg/g**
Total HxCDF	**0.22**		**5.2**	**0.015**	**pg/g**
1,2,3,4,6,7,8-HpCDF	**0.14**	**J Q**	**5.2**	**0.026**	**pg/g**
1,2,3,4,7,8,9-HpCDF	ND		5.2	0.030	pg/g
Total HpCDF	**0.14**		**5.2**	**0.028**	**pg/g**
OCDF	**0.14**	**J Q B**	**10**	**0.040**	**pg/g**

1577

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NCA Labs Korea Co, Ltd.

Sample ID: B09-194-S2

Trace Level Organic Compounds

SW846 8290

Lot - Sample #....:	G9I240378 - 039	**Work Order #....:**	LLJCR1AF	**Matrix....:**	SOLID
Date Sampled....:	09/22/09	**Date Received....:**	09/25/09	**Dilution Factor:**	0.97
Prep Date....:	10/19/09	**Analysis Date....:**	10/28/09	**Percent Moisture:**	9.4
Prep Batch # ....:	9292309	**Instrument ID....:**	4D5		
Initial Wgt/Vol :	10.27 g	**Analyst ID....:**	Susan X. Yan		

PARAMETER	RESULT		REPORTING LIMIT	ESTIMATED DETECTION LIMIT	UNITS
2,3,7,8-TCDD	0.074	J Q	1.1	0.0039	pg/g
Total TCDD	0.074		1.1	0.0039	pg/g
1,2,3,7,8-PeCDD	0.089	J	5.4	0.014	pg/g
Total PeCDD	0.45		5.4	0.014	pg/g
1,2,3,4,7,8-HxCDD	0.29	J Q	5.4	0.038	pg/g
1,2,3,6,7,8-HxCDD	1.1	J	5.4	0.032	pg/g
1,2,3,7,8,9-HxCDD	0.86	J B	5.4	0.032	pg/g
Total HxCDD	6.5		5.4	0.034	pg/g
1,2,3,4,6,7,8-HpCDD	38	B	5.4	0.26	pg/g
Total HpCDD	74		5.4	0.26	pg/g
OCDD	440	B	11	0.40	pg/g
2,3,7,8-TCDF	0.12	J Q	1.1	0.031	pg/g
Total TCDF	0.35		1.1	0.031	pg/g
1,2,3,7,8-PeCDF	0.12	J Q	5.4	0.068	pg/g
2,3,4,7,8-PeCDF	0.12	J	5.4	0.071	pg/g
Total PeCDF	1.5		5.4	0.069	pg/g
1,2,3,4,7,8-HxCDF	1.3	J B	5.4	0.11	pg/g
1,2,3,6,7,8-HxCDF	0.57	J B	5.4	0.11	pg/g
2,3,4,6,7,8-HxCDF	0.22	J Q	5.4	0.11	pg/g
1,2,3,7,8,9-HxCDF	ND		5.4	0.13	pg/g
Total HxCDF	25		5.4	0.11	pg/g
1,2,3,4,6,7,8-HpCDF	19	B	5.4	0.24	pg/g
1,2,3,4,7,8,9-HpCDF	1.3	J	5.4	0.28	pg/g
Total HpCDF	80		5.4	0.26	pg/g
OCDF	57	B	11	0.23	pg/g

1578

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Table - Summary of Dioxin Test Results
Soil and Groundwater Samples of Camp Carroll

Project Year and Location		Numbers of Borehole	Samples for Dioxin analysis		Detection of 2,3,7,8-TCDD		I-TEQ*	
			Soil	Ground water	Number of Hit	Concentration (pg/g)	Soil (pg/g)	Groundwater (ng/L)
2004 FED	BEQ Hill	7	21	0	-	-	0.179 - 2.02	no sample
	Landfarm	6	18	0	1 soil sample	0.304	0.482 - 0.962	no sample
2004 Samsung	Area 41	4	4	2	1 soil sample	0.244 EMPC[1]	0.717 - 2.04	0.00017 - 0.00336
	Area D	No borehole	6**	2	-	-	0.0026 - 0.717	0.00001 - 0.00097
2011 FED	Area41	13	31	0	1 soil sample	0.070 JQ[2]	0.001 - 1.33	no sample
	Area D	13	26	0	2 soil samples	0.074 JQ	0.03 - 1.73	no sample
						0.030 JQB[3]		no sample

* International Toxic Equivalent calculated using International-89 Toxicity Equivalent Factors based on 2,3,7,8-TCDD.

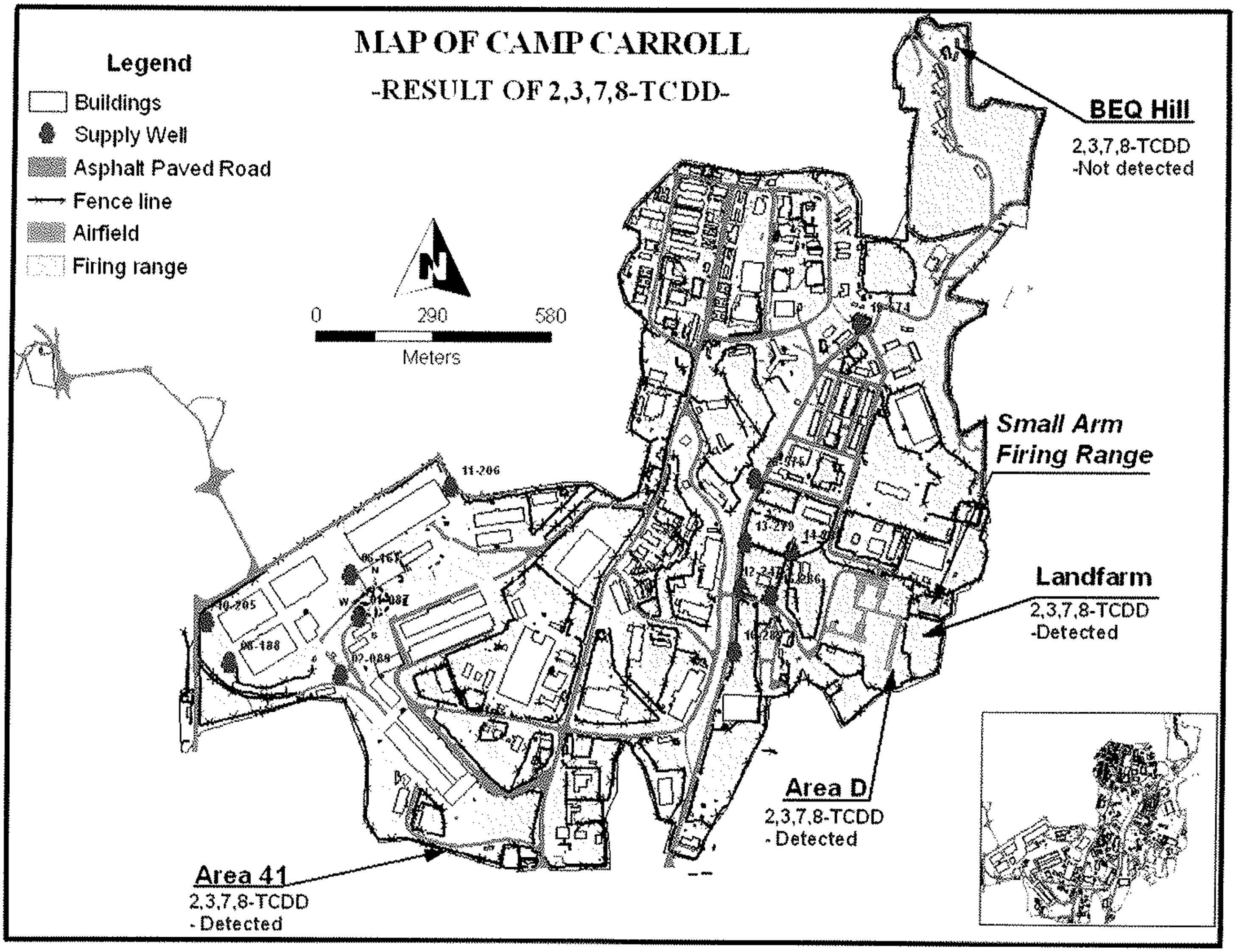
** Samples were collected using a backhoe.

[1] Estimated Maximum Possible Concentration

[2] J: the quantitation is estimated, Q: QC parameter out of acceptable range.

[3] B: Indicates the analyte is found in a blank associated with the sample.

Figure - Summary of 2,3,7,8-TCDD Test Result.



APPENDIX

2,3,7,8-TCDD Data Sheet

1581

2004 Samsung - Area 41

Table 4-8
Summary of Dioxin Detections: Soil

Sample ID	CC051SS01	CC055SS01	CC066BS01	CC066SS01	CC067SS01	CC161BS01	CC001SS01	CC004SS01	CC006BS02
Lab ID	1033224003	1033224004	1032224002	1032224001	1033224005	1031902006	103182003	103182002	103182017
Location	Area 41	Area 41	Area 41	Area 41	Area 41	Area 41	Area D	Area D	Area D
Unit	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)	(pg/g)
2,3,7,8-TCDD	ND	ND	ND	EMPC=0.244	ND	ND	ND	ND	ND
1,2,3,7,8-PeCDD	EMPC=0.268	ND	ND	EMPC=0.253	ND	ND	ND	ND	ND
1,2,3,4,7,8-HxCDD	EMPC=0.559	ND	ND	EMPC=0.278	ND	ND	ND	ND	ND
1,2,3,6,7,8-HxCDD	1.74	ND	ND	0.594	ND	ND	ND	ND	ND
1,2,3,7,8,9-HxCDD	1.1	ND	ND	EMPC=0.467	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-HpCDD	54.5	1.14	0.378	11.6	0.865	0.926	0.607	0.394	0.627
OCDD	793	40	4.15	111	30.2	51.7	26.1	18.7	38.5
2,3,7,8-TCDF	EMPC=0.318	ND	ND	0.235	ND	0.107	ND	ND	ND
1,2,3,7,8-PeCDF	0.493	ND	ND	0.131	EMPC=0.119	ND	ND	ND	ND
2,3,4,7,8-PeCDF	0.25	ND	ND	0.278	0.0956	ND	ND	ND	ND
1,2,3,4,7,8-HxCDF	0.766	ND	ND	0.393	EMPC=0.110	ND	ND	ND	ND
1,2,3,6,7,8-HxCDF	EMPC=0.555	ND	ND	EMPC=0.341	0.119	ND	ND	0.0522	ND
2,3,4,5,6,7-HxCDF	0.584	ND	ND	0.414	ND	ND	ND	ND	ND
1,2,3,7,8,9-HxCDF	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-HpCDF	10.5	0.312	ND	4.53	0.336	EMPC=0.118	EMPC=0.0883	0.106	0.0988
1,2,3,4,7,8,9-HpCDF	0.859	ND	ND	0.382	ND	ND	ND	ND	ND
OCDF	23.1	1.08	ND	11.3	EMPC=0.559	ND	EMPC=0.136	ND	ND
Total TCDDs	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PeCDDs	0.557	ND	ND	0.223	ND	ND	ND	ND	ND
Total HxCDDs	7.62	ND	ND	0.594	ND	ND	ND	ND	ND
Total HpCDDs	97.7	2.52	0.737	21.1	2	3.01	1.44	1.14	0.627
Total TCDFs	2.6	ND	ND	0.64	ND	0.186	ND	ND	ND
Total PeCDFs	4.55	ND	ND	2.4	0.0956	ND	ND	ND	ND
Total HxCDFs	11.8	ND	ND	7.14	0.224	ND	ND	0.0522	ND
Total HpCDFs	28.2	0.312	ND	13	0.732	ND	ND	0.106	0.186
ITEF TEQ (ND = 0)	2.04	0.0556	0.00793	0.596	0.102	0.0717	0.0322	0.0289	0.0458
ITEF TEQ (ND = 1/2)	2.34	0.584	0.436	0.825	0.492	0.362	0.331	0.293	0.323

Notes:
pg/g = picograms per gram
ND = not detected
na = not analyzed

Method 8290

1042930024

SGS Environmental

Analytical Data Summary Sheet

Analyte	Amount (pg/g)	EDL (pg/g)	EMPC (pg/g)	RT (min.)	Ratio	Qualifier
2,3,7,8-TCDD	0.304			31:17	0.82	A
1,2,3,7,8-PeCDD	0.240			34:07	1.37	A
1,2,3,4,7,8-HxCDD	0.232			36:42	1.13	A
1,2,3,6,7,8-HxCDD	EMPC	0.500	0.732	36:47	1.02	A
1,2,3,7,8,9-HxCDD	EMPC	0.500	0.388	37:02	1.60	A
1,2,3,4,6,7,8-HpCDD	21.0			40:06	1.02	
OCDD	339			44:23	0.85	
2,3,7,8-TCDF	1.47			30:36	0.79	A
1,2,3,7,8-PeCDF	0.851			33:19	1.53	A
2,3,4,7,8-PeCDF	0.628			33:56	1.57	A
1,2,3,4,7,8-HxCDF	1.55			35:59	1.15	A
1,2,3,6,7,8-HxCDF	EMPC	0.500	0.915	36:06	1.05	A
2,3,4,6,7,8-HxCDF	0.748			36:35	1.21	A
1,2,3,7,8,9-HxCDF	ND	0.500				
1,2,3,4,6,7,8-HpCDF	6.84			38:51	1.06	
1,2,3,4,7,8,9-HpCDF	0.787			40:48	0.97	A
OCDF	28.2			44:41	0.81	
Total TCDDs	1.52		2.66			
Total PeCDDs	1.71					
Total HxCDDs	4.29		6.33			
Total HpCDDs	42.1					
Total TCDFs	7.68		12.8			
Total PeCDFs	7.27		8.46			
Total HxCDFs	9.25		10.2			
Total HpCDFs	17.0					
ITEF TEQ (ND=0)	1.83		2.04			
ITEF TEQ (ND=½)	1.93		2.06			

Client Information		**Sample Information**	
Project Name:	Cp Carroll 03-079e	Report Basis:	Dry Weight
		Matrix:	Soil
Sample ID:	1042930024	Weight / Volume:	05.52 g
		Solids / Lipids:	90.6 %
		Original pH :	NA
Laboratory Information		Batch ID:	WG10361
Project ID:	G552-81		
Sample ID:	G552-81-20B	Filename:	a07jun04b_7-8
Collection Date/Time:	17-May-04 12:50	Retchk:	a07jun04b_6-14
Receipt Date:	29-May-04	Begin ConCal:	a07jun04b_6-14
Extraction Date:	03-Jun-04	End ConCal:	a07jun04b_7-14
Analysis Date:	10-Jun-04	Initial Cal:	m8290-122203b

1583

NCA Labs Korea Co, Ltd.

Sample ID: B09-191-S2

Trace Level Organic Compounds

SW846 8290

Lot - Sample #....:	G9J100225 - 018	**Work Order #....:**	LMD842AG	**Matrix....:**	SOLID
Date Sampled....:	10/07/09	**Date Received....:**	10/14/09	**Dilution Factor:**	0.98
Prep Date....:	11/05/09	**Analysis Date....:**	11/07/09	**Percent Moisture:**	13
Prep Batch # ....:	9309558	**Instrument ID....:**	3D5		
Initial Wgt/Vol :	10.21 g	**Analyst ID....:**	Grandfield S. Virginia		

PARAMETER	RESULT		REPORTING LIMIT	ESTIMATED DETECTION LIMIT	UNITS
2,3,7,8-TCDD	**0.070**	**J Q**	**1.1**	**0.036**	**pg/g**
Total TCDD	**0.070**		**1.1**	**0.036**	**pg/g**
1,2,3,7,8-PeCDD	ND		5.6	0.057	pg/g
Total PeCDD	ND		5.6	0.057	pg/g
1,2,3,4,7,8-HxCDD	**0.054**	**J Q**	**5.6**	**0.039**	**pg/g**
1,2,3,6,7,8-HxCDD	**0.059**	**J Q**	**5.6**	**0.032**	**pg/g**
1,2,3,7,8,9-HxCDD	**0.040**	**J**	**5.6**	**0.033**	**pg/g**
Total HxCDD	**0.22**		**5.6**	**0.034**	**pg/g**
1,2,3,4,6,7,8-HpCDD	**0.70**	**J B**	**5.6**	**0.058**	**pg/g**
Total HpCDD	**1.4**		**5.6**	**0.058**	**pg/g**
OCDD	**10**	**J B**	**11**	**0.15**	**pg/g**
2,3,7,8-TCDF	**0.096**	**J**	**1.1**	**0.026**	**pg/g**
Total TCDF	**0.17**		**1.1**	**0.026**	**pg/g**
1,2,3,7,8-PeCDF	ND		5.6	0.041	pg/g
2,3,4,7,8-PeCDF	ND		5.6	0.043	pg/g
Total PeCDF	ND		5.6	0.043	pg/g
1,2,3,4,7,8-HxCDF	**0.068**	**J**	**5.6**	**0.023**	**pg/g**
1,2,3,6,7,8-HxCDF	**0.031**	**J Q**	**5.6**	**0.020**	**pg/g**
2,3,4,6,7,8-HxCDF	**0.056**	**J**	**5.6**	**0.022**	**pg/g**
1,2,3,7,8,9-HxCDF	**0.046**	**J**	**5.6**	**0.024**	**pg/g**
Total HxCDF	**0.29**		**5.6**	**0.022**	**pg/g**
1,2,3,4,6,7,8-HpCDF	**0.21**	**J**	**5.6**	**0.036**	**pg/g**
1,2,3,4,7,8,9-HpCDF	**0.055**	**J Q**	**5.6**	**0.043**	**pg/g**
Total HpCDF	**0.42**		**5.6**	**0.039**	**pg/g**
OCDF	**0.081**	**J Q**	**11**	**0.079**	**pg/g**

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NCA Labs Korea Co, Ltd.

Sample ID: B09-198-S1

Trace Level Organic Compounds

SW846 8290

Lot - Sample #....:	G9I240378 - 020	**Work Order #....:**	LLF3Q2AQ	**Matrix....:**	SOLID
Date Sampled....:	09/22/09	**Date Received....:**	09/25/09	**Dilution Factor:**	0.95
Prep Date....:	10/21/09	**Analysis Date....:**	10/29/09	**Percent Moisture:**	8.1
Prep Batch # ....:	9294334	**Instrument ID....:**	3D5		
Initial Wgt/Vol :	10.5 g	**Analyst ID....:**	Sonia Ouni		

PARAMETER	RESULT		REPORTING LIMIT	ESTIMATED DETECTION LIMIT	UNITS
2,3,7,8-TCDD	**0.030**	**J Q B**	**1.0**	**0.026**	**pg/g**
Total TCDD	**0.030**		**1.0**	**0.026**	**pg/g**
1,2,3,7,8-PeCDD	ND		5.2	0.057	pg/g
Total PeCDD	ND		5.2	0.057	pg/g
1,2,3,4,7,8-HxCDD	ND		5.2	0.027	pg/g
1,2,3,6,7,8-HxCDD	**0.036**	**J Q**	**5.2**	**0.022**	**pg/g**
1,2,3,7,8,9-HxCDD	**0.079**	**J Q**	**5.2**	**0.023**	**pg/g**
Total HxCDD	**0.17**		**5.2**	**0.024**	**pg/g**
1,2,3,4,6,7,8-HpCDD	**0.56**	**J B**	**5.2**	**0.043**	**pg/g**
Total HpCDD	**1.6**		**5.2**	**0.043**	**pg/g**
OCDD	**26**	**B**	**10**	**0.12**	**pg/g**
2,3,7,8-TCDF	**0.14**	**J B**	**1.0**	**0.023**	**pg/g**
Total TCDF	**0.22**		**1.0**	**0.023**	**pg/g**
1,2,3,7,8-PeCDF	ND		5.2	0.031	pg/g
2,3,4,7,8-PeCDF	ND		5.2	0.032	pg/g
Total PeCDF	ND		5.2	0.033	pg/g
1,2,3,4,7,8-HxCDF	**0.067**	**J Q**	**5.2**	**0.015**	**pg/g**
1,2,3,6,7,8-HxCDF	**0.048**	**J Q**	**5.2**	**0.014**	**pg/g**
2,3,4,6,7,8-HxCDF	**0.036**	**J Q**	**5.2**	**0.014**	**pg/g**
1,2,3,7,8,9-HxCDF	**0.044**	**J**	**5.2**	**0.016**	**pg/g**
Total HxCDF	**0.22**		**5.2**	**0.015**	**pg/g**
1,2,3,4,6,7,8-HpCDF	**0.14**	**J Q**	**5.2**	**0.026**	**pg/g**
1,2,3,4,7,8,9-HpCDF	ND		5.2	0.030	pg/g
Total HpCDF	**0.14**		**5.2**	**0.028**	**pg/g**
OCDF	**0.14**	**J Q B**	**10**	**0.040**	**pg/g**

NCA Labs Korea Co, Ltd.

Sample ID: B09-194-S2

Trace Level Organic Compounds

SW846 8290

Lot - Sample #....:	G9I240378 - 039	**Work Order #....:**	LLJCR1AF	**Matrix....:**	SOLID
Date Sampled....:	09/22/09	**Date Received....:**	09/25/09	**Dilution Factor:**	0.97
Prep Date....:	10/19/09	**Analysis Date....:**	10/28/09	**Percent Moisture:**	9.4
Prep Batch # ....:	9292309	**Instrument ID....:**	4D5		
Initial Wgt/Vol :	10.27 g	**Analyst ID....:**	Susan X. Yan		

PARAMETER	RESULT		REPORTING LIMIT	ESTIMATED DETECTION LIMIT	UNITS
2,3,7,8-TCDD	**0.074**	**J Q**	**1.1**	**0.0039**	**pg/g**
Total TCDD	**0.074**		**1.1**	**0.0039**	**pg/g**
1,2,3,7,8-PeCDD	**0.089**	**J**	**5.4**	**0.014**	**pg/g**
Total PeCDD	**0.45**		**5.4**	**0.014**	**pg/g**
1,2,3,4,7,8-HxCDD	**0.29**	**J Q**	**5.4**	**0.038**	**pg/g**
1,2,3,6,7,8-HxCDD	**1.1**	**J**	**5.4**	**0.032**	**pg/g**
1,2,3,7,8,9-HxCDD	**0.86**	**J B**	**5.4**	**0.032**	**pg/g**
Total HxCDD	**6.5**		**5.4**	**0.034**	**pg/g**
1,2,3,4,6,7,8-HpCDD	**38**	**B**	**5.4**	**0.26**	**pg/g**
Total HpCDD	**74**		**5.4**	**0.26**	**pg/g**
OCDD	**440**	**B**	**11**	**0.40**	**pg/g**
2,3,7,8-TCDF	**0.12**	**J Q**	**1.1**	**0.031**	**pg/g**
Total TCDF	**0.35**		**1.1**	**0.031**	**pg/g**
1,2,3,7,8-PeCDF	**0.12**	**J Q**	**5.4**	**0.068**	**pg/g**
2,3,4,7,8-PeCDF	**0.12**	**J**	**5.4**	**0.071**	**pg/g**
Total PeCDF	**1.5**		**5.4**	**0.069**	**pg/g**
1,2,3,4,7,8-HxCDF	**1.3**	**J B**	**5.4**	**0.11**	**pg/g**
1,2,3,6,7,8-HxCDF	**0.57**	**J B**	**5.4**	**0.11**	**pg/g**
2,3,4,6,7,8-HxCDF	**0.22**	**J Q**	**5.4**	**0.11**	**pg/g**
1,2,3,7,8,9-HxCDF	ND		5.4	0.13	pg/g
Total HxCDF	**25**		**5.4**	**0.11**	**pg/g**
1,2,3,4,6,7,8-HpCDF	**19**	**B**	**5.4**	**0.24**	**pg/g**
1,2,3,4,7,8,9-HpCDF	**1.3**	**J**	**5.4**	**0.28**	**pg/g**
Total HpCDF	**80**		**5.4**	**0.26**	**pg/g**
OCDF	**57**	**B**	**11**	**0.23**	**pg/g**

1586

[redacted] 11/20/2009

66

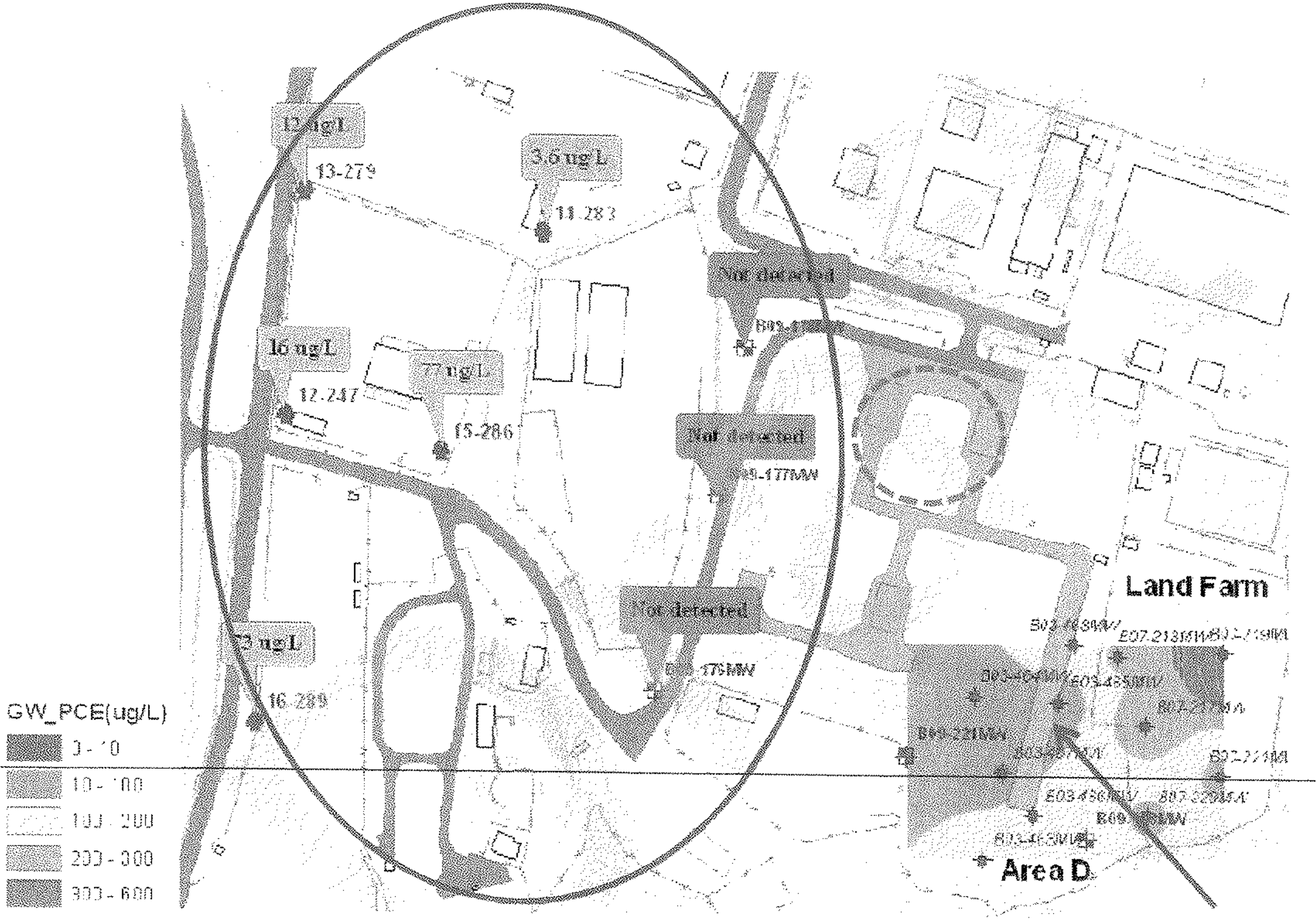
66

Water level as above mean sea level,
the arrow indicates flow direction.

Groundwater flow direction at Landfarm-Area D of Cp Carroll (FED survey in FY10)

FYI: FED analyzed dioxin for SOIL only because dioxin was not a chemical of concern at that time. FED focused on POL contamination for the survey

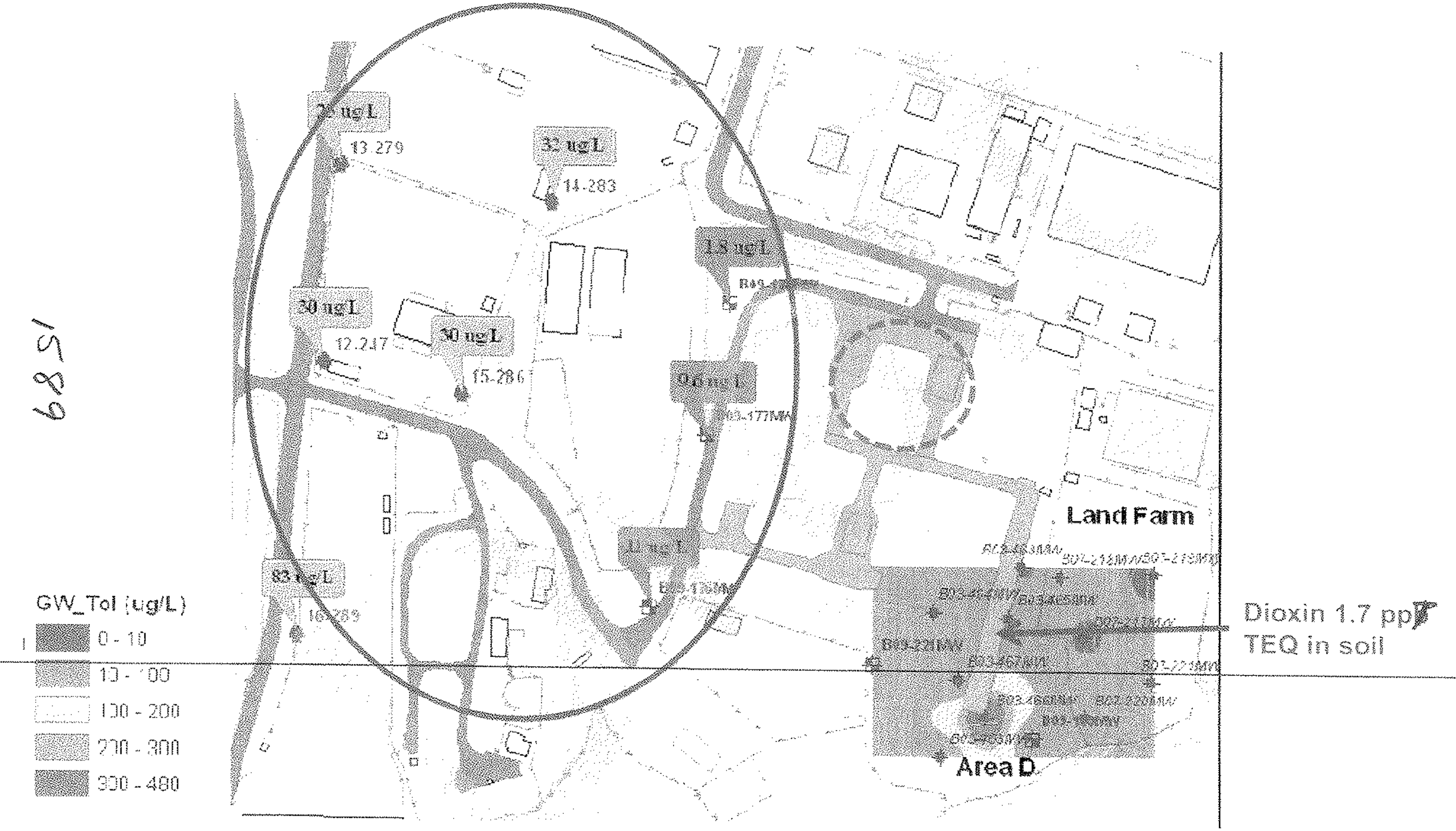
1588



Dioxin 1.7 ppb
TEQ in soil

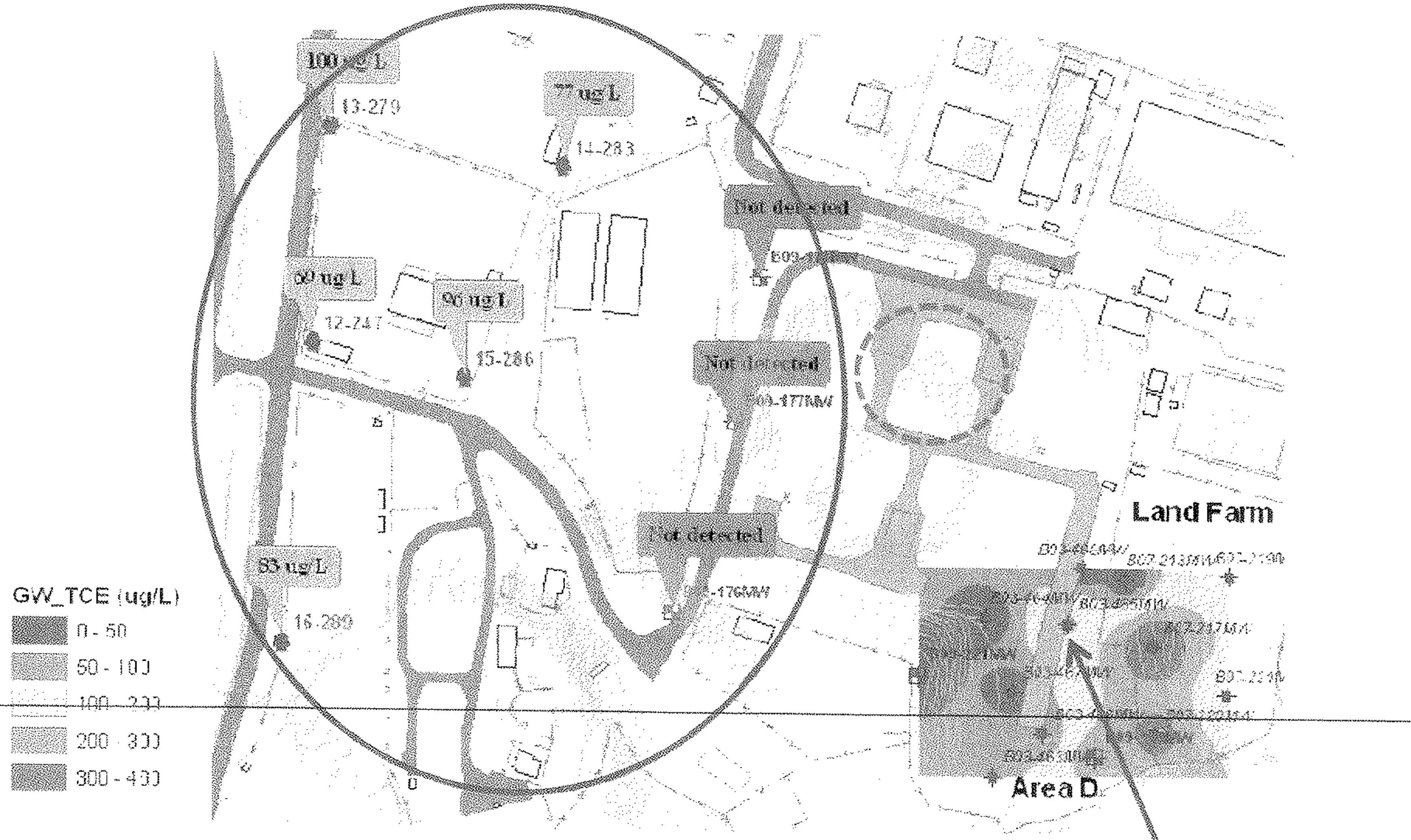
PCE (perchloroethylene)in Groundwater (FED survey in FY10):
FYI: PCE is green around helipads & 5 ea. supply wells. Red at Area D & Landfarm area.

1589



Dioxin 1.7 pp
TEQ in soil

Toluene in Groundwater (FED survey in FY10):
FYI: Toluene is green around helipads & 5 ea. supply wells. Red at Area D & Landfarm area.



Dioxin 1.7 ppT
TEQ in soil

TCE (trichloroethylene) in Groundwater (FED survey in FY10):
FYI: TCE is green around helipads & 5 ea. supply wells. Red at Area D & Landfarm area.

Drinking water analysis in FY09 (CHPPM-PAC)

Well ID	Dioxin		VOCs		Remarks
	Concentration	MCL	Concentration	MCL	
12-247	Not tested	N/A	TTE:15.6	5 mg/L	- Supply wells nearby Helipads. - Dioxin and VOCs tests for raw water are not required by USFK Pam 200-1 (EGS).
13-279	Not tested	N/A	TTE:10.3	5 mg/L	
14-283	Not tested	N/A	TCE: 15.8	5 mg/L	
15-286	Not tested	N/A	TCE:86.2, TTE:58.1	5 mg/L	
16-289	Not tested	N/A	TCE:61.9, TTE:9.9	5 mg/L	
3-130	Not tested	N/A			
6-167	Not tested	N/A	TCE: 9.9	5 mg/L	
8-188	Not tested	N/A	TCE: 211	5 mg/L	
10-205	Not tested	N/A	TCE: 15.6	5 mg/L	
11-206	Not tested	N/A			
19-574	Not tested	N/A	TCE:16.7	5 mg/L	
20-575	Not tested	N/A	TCE:76.9	5 mg/L	

Treated Water	Dioxin		VOCs		Remarks
	Concentration	MCL	Concentration	MCL	
Carroll Water Plant	< 5	30 pg/L			Comly with EPA

Note:

Next analysis for Well #12-16: End of May 2011

Next analysis for Treated water: Year of 2013

MCL: Maximum Contaminant Level

TTE: Tetrachloroethylene

TCE: Trichloroethylene

1591

FINAL DRAFT

Historical Land Use and Background Survey
Camp Carroll, Korea

Prepared for

U.S. Army Corps of Engineers
Pacific Ocean Division

January 30, 1992

Prepared by

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014

1592

1992 Report, Corps of Engineers
"Historical Land Use and Background Survey:

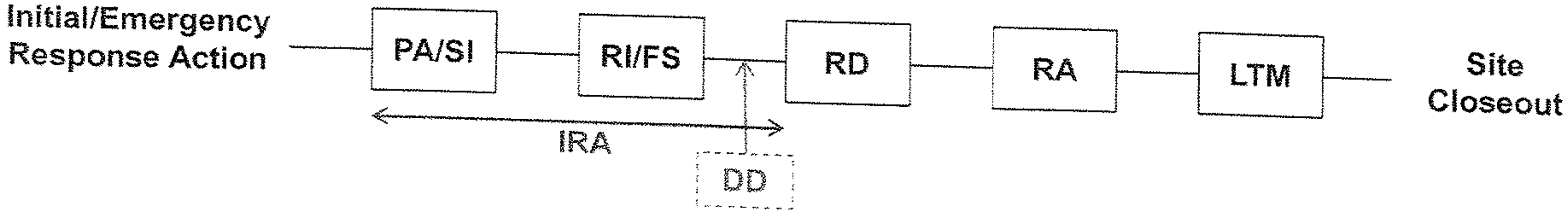
1. "Large numbers of drums were stored in Area 41 containing, among other things, chemicals, pesticides, herbicides, and solvents. There was reported leaking and soil contamination. Debris and soil from this area were reportedly land-filled at Area D.
2. Contaminated soil and debris were reported to have been landfilled in Area D in 1978. Contaminates reportedly included pesticides, herbicides, and solvents as well as over 100 other detected chemicals. From 1979 to 1980, approximately 6100 cubic feet (40 – 60 tons) of soil were reportedly excavated from this area and disposed offsite.

Camp Carroll Study, 2004

No Human health risk related to Dioxin.
No recommendations for remediation.

USAG Daegu
AEDB-CC
(Army Environmental Data Base- Compliance & Cleanup

CC Survey Phases



Initial/Emergency Response Action

PA/SI

RI/FS

RD

RA

LTM

Site Closeout

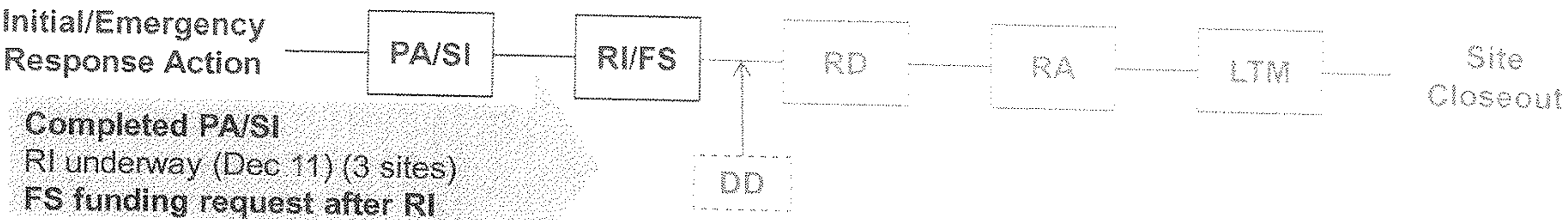
IRA

DD

1596

- •Initial/Emergency Response Action - Action taken immediately after a release occurs or is discovered to prevent further migration.
- •Preliminary Assessment (PA) / Site Inspection (SI) - Used to evaluate releases or potential releases that pose a potential threat to public health, welfare, or the environment. Supports emergency response and furnishes early information as the first step in the site assessment process.
- •Remedial Investigation (RI) / Feasibility Study (FS) - Used for assessment of the nature and extent of contamination and evaluation of appropriate site cleanup remedies.
- •Decision Document (DD) - Document that describes the final environmental response or corrective actions and remedial action goals at Army installations regardless of funding source.
- •Interim Remedial Action (IRA) - Conduct any remedial/removal action when the investigation phase is underway and an immediate threat to human health and/or the environment exists.
- •Design (RD) - Final Plans and Specifications. The specifications, drawings, and schematics will be finalized during this phase.
- •Remedial Action (RA) - Those actions consistent with permanent remedy taken to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or the environment.
- •Long-Term Management (LTM) - Term used for environmental monitoring, review of site conditions, and/or maintenance of a remedial action to ensure continued protection as designed once a site achieves Response Complete.
- •Site Closeout - The point at which DoD will no longer engage in active management or monitoring at an environmental cleanup site and no additional environmental funds will be expended unless additional cleanup is required.

USAG Daegu CC Sites (16 sites)



Initial/Emergency Response Action

PA/SI

RI/FS

DD

RD

RA

LTM

Site Closeout

Completed PA/SI
RI underway (Dec 11) (3 sites)
FS funding request after RI (EBP2)

CCBPUS003 – Bldg 1436/1439 (warehouses)
CCBPUS004 – Bldg 1317 (paint shop)
CCMASA001 – Bldg 7535 (mech bldg)

Completed PA/SI
RI/FS almost done **(Dec 11)** (13 sites)

CCWALK001 – Army Lodge
CCWALK002 – BTL (need monitoring)
CCWALK003 – Bldg 205
CCWALK004 – Bldg 318 (need IRA)
CCWALK005 – Walker Commissary
CCCARR001 – Area 41
CCCARR002 – Area D
CCCARR003 – Land Farm
CCCARR004 – BEQ Hill
CCCARR005 – Bldg 326
CCCARR006 – Vehicle Cutting Area
CCBPUS001 – POL site
CCBPUS002 – Bldg 1330/1352

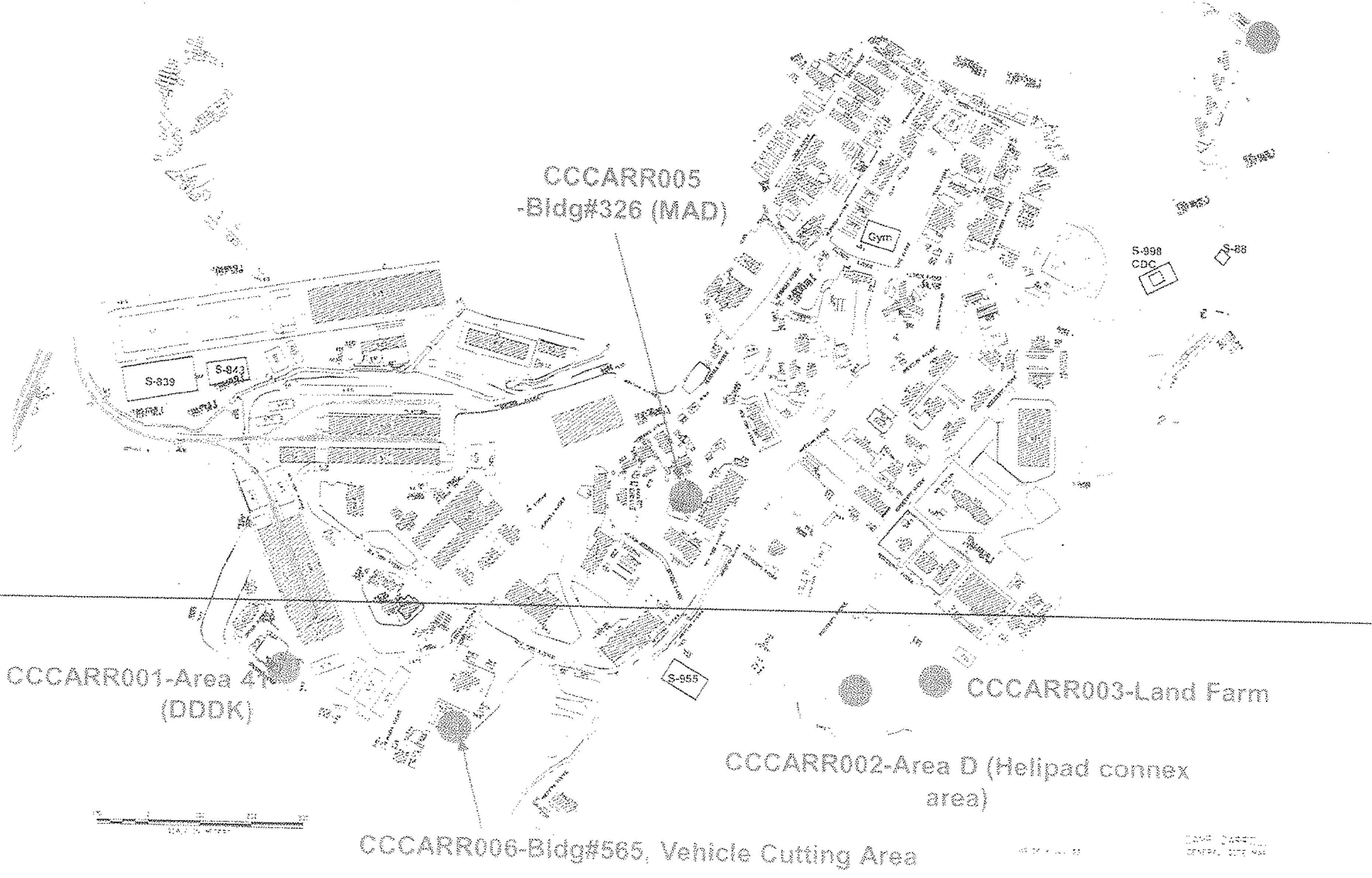
Prior to DD submission (FY11)

Upon completion of the RI/FS, results of the RI/FS will be sent to Medical Authority for review and determination of one of three options 1) Conduct RD/RA (KISE), 2) Conduct LTM, or 3) Close the site as no Known Imminent or Substantial Endangerment (KISE) exists.

DD submission

If RA is determined to be the course of action (option 1), an RD/RA will be selected with an approval packet staffed to the Environmental Executive Agent.

Camp Carroll



1598

Entry: 79105
Korean DMZ Agent Orange Information Center

South Korean National Task Force

[redacted] b6 wrote on 2011-05-30 10:42:22.0

Send Email To [redacted] b6

Comments: Dear Korean War Project,

I am e-mailing you (on behalf of the National Task Force for Investigation and Resolution of Agent Orange Burial by US Military, more info in the 2nd paragraph) with the hopes of contacting (or someone that can contact) U.S. GIs that have come forward as having taken part in the burial of Agent Orange in US Military bases in South Korea. Through your website and through the website of Vets helping Vets I am aware that Veteran [redacted] b6 and Veteran Steve House have come forward as having come forward as having either witnessed or been involved in the burial of Agent Orange. I wanted to seek your help in contacting both of these individuals and possibly inviting them to come to South Korea.

1599 As you may know currently in Korea it has come to light that there has been many toxic chemicals in particular Agent Orange, a fat soluble toxin, that had been improperly disposed of in US military bases in South Korea. Right now we are leading a campaign for the full dislosure of the disposal of Agent Orange in U.S. Military bases in South Korea and for the full resolution of this conflict.

Sincerely,

b6
[redacted] International Coordinator, National Task Force for the Investigation and Resolution of Agent Orange Burial by the US Military

Keywords:

Entry: 79062
Korean DMZ Agent Orange Information Center

Agent Orange 1961 or I962